PROCEEDINGS OF THE
FIRST ASIAN CONGRESS OF NUTRITION

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EDITED BY
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HYDERABAD

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PROCEEDINGS OF THE
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NUTRITION
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The First Asian Congress of Nutrition was held under the auspices of the Nutrition Society of India, the Indian National Science Academy and the International Union of Nutritional Sciences, in Hyderabad between 28th January and 2nd February, 1971. The organisation of the Congress was spearheaded by the staff of the National Institute of Nutrition, Hyderabad and Dr. P. G. Tulpule, Deputy Director of the Institute, who was the Secretary General of the Congress, played a notable and leading part in ensuring its success.

The theme of the Congress was NUTRITION AND NATIONAL DEVELOPMENT and special emphasis was laid on practical problems of malnutrition confronting developing countries. Ten symposia, eighteen special reports and eighty research communications selected from a large number of papers submitted were presented at the Congress.

Nearly six hundred delegates drawn from all over Asia and from other parts of the world participated in the Congress. The delegates included planners, policy makers, administrators, nutrition scientists, sociologists, economists, agricultural scientists and public health workers.

Nutrition and population problems which afflict Asian countries have many similarities. Many Asian countries are today poised for undertaking major advances in social and economic development. Among top planners in these countries there is at present an increasing awareness of the importance of nutrition in national development. Large-scale nutrition programmes are finding an important place in many national plans. In this context, to Asian planners and nutrition scientists, the Congress provided a timely and valuable forum for the exchange of experience, and
imparted a new impetus for a massive "Nutrition Movement" in Asia.

A proof of the impact of the Congress was the unanimous decision taken by the delegates that the Congress in Hyderabad should be followed by similar Asian Congresses at periodic intervals in other parts of the continent. The Steering Committee set-up for the purpose of making arrangements for the Second Asian Congress of Nutrition has selected Manila as the venue. It is gratifying that the exercise in collaborative action initiated in Hyderabad is thus being followed-up and further developed.

It is hoped that this volume edited by Dr. P. G. Tulpule and Dr. Kamala S. Jaya Rao, containing the proceedings of this Congress will be useful to all those interested in the science of nutrition.

C. Gopalan
President
FIRST ASIAN CONGRESS OF NUTRITION
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PRESIDENT, NUTRITION SOCIETY OF INDIA AND DIRECTOR, NATIONAL INSTITUTE OF NUTRITION, HYDERABAD.

Shri Khandubhai Desai, Mr. Boerma, Prof. Roina, Smt. Roda Mistry, Distinguished Delegates, Ladies and Gentlemen,

It is a matter of great pleasure and pride to me and my colleagues that this First Asian Congress of Nutrition is being held in Hyderabad.

There have of course been many International Congresses and Conventions in this part of the world. But I believe that this Congress is of the utmost importance and relevance to Asia because the problems we are going to discuss here are among the gravest and most urgent confronting our continent.

Asia accounts today for nearly 55 per cent of the world's population but enjoys no more than 10 per cent of the world's total income. There exists today an enormous economic gap between most parts of Asia and the rest of the world. Even more distressing is the fact that this economic gap has been progressively widening over the years. Apparently while the technological revolution has enabled rapid and self-generating economic growth in the developed countries of the world, the only major effect of the technological revolution as far as most Asian countries are concerned has been a marked reduction in the death rate.

This sharp decline in the death rate has been a major contributory factor in the alarming increase of Asia's population. For example, at the present growth rate of 2.5 per cent per year, India's population will reach the alarming figure of one billion before the turn of this century. The present annual increase in India's population is of the order of 13 million—almost the total population of Australia or Holland. The picture with regard to population growth in other parts of South-East Asia is no less alarming.

During the last twenty years, it is no doubt true that many Asian countries have achieved notable advances in industrial and agricultural sectors. But the growth in population has practically neutralised these achievements.
Apart from population growth, the age structure of the population and the prevailing pattern of mortality in Asian countries are also unfavourable from the economic and nutritional standpoint. Thus, children below 5 years of age, from the nutritional standpoint, are the most vulnerable, constitute over 15 per cent of the population in many Asian countries as against 8 to 10 per cent in the technologically advanced countries of the West.

Furthermore, there is a rapid turnover of the pre-school child population segment. Thus, about 40 per cent of the total deaths in most Asian countries take place among children below 5 years as against less than 4 per cent in the developed countries. Therefore, a large number of children in Asia never reach adulthood and the expenditure incurred on their rearing yields no returns to the State. This enormous 'wastage' of children is apparently a motivation for large families, especially among poor segments of our people. We are thus caught in a vicious cycle of malnutrition leading to high child mortality which in its wake, motivates large families, resulting in further aggravation of malnutrition.

It is not, therefore, surprising that some of the worst forms of malnutrition occurring in the world today are to be seen in Asia.

Nearly 70 per cent of poor school children in some Asian countries have been reported to suffer from what is generally referred to as second degree of malnutrition or moderate malnutrition.

A survey of the pattern of expenditure on food among different sections of the population in India indicates that the amount being spent on food by nearly 70 per cent of India's population would be insufficient to provide even the least expensive balanced diet. This may be representative of the situation in a number of Asian countries.

Thus, the problem which confronts us is indeed enormous. Clearly, the two major approaches available to us are, stabilization of population and marked augmentation of food production. Family Planning has now been accepted as a major national policy by some Asian countries. The present rate of population growth may decline during the next few decades, with introduction of vigorous birth control programmes, increasing urbanization, industrialization and education. But we may not be justified in expecting real relief from the current oppressive pattern of population growth for at least a generation. Even if population is stabilized the demand for food in all our countries will greatly increase in the next few years because of rising incomes of the poor groups and increasing nutrient requirements.
During the last few years, we have no doubt witnessed some heartening and spectacular advances in the field of foodgrain production.

It is essential at this point to emphasize the overriding importance of building what one may call the “nutritional dimension” into the green revolution. Asian diets are likely to be predominantly cereal-based for many years to come. It is, therefore, essential to ensure that in our attempts to increase the yield of foodgrains per unit land area, we do not lose sight of the nutritional value of the foodgrains. Fortunately, many of the high-yielding varieties of foodgrains which have been recently evolved are also of high nutritive value.

A disturbing finding however has been that the production of pulses and legumes has not only not kept pace with cereal production but has actually showed a tendency to decline. This trend has to be arrested.

The green revolution has so far been largely a wheat revolution. It has to be extended not only to cover other foodgrains and legumes but also other items of food. With 40 per cent of the world’s live-stock resources, Asia today contributes only 13 per cent of the total milk production and in spite of its enormous coastline only 24 per cent of the total world fish production.

Increase of food production is, however, just one aspect. We must not forget that undernutrition is only one of several inter-related attributes of under development. Underdeveloped countries are not only undernourished: they have a per capita gross national product which is just a fraction of that of developed countries; they have a high proportion of child population and high child mortality rate; they also have a high rate of illiteracy and poor environmental sanitation. The nutritional uplift of a nation cannot be brought about as an isolated achievement but can only be a part of overall economic development of that nation. Our theme “NUTRITION AND NATIONAL DEVELOPMENT” is thus extremely appropriate especially for an Asian Congress.

Unfortunately, many Asian countries have been beset by several natural calamities like floods, famines and droughts and the resources of our governments are often strained to meet these emergencies. These calamities have been occurring with such distressing frequency that we seem to be moving from one emergency to another. We have witnessed in recent years some remarkable rescue operations which have helped us to tide over major emergencies. But it must be remembered that the strategies which are involved in these short-term emergency operations are very different from the strategies which are called for in long-term planning for nutritional uplift. Sound
foundations of good nutrition of a nation can obviously be laid only through a
well planned and integrated programme of development which will ensure the
maximal utilisation of available resources. We must also utilise wisely the
generous help offered to us by more fortunate countries in a manner which will
not distort or distract our efforts. We must remember that programmes which
have no element of self-generation and true community participation are
bound to languish in the long run when the artificial props which support
them, for the time being, are withdrawn. It will be far better strategy to
identify solutions to our pressing problems rather than to identify problems
to fit in with certain ready-made solutions that may be offered to us.

Unfortunately in many situations in Asia, we are often unable to fully utilise
the capital resources which are available. It is not just mere increase of food
production alone that will solve our problems. The removal of numerous
administrative and organisational bottlenecks which hamper our programmes
is nearly as important.

Ladies and Gentlemen, the problems before us are truly vast and stupendous.
There is ample scope and urgent need for collaborative action among nutrition
scientists of Asia for the solution of the many common problems that confront
this continent.

This Congress is only a first step in forging such collaboration. I am certain
that this Congress will be followed by Congresses of Nutrition in other parts
of Asia. I hope that before we disperse we will also consider the setting up
of a permanent machinery which will organise and foster collaborative action
in the field of nutrition among Asian nations. Perhaps the establishment of
an Asian Chapter of the International Union of Nutritional Sciences may
serve this purpose.

Our ultimate goal is to ensure the eradication of malnutrition from this
part of the world. We have a long way to go. I am, however, certain that
this Congress will prove to be an important milestone in our march to this
goal.
Mr. Chairman, Ladies and Gentlemen,

I feel greatly honoured to address you at this First Asian Congress of Nutrition which has been organized here in India—a country which, as so often in the past, has once again pioneered an international approach to an extremely grave problem facing this vast continent.

This Congress is an extremely important initiative. For, as you know only too well, there are few problems which demand Asia’s attention more urgently and insistently than that of nutrition. Tables recently drawn up in FAO to show the nutritional situation in different regions of the world make starkly clear how disadvantaged are the developing countries here in what we classify as the Far East Region. It is in the Far East that calorie supplies fall shortest of requirements. Its total protein supplies also fall short of requirements and, although the percentage of these supplies as against requirements is not the lowest in the world, there has been a downward trend since the 1950’s. The proportion of animal protein in total protein is less in the Far East than in any other Region of the world—about 15 per cent. And, even more significant as an indicator of the quality of diets, the proportion of calories derived from carbohydrates—over 75 per cent—is the highest of any Region in the world.

The human story represented by these tables and percentages is told more simply and demonstratively by the millions of hungry faces and wasted bodies in so many cities and rural areas. It is, as I have said, a story with which you in Asia are only too painfully familiar. It is also a story which, thankfully, has not been entirely lost on the richer countries of the world. People in many of them have been making generous and imaginative efforts to help in one way or another. But it is not of course emergency shipments of food at times of threatened starvation crises that are going to solve the long term problem. Nor can the most brilliant and adventurous scientific discoveries in the laboratories of the richer countries be automatically applied in the different social and ecological surroundings of a continent such as this. You
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know very well from experience that, whatever assistance may come from outside, the future of Asia can only be won in Asia and its problems can only be solved in Asian conditions. At the same time, you also know that, in the modern world, problems have to be tackled on a much larger scale than ever before.

It is for these reasons that I particularly welcome the initiative which has been taken in convening this First Asian Congress of Nutrition, bringing together as it does scientists from all over Asia and also, I understand, from some other countries as well. A gathering such as this is an admirable example of the determination of developing countries to band together to help one another solve their problems in their own way and in terms of their own cultures and patterns of life.

It is not my intention today, Mr. Chairman, to speak about the scientific aspects of nutrition, in which most of those present at this Congress are much better versed than I am. I would like to look at the subject from a more general viewpoint, although bearing in mind aspects of it that particularly concern Asia and FAO.

Nutrition, as you know, is a relatively new science which has really only emerged in the present century. And it has gained ground slowly, its aims obscured and its progress obstructed by the claims of other priorities in men’s minds. Today, looking back 25 years to the foundation of FAO, it seems to us both logical and imperative that the first of the objectives assigned to the Organization in the Preamble to its Constitution should have been that of “raising levels of nutrition and standards of living”. But the idea was comparatively recent at the time. The authorities of the pre-war world saw food and agriculture primarily in terms of the market economy. Few had either the inclination or the imagination to link agriculture with health. Frank McDougall, who has been described as the true father of FAO, was breaking new ground when he wrote as late as 1935 that “It would argue a bankruptcy of statesmanship if it should prove impossible to bring together a great unsatisfied need for highly nutritious food and the immense potential production of modern agriculture”.

Times have changed, but even today nutrition has not yet attained its full and proper place in the scale of priorities that guide the thinking of those who devise the policies that govern our lives. This is particularly evident when we look at policies for development—the pre-eminent concern today of the developing countries and of international organizations such as FAO.
One may well ask why should this be so. The development process is designed to improve the conditions of life of human beings. It can only be effectively implemented with the vigorous and widespread participation of human beings. Thus, continued malnutrition mocks the basic aim of development and hinders its effective realization. If development is looked at primarily in human terms—as it should be, surely nutrition is one of the key factors. How is it that this is not recognized?

The principal answer is that, just as the authorities of the pre-war world tended to think of food and agriculture in economic terms, so the policy-makers of today regard development as primarily a matter of economic growth. The pressing imperatives of increasing gross national product, trade and so forth push nutritional policies to one side.

Now, it is of course true that economic growth is essential to the abolition of hunger and malnutrition. So long as the masses of the population remain mired in poverty, they are unable to buy the food they need and there is not enough effective demand to induce farmers to increase production sufficiently. But there is more to the story than this. There are, I believe, three main reasons why we should take another look at the relationship between economic growth, nutrition and development itself.

In the first place, nutrition is more closely linked to economic growth than is sometimes realized. Malnutrition can wreak havoc with a country’s growth potential. To look at it in the most cold-blooded way, the lives of children prematurely shortened by malnutrition—and malnutrition is a proven killer of young children on a horrendous scale—represent a severe economic loss to society. The resources that have gone into rearing them during their brief, pitiful passage through life have simply been wasted. For they will never grow up to make a productive contribution to society that would have been a return on those resources.

But, even when malnourished children do grow up, the situation is not greatly improved. The early years of malnutrition have already taken their toll, notably reducing their productive capacity as adults. Physically, they lack the energy which is essential for the satisfactory performance of work. And if, as now seems likely, a definite scientific link is established between malnutrition and mental retardment, the economic loss to society in terms of the skills of rising generations must undoubtedly be such as to seriously cripple the whole development effort.

In a word, the problem of malnutrition is so urgent that it cannot wait for a
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satisfactory level of economic growth to be achieved. For to neglect it will mean that economic growth itself would be held back for a critical and perhaps indefinite period.

The second point to be made about economic growth and nutritional levels is that economic growth is often a very uncertain measure of these levels. As I have said, I do not dispute that in the long run economic growth is essential to the elimination of hunger and malnutrition. But, in the meantime, it is a very unreliable index of what is happening. Economic growth is a relatively slow process and it tends to be measured in academic terms which may often bear little relation to reality. For example, we all know full well that an increase in a country's average per capita income—perhaps the most important statistical standard in the measurement of economic growth—does not necessarily, or even normally, lead to an increase in the per capita incomes of the poorer sections of society. Nor is it correct to assume that, where there is an increase in the income of the poor it is automatically going to be spent on food. The humblest of men have their status symbols which will compete for any extra money that is going. Even when more money is spent on food, it is not always for better food. Traditional feeding habits on the one hand and mistaken preferences for new kinds of food on the other can mean that a family pays more to eat no better, and possibly worse, than before. Finally, supposing that families do spend their increased income on better food, there is a strong likelihood that they will be ignorant of the need to pay special attention to the feeding of the younger children whose nutritional deficiencies are greater. All this shows that economic growth is far from being the simple, readymade solution to malnutrition that it is often supposed to be.

My third comment about economic growth is quite simply that it has come to assume too large a part in our ideas about development. It is of course an essential part. Little of lasting value could be achieved without it. My point, however, is that, if we stand back a moment from the hurly-burly of the urgent priorities for development action that crowd in upon us, we can see that it is primarily a means to an end. My fear is that we have concentrated so intensively on this means that we often lose sight not only of the end but also of other means of achieving it.

What, after all, is the end, the objective, of development? It is not simply to make everybody richer and richer. The affluent societies of the world—choked with the fumes of their automobiles, threatened with the poison of industrial waste dumped into their rivers, their citizens increasingly distraught by the strain inflicted on their nerves—show the blind alley into which that can lead.
No. The ultimate aim of development must surely be the improvement of what is increasingly coming to be known as the quality of life. And this is something which certainly cannot be achieved by economic growth alone, especially not economic growth as measured by national per capita income. Indeed, there are aspects of it which could be achieved faster and more effectively if planners were to devote more of their time to policies, such as nutritional policies, directly aimed at bettering social conditions. If the quality of life means anything, it means that human beings everywhere have the food they need to keep them in good health. This, to be sure, is in large part an economic question. But it is also much more than that. People have to be educated in the kinds of food that they and their children need. They can be educated too, in ways of producing more of this food at minimal expense. In the present state of widespread malnutrition, there is tremendous scope for bold, imaginative schemes by authorities which could bring better food within the reach of the underprivileged at a very small cost compared with the benefits.

There is another aspect of the quality of life which must be mentioned. You in Asia have better and more bitter reason than people in most other parts of the world to know that our hopes of improving social conditions are now threatened, more than anything, with being swamped by the flood of over-population which now in this continent shows signs of breaking all bounds. Since the population explosion was triggered by a fall in death rates, it may seem curious to suggest that improved nutrition—which would save even more lives, especially among young children—could help in solving the problem. But there is definite evidence that it could. For the continued thrust of the population explosion is far less due than is often supposed to ignorance or lack of contraceptive methods. The fact that a large number of people, especially in primitive societies largely bereft of social security systems, want to have more children than either they or society can afford in order to be sure that at least one or two survive. Quite clearly, then, if measures were taken to greatly increase the assurance of survival of, say, the first two children as a result of better nutrition, the parents would feel much less necessity to have further children, and would accordingly be far more psychologically receptive to the ideas and methods of family planning.

In short, what I have said in the context of the quality of life shows that enlightened nutritional policies could do a great deal towards directly achieving the social aims of development without our having to postulate massive economic growth.

Mr. Chairman, I have so far spoken in rather general terms. I should now like to look more closely at some of the opportunities that lie before us and
at some of the ways in which we can more effectively improve the levels of nutrition.

Before I do so, however, I think that it is only right, if I am to give a balanced appraisal, to mention the very considerable amount of research and activities on nutrition that have already taken place in Asia. I should particularly point to the work done towards the eradication of beriberi; to the prevention of eye diseases resulting from a lack of Vitamin A which has been achieved through increasing the production and consumption of green leaves, fruit and vegetables; and to the large amount of research on the etiology of the protein-calorie deficiency diseases and the application of this research to their prevention.

I should also mention the Applied Nutrition Programmes in countries such as India. These admirable Programmes, carried out by agricultural extension services and experts in nutritional education and home economics, are aimed, among other things, at showing people how they can themselves produce some of the better kinds of food they need at very little cost. The educational function of these Programmes and their orientation towards self-help meet one of the most important objectives of nutritional policies, especially at impoverished levels of society.

I should also make special reference to an extremely promising experiment in a different kind of programme which, although primarily directed towards economic aims, is of great nutritional importance. This is Operation Flood in India. I shall have more to say about its significance to FAO in a few minutes. For the moment, it is sufficient to point out that this large-scale enterprise designed to re-structure and build up the dairy industry and at the same time to provide steady, increased supplies of better-quality milk to urban populations at a reduced price is a model of tremendous potential value in relation to efforts that are being made to meet the crucial need for more protein, especially in the developing world.

Let me now turn to some of the other, wider prospects and priorities that must increasingly engage our attention if we are to bring about better standards of nutrition on the immense scale that is needed.

Standing here today in Asia, it would be appropriate for me to begin with the Green Revolution. There is no doubt that this has introduced an entirely new factor into our calculations of how we can adequately feed the poorer majority of mankind. Countries such as India deserve the highest praise for the energetic way in which they have seized the opportunities held out by this prodigy of technology. As you may know, we in FAO are also concentrating great efforts on the promotion of the high-yielding varieties.
I need hardly remind you, however, that the Green Revolution is still largely a promise that remains to be fulfilled. You are all undoubtedly aware of some of the problems that have already arisen in the early stages—the question of adaptability to differing climatic conditions; the need for large supplies of material inputs such as fertilisers, plant protection chemicals and all that is required to ensure a regular supply of water; not to mention the necessity for improved transport, distribution and storage facilities and the expansion to farmers of credit and extension services.

These problems are chiefly economic ones, concerned primarily with the production and marketing of high-yielding varieties of crops. But, even if these problems are solved, you as nutritionists know that the Green Revolution will still not have achieved full success. That can only come when its benefits are available to all sections of the population, including the masses of the poor. And here we have perhaps the most serious problem of all. For, while the machinery for solving it is mainly economic, the motivation for solving it is social—that all too fragile sense of social justice which is so often incapable of standing up to the buffetings of self-interest, but, without which, the material gains in the struggle for development will fall far short of the real objective.

The tremendous promise of the Green Revolution nevertheless remains. If its benefits are made to reach through to all levels of society, it could ensure basic food supplies far more widely and securely than ever before. Equally important, it could significantly help towards closing the protein gap, which is the greatest nutritional deficiency in Asia. It could do this in two ways. Firstly, of course, it would increase the supplies of vegetable protein. And secondly, surpluses of cereals could be used for livestock feeding, thereby increasing—to the extent that it is compatible with religious convictions—the amount of animal protein available.

These are exciting prospects. But I must again remind you that the Green Revolution is still not much more than a promise that has yet to be fulfilled. Moreover, to whatever extent it is fulfilled, it must largely be regarded as an uncoordinated bonus to nutritional prospects. We now need to consider briefly one or two of the elements that are essentially inherent in progressive nutritional policies and programmes under whatever circumstances.

Fundamental to advances in meeting human nutritional requirements, as the Green Revolution itself has shown, is continuous experimentation and research. I have already referred to research, and I think that it is something so obvious that I do not need to urge it further.
A second vital priority is for those who are responsible for agricultural development planning to be adequately trained in matters relating to food and nutrition.

Looking first at the long-term situation, it is essential that courses on human nutrition and food economics should be introduced into faculties of agriculture. The kind of training I envisage should cover not only basic nutrition, the pattern of human nutrition requirements, food composition and food economics, but also the methods of making projections of food demand and of using these in planning future food supplies. I believe it is indispensable that this kind of training should be given to all agronomists.

Such training, however, cannot be expected to pay off on a sufficiently large scale in the immediate future. It is therefore also essential that food and nutrition units should be established without delay in Ministries of Agriculture in order to advise top officials there on the human nutritional requirements that must be taken into account in planning food production policies. I understand that such units have already been set up in some Ministries of Agriculture in some Asian countries. But nutrition is too often thought of as being within the exclusive province of Ministries of Health. This is a somewhat narrow and restricted approach to the many-sided problems of nutrition, since it is after all Ministries of Agriculture which are responsible for food production policies. I therefore urge that the units I have mentioned should be created in all Ministries of Agriculture as soon as possible. The staff of these units should receive training on the lines which I have advocated for agronomy students, although it would necessarily have to take the form of crash courses. I am glad to say that FAO is planning to hold such courses, the first of which is scheduled to take place in the autumn of this year. Regional inter-disciplinary courses in collaboration with WHO and UNICEF have already begun, and it is hoped to start a course of this kind in the Far East in 1972.

The types of training I have described will go a long way towards enabling countries to draw up and execute the kinds of comprehensive national food and nutrition policies and programmes of which their people are so greatly in need. Such policies and programmes should take into account food production, storage, processing, import and export requirements, distribution and consumption. They should also be concerned with the prevention and treatment of under-nutrition and malnutrition. This calls for a variety of programmes in agriculture, health and education, food enrichment, food quality control and the development of food standards in line with the recommendations of the joint FAO/WHO Codex Alimentarius Commission. It also requires
feeding programmes, notably special programmes for the vulnerable groups of
the population which would include, for example, the production of formulated
protein-rich weaning foods made as far as possible from locally-available
produce.

I must stress once again that it is essential that these national food and
nutrition policies and programmes should be an integral part of overall national
plans for economic and social development. I think I have already given
earlier sufficient reasons for showing that nutrition is a key to development.
If Governments wish to see their development plans succeed, they must pay
closer attention than in the past to the immediate minimal standards of well-
being of those whom these plans are designed to benefit and whose fullest
energies will be required in carrying them out.

It is now time, Mr. Chairman, for me to say something more about FAO’s
own concern with nutrition. I mentioned earlier the basic injunction that
was laid upon the Organization in the Preamble to its Constitution. It
subsequently became clear of course that the concept of raising levels
of nutrition involves much more than might appear at first sight. We
have all along been faced, not just with the problem of shortages of proper
food, but with a host of other problems encompassing ignorance about what
is needed for a balanced diet, the stranglehold of traditional feeding habits,
inadequate food policies, waste and other manifestations of what I would call
“sins against nutrition”. I do not propose to go into the detailed activities
of our Nutrition Division, but I can assure you that they are extremely
diversified, covering such matters as food policy, food science, nutrition training
and education, food habits, the development of protein-rich foods, home
economics and so forth.

It is also, I think, worth mentioning that, in the new strategy of FAO drawn
up since I took office, the objective of filling the protein gap figures as one of
the Five Areas of Concentration designed to focus the Organization’s activities
and direct them along clearly identifiable, high-priority and practical lines in
the years ahead.

Mention of the years ahead leads me to our Indicative World Plan—or
Perspective Study of World Agricultural Development, as it is now to be called.
Most of you, I believe, will at least have heard of the Indicative World Plan—
the IWP—which is an immense and unprecedented attempt at a synthesis
and analysis of factors relevant to world, regional and national agricultural
development in the years up to 1985. It devotes considerable attention to
matters relating to nutrition.
Earlier on, I made the point that, although economic growth is essential to the abolition of hunger and malnutrition, improved nutritional levels depend on several other factors apart from economic ones. And I laid particular stress on these other factors. I should not like to give you the impression, however, that I in any way under-rate the importance of the play of economic forces on the nutritional situation. To take a very simple and obvious example, it is clear that it is market demand in relation to supply that determines whether prices will rise, thereby causing a food crisis which will inflict the greatest hardship among the lower income groups. In any event, it is useful, in view of the attention I have devoted to non-economic factors, to look at a few of the conclusions of the IWP, which is primarily conceived within an economic framework.

The Plan estimates that the demand for food in the developing regions of the world between 1962 and 1985 will have increased about two-and-a-half times over. Some 70 per cent of this increase will simply be the result of population growth, while about 30 per cent will be due to increased incomes.

The essential question obviously is—will food supplies be able to keep pace with this increase in demand? The IWP says that, if the rates of increase in Gross Domestic Product which it projects are achieved, if the rate of increase in food production which it likewise projects (an overall total of about 4 per cent a year) can also be achieved and if population increase does not occur faster than the predictions of the United Nations, then food supplies should be able to cover energy and protein requirements at per capita level by 1985, although they will not quite meet the expected economic demand.

For a nutritionist, this forecast of the IWP will at first sight seem extremely encouraging. I must here, however, sound a very strong note of caution. In the first place, the “ifs” conditioning the forecast are very big “ifs”. To take the IWP’s projected 4 per cent annual rate of increase in food production, we find that, for the eight years of the Plan period that have now already elapsed, the rate of increase in the developing countries has been below 3 per cent a year. Moreover, even if the Plan’s forecast were to be fulfilled by 1985, it must be remembered that the projections are at per capita level and that it is only too likely that, due to inequalities of distribution, a certain part of the world’s population will remain under-nourished or malnourished. It is perfectly clear from these considerations that greatly increased efforts are going to be needed in the years ahead, not only in food production but also in nutrition policies and programmes. However, despite the uncertainties, the imponderables and the discouraging signs, I believe that the Indicative World Plan remains an invaluable analysis of the directions in which we should move to overcome hunger and malnutrition.
There are several other aspects, Mr. Chairman, of FAO's concern with nutritional problems, but you will understand that time prevents me from listing them all. I should therefore just like to mention one or two special instances. Among the numerous field projects connected with nutrition in which we are involved in Asia and elsewhere, I should like to refer to the assistance we have been able to provide to some of the Applied Nutrition Programmes. I should also like to return for a moment to Operation Flood which I mentioned earlier. This, as I said, is something which is of considerable significance to FAO. In the first place, the joint United Nations/FAO World Food Programme is supplying it with over $50 million worth of skim milk powder and butter oil. But I regard it as of much greater potential importance in the long run in connection with the International Scheme for Co-ordination of Dairy Development which I proposed to the FAO Conference in November 1969 to provide an informal framework for greater efforts, both multilateral and bilateral, to speed up the development of local dairy industries in developing countries and to raise their levels of consumption of milk and milk products. Operation Flood is closely bound up with the whole future of this Scheme. I regard it as a test-case whose viability will very largely influence our thinking with regard to the prospects and conditions for the Scheme's success in other countries.

To conclude, Mr. Chairman,—and I can think of no better point at which to conclude—there was the Second World Food Congress convened by FAO at The Hague in June last year. The Congress, attended by some 1,800 individual people from all over the world, was very much concerned with nutrition problems. One of its eight Commissions, for example, was devoted to the subject of higher living standards and improved diets. Out of its intense,—indeed sometimes passionate—discussions there emerged a number of hard-headed recommendations for action. One of them recognized that higher living standards and improved diets can only be achieved through integrating food and nutrition policies with overall economic plans. Another stated that, in order to meet the inevitable increase in demand for protein foods arising from population and income growth, every conventional and non-conventional resource must be mobilized. A third called for first priority in nutrition policies to be given to meet the needs of vulnerable groups—for example, infants and small children, expectant and nursing mothers. Others dealt with the vital role of education and training for both producers and consumers, with the need to expand research programmes, with the role of food aid, and with the decisive importance of having those responsible for national planning acquire a basic understanding of nutritional as well as economic principles.
But even more important than the recommendations of the World Food Congress was the spirit that infused it. Time and again, whatever the subject under discussion, came the cry for greater social justice and for the humanization of the whole development process. This, I believe, is also what inspires your work as nutritionists. And it is what I have tried to evoke most strongly to-day.

For, in whatever we do to try and improve the human condition through the processes of development, we need above all to keep in our minds the thought expressed in the famous words of the great Roman poet, Terence:

"I am a man, and reckon nothing human alien to me."

Thank you.
SYMPOSIUM ON
AGRICULTURAL DEVELOPMENT IN RELATION TO NATIONAL NUTRITIONAL NEEDS

Chairman: R. F. CHANDLER, Philippines
and
B. VENKATAPPIAH, India

Rapporteur: N. GANGA PRASAD RAo, India

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 Since most of the statistics available to us relate to national totals or averages, the part of the territory of USSR lying in the continent of Asia has to be left out. Asia thus delimited, still sprawls far and wide on the globe stretching from 50° North to 10° South of the Equator and from 30° to 140° east of Greenwich. It has an area of 10.8 million sq. miles which is about a fifth of the world’s land surface. Some 2 billion people, more than half the population of the world, live on this area, an average of over 190 people per sq. mile. With current population growth of over 2% per annum, the region is expected to have nearly 4 billion people at the end of the century and a population density far exceeding that of Europe, excluding USSR.

Agriculture had its earliest beginnings in this region but the course of development was not uniform everywhere with the result that we still find a wide range of agricultural systems from the primitive types to the mechanized chemical agriculture of today. What is more, there is not any great flow in trade of food products. On the contrary, individual countries are rather pre-occupied with building-up food autarky. In this background one wonders whether a regional study of the food and nutrition situation is meaningful. On the other hand, even a glance at the current levels of consumption is adequate to show that ‘there exist enough similarities among the countries to make comparisons rewarding’. Space will not permit us to present statistics for each of the several countries comprising the region. For purposes of this paper we shall group the 29 countries detailed below which practically comprise the region into seven sub-regions, as follows:

I South Asia
Ceylon, India, Nepal, Pakistan.

II East & S.E. Asia
Burma, Cambodia, China, Taiwan, Hong Kong, Indonesia, Rep. of Korea, Laos, Malaysia, Philippines, Singapore, Thailand, Rep. of Viet-Nam.

III Japan

IV China Mainland
The grouping has been done in accordance with the UN system of classification on the basis of geographic proximity, stages of development and types of economy.

Almost all the countries with the exception of Japan and Israel are underdeveloped with levels of food consumption far below those of the developed countries. These levels have continued to be low despite attempts at economic development. The high rate of population growth in this already densely populated region is in fact one of the principal factors which makes it difficult to improve the current level of diet.

**PATTERN OF AVAILABILITY OF FOODS:**

It is domestic production which largely determines the availability of foods in the region. No doubt there has been an increasing trend of food imports over the years, and several countries which used to export foods before the War have now become net importers. Still the region and the countries individually produce most of the foods they consume and would continue to rely increasingly on domestic production to feed their growing millions. The reason is that agriculture is the mainstay of the bulk of their populations. They not only produce their own foods but meet their other needs by selling surplus foods and other agricultural products. Moreover, most of the countries depend on agricultural exports for earning their much needed foreign exchange (the major exceptions are the few oil-rich countries of the Near East sub-region). In fact, they need much more foreign exchange than they earn for their economic development and their export outlets are not expanding to requirements. In this situation the offer of food on concessional terms by some rich countries has been a significant factor favouring food imports. However, the countries in the region are now intensifying their efforts to increase food production to eliminate or at least reduce this precarious dependence on food supplies from outside. Fortunately new possibilities have been opened up by the recent high-yielding varieties suitable for the agroclimatic conditions of a large part of the region. In fact some of the countries are already well on the way to reversing the rising trend of food imports.

Table 1 shows the present pattern of availability of foods by sub-regions. The diet of the region, as can be seen from the table, is based on cereals and it
Production and availability of foods

is the cultivation of cereals which dominates the agricultural activity of the region. The marginal supplies from outside consist of a small quantity of milk products and the rest of cereals, mainly wheat. The only effect of outside supplies on the dietetic pattern of the countries importing food or receiving it as aid has been a slight shift from rice to wheat. Rice is more popular and is widely consumed in the region, except in Mongolia which has a predominantly pastoral economy and in sub-regions VI and VII (vide Table 2). Sub-regions I-V (Far East) enclose practically the entire rice-growing area of the world. Most of the rice produced in this area is consumed within these sub-regions. It accounts for about two-thirds of the cereal consumed and as an article of diet enjoys a high degree of preference.

**TABLE 1**

<table>
<thead>
<tr>
<th>Current Levels of Diet (Grams per caput per day at retail levels)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>South Asia</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Cereals</td>
</tr>
<tr>
<td>Starchy Roots</td>
</tr>
<tr>
<td>Sugar</td>
</tr>
<tr>
<td>Pulses and Nuts</td>
</tr>
<tr>
<td>Fruits and Vegetables</td>
</tr>
<tr>
<td>Meat</td>
</tr>
<tr>
<td>Eggs</td>
</tr>
<tr>
<td>Fish</td>
</tr>
<tr>
<td>Milk</td>
</tr>
<tr>
<td>Oils and Fats</td>
</tr>
<tr>
<td>Calories</td>
</tr>
<tr>
<td>Protein</td>
</tr>
</tbody>
</table>

**TABLE 2**

Relative importance of Rice and Wheat expressed as percentage of total Cereal consumption

<table>
<thead>
<tr>
<th>Sub-Region</th>
<th>Rice</th>
<th>Wheat</th>
<th>Other Cereals</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>47</td>
<td>22</td>
<td>32</td>
</tr>
<tr>
<td>East and South East Asia</td>
<td>76</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>Japan</td>
<td>82</td>
<td>18</td>
<td>—</td>
</tr>
<tr>
<td>China Mainland</td>
<td>50</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>Asian Centrally Planned Economy</td>
<td>89</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Near East in Asia</td>
<td>8</td>
<td>78</td>
<td>14</td>
</tr>
<tr>
<td>Israel</td>
<td>5</td>
<td>91</td>
<td>4</td>
</tr>
<tr>
<td>Sub-Region</td>
<td>Cereals</td>
<td>Starchy Roots</td>
<td>Sugar + Nuts</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>South Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>69.0</td>
<td>2.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Prot.</td>
<td>64.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>East and South East Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>67.2</td>
<td>10.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Prot.</td>
<td>58.9</td>
<td>4.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>52.9</td>
<td>5.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Prot.</td>
<td>35.3</td>
<td>1.2</td>
<td>—</td>
</tr>
<tr>
<td>China Mainland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>67.6</td>
<td>10.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Prot.</td>
<td>56.6</td>
<td>5.4</td>
<td>—</td>
</tr>
<tr>
<td>Asian Centrally Planned Economy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>72.5</td>
<td>8.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Prot.</td>
<td>60.0</td>
<td>3.8</td>
<td>—</td>
</tr>
<tr>
<td>Near East in Asia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>62.8</td>
<td>1.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Prot.</td>
<td>69.0</td>
<td>0.7</td>
<td>—</td>
</tr>
<tr>
<td>Israel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cals.</td>
<td>36.5</td>
<td>2.5</td>
<td>14.4</td>
</tr>
<tr>
<td>Prot.</td>
<td>39.0</td>
<td>1.8</td>
<td>—</td>
</tr>
</tbody>
</table>
To bring out the relative importance of different foods in the dietary patterns, the contributions of different foods to the total per capita supplies of calories and protein are shown in Table 3. There is a fair degree of homogeneity in the food consumption patterns between the different sub-regions because of the overwhelming importance of cereals. Table 3 shows that cereals constitute the principal source of both calories and protein. The only exception is Israel (sub-region VII) which has a more varied diet, cereals contributing less than 40% of calorie and protein supplies. Japan, in spite of its present high level of income, derives still over half the calories from cereals but as it is a rice eating country and rice contains less protein than wheat the contribution of cereals to protein intake is much less. Sub-regions I-V derive an average of around 70% of calories and 60% of protein from cereals while in the Near East (sub-region VI) cereals contribute less calories, a little over 60%, but more protein, about 70%. This contrast reflects the widely differing rice-wheat ratio between the two parts of the region, as can be seen from Table 2. However, some of the rice-eating countries, make up for the lower protein content of rice by taking larger quantities of pulses and nuts.

Pulses and nuts are important in the region as a source of protein. They contribute over 15% of the total protein in the Far East and over 5% in the Near East. Their chief importance lies in their supplementing value as a source of lysine. Taken together with cereals, even in a ratio of 1:10, the diet gives NDpCal% of well over 5 which is needed for growth and maintenance. Pulses and nuts are also important for another reason. They provide a comparatively cheap source of protein and therefore are particularly valuable for the low-income countries. It is only the two high-income countries in the region—Japan and Israel, and also Mongolia for a different reason altogether—that get substantial quantities of animal protein, 30, 40 and 50 grams respectively. The per capita availability of animal protein in other sub-regions averages around 10 grams only. The relative importance of the source of animal protein varies from one sub-region to another. Broadly, milk is the primary source of animal protein in S. Asia, fish in East and S.E. Asia and Japan; meat in Mainland China and meat and milk in the Near East and Israel.

Starchy roots which constitute a principal source of calories for many less developed countries in other regions, markedly in Africa are unimportant in this region, except in Indonesia where they contribute some 25% of the calorie intake per caput. In Java, cassava has been gaining ground over the years. One explanation may be that agricultural labourers and other poorer sections of the population increasingly turn to high-yielding varieties when population becomes dense and in consequence the prices of rice increase or wages decline.
Sugar, the other carbohydrate food is, unlike starchy roots, an expensive item of food and, as an essential ingredient in many delicacies is, up to a certain point of saturation, consumed in greater quantity with every rise in income. As the countries in the region (except two) are not rich, only a moderate amount of sugar is consumed, contributing less than 10% of the total calorie supply. The level of consumption however, varies with Mainland China, North Viet-Nam, Nepal and Laos consuming very little sugar at one extreme, and at the other extreme Singapore consuming as much as 100 grams and deriving 15% of the total calorie supply from it. Of course, Israel, one of the two rich countries, consumes as much as Singapore but Japan consumes much less. Sugar is an imported commodity in Japan and carries a heavy duty on its price.

Of much less importance than sugar is the contribution of fruits and vegetables to calorie supply, except in Near East. In fact, Near Eastern countries derive an average of as high a percent of the calories as Israel, namely 8%, which is more than the amount Japan gets. Fruits and vegetables are never regarded as important sources of energy but they are important for vitamins and minerals. The calorific values are used as some kind of measure of quantity, as the actual weights vary enormously. But it is the range of varieties of fruits and vegetables that seems more important than the quantity.

Fats and oils in spite of their high energy value contribute hardly 5% of the total calories in the diet in sub-regions I, II, IV and V. The domestic production of sub-regions I and II is however higher than the low level of consumption indicates, as these two sub-regions have a sizeable export which is declining though. Israel’s consumption of fats and oils is pretty high and contributes 15% of the calories in the diet while that of Japan and Near East is moderate.

MACRO-ECONOMIC VIEW OF THE FOOD AND NUTRITION SITUATION IN ASIA:

We shall consider in this section broad nutritional implications of the levels of availability of different foodstuffs described in the preceding section but in the reverse order to highlight the elements which are important for planning the future.

The per caput consumption of fats is rather low in most countries of the region. However, the recent medical opinions tend to de-emphasize its importance in the diet and even consider its consumption above a certain level positively harmful, particularly if it is from ruminant animals. But the greater part of consumption in the region is vegetable oil. Even if it were not so, there cannot be any harmful effect at the current level of consumption. On
the contrary, the per capita availability in many countries is so low that it
should be increased to ensure meeting the requirements of the essential fatty
acids and to reduce, wherever it is necessary to do so, the bulk of total food
intake by providing calories in concentrated forms. Also, we cannot ignore
the high protein content of the oilseeds grown in the region. In fact, a part of
the oilseeds is eaten directly in some countries. Of the oil converted into
oil, the residues thrown up in the course of processing are rich in protein and,
as such, fed to cattle. So all possibilities of additional production of oilseeds
in the region should be exploited to the full.

Fruits and vegetables on the other hand are poor in both calories and proteins
and we cannot eat them in large enough quantities to replace an appreciable
part of calories or protein from other sources. In countries which are deficient
in calories or protein or are marginally self-sufficient one cannot advocate
the expansion of production of fruits and vegetables at the expense of the
primary source of these two basic nutrients, though one must continue to
stress the value of growing them in back-yards, kitchen gardens etc., for the
vitamins and minerals they provide, lest one may come to take a smaller quantity
as has probably happened in the case of leafy vegetables which are a rich source
of vitamin A. Admittedly, some countries, as Table I shows, consume small
quantities of fruits and vegetables. But the majority get around 200 grams
which though insignificant in terms of contribution to calories and proteins
may not be so in terms of contribution to vitamins and minerals. What seems
pertinent to observe in this context is that in these countries fruits and vegetables
are locally grown and locally consumed and, as such, bear no transport costs:
they are cheap and available to the poorer sections of the people. Generally
they take fruits in raw or semi-processed form and what is more important
they do not throw away any part. This practice they follow in respect of
other foodstuffs as well. For example, the fish-loving population of West
Bengal and East Pakistan do not even throw away fish-guts which are considered
rich in vitamin A. In this respect, poverty and lack of technical progress
associated with processing may be regarded as a blessing and the actual situation
may not be as gloomy as a bare comparison of the low level of consumption
of fruits and vegetables in the countries of the region with that in the developed
countries would indicate.

Sugar and starchy roots belong to the same group, i.e., carbohydrate foods
but they follow contrasting trends. Starchy roots are cheap, and, as a source
of calorie, is progressively replaced by other foods with increasing income.
Because of the exceptionally high-yields which could be obtained, some root
crops are valuable sources of food during periods of shortages. However,

Sugar and starchy roots belong to the same group, i.e., carbohydrate foods
but they follow contrasting trends. Starchy roots are cheap, and, as a source
of calorie, is progressively replaced by other foods with increasing income.
of calories with the introduction of high-yielding varieties of cereals in the region. In Indonesia, too, it is expected that starchy roots will before long, cease to be a staple food and be relegated to the position of a useful supplement to vegetable dishes as elsewhere in the region.

Sugar, on the other hand, is not cheap and, as mentioned above, its consumption shows an increasing trend with income. So the per cent consumption of sugar will tend to increase with economic growth. There is no harm if it does. Like fats and oils, the present intake is so low that the incidence of the diseases usually ascribed to high intake of sugar is not likely to increase. On the contrary, any increase in sugar consumption due to economic growth would help these countries in their none-too-satisfactory state of overall calorie supply. Sugar provides a natural source of energy most readily utilized by the body. This is why sugary foods as drinks are often taken during work to keep fatigue away. There are large possibilities for increasing the production of sugar in several areas of the region. In fact the production of cane sugar originated in South-East Asia, though Tropical America is at present the main area of its production. Currently, the less developed countries of Asia together produce some 18 million tons and they export about as much as they import. And there are reasons to believe that they could together produce more to meet their increasing requirement and even turn into a net exporter depending of course on the international sugar market.

Of the animal products we shall consider fish first since fishery makes very little claim on lands and marine fishery none at all. The total production, shares of fresh water fish and sea fish, and per capita production of fish for food are shown in Table 4. The table shows that of the total catch a little over one-fifth is fresh-water fish. This overall picture of the relative importance of inland fishery is however somewhat deceptive. Japan alone accounts for one-third of the total fish production of the region but almost all this quantity comes from the seas. If we exclude the two developed countries of the region, Japan and Israel, the proportion of fish which the less developed countries raise from inland fishery rises to over one-third (nearly 5 million tons out of 14 million tons). The countries for which inland fishery is important are India, Pakistan, Cambodia, Indonesia, China Mainland and Iraq. Mainland China with an annual catch of nearly 3 million tons of fresh-water fish has probably the world's largest production of inland fish.

Since the region has large water surfaces, it is clearly of great importance to make the fullest use of this area. Inland fishery has been a long-established economic activity and fresh water fish a preferred food for a large section of the population in the region. Inland fisheries are generally operated on small
scales and these are well-spread out around the water bodies inside the countries and, in consequence, an important source of animal proteins in rural areas. Fish are sold and consumed within the small areas around the centres of catches. As a result, inland fisheries make very little demand on transport and storage facilities unlike marine fisheries, and the requirement of capital for fuller exploitation of this source of animal protein is also small.

**TABLE 4**

Fish production in Far East by Sub-Region

<table>
<thead>
<tr>
<th>Sub-Region</th>
<th>Total Catch 000 tons (l.w.)</th>
<th>% of fresh-water fish from the total</th>
<th>Total fish for food (sea and fresh-water) 000 tons (l.w.)</th>
<th>Per caput production of fish for food gr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>2094</td>
<td>43</td>
<td>1952</td>
<td>8.1</td>
</tr>
<tr>
<td>East and South East Asia</td>
<td>6067</td>
<td>18</td>
<td>5163</td>
<td>48.1</td>
</tr>
<tr>
<td>Japan</td>
<td>8670</td>
<td>3</td>
<td>6751</td>
<td>183.0</td>
</tr>
<tr>
<td>China Mainland</td>
<td>5800</td>
<td>48</td>
<td>5800</td>
<td>19.5</td>
</tr>
<tr>
<td>Asian Centrally Planned Economy</td>
<td>289</td>
<td>29</td>
<td>289</td>
<td>39.9</td>
</tr>
<tr>
<td>Near East in Asia</td>
<td>202</td>
<td>14</td>
<td>202</td>
<td>6.6</td>
</tr>
<tr>
<td>Israel</td>
<td>26</td>
<td>46</td>
<td>26</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>23148</td>
<td>22</td>
<td>20183</td>
<td>27.3</td>
</tr>
</tbody>
</table>

Note: Based on FAO Yearbook of Fishery Statistics, Vol. 28, 1969. The per caput production of fish for food shown in the last column is expressed in terms of landed weight and all the estimates relate to the year 1968 while those of per caput consumption of fish, in Table 1, are expressed in terms of edible weight and relate to different years from 1966-69.

There is a natural limit to the expansion of inland fishery since water surface is limited. The exploitation of the seas and oceans looks a much more promising line of development. Necessarily the development of marine fishery requires much more outlay than inland fisheries. As a result, the less developed countries are rather handicapped to exploit this source. It is Japan which has made the most impressive advance with a catch amounting to nearly half of the total catch landed by the region as a whole. Not that the developing countries are not making progress. India, for example, has joined the leading fishing nations with a catch of one million tons. Even if we assume that the less developed countries of the region can with government and international assistance exploit the seas fully, can they expect a substantial addition to the supplies of calories and proteins from the seas? True, there are still large
unexploited areas and numerous unexploited types of fish. It is equally true that certain areas are overfished and some stocks of fish greatly reduced. Also, there are large unfertile areas in the oceans. We have not yet learned to farm the sea. It is therefore necessary to be on guard against depletion of stocks. All that fishing biologists could in the present state of knowledge predict is that the production of fish could probably be doubled without damaging present known resources.

If we assume a similar order of increase in fresh-water fish to be possible and a 100 percent increase in total fish production to be realizable over the next 30 years, the per caput availability of fish will remain at about its current level. Still it will be a worthwhile task to maintain the current level of fish consumption by increasing the supplies of fish to match the population increase. Fish is, as mentioned before, an important source of animal protein for a number of countries and in some countries for certain sections of population though the per caput consumption of fish for the region is not an impressive figure. In fact, none of the other animal products singly, as can be seen in Table 1, makes a significantly higher contribution to the per caput animal protein supply of the region as a whole. What is particularly important about fish is that source of animal protein does not use-up any land resources, the scarcity of which is the limiting factor for the production of other animal foods in the region.

This limiting factor for livestock development is brought out in Table 5 which presents the utilization of land, per caput, for different purposes by regions of the world. The table shows that per caput availability of land for raising food or feed in Asia is very small and is comparable only to that of Europe excluding USSR. Because of her faster rate of population growth Asia will soon be far worse off than Europe even in quantitative terms of per caput availability of land resources. Near East Asia is somewhat better off and this is reflected in the higher per caput availability of meat and milk. However, it is not the lack of lands but lack of water resources that is a limiting factor in this sub-region. It is the Far East which is really very badly placed: the 50% of the World's population living in this area have only a fifth of a hectare of arable land and 1.1 hectare of land surface per head. Necessarily the pastures and woodlands are equally small and have very little scope for expansion. On the contrary, the areas under pastures and forests are shrinking as a result of expansion of croplands. In South Asia, already some 50% of land surface is utilized for crops. Table 6 shows how scarce land has already become in most sub-regions. It is only when a less developed country has abundant open grazing lands like Mongolia that its people can afford to have large livestock herds and take a large quantity of animal foods. To develop livestock
on produced fodder is difficult for most of these countries; the cost of production per unit of each livestock product would be too high for the general level of income. Indeed, the cost of drawing nutrients from foods of animal origin relative to that from foods of crop origin is very heavy. It is mainly for this high cost of production which these countries cannot reduce for lack of common grazing lands that they largely rely on food crops, mainly grains, for meeting the requirement of not only calories but of proteins as well.

<table>
<thead>
<tr>
<th>TABLE 5</th>
<th>Land Utilization in the World (per capita) (in hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regions</td>
<td>Land Area</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>Asia</td>
<td>1.3</td>
</tr>
<tr>
<td>Far East</td>
<td>1.1</td>
</tr>
<tr>
<td>Near East in Asia</td>
<td>5.6</td>
</tr>
<tr>
<td>Africa</td>
<td>8.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>7.3</td>
</tr>
<tr>
<td>Developing Regions</td>
<td>2.9</td>
</tr>
<tr>
<td>Europe</td>
<td>3.9</td>
</tr>
<tr>
<td>USSR</td>
<td>9.2</td>
</tr>
<tr>
<td>Europe, excl. USSR</td>
<td>1.1</td>
</tr>
<tr>
<td>North America</td>
<td>8.6</td>
</tr>
<tr>
<td>Oceania</td>
<td>44.8</td>
</tr>
<tr>
<td>Developed Regions</td>
<td>5.8</td>
</tr>
<tr>
<td>World</td>
<td>3.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 6</th>
<th>Land Utilization in Asia (ha/per capita)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Region</td>
<td>Land Area</td>
</tr>
<tr>
<td>South Asia</td>
<td>0.6</td>
</tr>
<tr>
<td>East &amp; South East Asia</td>
<td>1.4</td>
</tr>
<tr>
<td>Japan</td>
<td>0.4</td>
</tr>
<tr>
<td>China Mainland</td>
<td>1.2</td>
</tr>
<tr>
<td>Asian Centrally Planned Economies</td>
<td>5.2</td>
</tr>
<tr>
<td>Near East in Asia</td>
<td>5.8</td>
</tr>
<tr>
<td>Israel</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Paradoxically enough, the Far Eastern countries together have 30 percent of the world’s cattle. India alone has 20 percent and among them 50 million cows and nearly 30 million she-buffaloes. The primary purpose of cattle in India is however to provide draught animals. The production of milk, though highly prized as an article of food, is relegated to secondary importance. Cattle largely subsist on grass from common lands and fallows and stubbles from cultivated lands. These are supplemented by the by-products of agriculture and left-overs of foodstuffs. Within the limited availability of feed the farmer tries to allocate better rations for bullocks when they are working and for cows or she-buffaloes when they are giving substantial quantity of milk. Still the number is so large that most of feeds are used up in maintenance, growth and the production of bull-calves. In consequence, the cows give very little milk. This explains the extremely low per caput availability of milk in India in spite of her having a large production base. In fact, India could get much more milk from her cows and more work-output from working bullocks by feeding adequately a smaller herd of cattle.

The new technology which is now developing around the high-yielding varieties should provide some scope for the development of livestock in all the Asian countries even within the existing limitation of land-resources. The outstandingly high yields of these new varieties of cereals will permit marginal and sub-marginal lands currently under food crops to be released for fodder crops or pastures. As these varieties mature quickly and leave the lands free for a second crop, the latter could be to a large extent utilized for protein-rich legumes and fodder crops. In addition, larger quantities of by-products will be available and even a possibility of surplus grains for use as feed cannot be excluded. Also, demand for livestock products will increase, at least in urban areas, with rise in the level of income. This will provide price-incentive to the producers. Still, even if we take a very optimistic view of the growth of livestock industries in the less developed countries of the region, the increase in the per caput availability of animal protein due to this growth does not seem likely to be more than marginal.

What seems more certain is that countries in the region can produce more cereals. Indeed, the potentialities of the high-yielding varieties are so high that if the governments of these countries adopt appropriate policy measures, there should not be any shortage of cereals. On the contrary, the per caput availability is likely to increase wherever it is so necessary. What needs to be done is to increase the production of pulses, particularly in the rice-growing areas. Agricultural research under way indicates that a break-through in developing quickly maturing strains of pulses is imminent. This itself should go a long way in increasing production, apart from its value in permitting
multiple cropping and providing employment. If short duration characteristic can be combined with high yield in the same strains, as is being attempted, it will greatly help improve the position. All this implies that the people in the less developed countries of Asia will continue to draw their supplies of the two basic nutrients, calories and proteins, as much as, or even more than the existing patterns of diets allow. The contribution of the other supplies will remain marginal but these are important for making the diet palatable and varied, adding in the process other nutrients.

**NUTRITIONAL INADEQUACY OF THE AVAILABLE DIET IN THE REGION**

A. MACRO-ANALYSIS

We shall consider in this section the extent to which the diets are adequate in respect of total calories and protein. We have limited ourselves to calories and protein because standards of their requirements are more definite than those of other nutrients. Table 7 shows the relevant data on per caput basis. The estimates of per caput requirements in this table are based on two scales, one for calorie requirements by FAO and the other for protein requirements recommended by the joint FAO/WHO Expert Group in 1965. FAO scale of calorie requirements represents the best estimates available and has received wide acceptance while the recommendations of protein requirements though resting on sounder foundations than the earlier recommendations are still tentative and, in fact, will be reviewed again together with those for calories in March 1974.

It will be seen that all the less developed sub-regions of Asia show a deficit in calories and only one shows a marginal deficit in protein. However, a country-wise study shows that as many as 18 countries have deficits in calories while only 9 have deficits in protein. Furthermore, all the 9 countries which show a protein deficit have deficits in calories as well. It is likely that this is a particular feature of Asia where the diet is predominantly based on cereals and pulses. It shows that the protein problem is probably an indirect result of inadequate quantity of diet.

One consequence of this association between overall deficits in calories and protein, if also true of individual diets, is that the protein problem does not necessarily have to depend for its solution on the urgency of exploiting new sources of edible protein to augment the present protein supply as visualized by the UN Advisory Committee on Science and Technology, the solution does not even call for dietetic changes. For if the per caput availability of foods constituting the present diet is increased to meet energy needs, one would expect the current protein deficit to disappear also. By way of example we-
## TABLE 7

Availability and requirement of Calories and protein and their inter-relationship

<table>
<thead>
<tr>
<th>Sub-Region</th>
<th>Calories Supply</th>
<th>Calories Deficit (-) or Surplus (+)</th>
<th>Dietary Protein Supply (grams/day)</th>
<th>Dietary Protein Deficit (-) or Surplus (+)</th>
<th>Projected Deficit (−) or Supply Surplus (+) if deficits in calories are wiped out (gr/day)</th>
<th>Projected Deficit (−) or Supply Surplus (+) if deficits in protein are wiped out</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>1970</td>
<td>2210</td>
<td>48.5</td>
<td>49.4</td>
<td>54.4</td>
<td>2010</td>
</tr>
<tr>
<td>East &amp; South East Asia</td>
<td>2050</td>
<td>2130</td>
<td>48.4</td>
<td>46.8</td>
<td>50.3</td>
<td>2050</td>
</tr>
<tr>
<td>Japan</td>
<td>2460</td>
<td>2420</td>
<td>75.7</td>
<td>53.6</td>
<td>75.7</td>
<td>2460</td>
</tr>
<tr>
<td>China Main.</td>
<td>2050</td>
<td>2280</td>
<td>57.2</td>
<td>47.8</td>
<td>63.6</td>
<td>2050</td>
</tr>
<tr>
<td>Asian Cent. Plan. Econ.</td>
<td>2040</td>
<td>2190</td>
<td>48.0</td>
<td>46.8</td>
<td>51.5</td>
<td>2040</td>
</tr>
<tr>
<td>Near East in Asia</td>
<td>2310</td>
<td>2440</td>
<td>67.1</td>
<td>57.0</td>
<td>70.9</td>
<td>2310</td>
</tr>
<tr>
<td>Israel</td>
<td>2930</td>
<td>2480</td>
<td>88.9</td>
<td>60.0</td>
<td>88.9</td>
<td>2930</td>
</tr>
</tbody>
</table>
can see how it works by increasing the quantities of foods in the same proportion as in the existing diet of each of the 18 calorie deficit countries to provide adequate calories and then calculate the availability of protein in the increased diet. The results of such an exercise shows that the only country that will still have deficit in protein is Indonesia which, as we have said before, is the only country in the region that draws a substantial part of total calorie supply from starchy roots. But if we concentrate on eliminating the deficit in protein by increasing diets of the 9 protein deficit countries to provide adequate protein, we find that as many as 7 of these 9 countries will still have a deficit in calories. In addition to the 9 others which have at present a deficit in calories but not in protein. That is to say 16 countries will continue to have a deficit in calories. This brings into focus the crucial importance of calorie supply in dealing with the protein problem.

II. MICRO-ANALYSIS

The micro-analysis attempted above seriously under-estimates the size of the problem since the underlying assumption is that the available nutrients are distributed among the individuals in a country in accordance with their physiological needs. In actual fact, available food is very unevenly distributed, largely owing to inequality of income and also due to other socio-economic factors. Further, the macro-analysis does not bring out the crucial role of calories in the efficient utilization of protein. Indeed, one can visualize the diet adequate in protein and yet lacking sufficient calories to synthesize it, thereby creating the possibility of diverting part of the dietary protein from its rightful function to the provision of energy, since it is well known that a body will take recourse to anything and everything even to the extent of metabolizing its tissues in order to meet its energy needs first before attending to its other needs. Only a study on bivariate distributions of calories and protein in the diets of the people can throw full light on the extent to which protein deficiency is the indirect result of inadequate quantity of the diet and hence of inadequate total calorie supply. Given such bivariate data we can estimate the incidence of protein deficiency thus:

\[ I = A + B + E \]

where A, B and E denote the frequencies in the cells of the figure shown below:

<table>
<thead>
<tr>
<th>Protein</th>
<th>Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>E</td>
<td>F</td>
</tr>
</tbody>
</table>

in which the dividing lines are placed at the critical limit for calories and protein given by the average requirement of the nutrition unit minus times the standard deviation \( \sigma \).
The critical limits are set so low that the probability of individuals of the reference type having lower physiological requirements is very small. We should add that it is because the critical limit for calories happens to be about the same as the limit for maintenance of nitrogen balance in adults that the expression given above provides us with an estimate of the total incidence of protein deficiency whether due to lack of adequate protein in the diet or due to lack of adequate calories, or both.

By way of example, we reproduce in Table 8 the results of such analysis based on dietary surveys conducted in India. It will be seen that most households which are protein deficient are also calorie deficient. Further, an appreciable proportion of the households although receiving adequate protein, suffer from inadequate calorie supply. Only about 5% of the total diets seems to be deficient in protein per se. The analysis of the four sets of dietary survey data representing four different cross sections of diets in India presented in Table 8 confirms the crucial importance of increasing diets to provide adequate calories for the solution of the protein problem. It is the section of the population whose diets are deficient both in proteins and calories or whose protein intake though adequate is not fully utilized for lack of adequate calories that constitutes the major part of the incidence of protein malnutrition. Protein deficiency would thus appear to be larger the result of inadequate intake of total energy. When enough food of the type normally consumed by the people in the region is eaten protein needs are therefore likely to be met.

### TABLE 8

<table>
<thead>
<tr>
<th></th>
<th>PD</th>
<th>NPD</th>
<th>Sub-Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Andhra based on 2675 Households</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>14</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>(4.8)</td>
<td>(6.0)</td>
<td></td>
</tr>
<tr>
<td>NCD</td>
<td>6</td>
<td>68</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>(4.7)</td>
<td>(5.5)</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td>20</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td><strong>Bihar based on 2474 Households</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>5</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>(6.0)</td>
<td>(7.6)</td>
<td></td>
</tr>
<tr>
<td>NCD</td>
<td>83</td>
<td>83</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>(4.4)</td>
<td>(6.8)</td>
<td></td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td>5</td>
<td>95</td>
<td>100</td>
</tr>
</tbody>
</table>
That the primary emphasis needs to be placed on quantitative adequacy of the diet rather than on the improvement of the quality of its dietary protein is also borne-out by the values of NDpCaI % shown in the respective cells of the table. FAO/WHO scale of calorie/protein requirements indicates that diets which provide at least 5% of their calorie content in the form of utilizable protein (i.e. NDpCaI % 5) will satisfy the protein needs of individuals after the first year of life provided they are consumed in quantities which give sufficient calories.

The above findings are in full accord with those of Gopalan based on dietary and clinical surveys of individual children in South India. By way of example, we reproduce in Table 9 the results of one such survey carried out by him. The critical factor, as Gopalan puts it, in causing protein deficiency is low calorie intake and not protein. We therefore conclude that where, as in India, the staple food is a cereal, rice, wheat etc., and is accompanied by minimum amounts of pulses and vegetables, as appears to be the case in most countries of Asia, the protein value of the diet of the population will be adequate to meet the requirements for both protein and calorie, provided total supplies are adequate.
TABLE 9
Distribution of Pre-school Children by Calorie and Protein Intake

<table>
<thead>
<tr>
<th>Calorie Intake as % of Requirement based on Actual Body Weight</th>
<th>%</th>
<th>≤50</th>
<th>50-70</th>
<th>70-90</th>
<th>90-110</th>
<th>&gt;110</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7.6</td>
<td>5.1</td>
<td>1.2</td>
<td>1.3</td>
<td>0.5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>1.2</td>
<td>1.3</td>
<td>1.2</td>
<td>1.2</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.1</td>
<td>12.8</td>
<td>3.3</td>
<td>0.1</td>
<td>0.1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.3</td>
<td>6.3</td>
<td>6.3</td>
<td>6.3</td>
<td>6.3</td>
<td>21</td>
</tr>
<tr>
<td>Protein Intake as % of Requirement based on Actual Body Weight</td>
<td></td>
<td>110-130</td>
<td>6.4</td>
<td>10.5</td>
<td>10.5</td>
<td>2.4</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130-150</td>
<td>5.6</td>
<td>7.0</td>
<td>7.0</td>
<td>3.3</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>150+</td>
<td>7.1</td>
<td>12.8</td>
<td>1.6</td>
<td>1.6</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15</td>
<td>33</td>
<td>32</td>
<td>18</td>
<td>2</td>
<td>100</td>
</tr>
</tbody>
</table>

Clearly, the most important single factor which emerges from the above analysis is the need to improve the purchasing capacity of the low income section of the population in order that they may be able to buy adequate quantity of food of the type usually consumed. We shall discuss this in further detail in the following Section.

MICRO-ECONOMICS OF FOOD AVAILABILITY—THE HEART OF THE PROBLEM

If we calculate the weighted sum of surplus (+) or deficit (−) in calories the value of each country being weighted by its population, the region as a whole shows a deficit of approximately 8%. However, to set an order of magnitude of food deficit in Asia we should take only the 18 calorie-deficit countries into calculation since each country’s policy aims at national self-sufficiency in food. The weighted sum of the deficits of these 18 countries figures out at 10% of their requirement. As these countries draw over two-thirds of their calorie supply from cereals, only a 15% increase in the production of cereals is needed to wipe out the present overall deficit in calories. This is not to suggest however, that an increase of 15% in cereals would in fact wipe out the deficit in practice. The reason is that with rich taking enough and more and pressing for dietary variety and poor what they can afford, a production target in terms of cereals to meet the requirement will in itself not be adequate to solve the problem of uneven distribution of foods which is at the root of the problem of hunger and malnutrition. We estimate the requirement in terms of cereal production simply because the production possibilities of cereals are larger and the countries are concentrating on exploiting them. In fact the yield-rates of the new varieties of cereals already demonstrated are so high that these countries can even meet the increasing requirement due to population growth for some years to come largely through cereal production. Undoubtedly, this will tend to make the...
diet much less varied than it is at present, but again this is unlikely to happen since the postulated pattern will not materialize, given the pressures from those with growing incomes for dietary variety and the monotonous diets the poor already have.

It is one thing to aim at an overall sufficiency in calories and protein by equating the per capita availability with the per capita requirement for each country as a whole. It is another thing to ensure that the available foods would be distributed among households, and among individuals within each household according to physiological requirement. In fact, the incidence of undernutrition (calorie deficiency) and malnutrition (deficiency in other nutrients) as mentioned in the preceding Section, arises largely as a result of unequal distribution of food availability.

Table 10 which presents the distribution of households by calorie supply based on food consumption surveys in the two typical countries of the region, Burma and India, will give an idea of the dimension of incidence of undernutrition. Applying the critical limit explained in the preceding Section to these data and similar information of some other countries, Sukhatme estimated that a quarter of the population in the less developed countries of the region are undernourished*. All these undernourished people are also liable to protein deficiency. To get an estimate of incidence of the latter, we have to add to this 25% the percentage of the people who get adequate calories but not adequate protein, which could be another 5 per cent for this region. Broadly, we may put the estimate of protein deficiency at between a quarter and a third of the population for the region.

It is the low level of income in these less developed countries which, as said before, is the main contributing factor to the large incidence of undernutrition and malnutrition. The relationship between income and the consumption of food, which assures importance here, is brought out in Table 11 which presents the data on food consumption measured in terms of calories and protein at different levels of household income/total expenditure in two less developed countries of the region, Indonesia and India, and two developed countries, the UK and USA. As can be seen, in the table, per capita food intake in the two developed countries measured in terms of both calories and protein hardly shows any increase with rise in income while in the two less developed countries there is a marked upward trend in per capita food consumption with every rise in income.

* The estimate referred to the period 1957-59, since when per capita calorie supply has slightly increased and, as a result, the percentage incidence of undernutrition has probably somewhat decreased. A rough estimate of this increase is 1 to 2% but as the population has increased by 15% since 1958, the absolute number of undernourished people has increased.
in household total expenditure (which can be taken as a measure of household income). It is a well-known fact that the consumption of food in general increases with income but at a declining rate and gradually flattens out at the high income-level. The households of the two developed countries included in the surveys have, as the data in Table 11 indicate, practically reached this high-level. In contrast, per caput food intake of the poorest group of households in the two less developed countries is seen to be very low and increases practically all the way up the range of income included in the surveys, and, what is more important in the context, the percentage increase is more pronounced in protein than in calories and still more so in animal protein.

### TABLE 10
Distribution of Households surveyed in Burma (1939-41), Prepartition India (1935-48), India (Maharashtra State—1958) and U.S.A. (1955), by Calorie supplies per day per reference man

<table>
<thead>
<tr>
<th>Calorie per day per reference man</th>
<th>Percentage frequency of households</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Burma</td>
</tr>
<tr>
<td>Under 1300</td>
<td>0.3</td>
</tr>
<tr>
<td>1300-1700</td>
<td>5.2</td>
</tr>
<tr>
<td>1700-2100</td>
<td>20.3</td>
</tr>
<tr>
<td>2100-2500</td>
<td>29.4</td>
</tr>
<tr>
<td>2500-2900</td>
<td>23.9</td>
</tr>
<tr>
<td>2900-3300</td>
<td>10.4</td>
</tr>
<tr>
<td>3300-3700</td>
<td>5.7</td>
</tr>
<tr>
<td>3700-4100</td>
<td>3.3</td>
</tr>
<tr>
<td>4100-4500</td>
<td>1.0</td>
</tr>
<tr>
<td>4500 and over</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Percentage frequency of households

<table>
<thead>
<tr>
<th>North-Central Region</th>
<th>USA 1952</th>
<th>USA 1955</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural farm</td>
<td>Rural non-farm</td>
<td>Rural non-farm</td>
</tr>
<tr>
<td>Under 2000</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2000-2500</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>2500-3000</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>3000-3500</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>3500-4000</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td>4000-5000</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>5000-6000</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>6000 and over</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

P. V. Sukhatme and D. Basu
### TABLE 11

Household income and per capita food consumption expressed in calories and proteins

*Indonesia (Djawa and Madura) 1963/64*

*Urban and Rural*

<table>
<thead>
<tr>
<th>Limits of the groups:</th>
<th>Total expenditure per household per month (Rupees)</th>
<th>Average</th>
<th>Less than 6000</th>
<th>6001-10000</th>
<th>10001-16000</th>
<th>16001-30000</th>
<th>30001 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of households</td>
<td></td>
<td>14670</td>
<td>3105</td>
<td>3981</td>
<td>3886</td>
<td>2787</td>
<td>911</td>
</tr>
<tr>
<td>Average size of household</td>
<td></td>
<td>4.45</td>
<td>3.02</td>
<td>3.93</td>
<td>4.67</td>
<td>5.41</td>
<td>6.78</td>
</tr>
<tr>
<td>Total calories</td>
<td></td>
<td>1600</td>
<td>1972</td>
<td>1347</td>
<td>1572</td>
<td>1808</td>
<td>1809</td>
</tr>
<tr>
<td>Total protein (grams)</td>
<td></td>
<td>29.4</td>
<td>17.7</td>
<td>23.0</td>
<td>28.9</td>
<td>35.6</td>
<td>37.0</td>
</tr>
<tr>
<td>Animal protein (grams)</td>
<td></td>
<td>7.0</td>
<td>3.1</td>
<td>4.4</td>
<td>6.5</td>
<td>8.9</td>
<td>13.8</td>
</tr>
</tbody>
</table>

*India (Maharashtra) 1958 Urban and Rural*

<table>
<thead>
<tr>
<th>Limits of the groups:</th>
<th>Total expenditure per capita per month (Rupees)</th>
<th>Average</th>
<th>0-8</th>
<th>8-11</th>
<th>11-13</th>
<th>13-18</th>
<th>18-24</th>
<th>24-34</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total calories</td>
<td>2100</td>
<td>1120</td>
<td>1560</td>
<td>1850</td>
<td>2190</td>
<td>2440</td>
<td>2530</td>
<td>3340</td>
<td></td>
</tr>
<tr>
<td>Total protein (grams)</td>
<td>59.7</td>
<td>30.7</td>
<td>45.0</td>
<td>52.8</td>
<td>60.4</td>
<td>66.3</td>
<td>71.7</td>
<td>85.7</td>
<td></td>
</tr>
<tr>
<td>Animal protein (grams)</td>
<td>4.5</td>
<td>1.0</td>
<td>1.8</td>
<td>2.3</td>
<td>2.9</td>
<td>6.1</td>
<td>7.1</td>
<td>11.9</td>
<td></td>
</tr>
</tbody>
</table>

*United Kingdom 1956 Nationwide*

<table>
<thead>
<tr>
<th>Limits of the groups:</th>
<th>Income of head of household per week (Pounds)</th>
<th>Average</th>
<th>&lt;6</th>
<th>6-10</th>
<th>10-16</th>
<th>16-27</th>
<th>27 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of households</td>
<td></td>
<td>9617</td>
<td>1593</td>
<td>3185</td>
<td>3604</td>
<td>969</td>
<td>276</td>
</tr>
<tr>
<td>No. of persons per household</td>
<td></td>
<td>1.23</td>
<td>1.36</td>
<td>1.96</td>
<td>3.39</td>
<td>3.57</td>
<td>3.47</td>
</tr>
<tr>
<td>Total calories</td>
<td></td>
<td>2624</td>
<td>2565</td>
<td>2642</td>
<td>2624</td>
<td>2596</td>
<td>2603</td>
</tr>
<tr>
<td>Total protein (grams)</td>
<td></td>
<td>1.3</td>
<td>1.34</td>
<td>1.74</td>
<td>2.56</td>
<td>2.75</td>
<td>2.87</td>
</tr>
<tr>
<td>Animal protein (grams)</td>
<td></td>
<td>13</td>
<td>41</td>
<td>42</td>
<td>42</td>
<td>46</td>
<td>50</td>
</tr>
</tbody>
</table>
### TABLE 11—Contd.

**United States of America, Spring 1955**

Urban (households of 2 persons or more)

<table>
<thead>
<tr>
<th>Household income ($/year)</th>
<th>Average</th>
<th>Under 1000</th>
<th>1000-1999</th>
<th>2000-2999</th>
<th>3000-3999</th>
<th>4000-4999</th>
<th>5000-5999</th>
<th>6000-6999</th>
<th>7000-7999</th>
<th>8000-9999</th>
<th>10000 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of households</td>
<td>2299</td>
<td>58</td>
<td>166</td>
<td>267</td>
<td>423</td>
<td>488</td>
<td>300</td>
<td>338</td>
<td>117</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>No. of persons/households</td>
<td>3.39</td>
<td>2.51</td>
<td>2.88</td>
<td>3.21</td>
<td>3.53</td>
<td>3.50</td>
<td>3.48</td>
<td>3.40</td>
<td>3.45</td>
<td>3.61</td>
<td></td>
</tr>
<tr>
<td>Total income per week ($)</td>
<td>3050</td>
<td>2870</td>
<td>2760</td>
<td>2900</td>
<td>3010</td>
<td>3030</td>
<td>3110</td>
<td>3200</td>
<td>3080</td>
<td>3260</td>
<td></td>
</tr>
<tr>
<td>Total calories (caput/day)</td>
<td>103</td>
<td>88</td>
<td>87</td>
<td>95</td>
<td>98</td>
<td>103</td>
<td>107</td>
<td>110</td>
<td>105</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Animal Protein (grams)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rural non-farm (households of 2 persons or more)

| No. of households         | 1037    | 92         | 131       | 155       | 216       | 189       | 112       | 94        | 25        | 23        |                |
| No. of persons/household  | 3.70    | 2.99       | 3.46      | 3.78      | 3.81      | 3.77      | 4.03      | 3.77      | 3.83      | 3.61      |                |
| Total income ($/per week) | 20.3    | 4.4        | 9.4       | 13.4      | 17.5      | 22.9      | 25.5      | 34.2      | 41.9      | 64.3      |                |
| Total calories (caput/day) | 3280    | 3110       | 3160      | 3330      | 3320      | 3270      | 3250      | 3490      | 3360      |            |                |
| Total protein (gr./caput/day) | 101     | 84         | 91        | 101       | 101       | 106       | 106       | 107       | 113       | 111       |                |

Rural farm (households of 2 persons or more)

| No. of households         | 1679    | 382        | 350       | 270       | 228       | 188       | 101       | 98        | 39        | 23        |                |
| No. of persons/household  | 4.16    | 3.99       | 3.87      | 4.11      | 4.19      | 4.33      | 4.56      | 4.82      | 4.89      | 4.38      |                |
| Total income ($/per week) | 16.1    | 3.74       | 10.4      | 14.6      | 18.9      | 22.6      | 24.8      | 29.6      | 36.8      | 76.6      |                |
| Total calories (caput/day) | 3660    | 3570       | 3770      | 3740      | 3640      | 3650      | 3650      | 3530      | 3620      | 3650      |                |
| Total protein (grams)     | 109     | 98         | 108       | 111       | 109       | 114       | 114       | 109       | 113       | 121       |                |
TABLE 12

Distribution of households surveyed in Indonesia (DJAWA—Madura) 1963/64, by Calories and Proteins Per caput per week of different foodstuffs

<table>
<thead>
<tr>
<th>Item</th>
<th>Households Expenditure in Rs./month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Cal.</td>
</tr>
<tr>
<td>Total Expenditure (Rp/Caput/month)</td>
<td>2874</td>
</tr>
<tr>
<td>Number of households</td>
<td>14670</td>
</tr>
<tr>
<td>Average size of households</td>
<td>4.5</td>
</tr>
<tr>
<td>Calories &amp; Proteins derived from per caput availability of:</td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>7186</td>
</tr>
<tr>
<td>Starchy roots</td>
<td>1917</td>
</tr>
<tr>
<td>Sugar</td>
<td>742</td>
</tr>
<tr>
<td>Pulses Nuts &amp; Oilseeds</td>
<td>319</td>
</tr>
<tr>
<td>Fruits &amp; Vegetables</td>
<td>28</td>
</tr>
<tr>
<td>Meat</td>
<td>175</td>
</tr>
<tr>
<td>Eggs</td>
<td>7</td>
</tr>
<tr>
<td>Fish</td>
<td>210</td>
</tr>
<tr>
<td>Milk</td>
<td>8</td>
</tr>
<tr>
<td>Fats &amp; Oils</td>
<td>601</td>
</tr>
<tr>
<td>Total per week</td>
<td>11193</td>
</tr>
<tr>
<td>Total per day</td>
<td>1600</td>
</tr>
<tr>
<td>Animal Protein per day</td>
<td>7</td>
</tr>
</tbody>
</table>

Production and availability of foods.
The degree of responsiveness to income of consumption of any product or group of products is generally measured by income-elasticity of demand which is the ratio of the proportionate change in consumption to proportionate change in income. The income-elasticity of demand for food is generally found to decline as consumption grows but its magnitude and rate of decline vary from one food group to another. This phenomenon can be well-illustrated by the household survey data of Indonesia which, as we have seen before, consumes a substantial quantity of starchy roots and, as such, provides a wide spectrum of changes in food consumption due to income increases. The average income-elasticity of demand for food in Indonesia estimated on the basis of the household consumption data in Table 11 is found to be 0.37 for calories, 0.52 for total protein and 1.05 for animal protein. This indicates that as the people have more purchasing power, they want to buy more food in order to have enough to eat and more strongly to buy better food. This is more clearly seen in Table 12 which gives per caput consumption in terms of the major food groups. While the consumption of the better quality foods continues to increase all along the income scale, the consumption of cereals and starchy roots increases up to a certain level of income. Of the latter two, the consumption of starchy roots, the cheapest source of calories, increases only within a short range of income changes and thereafter is progressively replaced by cereals and other foodstuffs. The income-elasticity of demand for starchy roots estimated on the basis of the data in the table is +0.41 for the lowest income group, reached the value of zero at about the per caput income of 2500 rupees per month, thereafter becomes negative with a value of —1.47 for the highest income-group of households included in the survey.

It follows that the lower the level of income of a household, the more it relies for its calorie supply on cheaper foodstuffs which are poorer in nutrients, and as a result, the distribution of other nutrients especially vitamins and minerals becomes more uneven than that of calorie supply.

Inadequate income more than any other factor is thus the principal cause of the high incidence of undernutrition and malnutrition in the region. Not that national income has not increased all these years but the increase is not large enough to make its impact on the distribution of income so as to reach down to the poorer section of the people who cannot afford adequate diets. It will take years for them to have sufficient purchasing power if we depend on the present growth trend of national income. For example, it has been estimated for India that "On the optimistic assumption of a 3 percent per annum increase in per capita real income it would take 30 years, or until 2000 AD, for even one-third of India's families to have the income needed, on the basis of present expenditure patterns, to provide a minimally adequate diet."
Perhaps, the solution lies in the new possibilities opened up by the high-yielding varieties. These varieties of cereals are, unlike the traditional varieties, not only responsive to high doses of fertilizers but, what is more important, are not season-bound and mature quickly to leave the land free for a second crop. What has been already achieved in research is impressive but the job remaining is equally big. What these countries particularly need are high-yielding varieties which could be grown in the areas lacking adequate and controlled water supplies. Another equally important task would be to evolve improved high-yielding strains of pulses and legumes. As the pay-off of research proved higher than was reckoned before, the necessary intensification of research activities in plant-breeding and other associated disciplines will, it is expected, be forthcoming. Technically it does no longer seem an impossible task to raise production to equate it with the calorie and protein requirements at the national average levels at least for some years during which the countries of the region can hope to influence their population growth. What is really at the heart of the problem is to make this production available to all sections of the people. Hard as the task is, it is not harder than it was before the advent of the break-through in agriculture when there was a serious constraint on production and the feasibility of solving the distribution problem was low. The change in technology leaves the distribution problem as the problem of overwhelming importance with its needs different from those implied in raising overall production.

That constraint on production has been removed is seen from a steady increase in food production since the bad harvests of 1965 and 1966. Part of this increase is due to good weather but a larger part is due to the increasing adoption of new technology made possible by the programmes taken up in many countries of the region for the promotion of high-yielding varieties. The governments of these countries have responded readily to this break-through largely impelled by the overriding need to replace food imports by domestic production. The new varieties are in fact spreading rapidly and it does not seem unlikely that most countries in the region would soon be able to do away with imports of food grains. Already, Philippines is producing a surplus of rice. In Pakistan, though East Pakistan has still a deficit in rice, West Pakistan produces a surplus of rice and wheat which, taken together, can fill this deficit. India too has already covered a substantial part of its wheat area with the seeds of improved varieties and could seem be self-sufficient in wheat taken singly. But the area sown to high-yielding rice-varieties is at present much smaller though rice can to some extent be substituted by wheat, her attainment of self-sufficiency in foodgrains may somewhat be delayed.

One important question is that when the developing countries of the region
have attained self-sufficiency in foodgrains, can they find export outlet for further expansion of cereal production and regain the position of net exporter? Very unlikely, since the world market for grain export is shrinking and one of the contributing factors is also the adoption of high-yielding varieties. Some traditional exporters are already facing difficulties on this account. Even if some of the developing countries have comparative cost of production advantages, they may still not find it easy to secure export outlets. The reason is that grain exports from developed countries are already sold to the outsiders at less than the domestic price, and they are in a position to increase their export subsidies and hold their own on the world market.

It follows that the underdeveloped countries in Asia will have to look increasingly to the internal market for absorption of increase in production that will be harvested every year if the growth initiated with the green revolution has to be maintained. Apparently, the internal market is there since a large section of the people are underfed and malnourished. But their demand for food is not effective for lack of purchasing power which, as mentioned before, would grow slowly if we depend on the trend of economic growth. A much quicker way of making their demand effective would be to enable them to participate fully in the expansion of food production. The developing countries are predominantly rural and the poorer sections of their population are largely small farmers, share-croppers and land-less labourers. Land is very unevenly distributed and it is mainly large and medium farmers who have so far adopted this new technology of crop production. Not that they have more progressive outlook. A large number of farm studies have shown that given definite economic incentives all farmers small or big, adopt new practices readily. The real reason is that big farmers are better off to afford the high costs per hectare of the cultivation of these new varieties, while small, largely subsistence farmers, are hesitant to undertake the risk involved in it. More understandable is the lack of adequate response of share croppers. However, as no higher degree of mechanization is required than is practised at present the new technology should enable even a smaller farmer with his pair of bullocks to raise the productivity of his holdings far above the range of yields considered possible before, and the people subsisting on the small holdings would be more gainfully employed and better fed too. But to enlist the small farmers in the necessary social effort to bring this about, appropriate policy-measures and institutional changes such as land reforms, credit and market facilities, crop insurance etc., will be needed as much as the adequate and timely supplies of the essential inputs. In other words, the programmes adopted for promoting new technologies of crop production must be far-reaching enough to ensure that the less privileged farmers can benefit equally from the technological break-throughs in agriculture. Failing this, the differences in income between the rich farmers and poor farmers will increase.
In consequence and with population growth still showing no signs of perceptible decline and with land increasingly becoming a scarce factor, incidence of undernutrition and malnutrition will in all probability increase, thereby further aggravating social unrest and threatening peace and political stability which today appear to inhibit the full exploitation of the potential revealed by the technological break-through. In our view the current break-through in agriculture, if exploited in a planned way, provides a unique opportunity to remedy the situation, while simultaneously providing a breathing time in which to influence decisively population growth.

REFERENCES
3. FAO (1957)—Calorie Requirements, Nutrition Study No. 15.
5. United Nations (1968). "International Action to Avert the Impending Protein Crisis".
The cereal grains are more important as human food in Asia than any other region of the world. They supply about 68 percent of the food calories consumed by Asians. Rice is by far the most important food grain and accounts for 41 percent of the calorie intake while wheat provides 13 percent of the caloric intake, the remaining 14 percent is contributed by the coarse grain cereals—corn, sorghum, millets, and barley.

Between 1960-61 and 1964-65, Asia produced an average of 392 million tons of cereal foodgrains annually, about 40 percent of the world’s grain output (Table 1). This was not adequate to feed Asia which contains 55 percent of the world’s population. Consequently, huge quantities of cereals were imported from other regions. About 90 percent of the world’s rice is produced and consumed in Asia and there is very little net flow of rice grain between Asia and the rest of the world. Only 20 percent of the world’s wheat is produced in Asia. Wheat contributed a major portion of the foodgrains imported for direct human consumption. The coarse grain cereals are imported primarily for livestock feed.

**TABLE 1**

Cereal grain production in Asia and the World
(in million tons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total cereals</th>
<th>Wheat</th>
<th>Rough rice</th>
<th>Other cereals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Asia</td>
<td>World</td>
<td>Asia</td>
<td>World</td>
</tr>
<tr>
<td>1960-61</td>
<td>380.94</td>
<td>962.70</td>
<td>55.95</td>
<td>245.00</td>
</tr>
<tr>
<td>1961-62</td>
<td>389.09</td>
<td>937.70</td>
<td>57.58</td>
<td>236.70</td>
</tr>
<tr>
<td>1962-63</td>
<td>389.71</td>
<td>978.60</td>
<td>54.92</td>
<td>256.60</td>
</tr>
<tr>
<td>1963-64</td>
<td>396.51</td>
<td>974.30</td>
<td>55.24</td>
<td>239.00</td>
</tr>
<tr>
<td>1964-65</td>
<td>405.10</td>
<td>1021.60</td>
<td>54.76</td>
<td>273.20</td>
</tr>
<tr>
<td>Average</td>
<td>392.27</td>
<td>975.18</td>
<td>55.09</td>
<td>250.10</td>
</tr>
</tbody>
</table>

*Source: FAO Production Year Books, Vol. 17 and 19.*
During the period 1951-52—1955-56, Asia (excluding mainland China) imported an average of 6 million tons of cereal grains per year. The imports increased to 14.4 million tons in 1960-61, 20 million in 1964-65, and 27.4 million tons in 1966-67. During the pre-war period (1934-38) Asia was a net exporter of foodgrain. Although the foodgrain production has increased since then, the population has increased at a faster rate and per capita grain production therefore has decreased.

As rice and wheat are the principal foodgrains in Asia, this presentation deals primarily with recent advances in research on these cereals and their impact on food production.

FERTILIZER USED AND FOOD PRODUCTION

A major factor in modern agricultural production practices is the use of chemical fertilizer. Technologically-advanced countries were manufacturing fertilizer in substantial quantities early in the 20th century and production greatly expanded after World War II. Increased crop yields are largely dependent upon the amount of fertilizer used, though plant protection measures and other improved management practices are important too. Data on the use of fertilizer for individual crops are not available but Figure 1 shows average yield per hectare of rice and wheat in the ten most important producing countries (excluding U.S.S.R. and mainland China) as well as the average rate of chemical fertilizer used on all crops. Apparently, yield is related to the level of fertilizer used. Japan and West Germany produced the highest yields of rice and wheat, respectively, and these countries used more than 150 kg/ha of plant nutrients in the form of chemical fertilizer compared with less than 2 kg used by such countries as India, Pakistan, Burma and Thailand.

On the average the rice yields in countries of the Asian tropics ranged until recently from 1000 to 2000 kg/ha compared with more than 4000 kg/ha in Japan, U.S.A., and Australia. The wheat yields in most developing countries of Asia was less than 1000 kg/ha as against 2000 to 3500 kg/ha in Japan and many European countries.

In the early 1950's Asia (excluding mainland China) used only 10 percent of the world's total fertilizer consumption. Recently, developing nations in Asia with rapidly growing populations, realized that because land available for the extension of crop area is limited, additional output of food must come largely from higher yields. During the last two decades, several of these nations have made major efforts to increase the use of fertilizer. Traditional varieties of rice and wheat, however, did not respond efficiently to the applied
fertilizer. Heavy applications of fertilizer lowered yields instead of increasing them. Thus the ability of the variety to respond to fertilizer became the most important limiting factor when fertilizer, irrigation, water, and other agricultural inputs were available.

![Graph showing yield and fertilizer consumption in wheat and rice producing countries](image)

Fig. 1: Yield and fertilizer consumption in 10 leading wheat and rice producing countries (excluding USSR and mainland China). Source: FAO production yearbooks (average of the estimates for 1956/57 to 1960/61).
The traditional, tall-growing varieties of rice and wheat had been selected over the centuries for their ability to grow rapidly in initial stages, to compete well with weeds, and to give modest yields with minimum care under conditions of low soil fertility. Plant breeders in most Asian countries where low rates of fertilizer were used continued to develop tall varieties because they were generally suited to the conditions under which farmers grew them. The application of high rates of fertilizer (especially nitrogen) makes these varieties grow excessively tall and they lodge (fall over). Lodging destroys the morphological framework essential for efficient manufacture of carbohydrates and their translocation to the grain. The earlier the plants lodge, the greater the loss in yield. Tall varieties generally respond to as much as 40 kg/ha of nitrogen but beyond this rate the use of fertilizer is unprofitable because of lodging.

Rice breeders have traditionally recognized two major varietal groups: japonica varieties grown in the temperate region, and indica varieties grown in the tropics. The two groups differ in grain characteristics and tolerance to cold. Modern rice breeding which involves hybridization among indica and japonica varieties is gradually eliminating any distinction between the two groups.

Through systematic breeding work since the beginning of the century, Japanese rice breeders developed improved japonica varieties that are highly responsive to fertilizer. These varieties are relatively short, have stiff straw, and dark green, erect leaves. The japonica rice varieties have been introduced into other temperate countries but they are not adapted to the tropics. Rice breeders in the tropics attempted indica-japonica hybridization to develop fertilizer responsive varieties but the results were generally not satisfactory.

Taiwan, a sub-tropical country which grew only indica rice until 1922 introduced japonica varieties during the Japanese occupation of the island and developed the ponlai rice from crosses among japonica varieties. The ponlai rice resembles japonica rice but it is better adapted to the sub-tropical climate. Because the ponlai varieties were more responsive to fertilizer than indicas the area planted to them in Taiwan rapidly increased. The improvement of native rice (indica) received little attention. A semi-dwarf indica variety, Dee-geowoo-gen existed in Taiwan since the beginning of the 20th century, but the full significance of the semi-dwarf plant type in breeding fertilizer responsive indicas was not recognized.
Although Japan is not an important wheat growing country, farmers in Japan grew fertilizer responsive short-statured wheat varieties even before systematic breeding work was begun. Starting in the 1920's, Japanese wheat breeders developed many improved semi-dwarf wheats which were highly responsive to fertilizer. However, the Japanese semi-dwarf wheats could not be directly introduced into other countries because of their winter growth habit or susceptibility to diseases. In other countries (except Italy) plant breeders did not start using the semi-dwarf wheats in their breeding programmes until 1949. The wheat breeding programmes in several European countries emphasized the development of short, stiff-strawed, lodging-resistant, and fertilizer-responsive varieties since the beginning of the century. Although the varieties that were shorter than the conventional varieties and more responsive to nitrogen were developed, the programmes did not succeed in producing varieties with a drastic reduction in plant height accompanied by a high degree of lodging resistance.

The most important features of the breeding work until the 1960's was the improvement of grain quality and the addition of genes for disease resistance which enabled varieties to exhibit their full yield potential. In the absence of diseases, however, the new varieties showed little increase in yield potential over the older ones.

The real breakthrough in breeding for high yield potential came with the discovery and utilization of semi-dwarfing genes of the Chinese rice Dee-geo-woo-gen and the Japanese wheat Norin 10 during the last two decades. Earlier, breeders used multiple genes in attempts to shorten plant height and develop lodging-resistant varieties. Multiple genes caused small differences in height which showed low heritability, so not much progress was made. The simply inherited semi-dwarfism of Dee-geo-woo-gen and Norin 10 was a major factor in the dramatic success of rice and wheat breeding in recent years. Many genetic anomalies with dwarf stature had long been known both in rice and wheat but they did not have any breeding value, because their short stature was accompanied by many miniature plant parts and poor grain development. Dee-geo-woo-gen and Norin 10 are not abnormal dwarfs; their shortened plant height is not associated with any undesirable plant characteristics and in spite of their reduced culm length, the number of nodes and leaves and the size of grain head are normal.

**SEMI-DWARF RICE VARIETIES FOR THE ASIAN TROPICS**

The first semi-dwarf variety of indica rice (Taichung Native 1) was developed in Taiwan in 1956 from a cross between Dee-geo-woo-gen and a tall growing
variety Taai-Yuan-Chung. For several years, however, the Taiwan Government made no organized attempts to multiply its seed or to encourage its spread because of the long-standing policy to produce rice for export to Japan. The Japanese brought ponlai rice but not indica rice because they did not like the grain type of indica rice. In 1960, the Joint Commission on Rural Reconstruction provided financial assistance to the Taiwan Provincial Department of Agriculture for large-scale trials, seed production, and the introduction of Taichung Native 1. Its yields were as high as those of ponlai varieties and it demonstrated that fertilizer-responsiveness was not the exclusive property of japonica rice. Taichung Native 1 soon became the most widely grown indica variety in Taiwan. But outside Taiwan, the value of Taichung Native 1 was not fully recognized until after 1962.

In 1962, the International Rice Research Institute, located in the Philippines, began research on rice production in the tropics. The Institute scientists realized that the most important single reason for low yields in the tropics was the lack of fertilizer-responsive varieties. The Institute breeding programme was designed to develop rice varieties that would be short and stiff-strawed, that would have short, upright leaves, and that would resist lodging even when heavily fertilized and intensively managed.

The Institute obtained seed of three semi-dwarf rice varieties from Taiwan, Dee-geo-woo-gen, Taichung Native 1, and I-geo-t'ee for use in its breeding programme. In 1962, many crosses were made between these semi-dwarfs and tall indica varieties with the objective of improving the plant type of tropical rice. The most successful cross proved to be one between Peta, a tall Indonesian variety which possessed disease resistance and heavy tillering, and the semi-dwarf Dee-geo-woo-gen. From this cross came the variety eventually named IR8.

In trials at the Institute in 1964, Taichung Native 1 was one of the highest yielding varieties. Although it did not perform as well as IR8, Taichung Native 1 attracted considerable attention in India. In December, 1964, the Institute supplied 1 kg. of Taichung Native 1 seed for trials in India where it yielded up to 8 t/ha in preliminary trials. It was released for commercial cultivation in India in 1966.

IR8 was planted in its first trial at IRRI in March, 1965, and during the next two seasons, it produced from 6 to 9 t/ha. In 1965 and 1966, it was thoroughly tested in India, Pakistan, Thailand, Malaysia, and the Philippines. Occasionally, computed yields approached 10 t/ha. On the basis of its proved performance and adaptability, IR8 was named and released for commercial
cultivation in November 1966. IR8 is superior to Taichung Native 1 because of its higher resistance to disease, greater response to fertilizer and stiffer straw.

The characteristics of the new plant type of indica rice as represented by IR8 is stiff straw, a height of 90 to 100 cm, upright tillers, and short, erect leaves. Traditional indica varieties are 150 to 180 cm tall and have long, drooping leaves. IR8 has a grain/straw ratio of about 1.0 compared with a ratio of 0.5 to 0.6 for the tall varieties.

Another variety, IR5, was released by the Institute in 1967. Although the plant type of IR5 is not as good as that of IR8, IR5 has more resistance to bacterial leaf blight. The grains of both have a white belly (chalky area) which lowers milling quality and market value.

After the new plant type established a breakthrough in rice production in the tropics, the major breeding emphasis shifted to improving the grain quality. This was successfully achieved by the release of IR20 and IR22 in November, 1969. These varieties are similar to IR8 in plant type and yielding ability but they have much better grain quality. IR20 is a medium-grain rice while IR22 is a long-grain rice. Both varieties have slender, hard translucent grains which are basically free of chalkiness.

Simultaneous to the development of IR8, the production practices to realize its full yield potential were standardized. These included water management, weed control, fertilizer application, and insect control. The use of various agricultural inputs became highly profitable when used with semi-dwarf varieties possessing high yield potential.

DEVELOPMENT OF SEMI-DWARF WHEAT VARIETIES

In 1946, S. C. Salmon, an agricultural adviser to the U.S. army in Japan, observed that Japanese farmers were growing short, stiff-strawed wheat varieties. He brought seeds of semi-dwarf Norin 10 and several other varieties of this type to the U.S. In 1949, at the Washington Agricultural Experiment Station, Pullman, Washington, O. A. Ogil made a series of crosses between U.S. and Japanese wheats, including Norin 10 x Brevor. Selections of this cross were used extensively in the wheat breeding programmes of the Washington Agricultural Experiment Station and were also sent to many U.S. and foreign breeders.

Gaines, a soft winter wheat, was the first semi-dwarf variety developed at Pullman, Washington. It was released in 1961. Gaines out-yielded the best varieties in Washington and Oregon by 5 to 20 percent. On well-managed,
Foodgrain Production in Asia

highly productive soils, however, the differences occasionally exceeded 50 percent. Individual farmers obtained record yields of 8.3 t/ha in 1962, 9.1 t/ha in 1964, and 11.2 t/ha in 1965.10

The first extensive breeding programme to develop semi-dwarf spring wheats was started by N. E. Borlaug in 1954 in Mexico. He crossed Norin 10 x Brevor lines with Mexican varieties. This led to the development of short-statured and lodging-resistant spring varieties, Ptuí 62 and Penjamo 62, which were commercially grown in Mexico in 1962. They were followed by the release of several other semi-dwarf varieties including Sonora 63, Sonora 64, Lerma Rojo 64, Inla 66, Ciete Cerros 66, Super X, and Norteno 67.11 The first releases possessed only one dwarfing gene but more recent ones have two dwarfing genes. Two-gene dwarfs are shorter than one-gene dwarfs and they respond better to heavier applications of fertilizer.

Not only have the semi-dwarf Mexican varieties and improved management practices revolutionized wheat production in Mexico but they have also contributed to the beginning of similar revolutions in many other countries. Like Mexico, most Asian countries grow spring wheat and the Mexican wheat material was found to be well-adapted in those countries.

THE RAPID SPREAD OF SEMI-DWARF VARIETIES

The unprecedented export of seed for direct commercial use from Mexico and the Philippines to Asian countries shows the great popularity of semi-dwarf varieties. Tables 2 and 3 give the amount of seed imported by individual countries in Asia and the estimated area under semi-dwarf wheat and rice in those countries. About 84,000 tons of wheat seed was supplied by Mexico and 6600 tons of rice seed by the Philippines. Although the rice seed supply was relatively smaller, it can be multiplied faster in the tropics because two or three crops can be grown in a year and it is seeded at a lower rate than wheat. In Asia, about 10 million ha were planted to semi-dwarf wheat and 7 million ha to semi-dwarf rice in 1969-70. In addition to varieties introduced from the Philippines and Mexico, several countries have begun to grow semi-dwarf varieties developed locally. They are gradually replacing the foreign varieties.

IMPACT OF SEMI-DWARF VARIETIES ON PRODUCTION

The semi-dwarf varieties are beginning to make an impact on agricultural production in many countries in Asia. The agricultural revolution brought about by the use of new seeds and improved management practices are most advanced in the Philippines, India and West Pakistan.
### TABLE 2
Quantities of seed of semi-dwarf wheats imported and area planted to them by different countries

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia—India</td>
<td>250</td>
<td>10000</td>
<td>4793</td>
<td>5099</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakistan (West)</td>
<td>350</td>
<td>42000</td>
<td>579</td>
<td>122</td>
<td>146</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>60</td>
<td>22100</td>
<td>623</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Afghanistan</td>
<td>50</td>
<td>420*</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>38</td>
<td>450*</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iran</td>
<td></td>
<td></td>
<td></td>
<td>100*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (Burma, Lebanon, Iraq, Saudi Arabia, and Syria)</td>
<td></td>
<td></td>
<td></td>
<td>(800)</td>
<td>(700)*</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Total</td>
<td>650</td>
<td>18568</td>
<td>64550</td>
<td>2302</td>
<td>1200</td>
<td>7945</td>
<td>9205</td>
</tr>
</tbody>
</table>

Principal Source: Dalrymple (1969), figures in parenthesis represent authorization rather than actual import; estimates of area partially revised on the basis of current survey of Dalrymple (personal communication).

N.A. = Not available. * Includes 170 t from Pakistan.

* From Pakistan, India, or Turkey. **Data from CIMMYT staff.

Note: All seed imported from Mexico except when indicated otherwise.

### TABLE 3
Quantities of seed of semi-dwarf rice varieties imported from the Philippines and the area planted to them by different countries

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
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<tbody>
<tr>
<td>Asia—India</td>
<td>10*</td>
<td>10</td>
<td>2680</td>
<td>3885</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakistan (East)</td>
<td>10</td>
<td>1500</td>
<td>1804</td>
<td>154</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>2*</td>
<td>50</td>
<td>356</td>
<td>501</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burma</td>
<td></td>
<td>200</td>
<td>200*</td>
<td>167</td>
<td>144</td>
<td></td>
</tr>
<tr>
<td>South Vietnam</td>
<td></td>
<td>45</td>
<td>2003</td>
<td>44</td>
<td>202</td>
<td></td>
</tr>
<tr>
<td>Ceylon</td>
<td></td>
<td>210</td>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (Laos, Nepal, Israel, Malaysia, and Iraq)</td>
<td>3</td>
<td>301*</td>
<td>112*</td>
<td></td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>2106</td>
<td>2327</td>
<td>1904</td>
<td>3571</td>
<td>5785</td>
</tr>
</tbody>
</table>

Principal Source: Dalrymple (1969), partially revised on the basis of current survey by Dalrymple (personal communication); N.A. = Not available.

* Data from Rice and Corn Administration, Philippine Government and IRRI.

* Data from Agri. Dept., Govt. of West Pakistan.

* From a mimeographed report on "National Rice Research Program of Indonesia" prepared by S. V. S. Shastry, 1970. Includes area under C4-63.
Philippines: The Philippines was the first beneficiary of research at the International Rice Research Institute. In July 1966, when the high yielding


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Foodgrain Production in Asia

Philippines: The Philippines was the first beneficiary of research at the International Rice Research Institute. In July 1966, when the high yielding
potential of IR8 was widely recognized, about 2400 Filipino farmers came to
the Institute to receive 2-kg samples of IR8. Sixty-two tons of its seed were
supplied to various Filipino agencies for large scale trials and multiplication.
The area under IR8 and IR5 (released in 1967) increased rapidly. IR8 and
IR5 were planted on 13 percent of the rice area in 1967-68 and 27 percent in
1968-69 (Fig. 2).

Rice is the most important crop in the Philippines and is grown on more than
3 million ha. Until 1967-68 about 10 percent of the rice consumed annually
was imported. Both the area and production of rice showed a significant
upward trend in 1967-68 (Fig. 2) when the country became self-sufficient in
rice and even started exporting some rice to other countries. Due to unfa
vourable weather, production in 1968-69 did not increase further but in 1969-70
a record production and yield were achieved. Both were more than 25 percent
higher than the best corresponding figures prior to the introduction of semi-
dwarf rice varieties.

India : In 1963, India received a large collection of dwarf wheat material
from Mexico. This included 100 kg each of the varieties Sonora 63, Sonora 64,
Mayo 64, and Lerma Rojo 64, and smaller samples of about 600 advanced
generation experimental lines. The seeds were grown and evaluated at high
fertility levels at several research centres in 1963-64 and 1964-65. Two Mexican
wheats, Lerma Rojo 64 and Sonora 64, were approved by the Indian Council
of Agricultural Research in 1965 for commercial cultivation.

At the same time the Indian wheat breeders quickly evaluated the 600 genetic
lines received from Mexico. They found that under Indian conditions some
of the lines were superior to the commercial Mexican varieties. In 1966 and
1967 several selections from this material, namely PV18, Kalyan Sona 227,
Sonalika, Safed Lerma and Chhoti Lerma were released for commercial
cultivation. One of them, Kalyan Sona 227, became the dominant semi-
dwarf wheat throughout India. An amber-grained strain developed at the
Indian Agricultural Research Institute by irradiating Sonora 64 was also
released under the name Sharbat Sonora.

When adequately fertilized and well managed the yields of the dwarf strains
were much higher than those of traditional varieties. Yields occasionally
approached 8 t/ha. The farmers accepted the new strains without any hesitation
and were willing to pay higher price for their seed. Fertilizer use went up and
the area under dwarf wheats increased rapidly from 500,000 ha in 1966-67 to
nearly 3 million ha in 1967-68 when India produced 16.5 million tons of wheat,
an increase of about 40 per cent over the previous year. Although part of the
increase in production was the result of increased area under wheat the average yield jumped to 1100 kg/ha compared with the highest previous figure of 910 kg/ha in 1964-65. This is particularly remarkable because yields oscillated between 700 to 900 kg/ha during the previous decade. The total wheat produc-
tion and yield have continued to increase. Changes in area, production, and yield of wheat are shown in Figure 3.

Taichung Native I was the first semi-dwarf indica rice grown in India in 1964-65. From 60 ha planted for seed production in the 1965 monsoon season, the area under Taichung Native I expanded to about 600,000 ha in 1966 monsoon season. The high yields kindled a wide interest in the dwarf rice varieties but the susceptibility of Taichung Native I to bacterial leaf blight prevented its use over a larger area.

IR8 was first tried in India in the 1965-66 dry season. It yielded better than any other variety including Taichung Native I and was approved for general cultivation in 1967. By the 1968 monsoon season, the area planted to IR8 leaped to 1.6 million ha. The area under dwarf rice varieties in 1969-70 was estimated to be 3.9 million ha, about 10 percent of the total rice area (Table 4).

**TABLE 4**
Area, Production, and yield of rough rice in India, 1955/56-1969/70

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (000 ha)</th>
<th>Production (000 t)</th>
<th>Yield (kg/ha)</th>
<th>Area under dwarf varieties* (000 ha) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955-56</td>
<td>31520</td>
<td>41336</td>
<td>1310</td>
<td></td>
</tr>
<tr>
<td>1956-57</td>
<td>32277</td>
<td>43556</td>
<td>1350</td>
<td></td>
</tr>
<tr>
<td>1957-58</td>
<td>32298</td>
<td>38288</td>
<td>1190</td>
<td></td>
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<tr>
<td>1958-59</td>
<td>33172</td>
<td>46271</td>
<td>1400</td>
<td></td>
</tr>
<tr>
<td>1959-60</td>
<td>33820</td>
<td>47514</td>
<td>1410</td>
<td></td>
</tr>
<tr>
<td>1960-61</td>
<td>34128</td>
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<tr>
<td>1961-62</td>
<td>34694</td>
<td>53494</td>
<td>1540</td>
<td></td>
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<td>1962-63</td>
<td>34934</td>
<td>47871</td>
<td>1370</td>
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</tr>
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<td>1963-64</td>
<td>35474</td>
<td>54734</td>
<td>1540</td>
<td></td>
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<td>1964-65</td>
<td>36077</td>
<td>58098</td>
<td>1610</td>
<td></td>
</tr>
<tr>
<td>1965-66</td>
<td>35273</td>
<td>45983</td>
<td>1300</td>
<td>5</td>
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<td>1966-67</td>
<td>35598</td>
<td>45660</td>
<td>1280</td>
<td>867</td>
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<tr>
<td>1967-68</td>
<td>36437</td>
<td>56418</td>
<td>1550</td>
<td>1790</td>
</tr>
<tr>
<td>1968-69</td>
<td>36966</td>
<td>59642</td>
<td>1610</td>
<td>2680</td>
</tr>
<tr>
<td>1969-70</td>
<td>37680</td>
<td>60645</td>
<td>1610</td>
<td>3885</td>
</tr>
</tbody>
</table>

* Source: Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

* From Dalrymple (1969) and Table 3.
The All-India Coordinated Rice Improvement Project accelerated efforts to breed dwarf rice. Two varieties, Jaya and Padma, were released to farmers in December 1968. They were the first products of local research designed to exploit the yield potential of the dwarf plant type. In 1970 India released several new varieties which inherited semidwarfism from IR8 or Taichung Native 1.

Rice yield in India fluctuates more than that of wheat. It is greatly influenced by the distribution and amount of rain received during the monsoon season. Low rainfall in any year would cancel out a major part of the gains resulting from the cultivation of new rice varieties. In spite of this, the data presented in Table 4 show a trend for more stable and higher yield per hectare and evidence of the beginning of a break through in total production. In 1970-71 rice production is estimated to be substantially higher than the last year.

The new rice varieties have not had quite the impact on production that the new wheat varieties had. The rice programme started later and the total rice area is much larger than the wheat area. While 31 percent of the wheat area was planted to dwarf varieties in 1969-70, only 10 percent of the rice area was planted to dwarf varieties. Most rice is grown in the cloudy monsoon season when low solar energy limits the yield and nitrogen response of the new rice varieties. Rice plant is the host of many fungal, viral, and bacterial diseases. It is also attacked by many insects. Better plant protection measures are needed to exploit the production opportunities offered by the new strains. Concentrated research now underway in India to incorporate resistance to local diseases and pests in the dwarf plant type will no doubt result in a widening of the area under high-yielding varieties.

The Punjab region (including Haryana), where crop production conditions are more favourable and sunlight is abundant, is the focal point of the revolution in wheat production in India. This region now produces one-third of the nation's wheat. With 62 percent of the wheat area in Punjab and Haryana planted to dwarf varieties in 1969-70, wheat production increased by 140 percent and yield per hectare by 70 percent compared with the 5 years (1962-1966) before dwarf varieties were introduced (Table 5). This is not an important rice-growing area but offers favourable conditions for rice production. The cultivation of the new rice varieties is leading to an increased area under rice. With only 15 percent of the area planted to dwarf rice varieties in 1969-70 the yield climbed to 2,260 kg/ha compared with the 1962-1966 average of 1,700 kg/ha (33% increase) and total production almost doubled during the same period.
### TABLE S

Area, production, and yield of wheat and rough rice Punjab and Haryana (India), 1965-66 to 1969-70

<table>
<thead>
<tr>
<th>Year</th>
<th>Area under dwarf varieties (000 ha)</th>
<th>Area (000 ha)</th>
<th>Production (000 t)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wheat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962-66 (mean)</td>
<td>624</td>
<td>2219</td>
<td>2840</td>
<td>1280</td>
</tr>
<tr>
<td>1966-67</td>
<td>68</td>
<td>2351</td>
<td>3510</td>
<td>1490</td>
</tr>
<tr>
<td>1967-68</td>
<td>724</td>
<td>2631</td>
<td>4773</td>
<td>1810</td>
</tr>
<tr>
<td>1968-69</td>
<td>1450</td>
<td>2691</td>
<td>6020</td>
<td>2030</td>
</tr>
<tr>
<td>1969-70</td>
<td>1942</td>
<td>3123</td>
<td>6844</td>
<td>2190</td>
</tr>
<tr>
<td><strong>Rice</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1962-66 (mean)</td>
<td>447</td>
<td>447</td>
<td>762</td>
<td>1700</td>
</tr>
<tr>
<td>1966-67</td>
<td>842</td>
<td>477</td>
<td>842</td>
<td>1760</td>
</tr>
<tr>
<td>1967-68</td>
<td>1053</td>
<td>531</td>
<td>1053</td>
<td>1980</td>
</tr>
<tr>
<td>1968-69</td>
<td>1113</td>
<td>574</td>
<td>1113</td>
<td>1940</td>
</tr>
<tr>
<td>1969-70</td>
<td>1368</td>
<td>606</td>
<td>1368</td>
<td>2260</td>
</tr>
</tbody>
</table>

Source: Directorates of Agriculture, Punjab and Haryana.

Pakistan: In Pakistan, nearly all the wheat crop is grown in West Pakistan. In 1963, West Pakistan obtained 100 kg lots of seed of Lermio Rojo and Penjamo 62 as well as several hundred experimental lines from Mexico. The seed of the Mexican varieties was increased and tested on farms during the 1964-65 season. The varieties yielded about 25 percent more than standard local varieties when adequately fertilized. Selections made locally from the segregating populations received from Mexico proved to be even better than the commercial Mexican wheats. Among them the most outstanding ones were Mexi-Pak 65 and Indus 66. These two selections closely resemble PV18 and Kalyan Sonas of India and Super X and Ciete Cerros of Mexico because they were all selected independently from progenies of the same cross (Penjamo Sib x Gabo 55) made in Mexico.
The area under dwarf wheats in West Pakistan increased from 5,000 ha in 1966-67 to 3.2 million in 1969-70 and the grain production increased by more than 50 percent during the same period. In the decade before the introduction

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**Fig. 4.** Area, production, and yield of wheat in West Pakistan, 1955/56-1969/70. Source: Agriculture Department, Government of West Pakistan.
of semi-dwarf wheat (1955-56—1964-65), the average yield in West Pakistan was stagnated between 750 and 870 kg/ha. In 1967-68 the first time Mexican wheats were grown on a substantial area (16% of the total wheat area) the average yield jumped to 1070 kg/ha and in 1969-70 it increased to 1200 kg/ha (Fig. 4). In 1968, 2 years ahead of schedule, Pakistan became self-sufficient in wheat.

Of about 11 million ha of rice grown in Pakistan, 9.5 million ha are grown in East Pakistan which is the main rice-consuming region. The first dwarf rice, IR8, introduced for commercial cultivation had little impact in East Pakistan where cold injury, virus diseases, and insect pests are major problems. IR8 was not the answer to East Pakistan’s needs, but when sown at the appropriate time and managed properly, IR8 produced from 7 to 10 t/ha which demonstrated the high yield potential of the new plant type. IR5 was more successful because it was more resistant to diseases. The recent release of IR20 which combines the IR8 plant type with greater resistance to diseases and insects, has given East Pakistan new hope for increasing production with semi-dwarf varieties. In 1970, the East Pakistan government imported 1800 tons of IR20 from the Philippines. The shipment was the single largest consignment of improved rice seed ever imported by any country.

In West Pakistan, however, IR8, was a great success. From 400 ha in 1967-68, the area increased to 501,000 ha in 1969-70 which is one-third of the entire rice area in West Pakistan. During the 3 year period ending 1969-70, production increased by about 80 percent and yield by 50 percent (Fig. 5).

INCREASED FOODGRAIN SUPPLY IN RELATION TO BALANCED NUTRITION

The diets of Asians are generally deficient in protein in addition to being deficient in calories. The cereal grains are a major source of protein and supply about 60 percent of the total protein intake by Asians. In North America and Australia where animal protein is consumed in larger quantities, the cereal grains provide only about 25 percent of the protein intake. Because animal protein food is more expensive, it is important to increase the supply of plant protein in the diet of Asian people.

Rice, the staple food in most Asian countries, has good quality protein but its total quantity is low. Considerable evidence is now available to show that applications of adequate quantities of nitrogenous fertilizer to high yielding dwarf varieties will increase the protein content in addition to increasing the yield of grain. Table 6 presents data on yield and protein content of rice varieties obtained from a field experiment conducted co-operatively by IRRI...
Foodgrain Production in Asia

and Bureau of Plant Industry in 1969 at three locations in the Philippines. Application of nitrogen at 120 kg/ha increased the grain yield and protein content of IR8 and IR22 by more than 25 percent. Nitrogen also increased the protein content of lodging-susceptible variety Peta but the magnitude of increase was relatively small. Apparently the susceptibility of tall traditional varieties to lodging limits their ability to use heavy amounts of nitrogen both for yield and protein increase. Because the grain yield of Peta was reduced by nitrogen applications, its total protein yield was much lower than that of IR8 and IR22.

Fig. 5. Area, production, and yield of rough rice in West Pakistan, 1955/56-1969/70. Source: Agriculture Department, Government of West Pakistan.

Work is in progress at several research centres in Asia to improve the nutritive value of rice and wheat grain. Although protein content is greatly influenced by environmental factors, the results so far obtained indicate the possibility of genetically increasing the protein content of grain. Strains
that possess adequate protein of good quality along with high yield potential would provide better nutrition for millions of people who primarily depend upon cereals for protein.

**TABLE 6**

Effect of level of nitrogen on grain yield and protein content of selected rice varieties. IRRI-BPI Cooperative Fertility Experiment (Mean of 3 locations in the Philippines, 1969 wet season)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Grain yield (kg/ha)</th>
<th>Protein Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen Appliedb/(kg/ha)</td>
<td>Nitrogen Appliedb/(Kg/ha)</td>
</tr>
<tr>
<td></td>
<td>0  40 / 20 / 100  20</td>
<td>0  40 / 20 / 100  20</td>
</tr>
<tr>
<td>IR8</td>
<td>4585  5379  5893</td>
<td>6.4  7.9  9.2</td>
</tr>
<tr>
<td>TR22</td>
<td>4083  5272  6220</td>
<td>7.3  8.4  9.1</td>
</tr>
<tr>
<td>IR480-5-9-3-3</td>
<td>3360  3835  4330</td>
<td>9.5  10.6  11.7</td>
</tr>
<tr>
<td>Peta</td>
<td>3802  3529  3096</td>
<td>8.3  9.8  9.9</td>
</tr>
</tbody>
</table>

* Applied basal / at panicle initiation.

I have confined my discussion to cereals with particular reference to rice and wheat. Pulses like soyabean, chickpea, and mungbean are cheap sources of high quality protein. These can be conveniently grown in rotation with cereals. In irrigated areas of the tropics and sub-tropics, crops can be grown year round. Increasing the number of crops per unit area per year is one way of increasing food production. Scientists at IRRI have developed several multiple cropping systems to maximize the use of land. Cropping systems involving cereal and pulse crops not only offer the opportunity of growing much more food but also of providing the tropical world with a balanced diet, richer in protein, minerals, and vitamins.

**CURRENT OUTLOOK AND FUTURE PROSPECTS**

The single step of creating the semi-dwarf plant type in wheat and in rice has doubled the yield potential of these cereals. If adequately fertilized and intensively managed, the semi-dwarf strains can produce yields which were never dreamt of a decade ago. The cultivation of new strains also had a profound effect on the attitudes of farmers. They are now willing to accept new research findings, use of fertilizers, and other agricultural inputs, and invest...
in farm machinery and irrigation facilities. The result is that production and yields of wheat and rice have started rising and the outlook for increased food supplies is now full of promise. Brown commented that the new seeds have triggered an agricultural revolution in developing countries that makes the earlier agricultural take off in the United States and Japan seem minor by comparison.

Because of the ability of new rice and wheat strains to use fertilizer more efficiently, fertilizer consumption has gone up rather abruptly in several countries during the last 4 years. In 1967-68, India and Pakistan consumed twice as much fertilizer as was done in 1965-66. During the same period the fertilizer consumption in Asia increased by 46 percent compared with a 22 percent increase in the world as a whole. The new strains have already tended to tilt the production advantage in favour of the developing countries (Table 7).

### TABLE 7

Changes in production and yields of wheat and rice in the world and selected countries in Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>Production Increase</th>
<th>Yield Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>51</td>
<td>70</td>
</tr>
<tr>
<td>West Pakistan</td>
<td>51</td>
<td>56</td>
</tr>
<tr>
<td>World</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Pakistan</td>
<td>19</td>
<td>61</td>
</tr>
<tr>
<td>Philippines</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Ceylon</td>
<td>36</td>
<td>41</td>
</tr>
<tr>
<td>World</td>
<td>13</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: Figures for world (exclude Mainland China) and Ceylon based on data from Grain Bulletins, Commonwealth Secretariat; others based on data from agriculture departments or ministries of respective governments.
While the world production of wheat in 1969-70 increased 10 percent compared with the annual average of the period 1962-63—1966-67, production increased 84 percent in India and 70 percent in Pakistan. The yield per hectare in these countries also increased much more than did the world yield. The change in production and yield of rice in West Pakistan, Ceylon, and Philippines are also very favourable. The imports of cereal grains into Asia which were continuously rising have begun to decline.

A radical shift in varieties following the development of semi-dwarf strains will favour the appearance of pests which were previously unknown or unimportant. The modern production practices used for the new strains provide environments which not only are good for plant growth but also encourage the development of diseases and the build-up of harmful insects. To fully exploit the potential offered by the semi-dwarf plant type, a high degree of resistance to different plant parasites must be incorporated in new varieties. Any complacency or inadequate investment in research could keep the new productive potential unrealized and lead to renewed food crises.

The dwarf strains have moved yields to a new plateau. Their higher yield potential is primarily due to improved plant morphology. Another quantum jump in yield potential is unlikely to occur by further improvement in plant type. Other ways to increase the yield potential should be examined in depth. Preliminary studies at IRRI have shown that the photosynthetic rates of rice varieties differ by up to 100 percent. Differences in photosynthetic efficiency have been discovered in several other crop plants. More intensive work should be carried out to identify wheat and rice varieties with high photosynthetic efficiency and to develop screening techniques to incorporate this characteristic in commercial varieties.

The superiority of new varieties and technologies has been demonstrated on only a fraction of the rice and wheat land—the lands where good water control or adequate soil moisture is available. This area is about a quarter of the rice area and half of the wheat area. Since a large area under rice and wheat has limited water supply, basic work should be carried out to develop drought-resistant strains which produce more efficiently and give high yield under such conditions.

Many research centres are engaged in studies on some of the aspects of rice and wheat improvement mentioned above. These research programmes should lead to a continuous improvement in crop production technologies. The potential exists to double or even triple food grain production during the next 2 or 3 decades by using high yielding varieties, and other agricultural inputs and
Foodgrain Production in Asia

intensive cropping. Whether this will actually happen is more difficult to answer, however, a massive investment is required to produce adequate quantities of fertilizer and other inputs, and to develop marketing transportation, and storage facilities. The problem is not merely one of increasing the potential of the world to feed the present population but it is also one of overcoming the social, economic, and political obstacles to producing enough food. When enough food is produced, people should have the capacity to buy it. Therefore, increased food production must be accompanied by rapid economic growth and improvement in per capita income.

The development of new strains and other technology do not provide a permanent solution to the population-food problem. Population control deserves as much attention as food production. There is a limit to the capacity of plants and other resources to produce food. Before too long population equilibrium must be attained and this should be done well before we are confronted with the impossibility of producing enough food, or exhaustion of natural resources due to overcrowing.

REFERENCES

GENETIC UPGRADING OF NUTRITIONAL QUALITY IN FOOD PLANTS

M. S. Swaminathan

Indian Agricultural Research Institute, New Delhi, India

The development of varieties with better yield and stability of performance through built-in resistance to diseases and pests was until recently the major goal of plant breeding research. Either through the incorporation of dwarfing genes as in wheat and rice or through the exploitation of hybrid vigour as in maize, Sorghum and pearl millet (Pennisetum typhoides), major advances were made in increasing the yield potential of these crops. The widespread use of fertilizers led not only to an increase in yield but also to a higher protein content in grains in several cases. It is now well recognised that the protein content of particular genotypes of wheat can be maintained at a high level under certain ecological conditions and agronomic management. This forms the basis for introducing protein content as a criterion of market classification of grains in countries like Australia, the U.S.S.R. and very recently, Canada.

Breeding for quality in India had until recently implied mainly breeding for market and consumer preferences. For example, in wheat the major stress was on the colour, size, lustre and vitreousness of the grain, since large, hard, amber and lustrous grains fetched a much higher price in the market than small, red and mottled grains. Protein content and gluten strength were introduced as criteria for increasing wheat varieties before they were released for cultivation at the Indian Agricultural Research Institute in 1955, primarily with a view to ensuring that the new varieties had good chapathi-making (unleavened bread) properties. Little work was done prior to 1965 on screening cereal varieties for lysine content, since such studies conducted in Europe and North America had generally led to the view that there is not much scope for increasing the biological value of cereal proteins, partly because of the small variation in lysine contents observed and partly because of the negative correlation between total protein and lysine content of the protein. However, the discovery that maize strains containing the opaque-2 and floury-2 genes have a much higher lysine content than those without them, led to a great upsurge of research activity designed to achieve genetic changes in the amino acid profile of the major food plants.
Since the basic cause of protein malnutrition in cereal based diets appears to be under-nutrition (see Sakhatme's paper in this Symposium), the first goal of agricultural improvement programmes in India should be the increase of productivity of the major food crops. Utilizing the potential that the tropics and sub-tropics offer for growing crops throughout the year, multiple, relay and mixed cropping systems have been developed for different parts of the country which can help to increase production substantially and at the same time enhance the employment opportunities in rural areas. The evolution of relatively photo and thermo-insensitive varieties of crop plants has made the introduction of the "productivity per day" concept possible. The yields obtained in a 4 crop relay system developed at the I.A.R.I. by the late Dr. S. S. Bains are given in Table 1. Several such systems are now available for irrigated areas and each farmer can choose from different alternatives of crop combinations the one which would suit his input-mobilizing capacity, marketability of the produce and seasonal conditions (Fig. 1). All scientific multiple cropping systems are based on the following principles.

Fig. 1. Different kinds of cropping sequences for areas with assured irrigation (top), dry areas (bottom, left) and areas with limited irrigation facilities (bottom, right).

(a) Crops grown in succession should not share the same pests and diseases. This is particularly important with regard to soil-borne pests like nematodes.
Nutritional Quality in Food Plants

(b) Crops with deep and shallow root systems should be grown alternately, so that nutrients are not tapped from the same soil layer and also different soil layers get enriched with root deposits.

c) Legumes should find a place in the rotations at least once a year.

By adopting such principles together with scientific tillage and soil fertility management practices it would be possible to increase continuously the economic yield per day per unit of land and per unit of water, without detriment to the long term productivity of the soil. Since over 10 tonnes of food grains per hectare can be produced by such techniques (Table 1), the production potential of Indian agriculture is obviously great, considering the fact that the country has over 50 million hectares of irrigated land.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total food (ton)</th>
<th>Protein (ton)</th>
<th>Production per day/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Food (kg)</td>
<td>Protein (kg)</td>
<td></td>
</tr>
<tr>
<td>1966-67</td>
<td>13.7</td>
<td>1.59</td>
<td>38.6</td>
</tr>
<tr>
<td>1967-68</td>
<td>14.4</td>
<td>1.66</td>
<td>40.6</td>
</tr>
<tr>
<td>1968-69</td>
<td>14.0</td>
<td>1.62</td>
<td>39.4</td>
</tr>
<tr>
<td>1969-70</td>
<td>15.2</td>
<td>1.76</td>
<td>42.8</td>
</tr>
</tbody>
</table>

The scope for increasing greatly the yield of food crops in irrigated areas through the cultivation of high-yielding varieties has opened up altogether new possibilities for restructuring cropping patterns in unirrigated areas in such a manner that the ecological benefits of a region are maximised and the ecological risks are minimised. Growing crops for home consumption other than for the market, poor post-harvest technology and communications and the prevalence of some limiting factors like pests or soil defects have so far led to farmers growing crops which are not necessarily the most efficient in utilising the available moisture in dry farming regions. For example, mustard will yield over 1.5 tonnes per hectare in Western Uttar Pradesh and Haryana under unirrigated conditions where wheat will give only about 6 quintals. Mustard also fetches double the price of wheat. Still farmers prefer wheat because aphids do much damage to mustard. Similarly, many pulse crops can become popular...
during the monsoon season, if pest control procedures are popularised. Many low-yield environments for cereals can prove to be high-yield environments for oilseeds and pulses if pest control measures are initiated and marketing is organised. The popularisation of recent scientific findings in the agriculture of dry land farming areas can help to increase both food supply and agrarian purchasing power. Many cereals grown under unirrigated conditions invariably contain a higher protein content, probably because of a lower yield (Table 2).

### TABLE 2

Weight of grains and protein content in some varieties of barley grown at IARI under irrigated (I) and reified conditions (R).

<table>
<thead>
<tr>
<th>Variety</th>
<th>1000 kernel weight in grams</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>R</td>
</tr>
<tr>
<td>Clipper</td>
<td>41</td>
<td>29</td>
</tr>
<tr>
<td>Prior</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>WI2137/6</td>
<td>41</td>
<td>35</td>
</tr>
<tr>
<td>R.S. 6</td>
<td>36</td>
<td>31</td>
</tr>
<tr>
<td>N.P. 21</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

Increasing the production of pulses.

According to available statistics, the per capita availability of pulses has been going down steadily (Table 3). The major reason for the decline is...

### TABLE 3

Production and availability of Pulses*

<table>
<thead>
<tr>
<th>Year</th>
<th>Net output in million tonnes</th>
<th>Net availability in million tonnes</th>
<th>Per capita availability in Kg per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951-52</td>
<td>8.42</td>
<td>7.97</td>
<td>21.6</td>
</tr>
<tr>
<td>1955-56</td>
<td>11.05</td>
<td>10.23</td>
<td>25.6</td>
</tr>
<tr>
<td>1958-59</td>
<td>13.15</td>
<td>11.55</td>
<td>27.3</td>
</tr>
<tr>
<td>1960-61</td>
<td>12.70</td>
<td>10.34</td>
<td>25.1</td>
</tr>
<tr>
<td>1965-66</td>
<td>9.80</td>
<td>8.58</td>
<td>17.0</td>
</tr>
<tr>
<td>1969-70</td>
<td>11.69</td>
<td>10.23</td>
<td>18.6</td>
</tr>
</tbody>
</table>

*Data from Economics and Statistics Directorate.
in output witnessed during the sixties appears to be the displacement of pulse crops like bengal gram (*Cicer arietinum*) with wheat and other high-yielding cereals, as soon as a farm has access to irrigation water. Thus, crop substitution accompanying the expansion of major and minor irrigation facilities may have adverse effects on the production of pulse crops, unless better and quick-yielding varieties of pulses are developed. Hence, research on these crops has been intensified in recent years under the All-India Co-ordinated Pulse Improvement Project of the Indian Council of Agricultural Research. Some of the recent research achievements which have a bearing on pulse production are the following:

(a) Development of high and quick-yielding varieties which can be fitted into suitable, multiple, relay and mixed cropping systems both in irrigated and rain-fed areas. Data on the yield obtained from three new varieties of red gram (*Cajanus cajan*) which have been recently recommended for release are given in Table 4.

(b) Development of all-pulse rotations and mixed cropping systems for areas with limited water supply and poor soil fertility. About 5 tonnes of pulses per hectare per year have been harvested in the Division of Agronomy of I.A.R.I. from an all-pulse crop rotation (Table 5).

(c) Standardisation of techniques of fertilizer application which will enhance yield.

(d) Development of bacterial cultures which are more efficient in nitrogen fixation and pelleting techniques which can help to buffer the bacteria against the rigours of the environment such as soil alkalinity or acidity.

(e) Introduction of integrated pest control schedules, which can increase the yield of pulse crops dramatically, particularly during the monsoon season.

(f) Genetic elimination of the neuro- and osteo-toxins present in *Khesari dal* (*Lathyrus sativus*) so that advantage can be taken of the high drought-resistance of this crop.

(a) Improvement in methionine content of pulse protein.

(b) Development of better milling and processing techniques.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S-3</td>
<td>Brazil 1-1 × NP WR-15</td>
<td>170</td>
<td>15.38</td>
<td>12.20</td>
<td>9.30</td>
<td>26.35</td>
<td>24.65</td>
</tr>
<tr>
<td>S-5</td>
<td>Brazil 1-1 × NP 69</td>
<td>150</td>
<td>16.25</td>
<td>13.90</td>
<td>10.24</td>
<td>25.85</td>
<td>25.52</td>
</tr>
<tr>
<td>S-8</td>
<td>Brazil 1-1 × NP (WR) 15</td>
<td>160</td>
<td>16.82</td>
<td>11.34</td>
<td>9.82</td>
<td>25.25</td>
<td>25.25</td>
</tr>
<tr>
<td>S-10</td>
<td>Brazil 1-1 × NP 69</td>
<td>180</td>
<td>12.50</td>
<td>10.69</td>
<td>8.58</td>
<td>23.50</td>
<td>21.48</td>
</tr>
<tr>
<td>R-60</td>
<td>Brazil 1-1 × NP (WR) 15</td>
<td>170</td>
<td>14.35</td>
<td>13.74</td>
<td>5.35</td>
<td>23.02</td>
<td>22.25</td>
</tr>
<tr>
<td>T-21</td>
<td></td>
<td>150</td>
<td>12.60</td>
<td>9.28</td>
<td>8.75</td>
<td>20.42</td>
<td>19.85</td>
</tr>
</tbody>
</table>
TABLE 5
All-Pulse crop multiple cropping
(I.A.R.I. 1968-70)

<table>
<thead>
<tr>
<th></th>
<th>Variety</th>
<th>Period</th>
<th>Average yield (Q/Ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green Gram (Phaseolus aureus)</strong></td>
<td>Pusa Baisakhti</td>
<td>April-June</td>
<td>30</td>
</tr>
<tr>
<td><strong>Red Gram (Cajanus cajan)</strong></td>
<td>Pusa Agei</td>
<td>July-November</td>
<td>25</td>
</tr>
<tr>
<td><strong>Black Gram</strong></td>
<td>T.9</td>
<td>July- November</td>
<td></td>
</tr>
<tr>
<td><strong>Lentil (Lens esculentum)</strong></td>
<td>T. 9-12</td>
<td>October-March</td>
<td>15</td>
</tr>
</tbody>
</table>

Details of the work done on the above mentioned problems are given in a recent publication of the I.A.R.I. The new varieties and practices already developed can immediately help to increase pulse production substantially, if they are popularised through suitable developmental projects. For example, the late Dr. S. S. Bains and Dr. S. L. Chowdhury have calculated that an additional annual production of over 7 million tonnes can be achieved in irrigated areas alone (Table 6).

TABLE 6
Potential for increasing the production of pulses in irrigated areas

<table>
<thead>
<tr>
<th>Crop</th>
<th>Recommended practices</th>
<th>Area to be covered in million hectares</th>
<th>Additional production expected in million tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mung</strong> (Phaseolus aureus)</td>
<td>Mung after wheat</td>
<td>2.9</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Mung inter-cropped in sugarcane</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Mung inter-cropped in cotton</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Gram</strong> (Cicer arietinum)</td>
<td>In lieu of wheat in areas with insufficient water supply</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Pea and lentil</strong> (Pisum sativum and Lens esculentum)**</td>
<td>Application of 30 to 40 Kg P₂O₅</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Red gram</strong> (Cajanus cajan)**</td>
<td>Red gram in lieu of maize or pearl millet in lands where the latter crops give low yields, Application of 200-300 kg. super phosphate per hectare.</td>
<td>1.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Nutritional Quality in Food Plants
Genetic enrichment of the nutritive quality of staple grains:

Studies on the incidence of variability for protein and other chemical constituents in the grain were initiated in maize by Hopkins in 1899. He started selecting for high and low protein as well as for high and low oil content in the variety, Burr White. Since then this work has been continued at the Illinois Agricultural Experiment Station. In the sixty-fifth cycle of this selection experiment, protein content reached 25% in the high strains and 4% in the low strain (Table 7). Even after 65 generations of selection, the Illinois High Protein strain still possessed significant amounts of genetic variability. Unfortunately, however, the protein quality of the high strain (I.H.P.) is very low, since zein, an endosperm protein deficient in lysine and tryptophan was primarily increased by selection. Further, starch synthesis is poor in the IHP lines and hybrids involving backcross recoveries of standard lines and IHP, though high in protein, were always poor in yield. However, in hybrids with a normal range of protein content (10 to 12%), yield and protein content were not significantly correlated.

TABLE 7
Effect of selection for protein content in Maize

<table>
<thead>
<tr>
<th>Decades of selection</th>
<th>Average protein percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>0</td>
<td>10.93</td>
</tr>
<tr>
<td>1</td>
<td>14.42</td>
</tr>
<tr>
<td>2</td>
<td>15.08</td>
</tr>
<tr>
<td>3</td>
<td>18.31</td>
</tr>
<tr>
<td>4</td>
<td>17.95</td>
</tr>
<tr>
<td>5</td>
<td>19.53</td>
</tr>
<tr>
<td>6</td>
<td>21.79</td>
</tr>
<tr>
<td>7</td>
<td>25.00</td>
</tr>
</tbody>
</table>

*Reference No. 12.

The discovery made in 1964 by Mertz, Bates and Nelson at the Purdue University that the opaque-2 mutation in maize profoundly influences the amino acid composition of endosperm protein led to a widespread interest in the genetic alteration of protein quality and quantity. While opaque-2 (op-2) and floury-2 (Fl-2) are commonly referred to as high lysine maize, it should be pointed out that in op-2, the amino acids lysine, tryptophan, histidine, arginine, aspartate and glycine are all increased, while there are substantial reductions in glutamate, alanine, leucine and to a smaller extent in tyrosine and phenylalanine. In Fl-2, there is an enhanced concentration...
of methionine, which is a welcome feature since in maize and legumes mixtures, methionine tends to be the first limiting amino acid. The pathway through which an increase in lysine and the other changes are brought about in \textit{op}-2 and \textit{Fl}-2 endosperm is known to be through a reduction in the amount of the alcohol-soluble fraction (the prolamins or zein) and a concomitant increase in the relative proportions of albumins, globulins and glutelins.\textsuperscript{18} Nelson\textsuperscript{15} and Balint\textsuperscript{16} have shown that through suitable breeding programmes, a good yield potential and a protein content of over 12\% with the desirable amino acid balance of \textit{op}-2 can be combined.

Following the \textit{op}-2 discovery in maize, research programmes on the development of rapid screening techniques, screening of germplasm material for protein content and amino acid profile, the choice of the strategy for the genetic upgrading of protein and nutritive properties and the effects of environmental parameters on quality characters were started in a systematic manner in several laboratories in different countries. Johnson \textit{et al}\textsuperscript{17} screened 4100 varieties of wheat for lysine content and found it to vary from 1.77 to 4.15\%. Mattern \textit{et al}\textsuperscript{18} reported data for protein and lysine content in 7000 varieties from the U.S.D.A. World Wheat Collection. By screening a world collection of barley, a strain from Ethiopia (C.I. 3947) was discovered to possess about 16-17\% protein and 4.1\% lysine.\textsuperscript{19} This strain was named Hiproly to distinguish it from another strain C.I. 4362 which had only a high protein content with a normal lysine ratio. The high lysine character of Hiproly barley was stable under different environments and since this character is simply inherited as a recessive factor, it offers great scope for improving the nutritional value of barley protein.\textsuperscript{20} Several promising mutants with over 15\% protein content have been reported in rice\textsuperscript{21} and recently a variety of Cassava with nearly 8\% protein, named Llana has been identified at the International Centre for Tropical Agriculture at Cali, Colombia. All these findings suggest that if sufficient research efforts are mobilised, it may be possible to make favourable changes in protein properties in the major food plants. Some of the results obtained in recent experiments in India are given below (for earlier results, see references 2 and 22).

\textbf{Maize:} Several composites incorporating the \textit{op}-2 character have been developed under the All India Co-ordinated Maize Improvement Project. Recently, three such composites possessing a good yield potential, with 10 to 12\% protein and about 3.5 gms. lysine/100 gm. protein, have been recommended for release for cultivation. Detailed data on the yield and quality characteristics of one of the \textit{op}-2 composites developed at I.A.R.I. are given in Tables 8 and 9. As will be seen from the data, it is possible
## Table 8

Performance of Yellow Opaque-2 Composite
(Yield Kg/ha at 15\% moisture)

<table>
<thead>
<tr>
<th></th>
<th>Delhi</th>
<th>Ludhiana</th>
<th>Udaipur</th>
<th>Pannagar</th>
<th>Chhindwara</th>
<th>Dharwar</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Opaque-2 Composite</td>
<td>2742</td>
<td>3380</td>
<td>1337</td>
<td>5767</td>
<td>4985</td>
<td>5048</td>
<td>3876</td>
</tr>
<tr>
<td>Local</td>
<td>2094</td>
<td>2689</td>
<td>902</td>
<td>2839</td>
<td>2851</td>
<td>2698</td>
<td>2345</td>
</tr>
<tr>
<td>Ganga 5</td>
<td>3734</td>
<td>3590</td>
<td>1185</td>
<td>4694</td>
<td>4177</td>
<td>6533</td>
<td>3985</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>456</td>
<td>803</td>
<td>241</td>
<td>913</td>
<td>926</td>
<td>1265</td>
<td></td>
</tr>
<tr>
<td>C.V.%</td>
<td>16.7</td>
<td>24.1</td>
<td>30.3</td>
<td>13.0</td>
<td>15.0</td>
<td>21.0</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 9
Amino acid composition of grains of Yellow opaque-2 Composite and Ganga 3, a popular maize, hybrid.

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Yellow Opaque-2 Composite</th>
<th>Ganga-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspartic acid</td>
<td>7.28</td>
<td>6.85</td>
</tr>
<tr>
<td>Threonine</td>
<td>3.22</td>
<td>3.16</td>
</tr>
<tr>
<td>Serine</td>
<td>5.33</td>
<td>5.02</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>20.64</td>
<td>23.29</td>
</tr>
<tr>
<td>Proline</td>
<td>8.65</td>
<td>10.00</td>
</tr>
<tr>
<td>Glycine</td>
<td>3.55</td>
<td>2.67</td>
</tr>
<tr>
<td>Alanine</td>
<td>7.79</td>
<td>9.30</td>
</tr>
<tr>
<td>Valine</td>
<td>3.59</td>
<td>5.36</td>
</tr>
<tr>
<td>Cysteine</td>
<td>1.98</td>
<td>1.84</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.77</td>
<td>1.49</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>4.00</td>
<td>3.90</td>
</tr>
<tr>
<td>Leucine</td>
<td>11.36</td>
<td>17.24</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>4.44</td>
<td>4.91</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>4.84</td>
<td>5.40</td>
</tr>
<tr>
<td>Ammonia</td>
<td>2.48</td>
<td>2.30</td>
</tr>
<tr>
<td>Lysine</td>
<td>3.45</td>
<td>1.64</td>
</tr>
<tr>
<td>Histidine</td>
<td>3.70</td>
<td>2.54</td>
</tr>
<tr>
<td>Arginine</td>
<td>3.90</td>
<td>3.26</td>
</tr>
<tr>
<td>Protein %</td>
<td>25.20</td>
<td>38.40</td>
</tr>
</tbody>
</table>

to combine a good yield potential with a good protein quality. PER values in 2 independent studies were found to be 3.38, 2.08, 1.20, 2.70, 2.45 and 0.88 for opaque-2 composite, Casein and Ganga 3, respectively. Two of the major problems in the popularisation of the op-2 composites are first, their soft kernel quality necessitating proper storage after harvest and secondly, the need for growing the composites in isolation, so that pollen from normal maize does not fertilize the op-2 plants. The flour of op-2 maize composites can be used for making suitable preparations for babies about 3 months in age and hence the popularisation of such maize in villages could make a significant contribution to the improvement of child nutrition.

Rice: The incidence of protein-calorie malnutrition is more severe in the parts of India where rice is the staple. Nutritionally, rice protein is superior to the protein of other cereals but there is generally a low (6 to 8%) quantity of protein in the rice grains, some of which may be lost on
polishing in the mills. World collections of rice are being screened for protein properties at the International Rice Research Institute, the Philippines and at the I.A.R.I. Single grain dye-binding and microscopic screening techniques have been developed for screening the quantity of protein, its distribution in the kernel and the content of lysine. The I.A.R.I. collection of primitive and current cultivars of rice from the Assam hills are being screened for grain cooking characteristics, starch properties and protein content and quality. Among 1800 samples so far analysed, 15 genotypes with more than 15% protein have been identified through the dye-binding and micro-kjeldahl techniques. Microscopic analysis and tryptophan estimation are being done to check the values. The behaviour of these genotypes under different environments and in hybrid combinations is also under study. In studies on the effects of fertilizer application on quality it was found that the split application of nitrogen in a 1:2:1 ratio at the time of planting, tillering and just prior to heading leads to a considerable improvement in protein content. The improvement is much better when the last dose is given as a foliar spray of Urea. There is thus scope for improving the protein content of rice both by genetic and agronomic methods.

Wheat: The variation in lysine content in spring wheat varieties is not as great as that reported in winter wheats. Also, to some extent there is a negative correlation between yield and protein content on the one hand and protein and lysine contents on the other. Environmental (both locational and agronomic) factors influence greatly protein content. Wheat grown under rain-fed conditions generally tends to have a higher protein content than that grown with irrigation. Progress in the improvement of protein content will have therefore to be measured in terms of protein production per hectare. The physical properties of the gluten also need to be taken into consideration while making selection in breeding material, since these are relevant to the end-use of the grain—whether for making "chapatties", baked bread, biscuits or cakes.

From the work done at the I.A.R.I. so far, the development of dwarf wheat varieties with a good yield potential containing about 16% protein with about 2.5 to 3.0% lysine in protein seems possible. To realise the full genetic potential for protein production, a specific set of agronomic practices, particularly fertilizer application, will have to be followed. The adoption of such practices is fostered by policies such as the introduction of a premium for protein content in pricing and making protein content as a criterion in the market-classification of grains, as has been done in the grain Act of Canada of 1970.
Nutritional Quality in Food Plants

Sorghum and Millets: Grain Sorghum occupies an important position in the cereal economy of India, being next to rice in importance in the area covered. Values varying from 8 to 12% for protein and from 0.72 to 3.37% for lysine were found in about 100 selections from recent breeding material. Correlation studies showed a highly significant negative correlation between protein and lysine content. However, some strains such as IS 4532 in the medium and IS 4952 in the high protein groups had 3.22% and 2.95% lysine content, respectively. It is such occasional deviations from general correlations that are significant in breeding programmes. It is also fortuitous that strains or recombinants with a higher lysine content have relatively lower leucine values, since studies at the National Institute of Nutrition, Hyderabad, have indicated that the incidence of pellagra in areas where Sorghum is staple may be due to the high leucine to isoleucine ratio in Sorghum protein.56

In addition to improving grain Sorghum for protein content and quality, there is scope for developing strains with a high/3-carotene content, using some yellow endosperm strains from Nigeria as donors of this trait.65

Breeding work is also in progress in Pearl Millet (Pennisetum typhoides) and other millets as Eleusine coracana, Panicum miliaceum, Setaria italica, Panicum miliare, Paspalum scrobiculatus and Echinochloa colona to combine yield with nutritional quality.67 In Pearl Millet, the protein fraction is poor in lysine but rich in tryptophan. Hence, an improvement in lysine content has to be achieved without diminishing the tryptophan content. In the other millets, some of which like Panicum miliaceum are rich in lysine, the digestibility of protein is being improved by selecting for a low fibre content in the seed.

Basic studies on storage protein biosynthesis:

The main physiological function of storage proteins is to supply amino nitrogen to the growing embryo during germination. Hence, in nearly all cereal grains glutamic acid, aspartic acid and alanine, which are non-essential as far as human nutrition is concerned account for more than half of the total nitrogen. The nutritional imbalance of the cereal grain proteins is thus a direct result of the physiological function for which they are synthesised in the seed. The proteins of the embryo of dormant seed are more balanced in amino acid content. It is interesting that in the unripe grain, lysine and tryptophan are present in substantial quantities but these are not incorporated into the storage proteins deposited in the endosperm. Studies are in progress to examine the scope for achieving genetic modi-
fication of patterns of protein synthesis in the ripening grain. If successful, this could be the ultimate solution to the problem of amino acid imbalance in cereal grain proteins.

REFERENCES

APPROACHES TO THE PROBLEM OF AUGMENTATION OF ANIMAL PROTEIN FOOD RESOURCES IN ASIA

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Rowett Research Institute, Scotland, United Kingdom.

It is extremely difficult if not impossible to consider the problems of animal production in Asia as a single entity. Not only do the Asian countries embrace enormous ranges of terrain, soil, water supplies and climate which in themselves impose different restrictions on the amount and variety of primary production of crop plants and natural plant communities, but the cultures, habits and traditions of their peoples are widely different and these impose different demands on their domesticated livestock. Furthermore, the structures of other sectors of the economies of countries and indeed of districts often create unique problems in the field of animal production, problems of supreme local importance but problems which an overall view must necessarily ignore. Even so, it is essential that we attempt to take an overall view for from such a view general principles may well emerge to be adapted to the local conditions which prevail. Perhaps this is why I a European who cannot pretend to a detailed knowledge of the vast variety of agricultures of Asia have been asked to talk about this subject. Certainly some of our experience in Europe has relevance to the broad problems involved in increasing animal protein supplies.

The primary question to be asked is the extent to which animal protein supplies need to be increased. This question is both a nutritional one and a social one. In Europe and N. America at the present time demand for animal products is still increasing. There is no nutritional justification for such a demand, for human diets are for the most part adequate; it simply reflects the desires of affluent people in a Western society with established food habits to consume more meat and protein-rich food. Affluence is a relative term and the Provincial Indicative World Plan for Agricultural Development indeed recognises that as the income of peoples in Asia rises, the structure of demand for foods will change. Initially such changes in demand structure can clearly be justified since they have the effect of com-
battling nutrient deficiencies in man's diet but in the longer term it must
be recognised that non-nutritional factors which we do not understand are
likely to become determinants of food demands. An example of change in
demand pattern is to be seen in Japan during recent years as shown in
Table 1.

TABLE 1
Change in per capita consumption of certain foods in Japan 1955-56 to 1965-66
(OECD, 1968)

<table>
<thead>
<tr>
<th>Item</th>
<th>1955-56</th>
<th>1965-66</th>
<th>Relative change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1955-56=100</td>
</tr>
<tr>
<td>Meat</td>
<td>8.8</td>
<td>25.1</td>
<td>285</td>
</tr>
<tr>
<td>Eggs</td>
<td>8.9</td>
<td>24.2</td>
<td>272</td>
</tr>
<tr>
<td>Milk</td>
<td>28.3</td>
<td>100.0</td>
<td>353</td>
</tr>
<tr>
<td>Fish</td>
<td>65.7</td>
<td>76.0</td>
<td>116</td>
</tr>
<tr>
<td>Cereals</td>
<td>424</td>
<td>394</td>
<td>95</td>
</tr>
<tr>
<td>Potatoes</td>
<td>49</td>
<td>43</td>
<td>88</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>84</td>
<td>22</td>
<td>26</td>
</tr>
</tbody>
</table>

Here the increase in the gross national product has been associated with
a change in the pattern of consumption towards more animal products, a
change very similar to that which has taken place in Europe. The change
has certainly improved the nutritional adequacy of the national diet, and
with a protein intake of 76 g/day of which 30 g is derived from animal
sources, the average Japanese diet is wholly adequate. However, the trend
towards greater consumption of animal products and decreased consumption
of cereals continues.

On nutritional grounds rather than complex social ones, it is evident
that amelioration of diets by provision of animal products is a pressing
problem. Rice, the staple cereal of large parts of Asia admittedly provides
a better balance of amino acids per 16 g N than does maize or wheat but
it is on average lower in total protein content. The primary amino acid
imbalance of rice proteins is readily abolished by addition of relatively small
amounts of animal products rich in lysine, but such diets are still low in
total protein content for the more demanding sectors of the population.
Much but not all of the nutritional need to increase the supply of animal
protein in diets based on rice is thus related to the need to increase their
total protein content. There are of course alternatives to animal protein for
this latter purpose, notably protein-rich seeds, pulses and some leafy veget-
Augmentation of animal protein foods

Augmentation of animal protein foods

...ables, and choice depends on local and regional circumstance. Seed proteins and pulses are obviously much cheaper sources of protein than is meat, and provided vitamin $B_{12}$ supplies are safeguarded, equally effective.

The extent to which animal production should be augmented is thus not a simple question but involves a series of other considerations. Foremost among these considerations are questions of the feasibility of obtaining worthwhile increase in food from animals, the prerequisites for any such efforts and the second effects they will have on the economy as a whole.

As a beginning it is useful to consider the present structure of the animal industry and the role of domesticated animals in Asian countries. The numbers of farm livestock in Asian countries are very large as judged by the oft criticised statistics of FAO. Table 2 summarises the relevant statistics where livestock density has been expressed as number of animals per 100 of the human population. These very broad statistics show that, relative to people, "cattle", including buffalo, banteng and gayal, are more numerous in Asia than they are in Europe; that sheep and goats are almost as common, that Asian poultry are less numerous than European; and that as to be expected because of religious considerations pigs are not very common in Asia.

**TABLE 2**

<table>
<thead>
<tr>
<th>Animal Category</th>
<th>Asia</th>
<th>Mainland China</th>
<th>Mainland Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horses, asses and mules</td>
<td>1.4</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Cattle and buffaloes</td>
<td>32.9</td>
<td>11.9</td>
<td>26.6</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>27.3</td>
<td>15.8</td>
<td>32.6</td>
</tr>
<tr>
<td>Pigs</td>
<td>3.7</td>
<td>26.4</td>
<td>27.5</td>
</tr>
<tr>
<td>Poultry</td>
<td>57.8</td>
<td>61.4</td>
<td>56.8</td>
</tr>
</tbody>
</table>

Judged by the amount of food they provide for man the productivity of Asian animal populations is however low, very low in fact by European standards. Table 3 gives a calculation of productivity per animal for defined FAO regions. This value which is carcass output or milk output divided by the total animal population is a simple statistic which equates for differences in age at slaughter or at milking and indeed includes the whole of the overheads of maintaining breeding stocks. This is why generally the outputs per animal are so much lower than values usually...
It is immediately outstanding that the productivity of cattle and buffalo in Asia is about one-tenth that in Europe. There are several reasons for this. Firstly, there is widespread under-recording of production because of local slaughtering for family and village use. Secondly those animals which are slaughtered tend to be smaller than European cattle. Thirdly, recorded milk production is depressed not only by local and unrecorded consumption but by the fact that the milk is often that surplus to the needs of the suckled calf. Fourthly, the statistics ignore the importance of the bullock as the source of at least half the motive power on farms and lastly in India a contributing reason is the impact of orthodox Hindu doctrine which has the effect of maintaining a large unproductive cattle population. With sheep and goats the disparity between temperate productivity and Asian productivity is not large particularly when it is considered that under-recording also applies to this class of stock but with pig production in Asia, although
productivity has increased very markedly in the last 10 years it operates at only 50% of the output rate of Europe. Poultry production also operates at a lower level of efficiency, though here the statistics are certainly unreliable for under-recording is particularly serious.

The low level of productivity in Asia needs an additional perspective. Byerley has shown that in the USA in the course of the 30 years up to 1965 milk production per cow increased by 100%, weight of meat and eggs produced per chicken by 150%, weight of cattle produced per cow by 70%, and weight of pigs per sow by 40%. At the same time the amounts of feed needed to produce unit gain or unit milk declined. Similar changes have taken place in Europe. While Byerley attributed these achievements to technological advance their genesis largely lies in the intensification of feed inputs, in the provision of more grain, more processed protein feeds, and less forage and fibrous wastes in the rations of animals. As Reid has pointed out this has come about as a result of grain surpluses in the countries concerned. It is thus not reasonable to compare animal performance in countries in grain surplus, and with large capital investment in intensive animal production systems with that in those countries in Asia in which farm animals do not draw heavily on grain resources. It is indeed for this very reason that the productivity of sheep and goats in Asian countries compares favourably with that in other regions of the world for the sheep of Europe and N. America have not been subject to anything like the same methods of intensive husbandry as have been applied to cattle, pigs and poultry.

The prospects of Asia as a whole moving into such a magnitude of grain surplus that it could warrant the development of animal production systems analogous to those of Europe or N. America do not appear immediately likely. Nor is it likely that the structural changes in farm or enterprise size, the development of sophisticated market economies and capital provision on the scale of present European investment in animal production can suddenly be brought into being. Dr. Boerma (FAO) has recently pointed out that the euphoria generated by successive percentage increases in cereal production in Asia should not blind us to the facts of the appalling and disastrous harvests of 1965 and 1966. Taking cognisance of the very real successes of the new varieties of rice and wheat, and predicting from the base of the production in the years since 1966 might suggest massive surpluses of wheat and rice of 26 million metric tons by 1975. Incursion of the years of hardship suggest no overall surplus by that time. No doubt the truth lies somewhere in between these extremes, but much more certainty is required about supplies before it can be assumed that land can be
diverted to the production of coarse grains and to intensive high quality forage production, and a general movement towards intensification can take place.

Nevertheless, while for Asia as a whole the prospects of an animal economy of the grain surplus type are unlikely, this does not mean that locally grain surpluses will not occur or that such economies will not develop. Indeed, in the Indicative World Plan which calls for an overall annual growth of 3.3 to 3.5% in the value of the output from the animal production industries of Asia and the Far East it is envisaged that expansion of the pig, poultry and dairying enterprises will be "principally in the modern or industrial sector". This implies large-scale, highly capitalised units practising modern technologies, usually located in the initial stages close to urban centres, employing few people, and very largely dependent on coarse grains and processed concentrated feeds. This type of industrial development has indeed taken place in Japan where in the course of 20 years mean annual growth rate in the poultry industry has been nearly 20%, much of the feed being imported. It has also taken place with pigs in Taiwan, while a much older and intrinsically more socially and biologically acceptable example but limited by poor supplies of coarse grains is the Anand milk project in India. Certainly as cereal surpluses develop, livestock industries based on cereals may well become economically acceptable alternatives to export of grain. One very great advantage they have is their ability to expand rapidly to accommodate surpluses of feed, a point to which I will return. To be effective in terms of improvement of the lot of people presupposes however considerable marketing and distribution facilities and the sophisticated secondary technologies which have been shown to accompany similar enterprises. Furthermore, it has to be realised that such developments, while they can provide more food will not provide more employment for people—a problem of very real importance in rural areas.

It is only right that I should point out that these new highly intensive economies have created problems both in Europe and N. America. One of these stems from difficulties of disposal of excreta from animals kept in high concentrations. This has led to air pollution problems in arid areas and to drainage difficulties in cool temperate ones. Even the most ambitious fish-farming enterprises linked to these systems could hardly cope with the daily outputs. Furthermore, the separation of animal farming from crop farming creates additional difficulties in the long term. In the United Kingdom economic necessity has forced farmers into virtual monocultures based on barley and there is ample evidence that as a result soil fertility has declined. This is not due to falls in plant nutrient status for
Augmentation of animal protein foods

these have been assiduously replaced by artificial fertilizers but rather to changes in soil structure due to a fall in humus content, humus which was previously provided by animal excreta and the residues of fodder crops. A contributing cause is soil compaction due to high use of machines in British farming for animals as motive power were replaced by tractors in the period 1930-1955. Other problems we have encountered concern public health. Diseases caused by organisms communicable to man—notably salmonellae—have proved to be hazards to man and animal alike, and their public health impact obviously is a function of scale. Our European experience may well be pertinent to Asian plans.

All evidence at present suggests, however, that intensive animal production enterprises in Asian countries account for less than 1% of the livestock kept and that developments analogous to those in Europe will occur only in those countries undergoing very considerable growth in other sectors of the economy. Over 80% of livestock farming is carried out in very small units catering for a family. The remainder consists of market oriented enterprises some of which are on a cooperative basis, the market usually being an intensely local one. It is unrealistic to suppose that the main increases in the production of human food from animals in Asia are going to arise from anything other than a slow improvement of existing agricultures, improvements which must entail the development of market economies and new institutional structures as well as technological advances.

Indeed it seems probable that the development of organized markets, of organized credit facilities and of general and local pricing policies may well be of greater importance in increasing the output from the larger part of Asian animal production than the development or importation of new animal production technologies. This is well recognized in the Indicative World Plan which when discussing the general problem of animal production in Zone C countries states “Traditional production methods are unlikely to change until new marketing opportunities have been opened up and farmers educated to understand their use and benefits”. Furthermore, marketing and other similar organizations provide excellent foci from which technical information can be disseminated. The developments of marketing organization for milk and eggs sponsored by the governments of the Philippines, Malaysia, Thailand and Ceylon, the government dairy cooperatives of India and Pakistan together with the farmers’ cooperatives of Taiwan and Japan not only have provided the base for economic advance but the means for the provision of the technical knowledge on which future advance must depend. There is every precedent from Europe to show that
agricultural progress depends on the provision of economic opportunities through government policies and the cooperative efforts of farmers themselves; technical knowledge alone is not enough.

On the technical side emphasis is needed on the improvement of the nutrition of all classes of stock and on adoption of superior husbandry practices, including parasite control and cropping policies for livestock. Improvement of native stocks through breeding and the importation of exotic strains, although it has always seemed an attractive proposition promising quick returns at little cost to the farmer is in fact out of place unless husbandry and nutrition have been improved. An analogy with the new rice varieties produced by the International Rice Research Institute is apt. The variety IR8-288-3 is not markedly superior to existing varieties when environmental conditions are limiting. Its value lies in its vastly superior yield achieved under conditions of high fertility with relatively heavy manuring. So with livestock, until environmental conditions, that is nutritional conditions, can be improved little response will be seen from individuals of greater genetic worth.

The improvement of nutrition of livestock has to take into account their role as converters and the materials they convert. In countries which are not in cereal surplus, animals exist for the most part on those parts of crop plants which man cannot use or the produce of land he cannot readily cultivate. The basic feeds are the byproducts of human food production, and vary from country to country. They include paddy straws, wheat bhoosa, sugarcane bagasse, corn stover, the milling residues from cereal staples, unmarketable or low-grade pulses and cereals, and the residues from oil seeds from extraction plants. These feeds in most combinations even when fed to appetite do not permit sufficient intakes of energy by animals to promote the levels of production achieved in Europe or N. America, where land can be diverted to cropping specifically for the stock and grain made available for them. Again, experience in Europe shows this to be so. In the 1939-45 War milk production per cow fell markedly when cattle in the U.K. were deprived by the blockade of N. American maize and barley and given diets containing large quantities of straws. The use of low nutritive value feeds even when given to appetite necessarily entails low individual animal productivity. Conversely, once maximal individual production has been obtained from the individual any increase in absolute production must come about from an increase in the number of stock carried. Again, our experience in Europe is relevant. The increases in production of carcass meat have not simply been achieved by an increase in the productivity of individuals. Numbers have also increased. Table 4.

Table 4
Augmentation of animal protein foods

summarises data for Europe during the last 4 years from which it is evident that with the exception of sheep, increases have come equally from increases in number and in the productivity of the individual. Despite the apparent low level of productivity of animals in Asia and the evident room for increases, a large part of any increase in the production of food of animal origin will come from expansion of stocks, continuing and increasing trends already evident.

TABLE 4

Percentage increases in total production of meat in animal numbers and their productivity in Europe 1964 to 1968

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Animals</th>
<th>Productivity of animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>16.9</td>
<td>7.2</td>
<td>9.0</td>
</tr>
<tr>
<td>Mutton and lamb</td>
<td>6.8</td>
<td>0.6</td>
<td>6.1</td>
</tr>
<tr>
<td>Pork</td>
<td>15.0</td>
<td>8.6</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Increasing stock numbers involves time and capital. These are inter-related. For any species, if growth is poor, reproduction occurs late and if nutrition is poor fecundity is low. To increase numbers entails keeping an excess of breeding stock for a long period of time and the extent of the excess increases with decreases in the overall reproductive performance. Capital commitment to breeding stock is thus greater the poorer the performance of the stock. Poultry have very great advantages here, particularly since central hatcheries can provide the new stock independent of farm operations. Pigs and goats with their shorter generation intervals and greater annual production of new individuals obviously have considerable advantages over cattle. It would seem that possibilities of expansion of numbers in situations in which capital is limited and general productivity is low lie largely with the smaller animals. The value of the goat is often overlooked in this respect, for properly managed it is highly productive in terms of meat and milk, a good user of byproducts, reproduces relatively quickly and, relative to cattle, makes smaller demands on capital resources. Its bad reputation as a despoiler of grazing is much over-emphasized.

In conclusion, and taking the widest possible view, the possibilities for increasing animal production in Asia are considerable. The keys are probably institutional, that is the provision of market economies and the infra-structure which any agriculture requires. Technical knowledge we
have in abundance, though admittedly more is required in some contexts, but more thought is required to provide the educational, sociological and economic frameworks in which this technical knowledge can be put to use. The prospects of increases in primary productivity of crops entailing more useful byproducts, local surpluses of grain, and of increased mechanization with its associated curtailment of animal stocks as sources of power, create however a series of technical problems for the most part new to Asian countries which must be tackled in ways not necessarily similar to those adopted in other parts of the world. These constitute new and exciting challenges to those concerned in augmenting animal production in Asian countries, and ones to which I am sure there will be vigorous and imaginative response.

REFERENCES

Addressing a gathering of distinguished scientists who have specialised in
the field of nutrition, it would be rather presumptuous on my part to
emphasize the importance of animal proteins in the human dietary.

It is well known that animal proteins contribute in a very large measure
to the protein and caloric requirements of countries which are considered
to be of high nutritional standards. On the other hand, the populations
of many countries of Asia are in a perpetual state of protein-calorie
malnutrition. Table 1 shows the supplies and requirements of calories and
proteins in various regions of the world. The protein available is also in
many instances not of high biological value. The possibility of augmenting
the protein resources through genetic improvement of cereals has been
opened up and it is equally possible that other sources of vegetable protein
would be found.

To provide animal protein, live-stock and dairy products do play an
important part but all the figures of projected increase in the availability
of protein resources for the Asian countries based on land resources are
discouraging. Even small increases are often offset by the pressure of
population. One-quarter of the world population lives around the Indian
Ocean countries and if we are to add to this the population of China and
the countries of south-west Pacific it is obvious that the largest chunk of
the human race is found in this part of the world. In an area where the
pressure on land use is already intense, the resource, which is, obviously
of the highest importance is that from water, both fresh water and marine.
In terms of quantity, the marine resources are by far the most valuable
because the yields are large, concentrated and amenable for industrial
treatment.

The total fish production for the Asian countries is today of the order
of about 18 million tons per annum out of the world annual output of 64
million metric tons. Out of this, Japan, which accounts for about 9 million
ton is the country which has reached a high standard of nutrition and
high availability of protein contributed from sea food resources. The
remaining major production of fish is from mainland China (about 5 million
tons, largely fresh water) and India is the next largest fish producing country
(1.3 million tons).
**TABLE 1**

Calorie and protein supplies and requirements by sub-regions in the base year

<table>
<thead>
<tr>
<th>Zone C^4</th>
<th>Calories</th>
<th>Proteins</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supply (in caput per day)</td>
<td>Requirements (in caput per day)</td>
</tr>
<tr>
<td>Asia &amp; Far East</td>
<td>1990</td>
<td>2210</td>
</tr>
<tr>
<td>India</td>
<td>1980</td>
<td>2200</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1940</td>
<td>2280</td>
</tr>
<tr>
<td>Other countries</td>
<td>2115</td>
<td>2200</td>
</tr>
<tr>
<td>Zone A^3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. America</td>
<td>3090</td>
<td>2710</td>
</tr>
<tr>
<td>Japan</td>
<td>2250</td>
<td>2390</td>
</tr>
<tr>
<td>Zone C^3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>2600</td>
<td>2180</td>
</tr>
<tr>
<td>Zone C^3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa south of Sahara</td>
<td>2130</td>
<td>2240</td>
</tr>
</tbody>
</table>

Speaking for marine resources alone, the Indian Ocean at present yields something like 2.5 million tons of which only about 1.8 million tons need be considered as coming within the purview of the Asian countries.

Various estimates on the potential yield of the Indian Ocean have been made beginning with the rough indication which I made five years ago that with the existing technology and known resources the Indian Ocean could yield something like 20 million tons per annum. Other estimates initially made by the F.A.O. placed the yield at about 11 million tons but a more careful estimation made subsequently has, even on a conservative basis, placed the yield at about 15 million tons as against the present 2.5 million tons. Considering that in the Indian Ocean and to a large extent the Indo-West Pacific, the largest yields come from zero and one year class of fish populations, the enormous possibilities in coastal fisheries, and the virtually untapped resources of molluscan and under-utilized Crustacean fisheries, I believe that the yield could certainly be much higher than 15 million tons and more towards the estimate which I have earlier reported. Fish supplies available today per capita is 76.17 gms. in Japan as against 2.7 gms. in India and 4.38 gms. for Pakistan (Table 2).

<table>
<thead>
<tr>
<th></th>
<th>Per capita fish supplies available for human consumption in selected countries (gm/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>13.15</td>
</tr>
<tr>
<td>Argentina</td>
<td>5.48</td>
</tr>
<tr>
<td>Brazil</td>
<td>7.67</td>
</tr>
<tr>
<td>Mexico</td>
<td>7.12</td>
</tr>
<tr>
<td>Chile</td>
<td>18.63</td>
</tr>
<tr>
<td>Peru</td>
<td>19.73</td>
</tr>
<tr>
<td>Ceylon</td>
<td>16.99</td>
</tr>
<tr>
<td>China (Taiwan)</td>
<td>37.54</td>
</tr>
<tr>
<td>India</td>
<td>2.74</td>
</tr>
<tr>
<td>Japan</td>
<td>76.17</td>
</tr>
<tr>
<td>Pakistan</td>
<td>4.38</td>
</tr>
<tr>
<td>Philippines</td>
<td>26.58</td>
</tr>
<tr>
<td>Mauritius</td>
<td>13.43</td>
</tr>
<tr>
<td>Australia</td>
<td>13.70</td>
</tr>
</tbody>
</table>

*Ref:* The State of Food and Agriculture, Publication of the FAO (1965).
TYPES OF FISHERIES:

Unlike the cold temperate waters, demersal stocks of fish like cod, halibut, hake, etc., are absent from the tropical waters and these do not contribute to large scale fisheries of most Asian countries. The major fisheries are pelagic and neritic pelagic stocks over the continental shelf. There is a slight change of pattern of stocks towards the northern part of West Pacific but the beneficiaries of these fisheries are limited to Japan, Korea and some parts of North China. The largest contribution to Asian fisheries is made by the group belonging to the sardines of the family Clupeidae, which accounts for something like 25 per cent of the total catches available to Asian countries. It would thus be seen that in terms of quantity these form the most important group. The fish caught are mostly small, seldom exceeding a size of 7" in length; in fact the vast majority of the sardines caught are between 3" and 6" in length. They are highly seasonal and easily caught because of their shoaling behaviour. Most of the stocks are not far away from the coast and they give excellent products in the canned and dried form. The highly oily character of some of the species has made them industrially important but, as a group, the value of the sardines in the Asian countries lies in their easy availability and handling in the type of food preparations which could make use of even the smallest fish. Together with the large amount of small and low quality miscellaneous fish which form a considerable part of the catches in the offshore fishing operations throughout Asia, they form the most important raw-material for reduction plants and fish meal production.

The second most important group are the Scombrids, that is, the mackerel, the tuna and their allies. The tuna are essentially the quality fish whose increases are promising but probably the largest single genus fishery is that contributed by another Scombrid, the Indo-Pacific Mackerel Rastrelliger. The Sardines and Mackerel together in Asia contribute to something like 30-40% of the marine catches.

There is a considerable difference in the tropical zone where the sardine and mackerel fisheries dominate and towards the northern west Pacific where the Croakers (Sciænids) assume greater importance. Both in the tropical and in the temperate parts there are a large number of smaller fisheries; some consist of high class fish like Stromateids, Percoids, Polynemids, etc., fisheries of large magnitude like Ribbon fishes (Trichiurids) Horse mackerel (Carangids) silver bellies (Leiognathids) and the like.

The resources of high economic value in the region are the prawns also
known by the trade name 'Shrimp' which are abundant in the shallow shelf areas and probably in the deeper slopes. India has a production of nearly 100 thousand tons of Shrimps per annum and so has Japan with many of the Asian countries having smaller but significant yields. The estimates are that the Shrimp resources are very considerable and may be found in many areas of the Asian coastline where it is now hardly fished. The shrimps are harvestable in less than one year and their peculiar habit of breeding near the coast and entering tidal creeks and estuarine areas as larvae has made them ideal for coastal aquaculture as already practised on the Malabar coast. The prawns and other crustacea are rich in amino acids of high biological value.

The exploitation of marine resources in most Asian countries other than Japan, Korea and Hongkong is by old and traditional coastal fishing employing small craft and gear without the use of machinery. Landings are consequently widely scattered. The two large changes which have taken place in recent times helping to modernize the fisheries are the mechanization of fishing through introduction of engines and better designed boats which could cover long distances and the adoption of some efficient modern gear for fishing including the replacement of cotton and hemp by synthetic fibres. The large increase in annual landings registered by most Asian countries in recent times has been the result of these two applications of modern technology to fishing. However, in the not distant future era increase of yields in marine fisheries may require new technology to concentrate tropical fish schools which are less dense than in temperate waters. The use of light, sound or even electricity are new possibilities in raising the efficiency of fishing practices.

The mechanization of fishing has had important impact in concentration of shore facilities for storing, freezing, processing and other activities on a concentrated scale resulting in the development of industrial approach to the utilization of marine products. In the wake of all these developments there is room for confidence that good quality fish and fish products will increasingly enter the diet of the Asian peoples.

**Utilization of Fish:**

From the type of fishing activities outlined above, it may be seen that the secondary stage of the industry has not made much headway. Marketing is poorly organized. We may illustrate with reference to India how the changes are taking place. Until recently, nearly half the production of sea fish was converted into low quality dried fish and consumed by the poorer
sections of the Indian population or exported out of India to Ceylon, Burma and other markets. With increasing facilities for ice, storage and refrigeration there has been a big fall in the amount of fish converted into the crude dried fish and many parts of India are able to secure fresh fish packed in ice for consumption. The processing plants are absorbing a good fraction of certain types of fish like sardines, shrimps and mackerel for canning and freezing. The present estimate is that not more than 20% of sea fish landings are converted to dried fish and in course of time this category of utilization will virtually disappear with better means of transportation and storage. Economic incentive for this is provided by better returns for the frozen and processed products, both in India and in the export market.

The countries of South-East Asia have utilized low quality fish for meeting their protein requirement through the manufacture of fish sauces which are really protein hydrolysates from fish. The principle is to keep fish and salt in different layers under pressure which results in autodigestion and the production of a clear liquid highly rich in amino acids. The small quantity of sauce used along with food although contributing only a small part in terms of weight, is a significant addition to the quality of food consumed in South-East Asia.

In dealing with fish it is also necessary to consider its contribution as a feed for the livestock and poultry. The largest fish producing country in the world—Peru with an annual catch of 10 million tons, contributes the catch almost entirely to the production of fish meal for poultry and livestock in Europe and America. In these countries a certain amount of sea food is consumed whenever one eats an egg or part of a chicken. Fish meal is a high quality livestock ration, entering the diet of cattle for increasing milk production even in countries like India with strong vegetarian sentiments. I believe that in years to come fish meal production for poultry feed, which is not very important now in South Asia will be on a steeply increasing scale.

Except for estimated varieties of fish and prawns, the comparative cost of fish per unit is lower than the corresponding cost for meat, eggs and milk. In all Asian countries except Japan, the nutritional status is largely dependent upon the purchasing power of individuals, unlike high income countries where the individual income is no longer a major factor in the selection of diet. It is equally argued that income increase in rural and primitive societies has slight effect in preferential diet because of strong ecological backgrounds which inhibit changes in food consumption pattern. Asian countries fall between these two extremes and a conscious move
Marine fishery resources

towards an improved diet is evident. It is in this context that fishery resources which can provide cheap protein to the masses has an important contribution to make. Table 3 projects the fish requirements by Asian countries, taking into account the population growth.

**TABLE 3**

Projection of population and fish requirement in Asian countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population in millions (at 2 percent compound rate from 1970 onwards)</td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Yearly requirement of fish @ 10 gms. per day per head (in m.m.t.)</td>
<td>3.769</td>
<td>4.594</td>
<td>5.601</td>
<td>6.826</td>
</tr>
<tr>
<td>Yearly requirement of fish @ 20 gms. per day per head (in m.m.t.)</td>
<td>7.538</td>
<td>9.189</td>
<td>11.202</td>
<td>13.651</td>
</tr>
<tr>
<td>Yearly requirement of fish @ 56.7 gms (2 oz.) per day per head (in m.m.t.)</td>
<td>21.370</td>
<td>26.050</td>
<td>31.756</td>
<td>38.701</td>
</tr>
</tbody>
</table>

All people of Asia accept fish except for a section estimated at 35% of the total Indian population who are vegetarians and get their animal protein from milk. The present supplies of fish are far below the minimum demand in all countries except Japan.
SYMPOSIUM ON

ASPECTS OF VITAMIN NUTRITION

Chairman : C. G. King, U.S.A.

and

V. Ramalingaswami, India

Rapporteur : Bhavani Belavady, India

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VITAMIN D: METABOLICALLY ACTIVE FORMS
AND THEIR MECHANISMS OF ACTION*

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University of Wisconsin
Madison, Wisconsin 53706 USA

Seldom has an investigation lent itself to such rapid advances as has the
study of functional metabolism of vitamin D in recent years. This is parti­
cularly surprising since vitamin D has been known for some 50 years and
had especially in recent decades been a field of rather difficult progress and
slight activity. Since 1965 there has been a rapid sequence of discoveries
relating both to the mechanism and to the metabolism of vitamin D that is
seldom seen in any field.

It is well recognized that the end-effect of vitamin D is to bring about
calcification of organic matrix of bone. Certainly, the major factor in the
failure of calcification in vitamin D deficiency is the insufficient supply of
calcium and phosphate to the mineralization sites. It is well known that
plasma from rachitic animals is undersaturated with regard to hydroxyapatite
of bone. Normally plasma and extracellular fluid are supersaturated with
regard to the mineral component. The collagen fibrils properly prepared
serve to catalyze or nucleate the crystallization of the hydroxyapatite on the
collagen fibrils themselves. Thus in an undersaturated solution, this calci­
fication fails to occur and results in the disease rickets in the young and
osteomalacia in the adult. The primary problem then in vitamin D deficiency
is a poor supply of calcium and phosphate from the plasma. Whether
vitamin D plays a direct role in osteoblastic calcification remains a possi­
bility but has not yet been established on an experimental basis.

Physiologically the vitamin brings about the elevation of plasma calcium
and phosphate by two basic mechanisms. First, it is well recognized that
vitamin D increases intestinal absorption of calcium and secondarily phos­
phate. This fundamental observation was first put on a firm experimental
basis by Nicolaysen and his coworkers and has been reconfirmed by many
investigators using many elegant techniques. It was not until the work of

*Supported by a research grant from the USPHS No. AMO-3800-10 and by the Harry
Stembock Research Fund of the Dept. of Biochemistry.
Sachter and his colleagues\textsuperscript{7,8}, Harrison and Harrison\textsuperscript{9}, Wasserman\textsuperscript{8} and Martin and DeLuca\textsuperscript{10,11} that advances were made in our understanding of this calcium transport process. Suffice it to say that it has now been established that calcium is transported against an electro-chemical potential gradient and thus is an active cation-oriented transport process. Exactly how vitamin D functions in this process is not entirely clear and is still a matter of intense investigation. Thus by increasing the absorption of calcium and secondarily phosphate, plasma calcium and phosphate concentrations are elevated.

In what appears to be a paradoxical mechanism, vitamin D brings about a mobilization of mineral from previously formed bone\textsuperscript{12}. This process is enhanced by the parathyroid hormone\textsuperscript{13,14} and both of these humoral agents act in concert to effect the mobilization of calcium and phosphate from the bone. Whether vitamin D has a renal effect on tubular reabsorption of calcium and phosphate also remains a relatively uninvestigated area. It would appear, however, that the effect of vitamin D upon the kidney in terms of tubular reabsorption contributes quantitatively very little to the end-event of calcification. Thus two physiologic processes, the mobilization of bone mineral and intestinal calcium absorption, elevate plasma calcium and phosphate to supersaturation levels wherein normal mineralization of bone can occur (Figure 1).

**PHYSIOLOGIC ACTIONS OF VITAMIN D**

![Diagram](image-url)

Fig. 1. A diagrammatic representation of the known functions of vitamin D in calcium metabolism.
Active forms of vitamin D

Of great importance to the understanding of vitamin D action is the fact that there is a large lag between the time of administration of the vitamin and the appearance of its first physiologic response. An example of this is the intestinal calcium transport mechanism shown in Figure 2. Following

**RESPONSE OF INTESTINAL CA TRANSPORT**

**TO VITAMIN D₃**

![Graph](image)

Fig. 2. Time lag in manifestation of vitamin D action on calcium transport in small intestine. Vitamin D-deficient rats were given 0.25 ug vitamin D₃ in cottonseed oil (oral) or in 0.05 ml ethanol intravenously while the controls received either appropriate vehicle. Calcium transport was measured as described by Martin and DeLuca. The intravenous injection of 10 IU (0.25 µg) of vitamin D₃, a time period of 10 to 12 hr is required before intestinal calcium transport begins to rise. A similar but longer lag exists in the bone mineral mobilization mechanism following vitamin D administration.

The first great advance in our understanding of vitamin D action occurred in 1965 when Zull et al. demonstrated clearly that actinomycin D given prior but not following vitamin D was able to block completely both the intestinal calcium absorption response and the bone mineral mobilization response to vitamin D (Figure 3). This fundamental observation which
Fig. 3. Prevention of vitamin D-induced calcium transport system of intestine by actinomycin D. 66 ug/100 g rat was administered to vitamin D—deficient animals 1 hr prior to administration of 2,000 IU vitamin D₃ intraperitoneally. (From Zull et al.® reproduced with the kind permission of the publisher).
Fig. 4. Silicic acid column chromatography of the chloroform soluble fraction from tissues of rat given 0.25 µg \( ^3H \) vitamin \( D_3 \) intravenously 24 hr before. ——radioactivity; —— exponential gradient used.
was found also in chicks\textsuperscript{16} demonstrated clearly that the synthesis of RNA and of protein must mediate the function of vitamin D in both the bone mineral mobilization and in the intestinal calcium transport responses. Exactly what protein or proteins must be made remained unknown until very recently.

The next discovery followed extensive chemical work in synthesizing radioactive vitamin D\textsubscript{3} of extremely high specific activity and was accomplished in 1966 by Neville and DeLuca\textsuperscript{17}. Using this high specific activity material it was possible to demonstrate first that biologically active metabolites of vitamin D could be formed\textsuperscript{18}. Furthermore Lund and DeLuca\textsuperscript{19} were able to prepare a polar metabolite fraction of vitamin D (Figure 4) which was more effective than the parent vitamin in the cure of rickets in rats. In these experiments vitamin D-deficient rats were injected with radiochemically pure tritium labelled vitamin D\textsubscript{3} and 24 hr later the rats were killed, the tissues extracted with methanol and chloroform and

![Fig. 5. Structure of peak IV metabolite or 25-hydroxycholecalciferol (25HCC).](image)
A metabolite fraction more polar than vitamin D was formed which when readministered to rachitic rats was more effective in the cure of rickets than the parent vitamin. The peak I fraction proved to be an ester of vitamin D and long-chain fatty acids, peak II remains unidentified, peak III is unchanged vitamin D₃ and peak IV is a heterogeneous metabolite fraction which was subsequently separated into at least seven radioactive components. However, from the extract of blood only one of these metabolites retained the remarkable ability to cure rickets in rats. This metabolite was subsequently isolated in pure form by Blunt et al. and identified as 25-hydroxycholecalciferol (25-HCC) by means of mass spectrometry, nuclear magnetic resonance spectrometry, gas liquid chromatography and ultraviolet absorption spectrophotometry. The structure of this important metabolite is shown in Figure 5. This metabolite was subsequently synthesized chemically by three different routes in our laboratory and is now being prepared on a commercial scale for clinical trials in vitamin D-resistant diseases. By analogous techniques the active metabolite of vitamin D₃ was isolated and identified as 25-hydroxyergocalciferol (25-HEC).
25-HCC, when administered to vitamin D-deficient rats, elicited the rise in intestinal calcium transport within 3 hr as compared to 10 hr for a comparable dose of vitamin D₃ (Figure 6). Similarly, it was more rapid acting in the bone mineral mobilization assay as shown in Figure 7. Not only that, the 25-HCC is 1.5 times more effective than vitamin D₃ in curing rickets in rats and in chickens. Finally, in isolated bone cultures wherein bone mineral mobilization can be measured, the 25-HCC is effective in extremely small doses whereas vitamin D₃ even in large doses has no effect whatsoever, demonstrating at least in this isolated organ system that 25-HCC is effective whereas vitamin D₃ is not (Figure 8). This remarkable result indicates that vitamin D must be hydroxylated in the 25 position before it is effective. It also indicates that the 25-HCC is the circulating or hormonal form of the vitamin.

The 25-HCC is synthesized in the liver. The liver initially takes up large quantities of injected vitamin D₃ and from the liver 25-HCC is "secreted" into the blood stream. Hepatectomized animals are unable to metabolize vitamin D at all indicating that the 25-HCC formation is
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THE EFFECTS OF PEAK IV METABOLITE OF VITAMIN D AND PARATHYROID HORMONE (PTH) ON THE TIME COURSE OF 45Ca RELEASE FROM FETAL RAT BONES IN CULTURE.

Fig. 8. Time course of the release of previously incorporated 45Ca from fetal rat bones treated with either purified bovine parathyroid hormone (PTH) or 25-HCC (peak IV) in tissue culture. The shafts of the radius and ulna were dissected from 19-day fetal rats taken from mothers injected with 0.5 mc of 45Ca on the previous day. The bones were cultured at 37°C in a chemically defined medium in an atmosphere of 5% CO₂, 20% O₂, 15% N₂. (Trummel et al. (1969), reproduced with the kind permission of the publisher).

the first step in vitamin D metabolism. Perfused liver and liver homogenates fortified with reduced pyridine nucleotide and molecular oxygen are able to bring about the hydroxylation of vitamin D₂ to the 25-hydroxy derivative. This reaction is not inhibited by carbon monoxide-oxygen at a ratio of 3:1, diphenylyl paraphenylenediamine, cyanide, or azide. Clearly this is a unique hydroxylation system which does not involve cytochrome P450, cytochrome oxidase or the lipid peroxidation system. The calciferol
25-hydroxylase is a mitochondrial enzyme which requires a supernatant factor. This system is very strongly product inhibited by 25-HCC itself. It is not, however, inhibited by 25-hydroxydihydrotachysterol which is a very strong bone-mobilizer and structurally very similar to 25-HCC. This product inhibition of vitamin D metabolism serves two important functions. First it conserves vitamin D during times when it is present in excess so that it may be utilized later by the body when need develops. Secondly, it prevents toxicity due to wide variation in vitamin D intake or when vitamin D is produced in large excess by irradiation of skin. This hydroxylase system then serves as an endocrine system secreting in a controlled fashion active vitamin D into the plasma. It, therefore, appears that vitamin D$_3$ is the storage form of the vitamin and the 25-hydroxy derivative is the circulating or hormonal form.

It was next possible to synthesize radioactive 25-HCC as shown in Figure 9. This allowed the question to be asked of whether the 25-HCC
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Fig. 10. Silicic acid chromatography of lipid extract of intestinal mucosal nuclei after 0.025 μg of (26, 27-3H)-25-HCC—radio activity, —— gradient. (From Cousins et al. (1970), reproduced with the kind permission of the publisher).
is metabolised further to other metabolites that might be the tissue or metabolically active forms of the vitamin. This indeed proved to be the case\textsuperscript{a, 21} as shown in Figure 10. A metabolite more polar (peak V) than 25-HCC appears very rapidly in intestine and bone. In the case of intestine an even more polar (peak VI) metabolite appeared to be a precursor of peak V but recent results make this unlikely. The peak V fraction from plasma has been resolved into at least three major components (Figure 11) (Va, Vb, and Vc)\textsuperscript{32, 33}. Two (Va and Vc) of these polar metabolites have been isolated in pure form and identified. Peak Va which was identified as 21, 25-dihydroxycholecalciferol (Figure 12)\textsuperscript{34} is a metabolite most likely in bone that has preferential activity in stimulating bone mineral mobilisation while Vc which was identified as 25, 26-dihydroxycholecalciferol (Figure 13) probably originates in the liver and has no bone mineral mobilization activity and only slight intestinal calcium transport activity. These, however, are different from the peak V metabolite found

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{diagram.png}
\caption{Fig. 11. Resolution of plasma peak V into three major components (Va, Vb and Vc) by means of a multibore silicic and column chromatographic procedure. (From Suda et al. (1970), reproduced with permission of the publisher).}
\end{figure}
in intestinal tissue derived from 25-HCC and do not appear to be of central importance to vitamin D function. Of great importance is the peak V metabolite found in the intestine after physiologic doses of the vitamin. This metabolite initiates intestinal calcium absorption in chickens much more rapidly than even 25-HCC (Figure 14). It is not, however, as active as 25-HCC in curing rickets in rats and it does not appear to act more rapidly nor is it as effective as 25-HCC in the mobilization of bone mineral. This metabolite, however, does appear to be the metabolically active form of vitamin D in the intestine.\textsuperscript{14}

An important new finding is the fact that actinomycin D given prior to the radioactive 25-HCC prevents the metabolism of 25-HCC to the peak V metabolite\textsuperscript{12} (Figure 15). Similarly, the protein synthesis inhibitor cycloheximide also prevents the metabolism of 25-HCC to the peak V metabolite. These results suggest that the actinomycin D sensitive step
in vitamin D action on the intestine is the conversion of 25-HCC to the peak V metabolite. As might be expected, Table I shows that the action of 25-HCC in initiating intestinal calcium transport is blocked by the prior administration of actinomycin D. However, the action of the peak V metabolite in initiating intestinal calcium transport is not blocked by actinomycin D. Clearly then the peak V metabolite can initiate the action of vitamin D in the intestine in the presence of actinomycin D, demonstrating that the peak V metabolite carries out the function of vitamin D by a process not involving transcription of DNA into RNA. These results also show that the actinomycin D-sensitive step in vitamin D action on intestine is the conversion of 25-HCC to the peak V metabolite. They also suggest that the 25-HCC must interact with the genetic machinery in some way to induce the formation of an enzyme or enzymes responsible for its metabolism to the peak V metabolite. Unfortunately, the structure of the peak V metabolite is not yet known although the most likely guess is that it is the 1 of, 25-dihydroxycholecalciferol.
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Fig. 14. Response of chick intestinal calcium absorption to 25-HCC, vitamin D₃ and the intestinal peak V. Each point represents the average of 47 chicks ± standard error. • --- 325 pmoles given intravenously; --- 9 pmoles given intravenously; --- 325 pmoles administered orally.

TABLE 1

Failure of Actinomycin D to Prevent Intestinal Ca Transport Response to Peak V

<table>
<thead>
<tr>
<th>Actinomycin D</th>
<th>Treatment*</th>
<th>Transport J/O ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>—</td>
<td>—</td>
<td>1.7 ± 0.2 (4)</td>
</tr>
<tr>
<td>—</td>
<td>25-HCC</td>
<td>2.7 ± 0.1 (3)</td>
</tr>
<tr>
<td>+</td>
<td>25-HCC</td>
<td>1.8 ± 0.2 (4)</td>
</tr>
<tr>
<td>—</td>
<td>Peak V</td>
<td>2.9 ± 0.2 (4)</td>
</tr>
<tr>
<td>+</td>
<td>Peak V</td>
<td>3.1 ± 0.4 (4)</td>
</tr>
</tbody>
</table>

*60 pmoles of metabolite intravenously. Rats were killed 12 hr. later.
Fig. 15. Inhibition of metabolism of \( ^{3}H \)-25-HCC in intestine of rats given actinomycin D 2 hr before 0.25 \( \mu \)g \( ^{2}H \)-25-HCC intravenously. Chromatography of the chloroform extract of intestine was carried out as described by Ponchon and DeLuca. IV represents unchanged 25-HCC. The rats were killed 8 hr after administration of \( ^{2}H \)-25-HCC. (From Tanaka and DeLuca, reproduced with the permission of the publisher).
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The peak V metabolite is formed in the kidney in as much as nephrectomy prevents completely the formation of peak V metabolite while ureter ligation induced uremia does not inhibit peak V formation (Gray, Boyle and DeLuca, unpublished results) (Figure 16). In addition homogenates of kidney but not of intestine or liver will carry out this conversion. Thus the kidney is involved in the synthesis of the metabolite of 25-HCC which is in turn responsible for initiating intestinal calcium transport. These results suggest that 25-HCC must interact with the genetic machinery in the kidney to induce the formation of enzymes which then bring about the conversion of 25-HCC to the peak V metabolite.

At the present time it is not possible to decide what is the metabolically active form of vitamin D in inducing bone mineral mobilization. In isolated bone organ cultures, 25-HCC is effective without further metabolism. Furthermore, 25-HCC acts more rapidly than and is at least as effective as either the polar peak V from intestine or the 21, 25-dihydroxycholecalciferol. The evidence to date then suggests that 25-HCC itself is
the metabolically active form in inducing bone mineral mobilization. Its action on this system is blocked by actinomycin D suggesting that transcription of DNA is involved in the mechanism.

The nature of the intestinal calcium transport system induced by vitamin D has also received some attention. Martin and DeLuca have demonstrated quite conclusively that sodium ions are required for calcium transport across intestinal epithelium. This ion is required not for uptake of the calcium, but for expulsion of the calcium into the serosal medium. In sodium deficient medium wherein expulsion of calcium from the basement membrane surface is inhibited, intestines from animals treated with vitamin D reveal an increased uptake of calcium across the brush border surface. This can be measured directly as shown in Figure 17. In

![Graph](image)

**Fig. 17.** Effect of vitamin D on the rate of calcium uptake across mucosal surface of small intestine. A 0.317 cm² area of duodenum from either a D-deficient rat or one given 10 IU of vitamin D 48 hr before was exposed on only the mucosal side to the medium containing ⁴⁴Ca. (From Martin and DeLuca (1969), reproduced with permission of the publisher.)
intestinal mucosa exposed only on the mucosal surface to $^{40}\text{Ca}$, it can be shown that pretreatment with vitamin D brings about a very marked increase in the rate of calcium uptake across the brush border surface. This process is inhibited by a nitrogen atmosphere, by inhibitors of oxidative phosphorylation and thus is in some fashion dependent upon an energy transducing process.

Wasserman and his colleagues\textsuperscript{18,39} have isolated in pure form a calcium binding protein in chicks which appears to be secreted by the goblet cells on to the surface of the brush borders of intestinal epithelial cells\textsuperscript{40}. In our laboratory, a calcium binding protein has also been isolated from rat intestinal epithelium and has a molecular weight of between 8,000 and 13,000. Most likely, the molecular weight is in the neighbourhood of 8,000 to 9,000, and the protein is ellipsoidal in shape (Drescher and DeLuca, unpublished data). Wasserman and his colleagues consider the calcium binding protein to be that which is made in response to vitamin D and which promotes intestinal calcium absorption. In our laboratory, a calcium-stimulated adenosine triphosphatase has been found in the brush borders of intestinal epithelium following vitamin D treatment\textsuperscript{41-42}. Likely this calcium dependent adenosine triphosphatase represents the transport system which is assembled following vitamin D treatment. It may represent a combination of calcium binding protein and ATP transducing membrane system. Although attractive, this hypothesis has not yet been established.

Figure 18 then represents the mechanism of action of vitamin D especially in regard to intestinal epithelium. Vitamin D is the storage form of the vitamin and it is converted in the liver to 25-HCC by a very tightly product
inhibited reaction. This reaction secretes in a controlled fashion 25-HCC into the blood stream. This goes directly to the bone to induce bone mineral mobilization and to the kidney where it is converted still further to a very polar metabolite. This polar metabolite makes its appearance in the intestinal epithelium where by a non-transcriptive process brings about the formation or activation of an intestinal calcium transport protein. This protein may be the calcium binding protein of Wasserman which at the brush border surface makes its appearance as a calcium-dependent adenosine triphosphatase system. Calcium is then transferred across the intestinal epithelium by a process which consumes ATP. Mitochondria take up the calcium at the brush border surface because of the high concentration of calcium found there. At the serosal surface, a downhill sodium gradient brings about an exchange of calcium into the serosal medium. This exchange process maintains the calcium concentration in the cytoplasm in that region of the cell at extremely low levels bringing about release of calcium from the mitochondria. The sodium gradient is maintained by the Na⁺/K⁺ pump system. Thus the transepithelial transport of calcium has been effected against an electrochemical potential gradient.

Finally, it is gratifying to conclude that many new findings have come about in the field of vitamin D action in recent years and the promise for a complete elucidation of the vitamin D-induced mechanism in the intestine seems near at hand.

REFERENCES

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FOLATE NUTRITIONAL STATUS IN THE BURMESE:

The first reports from Burma of nutritional megaloblastic anaemia were those of Shwe Zan in 1962 and Izak et al in 1963. The latter workers observed low serum and whole blood *L. casei* activity in the megaloblastic patients seen by them. They also demonstrated a specific response to small doses of folic acid. The serum B12 levels of these patients were mostly normal or even elevated.

Following the above reports, studies were undertaken to assess the folate nutritional status of the Burmese population. The Haematology Department of the Burma Medical Research Institute has been measuring various folate parameters in several population groups. The significance of the findings in relation to the aetiology of the anaemias seen in the general population and in pregnancy has been assessed, and forms part of the present communication.

The method used by us for folate bioassay was as follows:

Venous blood was taken and arrived chilled in ice at the laboratory within 24 hours after collection. Serum or hemolysate was immediately prepared and added to phosphate buffer containing ascorbate. Extraction by autoclaving was performed after 90 minutes pre-incubation. The extract was stored at −20°C till assayed within 6 weeks. Microbiological assay was done according to the method of Grossowicz using *L. casei* with minor modification as follows: Since DIFCO acid hydrolysed casimino acid was used in place of enzymatic casein hydrolysate, the following components were added to 1 litre of double strength assay media: DL-tryptophan 0.4 g, L-cysteine 0.5 g, reduced glutathione (G-SH) 0.0025 g and vitamin B12 5μg. The coefficient of variation in our laboratory is 8%. A lyophilized WHO reference sample of serum obtained from Professor D. L. Mollin of London
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was determined to have a value of 14.9 ± SD 2.8 ng/ml compared to 15.5 ± SD 2.5 ng/ml in his laboratory.

In the first study folate determinations were made on anaemic and non-anaemic adults from two localities in central and lower Burma respectively. The subjects were as follows:

Group 1 consists of non-anaemic industrial workers and blood bank donors from Rangoon (Hb. men > 14 g/100 ml; women > 12 g/100 ml).

Group 1A consists of anaemic industrial workers (Hb < 11 g/100 ml), blood collection, storage and folate determination being identical and done simultaneously with Group 1.

Group 2 consists of non-anaemic subjects from a village in Central Burma.

Group 2A consists of anaemic subjects from the same villages, blood collection, storage and folate determination being identical to and simultaneous with Group 2.

The results are set out in Table 1. In the non-anaemic subjects the mean serum folate levels of 5.2 ng/ml in Rangoon is similar to 5.5 ng/ml seen by Toennies et al in USA, 5.4 ng/ml by Hensen and Weinfield in Sweden and 4.9 ng/ml by Spray in England. The relatively high mean serum level of 10.3 ng/ml in Central Burma is comparable to the values of 8.3 ng/ml found by Grossowicz et al in Israel and 9.7 ng/ml seen by Hoffbrand in England. No instance of deficient serum folate levels (3 ng/ml) was seen in Group 2 but the proportion deficient was 16% in Group 1.

The mean red cell folate level of 173.7 ng/ml and 175.7 ng/ml in Group 1 and 2 respectively are similar to the values of 165 ng/ml reported by Chanarin and of 152 ng/ml by Spray. Seven subjects (25%) in Group 1 and 2 subjects (8%) in Group 2 have red cell folate values below 100 ng/ml which is the criteria adopted by the WHO Expert Committee on Nutritional Anaemia as indicative of deficiency.

Taking the results as a whole it may be concluded that folate nutrition in the apparently healthy Burmese subjects, as judged by mean serum and red cell levels, is comparable to that in other populations. However, 16% have deficient serum level and 8–25% have deficient red cell levels respectively, as judged by WHO criteria.
<table>
<thead>
<tr>
<th>Group</th>
<th>Folate Levels Assayed by <em>L. casei</em> (ng/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
</tr>
<tr>
<td></td>
<td>Serum</td>
</tr>
<tr>
<td>Normal</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Anemia</td>
<td>1A Mean ± SD</td>
</tr>
<tr>
<td></td>
<td>2A Mean ± SD</td>
</tr>
</tbody>
</table>

Figures in parentheses indicate number of subjects.
*Including 7 pregnant women.
TABLE 2
Serum and Red Cell *L. casei* Activity in Burmese pregnant women. Effect of Different treatment Regimes

<table>
<thead>
<tr>
<th>Group</th>
<th>24th week (Hb gm/100 ml, ng/ml)</th>
<th>Full term (Hb gm/100 ml, ng/ml)</th>
<th>4 weeks post-partum (Hb gm/100 ml, ng/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R.B.C.</td>
<td>R.B.C.</td>
<td>R.B.C.</td>
</tr>
<tr>
<td>Iron only</td>
<td>Mean 10.9 (30) 6.8 (30) 202.0 (30)</td>
<td>Mean 11.3 (29) 105.4 (29) 4.3 (29) 134.5 (25)</td>
<td>Mean 12.7 (25) 85.2 (25) 2.7 (25) 124.5 (25)</td>
</tr>
<tr>
<td>Iron plus folic acid</td>
<td>Mean 10.8 (25) 6.3 (25) 167.4 (25)</td>
<td>Mean 11.4 (25) 106.0 (25) 16.3 (24) 498.8 (23)</td>
<td>Mean 13.1 (18) 106.0 (18) 8.8 (16) 401.4 (15)</td>
</tr>
<tr>
<td>Placebo</td>
<td>Mean 10.4 (22) 5.8 (22) 186.6 (22)</td>
<td>Mean 9.6 (21) 61.7 (21) 3.9 (21) 171.3 (21)</td>
<td>Mean 11.1 (15) 67.3 (15) 4.7 (15) 172.2 (15)</td>
</tr>
<tr>
<td>Folic acid only</td>
<td>Mean 10.3 (19) 5.6 (19) 201.3 (19)</td>
<td>Mean 9.6 (19) 59.6 (19) 18.3 (19) 224.1 (19)</td>
<td>Mean 11.1 (15) 59.1 (15) 11.3 (15) 554.8 (14)</td>
</tr>
</tbody>
</table>

Figures in parentheses indicate number of subjects studied.
It may be also seen from Table 1 that the mean serum and red cell folate levels in the anaemics are not lower than that found in their respective non-anaemic control groups. The only exception is the serum folate level in anaemic men from Rangoon which is lower than in the controls but the difference is not significant. The incidence of deficient values in all anaemics is 7% in the case of serum and 6% in the case of red cells, compared to 9% and 18% respectively in the controls. Taking all these results into consideration folate deficiency is not regarded as a significant factor in the anaemics so far studied.

In the second study, serum and red cell folate levels were measured serially at the 24th week of pregnancy, full term and 4 weeks post-partum in 4 randomly allotted groups of Burmese pregnant women of similar socio-economic status. After initial determination of folate levels at the 24th week, each of the 4 groups received either iron alone, folate alone, iron plus folate or placebo respectively. Iron was given as ferrous sulphate containing 60 mg elemental iron twice a day and folic acid as (PGA) pteroylglutamic acid 5 mg also twice a day.

The results are shown in Table 2. Serum PGA levels were initially 5.6 to 6.8 ng/ml in all groups. In the 2 groups not receiving folate the serum folate at full term fell to 4.3 and 3.9 ng/ml. By full term the serum folate level was below 3 ng/ml in 24% (8 subjects) and 40% (9 subjects) of the two groups not receiving folate. By one month post-partum the percent deficient were 60% (15 subjects) and 31% (5 subjects), respectively.

Red cell folate activity declined from the initial 202.0 and 186.6 ng/ml to 134.5 and 171.3 ng/ml at full term in the groups not receiving folate. The proportion with red cell activity less than 100 ng/ml was 31% (9 subjects) and 13% (3 subjects), respectively, at full term.

Serum B_{12} levels were not determined at that time but when done later by the charcoal-coated radio-assay method of Lau on another sample of pregnant women from the same socio-economic group the mean B_{12} level was found to be 383.8 \(\mu\text{g/ml}\) and less than 1% had a value lower than 100 \(\mu\text{g/ml}\).

It may be seen therefore that though initially satisfactory the serum and red cell folate levels declined markedly in those not given folate supplements and the proportion with deficient values also increased correspondingly. A similar fall of serum folate in the late pregnancy has been observed by various other investigators. As shown by Willoughby and Jewell¿, this fall may be pre-
vented by the administration of 300 μg of folic acid daily. Our results indicate that even though folate nutrition in the general Burmese population, as judged by serum and red cell folate levels, may be regarded as satisfactory, sufficient dietary folate is not available to meet the increased demands of pregnancy.

The significance of the low blood folate levels in relation to the development of anaemia requires consideration. Although a considerable proportion of our pregnant subjects supplemented with iron were found to have deficient serum and red cell folate levels at full term and post-partum, none developed anaemia. Their mean haemoglobin concentration rose from an initial value of 10.9 g/100 ml to 11.3 g/100 ml at term and 12.7 g post-partum. Karthigaini et al² have similarly observed low serum folate level < 4 μg/ml in pregnant women at Vellore (India) who had little significant anaemia. From the present study, it appears that in a pregnant population such as ours iron supplementation alone may prevent the occurrence of anaemia of pregnancy. Folate deficiency also occurs but not to the extent that it will by itself cause a significant amount of anaemia. As demonstrated by Herbert²¹ biochemical evidence of folate deficiency and megaloblastic haemopoiesis may be evident some time before anaemia develops. Therefore, it seems that if folate deficiency is not prolonged or severe enough women may go through pregnancy without developing anaemia and yet may be found to have low serum and red cell folate levels. If a marrow examination is done either routinely or because of anaemia brought on by iron deficiency a megaloblastic haemopoiesis may also be detected. None of our iron supplemented pregnant subjects developed anaemia and marrow examination was not routinely performed. But in another series of pregnant women of the same socio-economic group, none of whom were on regular hematins, 20% approximately of anaemics were found to have a megaloblastic marrow. This may be compared with the reported incidence of megaloblastic marrow in pregnant anaemics of 29% in Liverpool,²⁲ 39% in Indonesia,²³ and 70% in Vellore.²⁴ The true incidence of megaloblastic haemopoiesis without anaemia is not known. Chanarin et al²⁵ found unexpected megaloblastosis in 3 out of 16 pregnant controls.

RELATION OF IRON DEFICIENCY TO FOLIC ACID STATUS:

I would now like to consider the relation of iron deficiency to folic acid status in pregnancy. This is a matter of considerable interest because of the frequent co-existence of these two deficiencies especially in countries such as ours.
In 1965, Chanarin et al.\textsuperscript{17} reported a higher incidence of hypersegmented neutrophils and megaloblastic haemopoiesis in pregnant subjects given placebo as compared to those on iron supplement. Furthermore, they observed the greatest decline of serum \textit{L. casei} activity in the placebo group—a fall from a mean of 5.3 ng/ml at 30th week to 4.3 at the 39th week. They suggested that iron deficiency adversely affects folic acid status.

During our clinical trial of iron and folic acid in pregnancy mentioned before we had the opportunity to study some aspects of this interrelationship between iron and folic acid. The relevant data are shown in Table 3.

<table>
<thead>
<tr>
<th>TABLE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serum and Erythrocyte \textit{L. casei} Activity in Burmese Pregnants. Comparison between iron supplemented and placebo groups</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Serum</strong></td>
</tr>
<tr>
<td>24th week</td>
</tr>
<tr>
<td>Post-partum</td>
</tr>
<tr>
<td><strong>Folate</strong></td>
</tr>
<tr>
<td>Full term</td>
</tr>
<tr>
<td>24th week</td>
</tr>
<tr>
<td><strong>R.B.C.</strong></td>
</tr>
<tr>
<td>Full term</td>
</tr>
<tr>
<td>Post-Partum</td>
</tr>
</tbody>
</table>

* * P < 0.05
** Not Significant

It may be seen that serum PGA levels were initially 5.8 and 6.8 ng/ml in both iron supplemented and placebo groups. In the group on placebo, the serum folate fell from 5.8 ng/ml at 24th week of pregnancy to 3.9 at full term and 4.7 post-partum. On the other hand, in the iron supplemented group, serum PGA fell from 6.8 to 4.3 ng/ml at full term and furthermore to 2.7 ng/ml post-partum. Red cell folate levels in the iron supplemented
group similarly declined from an initial 202 ng/ml to 134 at full term and furthermore to 124.5 ng/ml post-partum whilst in the placebo group there was only a slight fall from 186.6 ng/ml initially to 171.3 ng/ml at full term and 172 ng/ml post-partum. Therefore, contrary to Chanarin, we observed a steeper decline of serum and also of red cell folate level in the iron supplemented group as compared to the placebo group. The pregnant women on placebo were obviously iron-deficient. Their mean serum iron level was low, but they did not show a steeper decline of serum and red cell folate levels. On the contrary, the iron-supplemented groups, whose mean serum iron was normal, presented a more pronounced fall of serum and especially of red cell folate level. Our findings are not in accordance with Chanarin’s view that iron deficiency produces an adverse effect on folic acid status. It appears that iron deficiency may conceal the extent of folate deficiency and that only when an adequate amount of iron is supplied will the blood folate truly reflect folic acid status.

Recently, Omer et al\(^\text{18}\) reported the results of a study of plasma and red cell folates in iron deficiency which is in general accord with our observations. They found that red cell folate levels were significantly higher in iron deficient subjects being 336 ng/ml packed cells as compared to 183 ng/ml in normal controls. Moreover, the higher red cell folate level in the iron deficient subjects declined significantly after treatment with oral iron. However, plasma folate levels were not higher in the iron deficient subjects and did not decline after oral iron but even showed a slight and unexplained increase.

Several other investigators have also studied this relationship between iron and folate metabolism. Velez et al\(^\text{19}\) reported 6 iron-deficient patients who had a megaloblastic marrow which reverted to normal after iron therapy. Vitale et al\(^\text{20}\) showed that iron deficient rats developed megaloblastoid erythropoiesis as well as increased excretion of FIGLU, decreased serum folate level and a decreased activity of the enzymes glutamate formimino transferase isolated from liver. They concluded that the derangement in folate metabolism is related to the decreased activity of formimino transferase, the optimal activity of which is dependent on iron. However, Burns and Spray\(^\text{21}\) were not able to demonstrate a reduced hepatic glutamate formimino transferase or reduced folate activity in the liver and serum of iron deficient rats.

Thus, it appears that conflicting results are being reported with regard to the influence of iron deficiency on the biochemical manifestations of deranged folate metabolism. Divergent results are being obtained by
Fig. 1. R.B.C. and Plasma Tritiated Folate activity in hemolyzed rat.
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Fig. 2

Fig. 2. R.B.C. and Plasma Tritiated Folate activity in hemolyzed rat and control.
different investigators as to whether serum folate and the liver enzyme glutamate formimino transferase are decreased or remain unaffected in iron deficiency. The studies done so far on tissue folate levels report a raised erythrocyte folate activity in iron deficiency whereas the liver folate remains unchanged. The differences observed are not readily explainable, and there will be those who cannot accept that iron deficiency influences folate metabolism. Yet I feel that there are enough stimulating facts uncovered to merit further examination of this possibility, which if proven would be of immense importance.

EXPERIMENTS ON THE FATE OF RED CELL FOLATE:

I shall now go on to report some observations with regard to the fate of folate in red cells. During our clinical trial of folic acid on pregnant women, it was observed that red cell folate levels in the folate supplemented group increased from the initial value of 201.8 ng/ml to 524.1 ng/ml at full term. They remained raised up to one month post-partum when last measured although therapy had been stopped after delivery. Perry and Chanarin12 have found similar persistently raised red cell folate values after folate administration. Very little or no folate enters mature red cells. Folate is believed to have become incorporated during erythropoiesis in the marrow and during the reticulocyte stage. Izak et al23 have shown that the mean red cell folate level, as determined by microbioassay, increases with reticulocytosis and falls concurrently with a fall in reticulocyte count. They inferred that the fall in L. casei activity which accompanies the fall in reticulocyte count may be due either to loss of folate from the cells or because of transformation into another form not detectable by microbioassay. Some observations made by us during experiments on the fate of red cell folate appear to shed some light on the question. We injected H3PGA into rats undergoing induced haemolysis and measured red cell radioactivity serially in a liquid scintillating counter. Preliminary results are shown in Figures 1 and 2. It may be seen that red cell radioactivity increased markedly with reticulocytosis. But unlike the result of microbioassay obtained by Izak et al23 red cell radio-activity did not decline concurrently with a fall in reticulocyte count. Assuming that red cell radioactivity measures folate, our results indicate that folate is not lost from red cells during maturation but remains locked in the cell till the end of their life-span.
REFERENCES

Recent developments in absorption and metabolism of retinoic acid

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The developments in the field of vitamin A research during the current century have been most fascinating indeed, although outwardly it may not seem so, when viewed against the present excitement in the areas of molecular biology etc. One of the most fascinating stories was the resolution of the confusion that arose regarding the relationship between the yellow colour of natural materials and their vitamin A potency. Thus, on the one hand, carotenes were coloured and were vitamin A active, while on the other hand, fish-liver oils were virtually colourless and yet were highly potent with respect to vitamin A activity. We all now recall how the genius of Paul Karrer and Richard Kuhn eventually resolved the confusion.

Since then there have been quite a few major developments in this field, the most important of them being the discovery of retinal in the eye by Wald, who has eventually worked out how retinal functions in the visual system.

There was yet another fascinating story in store and it was with respect to retinoic acid. This compound was synthesized long ago by the two Dutch chemists—van Dorp and Arens, who found that it could replace retinol in supporting growth of vitamin A-deficient rats. But, when they fed large amounts of this synthetic material to rats, they could find neither retinol nor retinal nor retinoic acid in the tissues of such rats. Out of sheer disappointment these two famous chemists forgot about this compound after publishing a short note in Nature. This preliminary information on the potentially explosive compound remained buried in the literature till 1953, when Moore made a provocative suggestion that, if retinoic acid cannot give rise to retinol or retinal, the visual system of vitamin A-deficient rats receiving this compound may not be normal. Indeed, soon Dowling and Wald proclaimed to the world that when rats are raised on a vitamin A-deficient diet supplemented with retinoic acid, they become blind.
In 1960, at the Karrer Symposium on vitamin A, which was organised by Roche at Burgenstock (Switzerland), after Wald presented his fascinating story on the visual system of rats receiving retinoic acid supplementation, the point was raised as to whether retinoic acid can meet the other physiological requirements like reproduction, etc. of animals. Soon after this, Morton's colleagues at Liverpool announced that both male and female rats receiving such supplements cannot reproduce normally. Independent work carried out almost simultaneously in my laboratory at Bangalore fully confirmed these findings. The story I wish to narrate here today is on several aspects of absorption and metabolism of retinoic acid that have been carried out by my colleagues in my laboratory at Bangalore.

**BIOGENESIS OF RETINOIC ACID:**

During all the excitement with the work on retinoic acid it was forgotten that this compound has never been found in any satisfactory amounts in nature and that all work was carried out with the synthetic material prepared by chemists. Now the question that arose was: if retinoic acid can sustain normal growth of rats, but at the same time cannot give rise to retinal or retinol, there should be proper machinery for constant generation of this compound from retinyl esters, because usually vitamin A is stored as retinyl esters. Chemically, the formation of retinoic acid from retinol involves stepwise oxidation with retinaldehyde as an intermediate.

During his work on vision, Wald had shown that the formation of retinaldehyde from the alcohol is catalyzed by an NAD-linked alcohol dehydrogenase. Soon after this, Dmitrovsky demonstrated enzymic oxidation of retinal to retinoic acid by a rat liver preparation, which was followed by our observation that rat liver contains two enzymes which can successively oxidise retinol to retinal and retinal to retinoic acid. Both enzyme systems were present in the 100,000 x g. supernatant fraction of rat liver homogenate and could be separated from each other by ammonium sulphate fractionation. Thus 0-45% (NH₄)₂SO₄ saturation precipitated retinal oxidase, while the retinol dehydrogenase was precipitated at 45-70% saturation. The retinal oxidase did not reveal any requirements for pyridine nucleotides, and like aldehyde oxidase and xanthine oxidase, it proved to be a molybdoflavoprotein. The retinol dehydrogenase, on the other hand, was an NAD-linked enzyme. These results were later extended by Lakshmanan et al, who showed the presence of similar enzymatic activities in pig and chicken liver.

However, liver is not the only tissue in the rat that is capable of oxidising
retinal to retinoic acid, because it was shown by us that the small intestine of rats readily catalyses this reaction under both in vivo and in vitro conditions. Thus, when Deshmukh et al. injected retinal intracardially into rats, large amounts of retinoic acid appeared in the liver, intestine and blood within 5 min. after injection of retinal, and also after incubating everted intestinal sacs of rats with retinal, they found large amounts of the acid in the medium as well as in the sac.

More recently Crain et al. have shown the formation of retinoic acid from \( \beta \)-carotene-\(^{14}C \) and retinal-\(^{14}C \) in the intestinal mucosa of rats. Besides liver and intestine other tissues such as spleen, kidney and lungs of rats also seem to oxidise retinal to retinoic acid.

**Absorption of Retinoic Acid:**

As already stated, van Dorp and Arens, found no retinoic acid in rats receiving this compound, which led them to conclude that it was not absorbed by rats. Later work of Wald supported this conclusion. In retrospect, it does appear interesting that we all accepted the opinion that retinoic acid is not absorbed by the rat, even though we all know that vitamin A-deficient rats receiving supplements of the acid grow normally. The first definitive evidence that retinoic acid is absorbed by rats came from our laboratory during our work on the biopotency of the acid. It was observed by Malathi et al. that vitamin A-deficient rats maintained a normal growth rate for almost four weeks following a single dose of 500 \( \mu \)g of retinoic acid. Soon after this, Deshmukh et al. found definite amounts of retinoic acid in several tissues of rats within a short period of administration of a massive dose of the acid as its sodium salt in buffer. However, the acid could not be detected in the tissues of rats 12 hr. after the dose.

In the meantime, in an extensive series of investigations, Olson and his colleagues demonstrated that, when \(^{14}C \)-labelled retinal or retinoic acid is injected intraportally or intravenously into rats, guinea pigs or chicks, retinyl glucuronides rapidly appear in the bile. Therefore, it began to become clear that while retinoic acid is rapidly absorbed, it is immediately excreted through the bile.

At about this time I had an opportunity of collaborating with Prof. DeWitt S. Goodman at Columbia University on the route of absorption of different vitamin A derivatives. In these experiments lymph and bile cannulae were established into a rat, whose normal bile supply was constantly
replenished by the bile flowing through a bile cannula from a donor rat. When such a rat was orally given \(^{14}C\)-labelled retinal, retinol or retinoic acid, in all cases, about 50\% of the fed radioactivity was recovered in the lymph within the first 24 hr. When retinal was fed, 70-80\% of the recovered radioactivity was found in the lymph, with the rest in the bile. On the other hand, when retinoic acid was fed, there was virtually no radioactivity in the lymph, while 95\% of the recovered radioactivity appeared in the bile. Analysis of the compounds in the lymph and bile revealed that most of the radioactivity in the bile was associated with retinoic acid and its derivatives, while that in the lymph was with retinol and its esters. It was thus demonstrated that retinoic acid is rapidly absorbed through the portal route and is quickly excreted through the bile.

It is now possible to explain as to why earlier workers had failed to detect the acid in rats, which had led to the general belief that it is not absorbed by rats. It is possible that in these early investigations attempts were not made to detect the acid immediately after a dose and that by the time analysis was started, it was excreted through the bile. Moreover, the amount of the acid present in the tissues was too low for detection by the then available methods. In this context it is interesting to recall that, when Morgan and Thompson\(^{13}\) gave 6\(\mu\)g of 6, 7-\(^{14}C\) retinoic acid to rats, even after 15 hr, they could find extremely small amounts of the acid (1-10 \(\mu\)g) in the liver, small intestine, kidney and seminal vesicles.

RETINOIC ACID AND REPRODUCTION:

Earlier classical nutritional work had repeatedly demonstrated that vitamin A-deficient rats fail to reproduce. But vitamin A deficiency leads to such widespread effects in many tissues of animals that it was difficult to pinpoint as to whether this failure of reproduction was directly due to vitamin A deficiency or was caused by secondary effects of this deficiency. The interesting point about the retinoic acid-fed rats is that they appear normal and healthy and therefore the effects found in such rats should more directly reflect the involvement of vitamin A in reproductive processes in both sexes.

As already indicated, work from both Liverpool and Bangalore showed that when weanling male rats are raised on a vitamin A-deficient diet supplemented with retinoic acid they grow normally, but their testes do not develop and they prove to be sterile when mated with normal females. Females treated similarly on the other hand, maintain normal oestrous cycle and conceive when mated with normal males, but the pregnancy is terminated by resorption starting from day 14 of gestation.
Extensive histological work from Liverpool has shown that the testes of such rats are small and oedematous and contain degenerative tubules, which show sloughing of the cells of the germinal epithelium. In such rats spermatogenesis stops, although some spermatogonia and occasionally a few spermatocytes persist for a long time. Attempts at correcting these lesions through hormonal therapy by injections of progesterone, pregnenolone and testosterone have not been successful. It is most interesting that, in these males, the seminiferous tubules of the testes alone degenerate, while other epithelial cells seemingly grow and function normally.

Similar histological examinations of the acid-fed females by the same workers did not reveal any marked changes in any of the reproductive organs. The only notable change observed by them was the appearance of necrosis in the placental discs on the 15th day of gestation and their attempts to prevent the resorption by administration of progesterone and estrone were unsuccessful.

Our observations at Bangalore were in general agreement with those of the Liverpool workers regarding resorption in such female rats. In addition, Juneja found that in these rats the ovulation index, as determined by the number of implantation sites, is comparable to those in the normal females, and he partially succeeded in preventing the gestation-resorption by daily administration of progesterone, while pregnenolone and estradiol-17β were fully effective in this regard.

Juneja could not only prevent resorption by hormonal therapy, but he was also able to demonstrate rather convincingly that the ovaries of such rats do not function normally. This conclusion of Juneja was based on several observations, which were as follows: (1) Injections of FSH, LH, HCG or extracts of whole pituitaries of normal rats uniformly failed to prevent resorption in the retinolate-fed rats. (2) When groups of regularly cycling retinyl acetate and retinolate-fed rats were subjected to compensatory hypertrophy, following unilateral ovariectomy, the per cent hypertrophy, in the retinolate-fed rats was markedly less. (3) No difference could be found in the levels of gonadotropins in the pituitary and plasma of the animals belonging to both groups.

During the same investigations Juneja produced further evidence by enzymological means, which substantiated his conclusions regarding such defects in the ovaries of the retinolate-fed rats, and for this purpose he studied the ovarian Δ\(^{3}\) 3β-ol steroid dehydrogenase, which is a key enzyme in steroidogenesis.
Retinoic acid — Absorption and metabolism

It was clearly demonstrated by him that while the activity of this enzyme increases in both retinyl acetate and retinoate-fed rats during compensatory hypertrophy following unilateral ovariectomy, the increase is markedly less in the retinoate-fed group. He also showed that the activities of this enzyme are comparable in the non-pregnant rats of both groups. However, during pregnancy, while it increased in both groups the increase was markedly higher in the retinyl acetate-fed rats. He therefore concluded, "It therefore seems probable that there are small differences in the functioning of these ovaries that are not perceptible under normal conditions, but become significant under stress conditions, such as pregnancy and compensatory hypertrophy".

These conclusions of Juneja have been fully substantiated by a very recent collaborative work between myself and the National Institute for Research in Dairying at Reading (UK). In this work the ovarian vein was cannulated in the pregnant rats fed retinyl acetate or retinoic acid, and blood was collected at various stages of gestation, after which the rates of secretion of progesterone and 20-hydroxy progesterone in the ovarian vein blood were determined. In both groups, although there were marked increases in the secretion rates of the two steroids as pregnancy advanced, the secretion rates were always about one-third less in the acid-fed rats.

Ever since an absolute requirement of vitamin A for proper growth and nutrition of animals was well established, heroic attempts were constantly made by many workers for finding its mode(s) of action and Wald's work has clearly defined one such area, viz. vision. Regarding other areas, attempts have been made by several workers over a period of years to find possible defects in physiology or in enzyme systems during vitamin A deficiency in animals, and during the past several years my laboratory also has been quite active in this respect. In all this work several enzyme systems were found to be affected by vitamin A deficiency. However, more recently the question has been raised that these effects may not be due directly to vitamin A-deficiency, but could be due to some secondary effects brought about by the deficiency. In this context, sustained work of Grangaud and his colleagues carried out over a period of years on the effects of steroid therapy in the vitamin A-deficient male and female rats deserves special mention. I think that they have produced sufficient evidence both in vitro and in vivo to prove that the step in the conversion of pregnenolone to progesterone is affected in the vitamin A-deficient rats. Juneja et al. also came to the same conclusion with vitamin A-deficient rats. The question of such indirect effects should however not arise in the case
of the retinol-fed rats, because these animals are virtually normal and do not suffer from the pathological damages usually found in the vitamin A-deficient animals. Therefore, by using such rats further information has now been obtained which has indicated that retinol is required for the normal functioning of at least one of the enzymes (\Delta^1 3\beta - ol steroid dehydrogenase) involved in steroidogenesis in rat ovary. This work has thus pinpointed at least one of the sites of action of retinol, which may eventually lead to the understanding of the mode of action of retinol.

ACKNOWLEDGMENT:

We wish to thank the Indian Council of Medical Research, New Delhi, for sustained and generous support of our work since 1955. Since 1965, our work is being partially financed by a PL-480 Project No. 314305 from the National Institute of Health, U.S.A. We are also grateful to the Rockefeller Foundation, New York, and the Wellcome Trust, London, for grants for equipment.

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Evaluation of nutritional status can be done by (1) physical examination of the subject; (2) dietary history; and (3) biochemical tests. In the development of a deficiency disease biochemical lesions precede pathological lesions. Hence, sensitive biochemical tests are of value in predicting deficiency at the sub-clinical stage.

Table 1 summarizes the methods which are at present available for biochemical assessment of some B-complex vitamins.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical evaluation of nutritional status of vitamin B₁, B₂ and B₄</td>
</tr>
</tbody>
</table>

(A) Vitamin levels in fluids and tissues:

- **Urine**
  - Basal excretion
  - Load test

- **Blood**
  - Whole blood
  - Serum
  - RBC, WBC

(B) Functional evaluation

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Enzymatic test</th>
<th>Metabolic test</th>
</tr>
</thead>
<tbody>
<tr>
<td>B₁</td>
<td>Erythrocyte transketolase</td>
<td>Glucose load test</td>
</tr>
<tr>
<td>B₂</td>
<td>Erythrocyte glutathione reductase</td>
<td></td>
</tr>
<tr>
<td>B₄</td>
<td>BGOT, EGP</td>
<td>Tryptophan load test</td>
</tr>
</tbody>
</table>
Urinary excretion is affected by a number of factors, especially immediate dietary intake. Hence, it is useful only for population surveys and not for individual assessment. Urinary excretion after a test dose of the vitamin is perhaps a better index of the state of the tissues.

Blood levels have been used by different workers with varying degrees of confidence. In case of riboflavin, it is still the most well accepted index.

Functional tests based on the adequacy of a vitamin at the cellular level to carry out a biochemical or physiological function are gaining popularity. Evaluation of this type can be done either by assaying the activity of an enzyme which requires the vitamin as a co-factor or by measuring the accumulation of a metabolite as a result of enzymatic lesion(s).

For an enzyme to serve as a biochemical tool, it should be present in blood cells and its Km for the vitamin should be high so that it gets depressed during early stages of deficiency. Both these criteria are met by the enzyme transketolase for thiamine, glutathione reductase for riboflavin and transaminases for pyridoxine. An ideal enzymatic test should be unaffected by factors other than the vitamin, but such an ideal is never achieved and hence to differentiate between enzymatic lesion due to vitamin deficiency and those from non-specific sources, an in vitro test consisting of stimulation of enzyme activity in the presence of saturating amounts of the co-enzyme has been suggested. However, these in vitro tests assume that only levels of co-enzymes fall during deficiency whereas apoenzyme levels remain unchanged. We have found that in thiamine deficiency, there is actual or functional loss of even the apoenzyme transketolase and hence this in vitro stimulation test is not very reliable.

THIAMINE:

Till sometime ago beri-beri used to be frequently seen amongst certain population groups in India. The disease has almost disappeared but milder forms of thiamine deficiency may still exist. An investigation was, therefore, taken up to evaluate the relative merits of the conventionally used parameter of urinary excretion and the more sophisticated transketolase assay for the assessment of thiamine nutritional status and requirement of Indians.

In a cross-sectional study on 65 subjects, urinary excretion before and after thiamine load and RBC-transketolase activity were measured. A direct correlation between any of these biochemical parameters or between
biochemical findings and clinical findings such as peripheral neuritis was not apparent. Results of this cross-sectional study set out in Table 2 also suggest that the biochemical evidence of thiamine deficiency was not frequent in the subjects studied.

To find an explanation for the inconsistencies seen in the cross-sectional study, a controlled longitudinal experiment on human volunteers was planned, wherein the effects of dietary thiamine depletion and step-wise dietary restoration on transketolase activity and urinary excretion were studied. Results of this experiment are set out in Fig. 1 and Table 3.

Both transketolase activity and urinary excretion were sensitive to small changes in dietary thiamine. The enzyme activity began to plateau with thiamine intake of 0.2—0.3 mg/100 cal., and at that level urinary excretion began to increase linearly. From these data, it would appear that the minimum requirement of thiamine is around 0.3 mg/1000 Cals.

Urinary excretion of these subjects was throughout very much higher than the values reported in literature for corresponding dietary intake (Fig. 1).
### TABLE 2

Transketolase activity and urinary excretion of thiamine of various groups under basal conditions

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Transketolase activity ug sedohexulose/ml RBC/30 min.</th>
<th>TPP effect % stimulation</th>
<th>Urinary thiamine in two hour sample ug/g creat.</th>
<th>Load return in four hours ug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal men</td>
<td>12</td>
<td>870</td>
<td>13</td>
<td>114</td>
<td>342</td>
</tr>
<tr>
<td>Normal women</td>
<td>14</td>
<td>770</td>
<td>13</td>
<td>294</td>
<td>223</td>
</tr>
<tr>
<td>Men with signs of B-complex vitamin deficiency</td>
<td>23</td>
<td>830</td>
<td>14</td>
<td>151</td>
<td>146</td>
</tr>
<tr>
<td>Pregnant women with signs of B-complex vitamin deficiency</td>
<td>16</td>
<td>610</td>
<td>19</td>
<td>384</td>
<td>159</td>
</tr>
</tbody>
</table>

Assessment - Thiamine and Riboflavine status
Data on transketolase activity clearly show that in the earlier stages of deficiency, enzyme activity can be stimulated to the original level with in vitro addition of TPP showing "TPP effect" but later this effect is not seen, indicating a lack of apoenzyme transketolase or inability of the apoenzyme to combine with the added coenzyme.

TABLE 3

<table>
<thead>
<tr>
<th>Dietary thiamine mg/1000 calories</th>
<th>Transketolase activity ug Sed./ml RBC/30 min.</th>
<th>% Stimulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-TPP (700-900)</td>
<td>+TPP (770-940)</td>
</tr>
<tr>
<td>Initial</td>
<td>785</td>
<td>860</td>
</tr>
<tr>
<td>0.1</td>
<td>472</td>
<td>570</td>
</tr>
<tr>
<td>0.2</td>
<td>672</td>
<td>860</td>
</tr>
<tr>
<td>0.4</td>
<td>810</td>
<td>970</td>
</tr>
</tbody>
</table>

RIBOFLAVIN:

Incidence of riboflavin deficiency as judged by the prevalence of oral lesions such as angular stomatitis, glossitis and nasolabial dyssebacea is very high in all segments of Indians.

Till a year ago, a sensitive enzymatic test for the evaluation of riboflavin status (similar to the transketolase assay for thiamine) was not available. Last year, it was reported by us and two other groups that the enzyme glutathione reductase of red blood cells, which has FAD as a co-factor, is sensitive to dietary riboflavin. We arrived at this conclusion from the results of a cross-sectional study as well as a controlled longitudinal study on human volunteers. Data on the cross-sectional study is set out in Table 4.

The glutathione reductase activity as well as RBC riboflavin levels of the subjects with oral lesions were significantly lower than those of the apparently
## TABLE 4

Biochemical evaluation of riboflavin status

<table>
<thead>
<tr>
<th>Clinical picture</th>
<th>No.</th>
<th>Erythrocyte glutathione reductase (units)*</th>
<th>FAD-effect stimulation %</th>
<th>RBC riboflavin ug/100 ml</th>
<th>Urinary riboflavin ug/g creatinine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>16</td>
<td>8.58—0.4164</td>
<td>29.14—7.0972</td>
<td>31.63—2.16</td>
<td>432.0—116.57</td>
</tr>
<tr>
<td>Deficient B.T.</td>
<td>11</td>
<td>5.03—0.4472</td>
<td>102.00—36.8089</td>
<td>22.82—1.957</td>
<td>194.2—39.58</td>
</tr>
<tr>
<td>A.T.</td>
<td>10</td>
<td>9.02—0.4107</td>
<td>11.89—5.7039</td>
<td>34.10—3.0018</td>
<td></td>
</tr>
</tbody>
</table>

*mg. reduced glutathione formed/ml RBC/15 min. in 0.5 ml incubation mixture.

B.T.—Before Treatment
healthy subjects. Both the parameters improved after treatment with 5-10 mg riboflavin for 7 days. There was marked in vitro stimulation of the enzyme with FAD in case of the deficient subjects. Urinary excretion of riboflavin showed such a wide scatter that the averages were not significantly different.

In nature one always encounters complex deficiency of nutrients. Hence to prove the point that the depression in glutathione reductase activity of patients was due to riboflavin deficiency, a longitudinal study was carried out. The design was similar to the earlier study on thiamine except that the limit-
ing nutrient in this case was riboflavin. Results are set out in Table 5 and Figure 2.

**TABLE 5**

<table>
<thead>
<tr>
<th>Riboflavin mg/1000 Cal.</th>
<th>Days</th>
<th>EGR (units)</th>
<th>FAD-effect (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>0</td>
<td>8.07</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.4-9.6)</td>
<td>(8.63)</td>
</tr>
<tr>
<td>0.3</td>
<td>7</td>
<td>7.5</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.5-9.2)</td>
<td>(55-74)</td>
</tr>
<tr>
<td>0.3</td>
<td>14</td>
<td>6.3</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.6-7.0)</td>
<td>(55-64)</td>
</tr>
<tr>
<td>0.3</td>
<td>17</td>
<td>6.1</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.0-6.2)</td>
<td>(23-60)</td>
</tr>
<tr>
<td>0.4</td>
<td>7</td>
<td>7.5</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.7-8.4)</td>
<td>(24-64)</td>
</tr>
<tr>
<td>0.5</td>
<td>7</td>
<td>9.5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8.8-9.9)</td>
<td>(19-25)</td>
</tr>
<tr>
<td>0.6</td>
<td>7</td>
<td>9.3</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9.9-10.4)</td>
<td>(523)</td>
</tr>
</tbody>
</table>

Enzyme activity diminished on the low riboflavin diet (0.3 mg/1000 Cals) and increased after treatment with riboflavin. *In vitro* stimulation of enzyme activity ("FAD-effect") was significantly high at intakes lower than 0.5 mg/1000 Cals.

Urinary excretion also followed dietary riboflavin. Changes in RBC riboflavin levels, however, were not as clear cut. This finding is surprising since enzyme activity would depend on the FAD content of the cell and most of the RBC riboflavin is believed to occur as FAD. It is possible that as deficiency progresses, the ratio of free riboflavin + FMN/FAD increases.

Although the results reported here clearly show that RBC glutathione reductase is sensitive to riboflavin nutritional status, its practical usefulness for nutritional assessment can only be judged after more information is available about the usefulness of other dietary factors and diseases on its activity. There are reports that deficiencies of vitamin C and folic acid also alter the activity of this enzyme.
Reduced glutathione levels of RBC are maintained through the activity of two enzymes—Glutathione reductase and glucose-6P-dehydrogenase (G6PD):

\[
\begin{align*}
G6PD & \quad G6P + NADP \rightarrow 6-P-gluconic acid + NADPH \\
\text{Glutathione reductase} & \quad GSSG + NADPH \rightarrow GSH + NADP
\end{align*}
\]

Subjects suffering from G6PD deficiency get acute haemolytic anaemia when exposed to certain oxidant drugs like sulfanilamide and the antimalarial premaquin. This is attributed to a sudden fall in RBC-GSH due to G6PD deficiency. We were interested to know if the glutathione reductase deficiency seen in riboflavin deficiency was critical enough to interfere with the cell’s ability to generate reduced glutathione, in the presence of an oxidant stress. If the enzyme deficiency in ariboflavinosis is critical, riboflavin deficient subjects would be expected to behave to some extent like G6PD deficient subjects.

To test this probability, “GSH stability test”, as described by Beutler, was carried out on healthy and riboflavin deficient subjects. In this test, blood is incubated in vitro for two hours with acetylphenylhydrazine and the fall in reduced glutathione levels at the end of this period measured. In the case of healthy subjects where GSH generating machinery is efficient, GSH levels remain almost unaltered, whereas G6PD deficient subjects show a marked fall.

We found that many apparently healthy subjects also showed slight impairment of GSH generating ability. This got corrected on treatment with riboflavin. However, subjects with clinical evidence of riboflavin deficiency and very low levels of glutathione reductase activity showed unusually good ability to maintain GSH levels in the presence of the drug (Table 6). To us, such a finding indicates the presence of some compensating mechanism which helps the cell to overcome glutathione reductase deficiency. This regulatory mechanism may be absent in cases of marginal deficiency but coming into operation in severe forms of deficiency.
### TABLE 6

Erythrocyte GSH, GSH stability, GSH reductase and G6PD in healthy and Riboflavin deficient subjects before and after treatment with riboflavin.

<table>
<thead>
<tr>
<th></th>
<th>Normal subjects</th>
<th></th>
<th>Deficient subjects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>BT</td>
<td>AT</td>
<td>No.</td>
</tr>
<tr>
<td>GSH mg/100 mL RBC</td>
<td>33</td>
<td>58.29—-3.90</td>
<td>58.27—-0.83</td>
<td>22</td>
</tr>
<tr>
<td>GSH stability (Recovery after incubation with APH %)</td>
<td>33</td>
<td>75.72—-2.10</td>
<td>86.18—-2.4</td>
<td>22</td>
</tr>
<tr>
<td>APH %)</td>
<td>*P &lt; 0.001</td>
<td>*P &lt; 0.01</td>
<td>6.90—-2.367</td>
<td>14</td>
</tr>
<tr>
<td>GSH reductase units</td>
<td>13</td>
<td>5.68—-0.110</td>
<td>14</td>
<td>2.57—-0.33</td>
</tr>
<tr>
<td>GAS FAD effect % units</td>
<td>13</td>
<td>32.73—-6.2</td>
<td>7.3 —-3.2</td>
<td>14</td>
</tr>
<tr>
<td>G6PD Units/g Hb.</td>
<td>13</td>
<td>6.9 —0.465</td>
<td>6.51—-3.448</td>
<td>10</td>
</tr>
</tbody>
</table>

APH — Acetyl phenylhydrazine
BT — Before treatment
AT — After treatment with riboflavin
*—test done on difference before and after treatment with riboflavin
**—P 0.001 as compared to normal subjects before treatment.
At present we do not know the exact nature of the regulatory mechanism, but three possibilities have been investigated:

1. Increased availability of the reductant NADPH by alteration of G6PD activity.

2. Increased affinity of the reductant NADPH for the enzyme glutathione reductase. This would facilitate faster turnover.

3. Decreased rate of oxidation of GSH by the drug.

Data on G6PD activity, set out in Table 6 show that this enzyme is not affected by riboflavin deficiency. In G6PD deficiency, increased glutathione reductase activity has been reported.

Affinity of glutathione reductase for NADPH in healthy and deficient subjects is similar. Thus ruling out the second possibility (Fig. 3).
Destruction of GSH by the drug acetylphenylhydrazine can precede even with boiled blood, or RBC haemolysate (Table 7). Thus, it is a non-enzymatic process and regulation at that site is not likely.

### Table 7

<table>
<thead>
<tr>
<th>Additions</th>
<th>Duration of incubation</th>
<th>GSH ug/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSH in water</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>GSH in water + APH</td>
<td>2 hr.</td>
<td>98</td>
</tr>
<tr>
<td>Haemolysate</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>Haemolysate + APH</td>
<td>2 hr.</td>
<td>60</td>
</tr>
<tr>
<td>Boiled haemolysate</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td>Boiled haemolysate + APH</td>
<td>2 hr.</td>
<td>20</td>
</tr>
<tr>
<td>Boiled haemolysate</td>
<td>2 hr.</td>
<td>0</td>
</tr>
</tbody>
</table>

APH = Acetylphenylhydrazine

Recently Srivastava and Beutler\(^1\) reported that glutathione reductase can catalyse release of glutathione bound to haemoglobin as shown in the following scheme:

\[
\text{GSSG + NADPH} \xrightarrow{\text{GR}} \text{GSH} + \text{NADP}
\]

\[
\text{APH} \quad \text{GR} \quad \text{O}_2
\]

\[
\text{GSH} + \text{Hb} \xrightarrow{\text{GR}} \text{Hb} - \text{GSH}
\]

GSH tends to bind to haemoglobin in the presence of an oxidant stress.

If this is the case, then in glutathione reductase deficiency as a result of riboflavin deficiency, more GSH will remain bound to haemoglobin and perhaps not made available for drug action. However, since the procedure involved in estimating blood GSH is not likely to estimate GSH bound to haemoglobin, if it is a disulphide bond, even this possibility is a moot point.
Our findings agree with the recent observation of Beutler and Srivastava that the life span of erythrocytes of riboflavin deficient rats in the presence of an oxidant drug is same as that of control animals. But, it does not support the report of Carson et al that drug sensitivity and lower erythrocyte life span were observed in a patient whose GSH reductase level was 57% of normal. Many of our riboflavin deficient subjects showed levels less than 30% of normal.

RIBOFLAVIN AND PYRIDOXINE INTER-RELATIONSHIP:

I have so far been saying that oral lesions such as angular stomatitis and glossitis are due to riboflavin deficiency and they respond to that vitamin. However, it has been observed in our Institute that sometimes these lesions are refractory to riboflavin alone and need B-complex vitamin for healing. More recently Dr. Leela Iyengar from our Institute observed that oral lesions, commonly seen in pregnant women, responded to pyridoxine very well (Table 8).

TABLE 8
Clinical response of oral lesions to vitamin B₆ and B₂

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose</th>
<th>Duration</th>
<th>Number treated</th>
<th>Number responded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B₂</td>
<td>5-10 mg</td>
<td>10 days</td>
<td>32</td>
<td>21</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>5-10 mg</td>
<td>10 days</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Vitamin B₂ followed by B₆</td>
<td>5-10 mg</td>
<td>10 days</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total No. 56</td>
</tr>
</tbody>
</table>

Leela Iyengar—Unpublished observations

Out of 32 subjects treated with riboflavin only 21 responded clinically, though they had low levels of glutathione reductase indicating riboflavin deficiency. The remaining eleven responded to pyridoxine. On the other hand, 24 subjects in whom treatment was initiated with pyridoxine the clinical response was good.
Data in Table 9 shows the effects of pyridoxine on RBC riboflavin, glutathione reductase and urinary riboflavin. Glutathione reductase activity which was initially very low in these subjects, did not record any change after pyridoxine but riboflavin levels dropped, indicating greater utilization of riboflavin when pyridoxine is administered.

**TABLE 9** 
Effect of pyridoxine treatment on RBC glutathione reductase, RBC-riboflavin and urinary riboflavin levels

<table>
<thead>
<tr>
<th>No.</th>
<th>RBC GSH-reductase units</th>
<th>RBC riboflavin ug/100 ml.</th>
<th>Urinary riboflavin ug/g creat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Before treatment</td>
<td>10</td>
<td>3.95 ± 0.23</td>
<td>27.8 ± 4.53</td>
</tr>
<tr>
<td>2. After treatment</td>
<td>10</td>
<td>4.44 ± 0.23</td>
<td><strong>16.7 ± 2.31</strong></td>
</tr>
</tbody>
</table>

---

A close biochemical inter-relationship between riboflavin and pyridoxine is well known. Formation of pyridoxal phosphate from pyridoxine is catalysed by pyridoxine-phosphate oxidase which is a flavoprotein requiring FMN as shown in the following diagram:

Pyridoxine → Pyridoxal → Pyridoxal Phosphate

Pyridoxal Phosphate → Pyridoxamine

Further, it has been shown that pyridoxine-phosphate oxidase is more active than pyridoxine oxidase. If this is the case, then it is reasonable to expect...
secondary deficiency of pyridoxine in the presence of riboflavin deficiency. It is possible that the common biochemical denominator for the oral lesions is deficiency of pyridoxal phosphate either due to dietary deficiency of pyridoxine per se or conditioned by riboflavin deficiency, or both. Depending on the dietary history or the exact nature of the bottleneck, the condition will respond to either or both these vitamins.

It has been shown in experimental animals that in riboflavin deficiency, pyridoxal phosphate levels of livers are low. Increased xanthurenic acid excretion following tryptophan load has also been reported in riboflavin deficiency.

Before concluding, I would like to comment about the lack of correlation between biochemical and clinical findings, often observed in cross-sectional studies. As mentioned earlier, biochemical lesions precede clinical lesions as disease sets in. Again, during recovery, biochemistry gets corrected before pathology. In a cross-sectional study, one can find an individual at any point in this spectrum. A subject with biochemical evidence but not the clinical evidence can be taken as suffering from sub-clinical deficiency. On the other hand a subject with clinical lesion without biochemical evidence may be recovering after a bout of deficiency.
STUDIES ON RIBOFLAVIN

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Institute of Biochemistry
Faculty of Medicine, University of Nagoya
Nagoya, Japan

Although the nutritional importance of riboflavin needs no further emphasis, it must still be stressed that care should not be spared in preventing human beings from any cause that may result in riboflavinosis, since the possibility of the occurrence of such a stance, owing to the continuous modification of circumstances surrounding us, cannot be ruled out. Ariboflavinosis-like disease caused by the administration of some antibiotics may be a good example of this problem. From the positive angle, on the other hand, attempts to promote the better utilization of naturally occurring essential nutrients such as vitamins should always be made by researchers in the field of nutrition. The chemical synthesis of fat-soluble riboflavin derivatives is one such attempt. Our recent results on these topics are presented in this symposium.

EFFECT OF CHLORTETRACYCLINE ON CAUSING DEFICIENCY OF RIBOFLAVIN:

Several clinical reports had suggested the association of ariboavlinosis-like disease with the administration of chlorotetracycline. A systematic study was, therefore, made using male albino rats of Wistar strain.

Nutritional experiments: Rats were divided into 7 groups, consisting of 5 animals each. Six of them were administered compulsorily riboflavin and/or chlorotetracycline solution at a definite time every day as shown in Table 1. The growth curves of all the 7 experimental groups are represented in Fig. 1.

The animals fed on riboflavin-deficient diet (group a) showed no growth (Fig. 1-a), and after 20 days displayed characteristic symptoms of ariboavlinosis. However, when animals were administered 10 μg of riboflavin per day (group b), normal weight gain (about 2 g per day) was observed as shown in Fig. 1-b. Symptoms of ariboavlinosis were never observed. On the other hand, the animals administered 5 mg of chlorotetracycline and no riboflavin (group c) showed no growth (Fig. 1-c) and became severe victims
of ariboflavinosis within 8-10 days of the administration. The intensity of ariboflavinosis symptoms was more serious in a shorter period of time than that in the animals fed riboflavin-deficient diet. This suggests that riboflavin deficiency is aggravated by administering the antibiotic. It should be noted here that the growth rate of animals given 10 μg of riboflavin per day (which is usually enough for the rat) considerably fell down when they were administered simultaneously 10 mg of chlortetracycline (Fig. 1-g). Their growth rate was interdependent on the relative amount of riboflavin added to the chlortetracycline administered (Fig. 1-d-g). Rats given 2 μg riboflavin and 5 mg of chlortetracycline showed nearly the same growth as those given 5 μg of riboflavin and 10 mg of chlortetracycline.

### TABLE 1
Dosages of Chlortetracycline and Riboflavin

<table>
<thead>
<tr>
<th>Experimental group</th>
<th>Chlortetracycline (mg/day)</th>
<th>Riboflavin (μg/24h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>c</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>e</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>f</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>g</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Basal diet is essentially the same as that of Folker and Morgan except that riboflavin was eliminated. Water and basal diet were given freely. All animals were housed in individual cages in a room maintained at 23°C. The growth rate of animals was measured by taking the body weight every noon.

As shown in Table 2, weights of the liver and kidney of animals fed on riboflavin-deficient diet were as low as 60 percent of those fed on complete diet. The organs of rats, suffering from enhanced riboflavin deficiency caused by the administration of chlortetracycline, were found to be much smaller. The growth of organs appeared to be promoted by simultaneous administration of riboflavin.

After 30 days of rearing, the flavin contents of the liver and kidney were measured. As can be seen from Table 3, total flavin levels in the liver and
Fig. 1. Change in body weight of each experimental group. Each plot of curves 1-g represents the mathematical mean of body weights of animals of groups a-g, respectively. In group c, 2 of 5 animals died at 24th and 25th day of the administration of chlortetracycline, respectively. After these days, the mathematical mean of body weights was calculated from the weights of surviving animals.

Kidney of rats fed on riboflavin-deficient diet (group a) are lower than those of rats fed on the complete diet (group b). This tendency was further enhanced by administering the antibiotic (group c). By increasing the dose of riboflavin administered simultaneously, flavin contents of the organs increased correspondingly (group d-g). Even in the case of rats administered 10 mg of chlortetracycline, flavin contents of the organs approached the level of the standard group, when they were simultaneously
given 10 μg of riboflavin. Free riboflavin, FMN and FAD contents of the organs are also listed in Table 3. In the animals administered chlortetracycline,

TABLE 2
Wcights of the Liver and Kidney after the Administration of Chlortetracycline and Riboflavin

<table>
<thead>
<tr>
<th>Experimental group</th>
<th>Liver</th>
<th>Kidney</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4.9</td>
<td>0.8</td>
</tr>
<tr>
<td>b</td>
<td>7.8</td>
<td>1.5</td>
</tr>
<tr>
<td>c</td>
<td>4.7</td>
<td>0.7</td>
</tr>
<tr>
<td>d</td>
<td>4.9</td>
<td>0.7</td>
</tr>
<tr>
<td>e</td>
<td>5.2</td>
<td>0.9</td>
</tr>
<tr>
<td>f</td>
<td>5.2</td>
<td>1.1</td>
</tr>
<tr>
<td>g</td>
<td>5.4</td>
<td>1.1</td>
</tr>
</tbody>
</table>

(mathematical mean, n=5)

TABLE 3
Flavin Content of the Liver and Kidney of Rats after the Administration of Chlortetracycline and Riboflavin

<table>
<thead>
<tr>
<th>Experimental group</th>
<th>Organ</th>
<th>Total flavin content</th>
<th>FAD *</th>
<th>%</th>
<th>FMN *</th>
<th>%</th>
<th>Riboflavin</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Liver</td>
<td>18.1 10.1 55.8</td>
<td>6.8 37.6 1.2 6.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>25.6 12.5 48.8</td>
<td>11.5 44.9 1.6 6.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>Liver</td>
<td>32.7 23.7 72.5</td>
<td>7.6 23.2 1.4 4.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>36.7 21.1 57.5</td>
<td>14.8 40.3 0.8 2.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>Liver</td>
<td>16.1 10.7 66.5</td>
<td>4.3 26.7 1.1 6.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>24.2 11.9 49.2</td>
<td>10.9 45.0 1.4 5.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Liver</td>
<td>25.5 13.1 51.4</td>
<td>9.6 37.6 2.8 11.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>27.9 13.7 49.1</td>
<td>12.6 45.2 1.6 5.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>Liver</td>
<td>17.0 10.8 63.6</td>
<td>5.7 33.5 0.5 2.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>26.0 13.5 53.9</td>
<td>10.4 40.0 2.1 8.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>Liver</td>
<td>28.1 16.6 59.0</td>
<td>8.7 31.0 2.8 10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>32.7 13.7 42.9</td>
<td>18.5 56.6 0.5 1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>Liver</td>
<td>31.1 19.9 64.0</td>
<td>8.1 26.0 3.1 10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>35.0 18.9 54.0</td>
<td>15.0 42.9 1.1 3.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Concentration is expressed in terms of riboflavin.
FAD concentrations were markedly decreased in these two organs, but this decrease could be prevented by simultaneous administration of riboflavin. It should be mentioned here that analytical data of flavins in the organs of these experimental groups were in good accord with the weights of organs.

All the results of the growth curves, weights of the liver and kidney and flavin concentration in these organs could be interpreted to indicate an apparent antagonistic action between riboflavin and chlortetracycline.

**Complex Formation of Chlortetracycline with flavins as a possible cause of ariboflavinosis**: Assuming that the biological significance of riboflavin is chiefly ascribed to the coenzyme action of the flavin moiety of flavoproteins, the causes of ariboflavinosis may be considered in light of Fig. 2.

Among the possible mechanisms, the inhibition of flavoproteins by this antibiotic may be worth mentioning, to explain at least partly the antagonistic action between chlortetracycline and riboflavin. The complex formation of chlortetracycline with flavins was demonstrated by its quenching action on the fluorescence of flavins and by the shift of the absorption spectrum of flavins, indicating that binding occurred between the isalloxazine nucleus of flavins, and chlortetracycline. Studies using D-amino acid oxidase indicated that chlortetracycline combines with FAD in competition with the
oxidase protein, resulting in the inhibition of the enzymic activity and that chlortetracycline does not bind with the protein moiety of the enzyme. It was further demonstrated that chlortetracycline can combine with free FAD but not with the enzyme-bound FAD, suggesting the involvement of the same binding site of FAD for the apoprotein and chlortetracycline. From these results, it is considered that chlortetracycline can combine with free flavins in animal body and, as a result, tends to cause ariboflavinosis.

Considering the above-mentioned data of model experiment as well as those of nutritional experiment, it would be fairly simple to take measures to meet such a side-effect of chlortetracycline: the occurrence of ariboflavinosis could be prevented by simultaneous administration of riboflavin equal to one-thousandth of the weight of chlortetracycline given to patients.

FAT-SOLUBLE RIBOFLAVIN DERIVATIVES:

Riboflavin tetrahydrofuran: The major disadvantage of administration of water-soluble vitamins is their fast excretion from the body, but the fat-soluble vitamins are retained for a much longer time. However, this handicap of fast excretion of water-soluble vitamins could be partly overcome, if they could be converted to fat-soluble substances without damaging their vitamin action. Studies were initiated in our laboratory to synthesize chemically fat-soluble riboflavin derivatives by esterifying hydroxy groups of the ribityl chain with fatty acids. The esterification was achieved by using appropriate fatty acid chloride (for palmitate, caprate and butyrate) or anhydride (for butyrate and propionate). All the riboflavin esters have characteristic orange-yellow colour and are practically free from bitter taste unlike the parent riboflavin. As expected, they are soluble in all organic solvents. The solubility increases with the increase in fatty acid chain-length.

Although, chemical synthesis of these vitamin esters was successfully achieved, their usefulness in place of conventional vitamin entirely depended on the ability of the body to hydrolyse these esters to free riboflavin. Pancreatic lipase was demonstrated to hydrolyse these synthetic esters to riboflavin and corresponding fatty acids. However, the degree of hydrolysis differed from one ester to the other. The rates of hydrolysis of fatty acid esters of riboflavin by pancreatic lipase are shown in Table 4.

In accord with the rate of hydrolysis, riboflavin tetrahydrofuran was found to have nearly the same nutritional value as free riboflavin as shown in Fig. 3, but, riboflavin tetrapalmitate had no vitamin activity. Riboflavin tetra-
### Studies on Riboflavin

#### TABLE 4

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Rate of hydrolysis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riboflavin tetrapalmitate</td>
<td>1.2</td>
</tr>
<tr>
<td>Riboflavin tetracaprate</td>
<td>3.4</td>
</tr>
<tr>
<td>Riboflavin tetrabutyrate</td>
<td>45.4</td>
</tr>
<tr>
<td>Riboflavin tetrapropionate</td>
<td>4.3</td>
</tr>
<tr>
<td>Riboflavin tetraacetate</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The reaction mixture was composed of ml of 4 mM substrate suspended in 1% polyvinyl alcohol (polymerization degree, 500), 0.5ml of enzyme solution (20 mg/ml) and 1.0ml of McIlvaine buffer. It was incubated at pH 7.3, 37° for 2 hours. The rate of hydrolysis was expressed as per cent of mole riboflavin to mole of the substrate.

![Graph A](image1.png)

![Graph B](image2.png)

**Fig. 3.** Change of body weight by administration of riboflavin or riboflavin tetrabutyrate.

A: animals were fed on a basal diet containing 10μg of riboflavin/ml/day.
B: animals were fed on a riboflavin-deficient diet and 17.4μg (10μg in terms of riboflavin) or riboflavin tetrabutyrate in cod liver oil.
Kunio Yagi

Fig. 4. Curative effect of riboflavin tetrabutyrate on riboflavin deficiency. 50μg of riboflavin tetrabutyrate (suspended in cod liver oil) was administered daily after being fed a riboflavin-deficient diet. The arrow shows the start of the administration.

butyrate was also found to have curative effect in riboflavin deficiency as shown by the body weight gain (Fig. 4). Although the nutritional experiments showed similar activity between riboflavin tetrabutyrate and its parent vitamin, the expected advantage, viz., deposit-type action, was really demonstrated with riboflavin tetrabutyrate. Figure 5 shows the blood flavin level after the administration of riboflavin or its tetrabutyrate and Figure 6, the pattern of excretion of flavin in urine after the injection of riboflavin or its tetrabutyrate. 
Fig. 6. Excretion of flavins in urine after injection of riboflavin or riboflavin tetrabutyrate.

A: administered 5 mg of riboflavin.

B: administered 8.7 mg of riboflavin tetrabutyrate (5 mg in terms of riboflavin).
Fig. 5: Concentration of flavin in blood of two rabbits after injection of riboflavin or riboflavin tetrabutyrate.
A: administered 5 mg of riboflavin.
B: administered 8.7 mg of riboflavin tetrabutyrate (5 mg in terms of riboflavin).
The administration of radioactive riboflavin tetrabutyrate-2-\(^{14}\)C synthesized from riboflavin-2-\(^{14}\)C to normal rats \textit{per os} or by injection results in the labelling of riboflavin, FMN and FAD in all organs of the rat as shown in Tables 5 and 6.\(^1\) Moreover, exchange rate between pre-existing flavin components and the newly administered compound, after its conversion to riboflavin, FMN or FAD was calculated to be 15\%.\(^6\) These results indicate that riboflavin tetrabutyrate administered is hydrolysed in the body to give free riboflavin which is incorporated into FMN and FAD. The direct absorption of a major portion of riboflavin tetrabutyrate through the digestive canal has also been noticed\(^1\) and it was further observed that the ester is deposited in the liver and is slowly hydrolysed to riboflavin and butyric acid.

A new noticeable action of this ester to suppress the level of blood lipoperoxide has also been found\(^2\), and this effect could be attributed to reaction between lipoperoxides and riboflavin tetrabutyrate observed \textit{in vitro}.\(^2\)\(^4\)

Considering that riboflavin tetrabutyrate is fat-soluble and has practically no taste, it can be recommended in enriching food containing large amounts of fat or oil.

\textit{Riboflavin tetranicotinate:} Being a water-soluble substance, nicotinic acid is also excreted fastly from the body like riboflavin. An attempt was, therefore, made to interlock these two vitamins by means of the four hydroxy groups of riboflavin and the carboxylic group of nicotinic acid. The resulting ester, riboflavin tetranicotinate, was expected to have a deposit-type action like riboflavin tetrabutyrate and to release the two vitamins simultaneously on hydrolysis. The synthesis of riboflavin tetranicotinate was achieved by the reaction between nicotinyl chloride monohydrochloride and dry riboflavin in the presence of dry pyridine. The product, a yellow precipitate, was recrystallized from benzene.\(^7\) Solubility in water of this ester is lower than that of free riboflavin, though much higher than that of riboflavin tetrabutyrate.

To examine the vitamin action of riboflavin tetranicotinate, nutritional experiments were done in the same way as in the case of riboflavin tetrabutyrate. The administration of riboflavin tetranicotinate prevents the development arioflavinosis.\(^8\) In addition, it showed a curative effect in rats suffering from arioflavinosis. However, its vitamin action was found to be comparatively lower than that of the conventional free riboflavin. The fact that increase in vitamin effect could be achieved by increasing the
### TABLE 5
Quantities and Specific Radioactivities of Each Flavin Compound in Organs of Rat after Administration of Riboflavin of Tetrabutyrate-2-14C per os

<table>
<thead>
<tr>
<th>Organs</th>
<th>Liver</th>
<th>Kidney</th>
<th>Heart</th>
<th>Small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total flavin</td>
<td>µg/g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAD µg/g</td>
<td>23.0</td>
<td>19.6</td>
<td>16.5</td>
<td>4.0</td>
</tr>
<tr>
<td>%</td>
<td>75.9</td>
<td>56.3</td>
<td>85.9</td>
<td>63.5</td>
</tr>
<tr>
<td>cpm/µg**</td>
<td>69.6</td>
<td>59.2</td>
<td>21.3</td>
<td>11.5</td>
</tr>
<tr>
<td>FMN µg/g</td>
<td>7.2</td>
<td>14.5</td>
<td>2.7</td>
<td>2.2</td>
</tr>
<tr>
<td>%</td>
<td>23.8</td>
<td>41.7</td>
<td>14.1</td>
<td>34.9</td>
</tr>
<tr>
<td>cpm/µg**</td>
<td>32.9</td>
<td>57.2</td>
<td>64.7</td>
<td>27.9</td>
</tr>
<tr>
<td>Riboflavin µg/g</td>
<td>0.1</td>
<td>0.7</td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>%</td>
<td>0.3</td>
<td>2.0</td>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td>cpm/µg**</td>
<td>20.0</td>
<td>110.0</td>
<td></td>
<td>75.0</td>
</tr>
</tbody>
</table>

*Per cent of the total amount of flavins.
**cpm/µg of flavin.
***Not detectable.

### TABLE 6
Quantities and Specific Radioactivities of Each Flavin Compound in Organs of Rat after Injection of Riboflavin Tetrabutyrate-2-14C

<table>
<thead>
<tr>
<th>Organ</th>
<th>Liver</th>
<th>Kidney</th>
<th>Heart</th>
<th>Small intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total flavin</td>
<td>µg/g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAD µg/g</td>
<td>26.6</td>
<td>23.7</td>
<td>16.1</td>
<td>3.3</td>
</tr>
<tr>
<td>%</td>
<td>75.1</td>
<td>72.9</td>
<td>81.7</td>
<td>63.5</td>
</tr>
<tr>
<td>cpm/µg**</td>
<td>82.1</td>
<td>40.4</td>
<td>42.8</td>
<td>61.8</td>
</tr>
<tr>
<td>FMN µg/g</td>
<td>8.5</td>
<td>8.3</td>
<td>2.8</td>
<td>1.8</td>
</tr>
<tr>
<td>%</td>
<td>24.0</td>
<td>25.5</td>
<td>14.2</td>
<td>34.6</td>
</tr>
<tr>
<td>cpm/µg**</td>
<td>86.6</td>
<td>28.2</td>
<td>50.0</td>
<td>70.6</td>
</tr>
<tr>
<td>Riboflavin µg/g</td>
<td>0.3</td>
<td>0.5</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>%</td>
<td>0.9</td>
<td>1.6</td>
<td>4.1</td>
<td>1.9</td>
</tr>
<tr>
<td>cpm/µg**</td>
<td>39.6</td>
<td>100.0</td>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Per cent of the total amount of flavins.
**cpm/µg of flavin.
***Not detectable.
Studies on Riboflavin

Dose indicates that this compound does not compete with free riboflavin. No chronic toxicity was found to be associated with this substance when as high a dosage as 230 mg/day/kg body weight was administered. The observation that riboflavin tetranicotinate has vitamin action implies that this ester is hydrolysed in the body to its constituent vitamin. However, lower vitamin action might be due to partial or incomplete hydrolysis of this compound and such products as mono, di, and tri esters were recovered from urine of the animals injected riboflavin tetranicotinate. Nevertheless, this excretion was much slower when compared to free riboflavin and riboflavin tetranicotinate can, therefore, be considered as a deposit-type riboflavin.

In this connection, it should be mentioned that the level of nicotinamide adenine dinucleotide in the liver was elevated by administering riboflavin tetranicotinate.

Although riboflavin tetranicotinate does not prevent the accumulation of fat in the liver in animals suffering from fatty liver caused by nutritional imbalance, it plays a complementary role in the cure of fatty livers. The orthodox lipotropic factors, namely choline and myo-inositol, seem to accelerate the removal of deposited fat from the liver by forming β-lipo-proteins. However, the peroxides formed are neither broken down nor removed as indicated by the high levels of TBA values in serum and liver. Riboflavin tetranicotinate seems to react with these toxic peroxides and its administration with lipotropic agents results in the lowering of the peroxide content of serum and liver. Similar action of riboflavin tetrabutyrate can be expected as already mentioned. Since the lipoperoxide reducing action seems to be due to isoxaloxazine ring of the fat-soluble riboflavin derivative and since the parent riboflavin does not prevent increase in the peroxide content, it can be considered that the affinity of the esters to lipids acquired by the esterification render the isoxaloxazine nucleus of riboflavin moiety reactive with these lipoperoxides.

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ORGANIZATION OF NUTRITION PROGRAMMES

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Rapporteur: V. N. Jai, India

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The practice of school feeding in Japan has a fairly long history. The idea was first initiated in 1889 by a Buddhist priest who ran a private elementary school in the precincts of a small temple in small town, Tsuruoka, located in Yamagata Prefecture. The children were supplied with lunch consisting mainly of boiled rice which was furnished by the alms earned by this priest.

School feeding of this kind can be regarded as pure social charity. In those days children belonging to poor families were not able to bring their lunch regularly and lunch contents of the children considerably differed according to the level of living of each family. Therefore, it was thought better to provide lunch at school to avoid unfavourable cultural aspects. Warm meals were thus merely provided equally to each child absolutely free of charge. Since then, school feeding gradually became popular as a charity movement in some places scattered through the nation and thence the aim turned out to take measures towards feeding children who cannot bring their meals to school or to serve warm meals at school.

In September 1932, when Japan encountered a drastic economic depression, it became a grave social problem to help children who were unable to bring lunch to school. The Ministry of Education issued an Ordinance to solve this matter. Steps were taken to establish a formal school feeding system financially supported by national funds.

At that time, Dr. T. Saiki, the first Director of our National Institute of Nutrition, was the first to emphasize to the Ministry of Education, the necessity of providing meals at school. Dr. Saiki stressed that consideration should be given for providing nutrients necessary for development in school meals; to establish facilities for mass boiling of rice, and as a media, to educate children in nutrition. In this way, school feeding gradually spread in this country until the outbreak of World War II.

The contemporary system practiced in Japan is a sort of recurrence of school feeding encouraged by the government but is run on a large scale, planned,
designed and practiced at the national level. Financial support is thus guaranteed in accordance with the school feeding law. Much progress has been accomplished. For instance, due consideration has been given to the nutritional content of the meals so that children can take nutrients required to promote physical fitness, and further, the programme is designed to improve the nutritional status of the children's families.

In the beginning, the primary object was to restore as early as possible normal growth of children, whose growth was drastically retarded by the poor food situation immediately after the war. In 1946 immediately after the war, school feeding was first tried as a test case in Tokyo and Osaka where the food situation was most depressed. This school feeding was something like an emergency relief, as imported goods such as wheat flour, skimmed milk and also the old canned foods left over by the army and navy were provided. The school authorities and the P.T.A. willingly erected emergency kitchens and gathered fuel which was valuable as it was difficult to obtain. Laborious work was done by the mothers.

In 1954, the School Feeding Law was passed through the Diet and after that the school feeding system spread throughout the nation. Let me now say a few words on the purport of this law.

1. School feeding must contribute to sound development of the child's physical and mental status.
2. School feeding is to be included in the curriculum of elementary and secondary schools as a part of the educational programme.
3. Wheat flour and milk is purchased from funds acquired from the Special Budget of the Food Control Board and disposed to the local governments at prices lower than the market.
4. Retail prices concerning payment of school feeding expenses will be decided by local public body laws.
5. For children of families needing financial support as designed by law, necessary expenses will be defrayed from national funds either partially or entirely according to the limits of the national budget to the head of the school provided this person exempts the school feeding expenses either in part or in total.

According to the school feeding law, school feeding is classified into two categories, namely full-feeding and partial-feeding. The former consists of a glass of milk, a piece of bread with a side-dish, while the latter either milk or a side-dish alone, and children have to bring rice or bread as their food for lunch.
At the present time the full feeding type of school feeding is practiced almost throughout the country. The beneficial effect of the school-lunch programme on the heights and weights of the children are shown in Figures 1 and 2. School feeding first started at places where it was possible and each school which had succeeded in partial feeding was directed to practice full-feeding.

Fig. 1. Physical Effect of School Lunch Program on Pupils (1968—1967)

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934</td>
<td>190.9</td>
<td>190.7</td>
</tr>
<tr>
<td>1935</td>
<td>191.2</td>
<td>191.7</td>
</tr>
<tr>
<td>1940</td>
<td>191.1</td>
<td>191.7</td>
</tr>
<tr>
<td>51</td>
<td>191.8</td>
<td>192.4</td>
</tr>
<tr>
<td>52</td>
<td>192.5</td>
<td>193.1</td>
</tr>
<tr>
<td>53</td>
<td>193.1</td>
<td>193.5</td>
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<tr>
<td>54</td>
<td>193.4</td>
<td>193.9</td>
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<td>194.9</td>
</tr>
<tr>
<td>56</td>
<td>194.5</td>
<td>195.8</td>
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<td>195.1</td>
<td>196.9</td>
</tr>
<tr>
<td>58</td>
<td>196.7</td>
<td>197.8</td>
</tr>
<tr>
<td>59</td>
<td>198.9</td>
<td>199.8</td>
</tr>
<tr>
<td>60</td>
<td>198.2</td>
<td>198.1</td>
</tr>
<tr>
<td>61</td>
<td>198.2</td>
<td>199.8</td>
</tr>
<tr>
<td>62</td>
<td>197.7</td>
<td>198.9</td>
</tr>
<tr>
<td>63</td>
<td>197.8</td>
<td>198.6</td>
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<tr>
<td>64</td>
<td>198.3</td>
<td>199.0</td>
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<tr>
<td>65</td>
<td>198.5</td>
<td>199.4</td>
</tr>
<tr>
<td>66</td>
<td>198.0</td>
<td>199.1</td>
</tr>
<tr>
<td>67</td>
<td>198.6</td>
<td>201.4</td>
</tr>
</tbody>
</table>

As of April, each year.

Fig. 2. Physical Effect of School Lunch Program on Pupils (1968—1967)

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935</td>
<td>28.6</td>
<td>29.2</td>
</tr>
<tr>
<td>1940</td>
<td>28.7</td>
<td>28.8</td>
</tr>
<tr>
<td>51</td>
<td>28.8</td>
<td>29.2</td>
</tr>
<tr>
<td>52</td>
<td>29.2</td>
<td>29.6</td>
</tr>
<tr>
<td>53</td>
<td>29.5</td>
<td>29.9</td>
</tr>
<tr>
<td>54</td>
<td>29.5</td>
<td>30.1</td>
</tr>
<tr>
<td>55</td>
<td>29.7</td>
<td>30.5</td>
</tr>
<tr>
<td>56</td>
<td>30.0</td>
<td>31.1</td>
</tr>
<tr>
<td>57</td>
<td>30.2</td>
<td>31.3</td>
</tr>
<tr>
<td>58</td>
<td>30.2</td>
<td>31.1</td>
</tr>
<tr>
<td>59</td>
<td>30.5</td>
<td>31.6</td>
</tr>
<tr>
<td>60</td>
<td>30.7</td>
<td>32.3</td>
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<tr>
<td>61</td>
<td>31.0</td>
<td>32.6</td>
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<tr>
<td>62</td>
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<td>32.9</td>
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<td>63</td>
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<td>32.9</td>
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<tr>
<td>64</td>
<td>31.8</td>
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<tr>
<td>65</td>
<td>32.2</td>
<td>33.7</td>
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<tr>
<td>66</td>
<td>32.6</td>
<td>34.3</td>
</tr>
<tr>
<td>67</td>
<td>33.0</td>
<td>34.5</td>
</tr>
</tbody>
</table>

As of April, each year.
As the local governments have up to this time been running the elementary and secondary schools, these authorities naturally receive financial support from the national government.

The school authorities and the P.T.A. have always cooperated in running the school feeding system. Though the school principal assumes the whole responsibility, details of practice are chalked out by a committee composed of teachers and parents after mutual consultation. As a rule each school has a nutritionist who prepares the recipe but afterwards it was found reasonable to combine several schools as a unit which have the same recipe. This saves expenses, labour and time. Nowadays, at some places the central kitchen system is under consideration. This system may be advantageous in some cases, since meals need not be prepared in each school kitchen, but the food is gathered, cooked en block and distributed to each school.

The school feeding committee established by the Ministry of Education deals with problems concerning the general principle related to nutritional standards and management.

The central school feeding section under the Bureau of physical Culture, Ministry of Education takes over the office work. In the local governaments a school feeding section set up under the Educational Committee handles these problems.

Table 1 gives the nutritional standards per child per day for school children

<table>
<thead>
<tr>
<th>Item</th>
<th>Elementary pupils</th>
<th>Lower secondary pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age 6-8</td>
<td>Age 9-11</td>
</tr>
<tr>
<td>Calories (Cal)</td>
<td>600</td>
<td>700</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>(10)*</td>
<td>(12)*</td>
</tr>
<tr>
<td>Calcium (g)</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Vitamin A [IU]</td>
<td>750</td>
<td>1000</td>
</tr>
<tr>
<td>Vitamin B₇ [mg]</td>
<td>(2250)*</td>
<td>(3000)*</td>
</tr>
<tr>
<td>Vitamin B₉ [mg]</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Vitamin C [mg]</td>
<td>30</td>
<td>45</td>
</tr>
</tbody>
</table>

*Animal protein. **Figures for carotene
set up by the Nutrition Council, Ministry of Health and Welfare as given in the Nutritional Standards for the Japanese issued by the above Ministry. Table 2 shows the actual intakes of the children compared to the nutritional standard.

Table 2
Nutritional standard and actual intakes

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-8 ears</td>
<td>9-11 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calories (kcal)</td>
<td>600 700</td>
<td>654</td>
<td>666</td>
<td>690</td>
<td>703</td>
<td>707</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>23 27</td>
<td>28.3</td>
<td>27.5</td>
<td>18.3</td>
<td>28.3</td>
<td>17.9</td>
</tr>
<tr>
<td>Animal protein (g)</td>
<td>10 11</td>
<td>13.8</td>
<td>13.6</td>
<td>14.2</td>
<td>13.9</td>
<td>13.6</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>10 12</td>
<td>13.9</td>
<td>17.0</td>
<td>18.1</td>
<td>19.3</td>
<td>20.2</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>300 400</td>
<td>422</td>
<td>412</td>
<td>419</td>
<td>416</td>
<td>403</td>
</tr>
<tr>
<td>Vitamin A (I.U.)*</td>
<td>750 1000</td>
<td>967</td>
<td>861</td>
<td>888</td>
<td>886</td>
<td>902</td>
</tr>
<tr>
<td>(carotene) (3250)</td>
<td>(3000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiamine (mg)*</td>
<td>0.6 0.6</td>
<td>0.54</td>
<td>0.61</td>
<td>0.63</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Riboflavin (mg)*</td>
<td>0.6 0.6</td>
<td>0.66</td>
<td>0.66</td>
<td>0.68</td>
<td>0.68</td>
<td>0.67</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>30 40</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>30</td>
</tr>
</tbody>
</table>

*Loss of vitamins during cooking is estimated as Vitamin A 20%, B1 30%, B2 25%, and C 50%.

It is recommended that school children should take more than one-third of their daily nutrient requirements which are somewhat difficult to take at home for example vitamin A and B6, Fe, Ca etc., at school. Therefore, the school lunch is so prepared as to contain one-third of the recommended nutrients per day per child. However, since it is difficult to take such large amounts of vitamin A and others in the regular school lunch, bread is now fortified by adequate amounts of vitamin A and 1-lysine.
There are three types of school-lunch programmes in the Philippines to-day. The first to be established dates back as early as 1906 and had a very inconspicuous start so that the only record we have of it is a small item in the annual report of the Bureau of Education that a group of teachers took the initiative to prepare and serve food to underweight school children who were patronizing the stores nearby for sweets and certain bakery products. In the years that followed, the pattern of setting up a lunch programme was practically the same. Financial requirements were met by teachers or by both teachers and parents allowing certain marginal profits for maintenance and replenishment of equipment.

It was not until 1932 however when the general office issued a set of instructions on how to start a meal programme. By this time nearly every province had some kind of lunch counters although few in number.

The UNAC fund campaign in 1951 was a tremendous boost to the programme. Only 4% of this fund was remitted back to the general office; the remaining 96% was kept by the schools to start a lunch programme. In 1952, detailed instructions were issued clarifying the objectives of the programme and providing guidelines for a self-sustaining, non-profit school lunch programme to meet the children’s nutritional needs. With these instructions, the lunch programme attained national acceptance. Nearly all the secondary schools and the big elementary schools in the cities and towns have this programme. These are the places where children have a minimal daily allowance from their working parents with which to purchase snacks or noon meals.

The programme, however, could not be launched in many more schools in the rural areas because the children cannot afford even to pay for a few centavos worth of food. So to this day, this type of programme is confined to the big cities and towns.

The problems associated with this type of programme are largely financial.
For example, there is a need for hiring additional qualified teachers to give full-time service to the programme. A recent survey showed that out of some 2,000 school lunch programmes included in the survey, only 18%, were managed by full-time qualified lunch teachers. It was found too that of the teachers involved, partly or fully in the programme, nearly half (49%) were not professionally prepared in the sense that they never had courses in nutrition in their college works. This needed a lot of training in the service.

Occasionally, a financial problem arose, not so much from the lack of funds but from a misguided administration of these funds. School authorities in many instances have transformed the programmes into a fund raising venture to support school improvements and other projects. Where profit is of prime importance, meal planning is usually based on popularity of the foods served rather than on their nutritional value. This problem can be eliminated if the Government subsidises the programme and through proper nutrition education of school administrators. As a corrective measure for the moment, the general office issued a circular on “Functional Coordination of Nutrition Education and Co-operative Education”.

The second type of lunch programme in Philippine public schools is that assisted by CARE through donation of food commodities. Prior to CARE assistance, the UNICEF had also channeled food commodities to the schools as early as 1950. The snacks or hot lunches served under this programme are entirely free, the government having put up a counterpart budget to cover expenses of administration and internal transportation of food commodities. This programme has indeed been a help to the recipient schools, especially those in the rural areas.

Again the main problem is lack of manpower to handle the programme full time. A teacher with a heavy workload has to sacrifice her time for this programme. It is not so much the planning since allocations are predetermined but the mechanics of the whole programme since the teacher generally has a class to handle in addition to this work or vice versa. Some schools took initiative in this regard of hiring helpers from outside and the funds for these helpers were pooled from PTA’s, mothers’ groups or from the regular school lunch programme.

Safe-guards against channeling food commodities to other sources have been put up and close supervision of the programme is expected from school administration. However, sometimes the food commodities come late from abroad so there are gaps in the feeding schedule. This problem is beyond the means of the schools.
The third type of school lunch programme is the feeding aspect of the UNICEF/FAO/WHO assisted applied nutrition programme which now covers 385 schools and communities in the rural areas. This programme is not a feeding programme per se but a vehicle for teaching nutrition to the school children and through them their parents and other members of the family. It is, therefore, envisioned to demonstrate the planning, preparation and serving of highly nutritious foods available in the community. Where needed foods are not available, it is then incumbent upon the school to raise these foods in the school garden in culturally approved ways with a view to expanding the use of these methods to the community.

In the ANP, the feeding aspect is initiated only after the whole teaching force and community leaders have been oriented to the objectives and approaches of the programme and the gardens have begun to yield some quantity of food. Often the garden yield is supplemented by parents’ contribution in kind. Only a snack programme has been started in most of the participating schools; a few in the mountain areas are adopting a hot lunch programme because pupils live some distance from schools and cannot return home for lunch. The programme generally starts with a lower allocation and less feeding frequency but the goal for the moment is to have daily feeding for all school children with at least an allocation of 500 Calories each.

For a constant supply of food to the ANP school meals, garden teachers have been taught certain cropping patterns. Vacant community lots have also been used to raise needed foods. The most important consideration is to get the parents involved so much so, that in their own home they will try to raise foods needed by them and also a little more to contribute to the school meals. It has been demonstrated in several places that this can be done.

The school lunch programme is heavily supported by a formal nutrition education programme which integrates nutrition in nearly all subjects in the elementary school curriculum in all grade levels. Teaching guides for their integration were developed by selected teachers last summer and are now being tried in various schools.

Likewise, nutrition has been integrated in the teacher education curriculum
in such subjects as health, home economics, agriculture and community and adult education. A regular student graduate receives six units of applied nutrition while a student who specialises in applied nutrition gets 18 units of credit work.

The preparation of teachers to teach nutrition in the elementary schools further supports the total concept of nutrition education for all. To bridge the gap between elementary school and college, plans have been finalised for the preparation of teaching guides integrating nutrition in the secondary curriculum.

In this light, therefore, the school meals are a part of the total education programme. The results of a nutrition education programme are not as dramatic as the rehabilitation of a severe malnutrition case but the results are permanent.

The secret of this programme lies in the quality of leadership that can engender community support for a programme that may well spell the difference between health and misery. Leadership training along this line has, therefore, been a continuing emphasis in the in-service training programme of the public schools of the Philippines.
School feeding programmes have been in operation in a number of countries for over 100 years. Most of the school meal programmes started with the objective of providing pupils a meal at school just to assuage the pangs of hunger resulting from either inadequate resources at home, or the distance of the school from the home. They were largely charity oriented and humanitarian in purpose.

Due to the newer knowledge of child development, nutrition and food technology, political developments and public awareness, the school meal programmes have undergone certain fundamental changes in some countries. Consequently, there are, today, school lunch legislations and definite provisions in national budgets for school lunch programmes in a few of those countries. However, it will take a long time for the governments of the different nations and their departments of education and health to consider the provision of an adequate meal in the school as "a must" and as an integral part of national development efforts to help pupils fulfil the following functions:

Gain knowledge of nutritional facts;

Appreciate the importance of good nutrition to health, well being, growth and development;

Translate the nutritional facts into actual consumption of adequate diets and thereby learn to eat desirable combinations of foods;

Develop good food habits;

Produce protective foods through raising school gardens, poultry and fish;

Increase school attendance and performance through increased learning ability and stamina;

and Avoid illness and absenteeism due to nutritional deficiencies.

The position with regard to school meal programmes in India is one of struggle between resources and the numbers to be fed. Initiated as a welfare programme, it is only recently that the central and state governments have taken interest in sponsoring and promoting school lunch programmes. However,
there is still no legislation anywhere, nor uniform pattern or provision for
school meals. Even in the meagre programmes which exist, there are many
shortcomings. But it is encouraging that increased allocations have been
made in the Fourth Five Year Plan for the school meals. Most of the states
have provided part of the funds under their Non-Plan budgets and yet some
others have provided the entire sum under the Non-Plan budgets. The state­
wise break up of the budget provision in the “Plan” and “Non-Plan” categories
for 1969-70 is indicated in Table 1.

TABLE 1
State wise budget provision for school meals 1969-70 *

<table>
<thead>
<tr>
<th>Name of State</th>
<th>Plan</th>
<th>Non-plan</th>
<th>Number covered in 1968-1969</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Rupees in lakhs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Andhra Pradesh</td>
<td>29.57</td>
<td>20.00</td>
<td>10.00</td>
</tr>
<tr>
<td>2. Bihar</td>
<td>24.00</td>
<td>10.70</td>
<td>240,000</td>
</tr>
<tr>
<td>3. Gujarat</td>
<td>1.40</td>
<td>51.24</td>
<td>1,600,000</td>
</tr>
<tr>
<td>4. Haryana</td>
<td>Information still awaited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Kerala</td>
<td>1.40</td>
<td>51.24</td>
<td>1,600,000</td>
</tr>
<tr>
<td>6. Madhya Pradesh</td>
<td>Information still awaited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Maharashtra</td>
<td>11.98</td>
<td>Not available</td>
<td>250,000</td>
</tr>
<tr>
<td>8. Mysore</td>
<td>44.00</td>
<td>800,000</td>
<td></td>
</tr>
<tr>
<td>9. Orissa</td>
<td>25.00</td>
<td>595,000</td>
<td></td>
</tr>
<tr>
<td>10. Punjab</td>
<td>7.00</td>
<td>300,000</td>
<td></td>
</tr>
<tr>
<td>11. Rajasthan</td>
<td>7.00</td>
<td>350,000</td>
<td></td>
</tr>
<tr>
<td>12. Tamil Nadu</td>
<td>190.00*</td>
<td>1,600,000</td>
<td></td>
</tr>
<tr>
<td>13. Uttar Pradesh</td>
<td>1.44</td>
<td>31.55</td>
<td>600,000</td>
</tr>
<tr>
<td>14. West Bengal</td>
<td>Information still awaited</td>
<td>1,500,000</td>
<td></td>
</tr>
</tbody>
</table>

Total 10,960,000

*Reference No. 5.
* *Communication from Government of Tamil Nadu.

Considering that there are more than 80 million children between 6-11 years
in India, the coverage of 11.0 million children (14 per cent) is very meagre.

The pride of starting the school meal programmes in India goes to Tamil
Nadu (Madras). Today, all states except Assam, Jammu and Kashmir and
Nagaland have school lunch programmes of one type or an other.
In Tamil Nadu, the scheme was started in 1925 by the Corporation of Madras to solve the problems of: (a) Hunger and starvation among children who attended the primary schools from the poor socio-economic classes and (b) Poor attendance at school. Starting with feeding 500 pupils, in 1925, nearly 35,000 children are given school lunch today in the city of Madras.

**ROLE OF CARE**

CARE started assisting the school meal programmes in India from 1961, giving valuable protective food items. Today CARE reaches nearly 8.5 million children throughout the country. Table 2 gives the number of children

<table>
<thead>
<tr>
<th>State</th>
<th>Year of starting</th>
<th>Number of Beneficiaries in 1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Andhra Pradesh</td>
<td>1962</td>
<td>529,000</td>
</tr>
<tr>
<td>2. Bihar</td>
<td>1968</td>
<td>610,000</td>
</tr>
<tr>
<td>3. Gujarat</td>
<td>1965</td>
<td>61,000</td>
</tr>
<tr>
<td>4. Haryana</td>
<td>1967</td>
<td>202,000</td>
</tr>
<tr>
<td>5. Himachal Pradesh</td>
<td>Not known</td>
<td>150,000</td>
</tr>
<tr>
<td>6. Kerala</td>
<td>1962</td>
<td>1500,000</td>
</tr>
<tr>
<td>7. Madhya Pradesh</td>
<td>1965</td>
<td>453,000</td>
</tr>
<tr>
<td>8. Maharashtra</td>
<td>1965</td>
<td>100,000</td>
</tr>
<tr>
<td>9. Mysore</td>
<td>1964</td>
<td>1620,000</td>
</tr>
<tr>
<td>10. Orissa</td>
<td>1965</td>
<td>482,000</td>
</tr>
<tr>
<td>11. Punjab</td>
<td>1962</td>
<td>117,000</td>
</tr>
<tr>
<td>12. Rajasthan</td>
<td>1963</td>
<td>116,000</td>
</tr>
<tr>
<td>13. Tamil Nadu</td>
<td>1961</td>
<td>1410,000</td>
</tr>
<tr>
<td>14. Uttar Pradesh</td>
<td>1965</td>
<td>270,000</td>
</tr>
<tr>
<td>15. West Bengal</td>
<td>1964</td>
<td>904,000</td>
</tr>
</tbody>
</table>

Total 8524,000

benefitting from CARE foods during 1969. Nearly 72 per cent of the children receiving school meals in the country benefit from CARE foods.

Table 3 shows the quantities of CARE supplements given to the children in the different states of India.

### Table 3
The CARE supplements (1969-1970)

<table>
<thead>
<tr>
<th>State</th>
<th>CSM/ Balahar*</th>
<th>Bulgar Wheat</th>
<th>Vegetable Oil</th>
<th>Calories</th>
<th>Protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Andhra Pradesh</td>
<td>85</td>
<td>14</td>
<td>425</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>2. Bihar</td>
<td>85</td>
<td>14</td>
<td>425</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>3. Gujarat</td>
<td>44</td>
<td>44</td>
<td>21</td>
<td>488</td>
<td>13.4</td>
</tr>
<tr>
<td>4. Haryana</td>
<td>57</td>
<td>28</td>
<td>450</td>
<td>11.4</td>
<td></td>
</tr>
<tr>
<td>5. Kerala</td>
<td>44</td>
<td>57</td>
<td>7</td>
<td>413</td>
<td>15.0</td>
</tr>
<tr>
<td>6. Madhya Pradesh</td>
<td>57</td>
<td>57</td>
<td>14</td>
<td>525</td>
<td>17.8</td>
</tr>
<tr>
<td>7. Maharashtra</td>
<td>57</td>
<td>14</td>
<td>325</td>
<td>11.4</td>
<td></td>
</tr>
<tr>
<td>8. Mysore</td>
<td>85</td>
<td>14</td>
<td>425</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>9. Orissa</td>
<td>57</td>
<td>28</td>
<td>7</td>
<td>363</td>
<td>14.6</td>
</tr>
<tr>
<td>10. Punjab</td>
<td>57</td>
<td>28</td>
<td>450</td>
<td>11.4</td>
<td></td>
</tr>
<tr>
<td>11. Rajasthan</td>
<td>85</td>
<td>28</td>
<td>550</td>
<td>17.1</td>
<td></td>
</tr>
<tr>
<td>12. Tamil Nadu</td>
<td>30</td>
<td>100</td>
<td>8</td>
<td>532</td>
<td>17.5</td>
</tr>
<tr>
<td>13. Uttar Pradesh</td>
<td>85</td>
<td>28</td>
<td>550</td>
<td>17.3</td>
<td></td>
</tr>
<tr>
<td>14. West Bengal</td>
<td>44</td>
<td>57</td>
<td>350</td>
<td>15.2</td>
<td></td>
</tr>
</tbody>
</table>

*CSM and Balahar have added vitamins and minerals. 28.4 g. (one ounce) of CSM/Balahar contains about 1650 I.U. of vitamin A and 11 mg. iron, plus some B vitamins and minerals.

The CARE supplements given per pupil per day include 44 to 85 g. CSM (Corn Soy Milk with 20 per cent protein) except in Tamil Nadu where 30 g. of CSM are given; 28 to 57 g. Bulgar wheat and 7 to 28 g. salad oil. These furnish around 325-550 kilo calories and 11.4 to 18 g. protein.

The school meal programmes where CARE participates are state government undertakings. Consequently the programme is different in different states. The bulk of the operational control in most states is under the respective
School Meal Programmes in India

Education Departments. The FAO-UNICEF-WHO-Government of India sponsored Applied Nutrition Programme caters school meal programmes in nearly 900 blocks of the ANP. Apart from CARE and state governments, voluntary organisations such as Catholic Relief Services (CRS), Church World Service (CWS), CASA and YWCA also help in the school meal programmes in some places.

A study was undertaken to find out the type and coverage of school lunch programmes operated in the country and the problems encountered, through a questionnaire sent to various government departments in the different states.

Table 4 gives the summary of the data collected.

While all the states depend only on CARE food commodities for their school meal programme, Tamil Nadu is a significant exception. Tamil Nadu purchases rice for the school lunch scheme, over and above the CARE supplies.

The CARE aided school meal programmes are in operation in many states of India. In Andhra Pradesh, CARE additionally assists a bottle-milk scheme in the twin cities of Hyderabad and Secunderabad which provides for 30,000 primary school children. In Madhya Pradesh this programme forms an integral part of the Applied Nutrition Programme. The vegetables, eggs and fish made available from the ANP are used in the school meals.

In Tamil Nadu, the school meal programme is in operation in all the 30,685 elementary schools in the state. About 1.6 million children, constituting one-third of those enrolled are fed. The Catholic Relief Society provides lunch for 80,000 children through orphanages.

Most often the teachers and the headmaster of the school are in charge of the preparation and distribution of food. Various authorities including officers of the Education Department look after the various administrative aspects and distribution of CARE commodities.

A Central Kitchen was started at Avadi (Madras) as a pilot project in 1967. At the Central Kitchen, food is cooked and delivered to 53 schools feeding 2,600 children.

As the Central Kitchen scheme has been found successful, CARE has come forward to set up 30 such kitchens in Tamil Nadu at a cost of Rs. 200,000 each.

Recently the Government of Tamil Nadu have accepted the proposal of the
### TABLE 4

The details of the school lunch programmes in the different states

<table>
<thead>
<tr>
<th>State</th>
<th>Year of Start</th>
<th>Number covered</th>
<th>During Year</th>
<th>Expenditure (1965-69) in Rs.</th>
<th>Food</th>
<th>Administration, Transport etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Schools</td>
<td>Pupils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Andhra Pradesh</td>
<td>1960</td>
<td>Not given</td>
<td>8,00,000</td>
<td>1970-1971</td>
<td>Nil</td>
<td>29,81,618</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Haryana</td>
<td>1962</td>
<td>4,013</td>
<td>3,25,000</td>
<td>1970-1971</td>
<td>Nil</td>
<td>5,81,113</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>school</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Rajasthan</td>
<td>1962</td>
<td>--</td>
<td>3,00,000</td>
<td>1970-1971</td>
<td>Nil</td>
<td>16,20,000</td>
</tr>
<tr>
<td>8. Tamil Nadu</td>
<td>Nov, 1955</td>
<td>30,685</td>
<td>18,00,000</td>
<td>1969-1970</td>
<td>196,00,000</td>
<td>48,60,000</td>
</tr>
<tr>
<td></td>
<td>with CARE Oct. 1961</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Gujarat</td>
<td>1965</td>
<td>3,944</td>
<td>2,11,000</td>
<td>1969-1970</td>
<td>Nil</td>
<td>10,70,000</td>
</tr>
<tr>
<td>11. Maharashtra</td>
<td>1968</td>
<td>1,100</td>
<td>1,20,000</td>
<td>1969-1970</td>
<td>donation</td>
<td>2,00,000</td>
</tr>
<tr>
<td>12. Punjab</td>
<td>1962</td>
<td>5,270</td>
<td>3,75,000</td>
<td>1969-1970</td>
<td>Nil</td>
<td>7,00,000</td>
</tr>
<tr>
<td>13. Union Territory of Pondicherry</td>
<td>1967</td>
<td>294</td>
<td>49,100</td>
<td>1970-1971</td>
<td>4,36,000</td>
<td>6,845</td>
</tr>
</tbody>
</table>
CARE organisation to build ten regional godowns approximately one for every 160 kilo metres (100 miles) to cater to the needs of schools and future central kitchens within a radius of 80 kms, or 50 miles, at a cost of about Rs. 300,000 per godown. For these, the Tamil Nadu Government will have to provide necessary land, 10%, of the cost of construction and the staff necessary for maintaining the godowns. This move is expected to reduce substantially the storage charges incurred at present at the Madras city godowns. The regional godowns are likely to store at a time, food commodities required for about three months for the region. Sites have been selected and construction in six places has commenced.

PROBLEMS IN IMPLEMENTING THE SCHOOL LUNCH PROGRAMMES

Since the inception of the postgraduate programme and research in nutrition in Sri Avinashilingam Home Science College, we have been intimately involved in the organization and implementation of school lunch programmes. We have tried to assess the problems involved in the feeding of school children from different points of view.

Absence of ideology, commitment and dedication to the cause which leads to lack of priority in planning for child nutrition is the greatest problem.

Local financing is a problem keenly felt by all the cadres. Absence of nutrition education for all those who deal with the feeding programmes and as integral part of the school curriculum and its lunch programme is another pressing problem.

Apart from paucity of funds, the many difficulties encountered in mobilizing public contribution and local participation on a continuing basis, on which the school meal programme has been developed in all the states, have been brought out by several groups. Equally harassing are the problems in transporting, stocking, storing and utilizing the gift foods from CARE.

1. Lack of community participation,
2. Lack of adequate and safe storage facilities in the school,
3. Difficulties in maintaining school gardens during vacations,
4. Lack of cooking facilities and personnel,
5. Difficulties in finding funds for appointment of cooks,
Rajammal P. Devadas

(6) Damages and losses during transit and storage due to defective packing.

The suggestions given by the State Governments to overcome these problems are:

(1) Allocate higher priority to the school meal programme and along with it, provide greater financial resources also.

(2) Select feeding centres based on need, interest of the people and people's participation.

(3) Provide nutrition education for pupils, teachers, parents, public and administrators.

(4) Appoint cooks

(5) Insist on village councils and people giving their contribution

(6) Union Ministry of Education should negotiate with CARE regarding proper packing of food supplies.

(7) Railway officers should certify any loss or shortage detailed while giving delivery of the consignment. This will ensure safety against misappropriation.

(8) Central Government should bear the claims for damage since state provision is low.

(9) Appoint personnel to help in the cooking of food and maintaining the gardens.

According to William P. Schellstede (Administrator, CARE, Tamil Nadu) the serious problems are perhaps in the areas of local financing. When the funds are not punctually forthcoming, the headmaster often becomes personally liable for the various costs which he must incur; he may himself pay the outstanding bills, thinking that he will be reimbursed by the local bodies. However, not infrequently, the reimbursement is not realised. After experiencing this once or twice, the quality of the programme in that particular feeding centre often begins to reflect the headmaster's flagging interest. Once the children begin to complain about the quality of the food, most hopes of increasing local contribution to the programme are dashed. Also, when the children begin refusing the food, the headmaster's stocks are not consumed in
time and infestation begins to occur. This infestation, in turn, makes the food even less attractive to the children, thus compounding the problem. This vicious circle is by no means the case throughout CARE's programmes in India. In the regions where local interest in education is high, local bodies such as Panchayat Unions, Panchayats, School Betterment Committees, local philanthropists and so forth, do come forward with adequate financing and the programme operates smoothly and to the benefit of the children. Indeed, the midday meals become a part of the school day for the children and in the minds of the parents.

The District Educational Officer and Inspector of Schools who supply CARE food materials and the Health Inspectors who supervises the sanitary aspects of the school meal programme find that:

(1) Headmasters do not produce correct accounts with regard to money and CARE provisions.

(2) There is no facility for transporting the food materials to the schools. Therefore, they have to wait for the teachers to come. They do not arrive in time.

(3) Headmasters return the old bags of CSM saying they are infested with weevils. They do not check them in time nor do they use them properly.

These can be rectified if there is an officer to take charge of all nutrition activities in the District.

The officers involved in the supervision and food production aspects of the school meal find that:

(1) They are expected to supervise without authority.

(2) All panchayats (village councils) are not able to meet the contribution of 4 paise/pupil/day.

(3) Lack of time and cooperation to mobilise the villagers to raise money as local contribution.

(4) Frequent transfers among the personnel discourage them and their efforts in different blocks.

(5) Many schools have no kitchen space or facilities.
It is, therefore, suggested that the entire grant towards school lunch (10 paise/child/day) should be given by the Government so that the burden on the teachers to collect donations can be removed.

A common midday meal central kitchen is needed in every Block to assure uniformity in feeding or all schools should have kitchen facilities and gardening.

It is at the village level which is the ultimate point of utilization and consumption of school meals that there are many small but pressing problems which go unnoticed by the policy makers, planners, administrators and scientists.

In one of our studies, 35 teachers from the Perianaickenpalayam Block and 164 teachers from the District revealed the following problems:

1. Inadequacy of funds. Grants from the Government are inadequate and some schools are in debt because of meeting the expenditure.

2. Lack of steady supply of funds: Collection of funds and contributions from the public, who cannot be enthusiastic all the time, is a heavy burden.

3. Carrying water from the well.

4. Scarcity of water and unhygienic supply of water.

5. Need for teachers to cook food which takes away their attention from teaching, which is their legitimate duty and responsibility.

6. Involving pupils for cooking, serving and washing. This practice takes them away from the classes, makes them tired and inattentive in the class.

7. Failure of Panchayat to meet their obligations. Therefore, schools are in debt and they are forced to maintain false accounts.

8. Infestation of CARE foods with weevils and other insects.

9. Transportation of CARE food to the village from the district centre is difficult. The expenditure of time, money and effort involved, are enormous.
School Meal Programmes in India

(10) Often, the supply of CARE foods is delayed and not regular.

(11) Inadequacy of space and utensils. Without kitchens thatched sheds, class rooms or verandahs are used for cooking and serving food.

(12) Non-acceptability of new foods by pupils.

(13) Lack of training for teachers in running the school meal programme.

(14) No facilities like land, water, fertilisers and pesticides for school gardens.

(15) Lack of storage facilities—infestation by rodents.

(16) Lack of provision to feed all the hungry children.

(17) Lack of cooperation from parents and the public.

Suggestions given by the teachers to overcome the problems:

(1) Advance release of adequate funds by Government and Panchayats.

(2) Establishment of central kitchens for neighbourhoods or supply of the CARE commodities in the schools themselves.

(3) Nutrition education for public, parents, teachers and administrators stressing the importance of the school meal programme and how to implement it.

(4) Provision of adequate kitchen, storage space, dining area, water and equipment.

(5) Better packing of commodities by CARE, in smaller packets, using polythene bags.

(6) Provision of cooks.

(7) Enrolment of all needy children in the school lunch programme.

(8) Provision of all the essentials for gardening.
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(9) Provision of technical guidance—at least one nutritionist at the district level.

It is heartening to note that over the last two decades, the school lunch programme has gained momentum and developed to a massive undertaking in India. While the objectives of the school lunch programmes are sound, there are numerous problems in fulfilling them. Formidable gaps such as lack of coordinated approach and leadership, absence of nutrition consciousness at all levels—from the administrators down to the school teachers—lack of nutrition education for parents, teachers and pupils, paucity of funds and inadequacy with regard to facilities exist in the implementation of the programme.

At present not even 20 per cent of the children in school are covered by the school lunch, and children in the school represent half the children in this age group. Most states are already finding it difficult to maintain the existing programmes. If at least half the number of children enrolled in the school are to be served lunches, larger governmental allocations will have to be made for this purpose. The National Agriculture Commission needs to explore the possibility of making food allocations for the school meals programme.

School feeding needs to be viewed not merely as a welfare project but as a development effort—to strengthen the social fabric. Therefore, school lunch programmes should be planned and evaluated in terms of social values. There is no economic net cost at all when children are adequately fed, since failure to do this will be very expensive in terms of shortened and damaged lives. 5, 6, 4

One of the gaps in the school lunch programmes is absence of evaluation. There have been committees studying the problems such as those of the National School Health Committee, 6 the Health Survey and Planning Committee under the Chairmanship of Sri A. Lakshmanaswamy Mudaliar, the study in Andhra Pradesh by the National Institute of Nutrition 6 and the Orissa Study. What is required is a ‘built in’ evaluation to ensure the regularity and adequacy of the nutritional feeding and the educational components of the programme. In the absence of internal assessment, the programme is seldom adequate and hence most of the evaluative studies have failed to report notable increments in growth of children. The built in evaluation will also reveal how the school lunch can supplement the home diets.

Above all in integrated national approach to the organization, implementation and evaluation of the school lunch programme is needed. Such an approach necessitates enactment of school lunch Acts or laws. For this purpose a chain
of dedicated and educated workers is required from the village level with a coordinator at the district level. The public should be educated on the beneficial outcomes of the school meal and urged to provide monetary and physical contribution to the programme. A practical guide and meal plan need to be drawn out and adapted to the needs of the various regions under the supervision of trained nutrition officers. The Union Ministries of Education and Health, the States of Tamil Nadu and Orissa, and the National Institute of Nutrition have made some efforts along these lines. The school lunch project needs to be integrated with the wider objectives of education with emphasis on better nutrition. Examples of such an integrated approach can be found in the school lunch programmes in our Institutions. They give hope for the future because of the convincing evidences of better nutritional status, nutrition information, school performance and attendance and socialization registered by the participants.

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PROBLEMS IN IMPLEMENTATION OF NUTRITION PROGRAMMES FOR PRESCHOOL CHILDREN IN INDONESIA

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As in most developing countries in Asia, nutritional problems in Indonesia, a country with about 120 million people—having an ethnic diversity—13000 islands stretching across an archipelago 3000 miles long, are evident in the preschool age sector of the population. Protein-calorie malnutrition and vitamin A deficiency occur most frequently among the preschool children which represent the future productive manpower within two decades. This group has been seen to be vulnerable to nutritional deprivation, both physical and psychological. In addition to the low dietary intake especially of protein, calorie and vitamin A, the most important factors causing an interaction between PCM and vitamin A deficiency are the common infectious diseases of childhood.

Other ecological factors producing these phenomena are multiple such as poverty, ignorance, food habits, traditions and in some areas foodshortage due to disasters of nature. In the islands of Java and Bali the rapid population increase is outstripping increases in food production. In the following presentation, I have chosen to highlight the problems in implementation of nutrition programmes for preschool children in Indonesia. The main problems related to malnutrition are problems of socio-economic and geographical diversities. Therefore, the nutritional improvement programmes cannot be considered separately from the Fifth National Development Plan (1969-1974). The Government of Indonesia is giving high priority to food productions and related aspects.

The Indonesian Workshop on Food, jointly sponsored by the Indonesian Institute of Sciences (LIPI) and the National Academy of Science USA (NAS) organized at Djakarta 1968, brought the whole problem of nutrition into a much sharper focus and endorsed the ANP approach as a practical solution to the problem in Indonesia.

The report of the workshop observed:

"The improvement of the nutritional state of the vulnerable groups of the
Indonesian population can be effected by practical nutrition education for pregnant and nursing mothers. This means taking measures to make the community aware of the seriousness of the nutrition problems affecting physical and mental development of children, and concurrently showing the means for improvement within the community's reach. In essence, measures for nutrition improvement are based on principles of home economics or home life improvement, taking into account the various socio-economic factors. Expressed in simple words, it means: increase of production of nutritious food, especially protein-rich foods, in the backyard, and consuming them. Nutrition-mindedness of the community can be of great benefit in enhancing programmes for increase of food production, and efficiently coordinated efforts should be geared to spread it. But nutrition-mindedness should start from the top level of the government and go down to the regional, country and village levels; it is of the utmost importance that executives, legislators, and policy makers at the national level be nutrition-minded". 

THE APPLIED NUTRITION PROGRAMMES (ANP) IN INDONESIA

For the years that followed the activities were confined to eight geographical regions: North Sumatra, South Sumatra, West—Central,—and East Java, Jogjakarta Special Territory, Bali, West Nusa Tenggara. The activities in the above areas have already commenced and are in various stages of development.

The multidepartmental, applied nutrition programmes can be divided into two main field of activities.5

1. Orientation and education to create an awareness of the problems as well as nutrition-mindedness both at the official and people's level.

2. Development of practical approaches for production of nutritive foods by the families for their ready-consumption.

Recently a study of social and cultural aspects of food patterns and food habits in five rural areas (in the ANP areas) had been conducted by Tan et al. The purpose of the study is to collect information on food patterns which exist in the five areas and the social and cultural factors which influence this pattern. Those are very important and essential to secure the success of any programme aimed towards improvement of the diet.

The fundamental problem is how to motivate people to change their food habits and improve their diet.
Some conclusions and implications related to the preschool age nutritional problems are: the variation by cultural area, inherent in the pluralistic nature of the Indonesian Society suggests that in the formulation of the ANP programme as in any programme concerned with social and cultural change, modification and adjustments commensurate with the situation in the various areas are imperative. The low level of formal education combined with the high incidence of not knowing Indonesian, has important implications for communication and the dissemination of information. It is obvious that for effective communications the local language should be used. The social and cultural homogeneity within each area is reflected in the daily meal pattern.

Considering the economic conditions prevailing in the rural areas, it seems unrealistic to expect an increase in the consumption of meat such as beef, goat or chicken. Animal protein is derived mainly from fish and this situation will undoubtedly continue for some time to come. This raises important questions as to the prospects for fish breeding.

The indulgence and permissiveness in regard to food towards children suggests that in the areas studied at least children are not a deprived group. This is contrary to findings observed elsewhere. This attitude could therefore be utilized to educate mothers to give their children food which is of a more nutritious nature. Beliefs and taboos related to food are more in the nature of avoidances rather than prohibitions with definite sanctions; any change in the diet of small children is entirely dependent on change in the diet of the adults because after they are two years old, no special food is given to them. In order to improve or change the diet in the family it is important to find out who decides what is eaten every day; it is ultimately the mother who decides what is eaten or it simply depends on the food that happens to be available or on both these circumstances. This means that it is the mother who needs to be educated.

**INTEGRATED HEALTH SERVICES AND ORGANIZATION OF VILLAGE SOCIAL DEVELOPMENT (LEMBAGA SOSIAL DESA=L.S.D.)**

The integrated Health Services of the Ministry of Health have undertaken action for curative and preventive measures. All the MCH centres will be integrated into the Integrated Health Services because until recently visits by preschool children especially 1-5 years, were scarce.

The L.S.D.'s are organized and maintained by the villagers themselves covering not merely social activities but also problems related to health and welfare.
It is feasible in the future that both organization channels scattered all over the country could be used as "instruments" for combating malnutrition.

RESEARCH AND DEVELOPMENT OF IMPLEMENTATION OF NUTRITION PROGRAMMES

In the last decade nutritional research has been conducted focusing the identifications and defining problems of preschool child malnutrition. However, there still exist gaps between the results of research and implementation of programmes in the community, because the numerous interrelated factors involved in the complex problems of child malnutrition demand a simultaneous, coordinated, multidisciplinary approach at all levels of the Government and communities.

REFERENCES

The subject I am going to present to-day concerns the practical problems in implementation of nutrition programme for pre-school children in Thailand. But before going into the details of the problems, I would like to describe the general nutritional problems of Thai pre-school children and the measures employed in correcting them.

Hospital statistics would show that there were 32,438 cases of young children aged 1 to 4 years admitted to various provincial hospitals in the year 1966, of which 2,090 cases suffered from deficiency diseases. And from the record of the Nutrition Division, there were 1,291 cases of protein-calorie malnutrition and 6,372 cases of vitamin deficiency in the year 1969. This confirms that nutritional deficiencies are among the serious problems facing Thai pre-school children.

The nutrition programme for pre-school children in Thailand is implemented through various channels:

1. APPROACH THROUGH MATERIAL AND CHILD HEALTH SERVICES

   Nutrition programme for pre-school children was implemented along with the material and child health services since 1941 by nurses and midwives at various health centres. During the routine examination of mothers and young children, instruction about nutrition including food demonstration and preparation are always given. In the year 1969, 534,457 children came to the health centres to attend the well-baby clinic organized by nurses and midwives.

2. APPROACH THROUGH NUTRITION EDUCATION OF MOTHERS AND THE PUBLIC

   In 1959, the National Nutrition Committee had organized the Subcommittee on Nutrition for Infants and pre-school children with the aim of recommending
supplementary feeding for infants, foods for pre-school children and to extend knowledge in nutrition to pregnant and lactating women. Nutrition education was also included in the training of various categories of personnel who were involved in the health and nutrition work.

3. ACTIVITIES OF APPLIED NUTRITION PROJECT

The Government of Thailand has established the Applied Nutrition Project in 1961 with the assistance of UNICEF, FAO and WHO. The objectives of the projects were to raise the nutritional status of the Thai people, to increase the food production and to combat malnutrition.

In August 1968, the plan of operation of the project was revised. Target population was redefined with higher priorities given to pre-school children and one of the approaches is the feeding of the children in day-care centres, so-called “Child Nutrition Centre”.

4. THROUGH THE DEVELOPMENT OF PROTEIN SUPPLEMENTS

Protein supplements used in the feeding programme have been developed through the Protein Food Development Project under USAID assistance with the co-operation of the Institute of Food Research and Product Development. The pilot plant to produce protein food using local material such as beans and fish has been established.

PRACTICAL PROBLEMS IN IMPLEMENTATION OF THE PROGRAMME

1. Problems encountered in the organization of training courses

In the integration of nutrition work with the activities of the health or midwifery centres, close co-ordination of the Nutrition Division and the Material and Child Health Division is needed. In this way, we could cover quite a number of pre-school children as I have already mentioned. Co-ordinated arrangement for the training in applied nutrition for nurses and midwives is necessary. Such training programmes, of course, require financial support. Up to the present, several such programmes have been possible through the assistance of UNICEF.

2. Problems involved in the organizing of the Child Nutrition Centre

The Child Nutrition Centre is usually located in the vicinity of health or midwifery centres. Locally available materials are used in the construction
and such construction is usually possible through the co-operation of the villagers. After the set up of the building, problem may arise later for it would not last long because the materials are bought from torn down bamboo or old houses provided by the villagers. Permanent building has to be considered after two or three years of the establishment of the original one. Each permanent centre will cost about 15,000 Baht ($750). With limited budget, expansion of the centre is rather slow.

In each Child Nutrition Centre, one attendant for every thirty children is employed. The attendants are selected from villages where the centres are located. They are trained for 15 days at the provincial health office and kindergarten schools. The method of taking care of children, organizing games and some principles of health and nutrition are among the subjects taught. We always face the problem that some attendants give up the work to find other better jobs and we have to train others to replace them.

The pre-school children who are admitted to the centres range from 1 to 5 years of age. Since we have set the aim that the centres have to be at least partially self-supported, the children have to pay an admission fee ranging from 5 Baht ($0.25) to 20 Baht ($1) per month. The money collected from each child is used as the salary of the attendants or for buying food materials to prepare lunch and other operational expenditure. Some children from low income families cannot afford to pay the fee so they have to be admitted free of charge but their parents have to come more often to the centre to work in return.

Another problem involved is that some centres cannot be operated effectively because the families are widely scattered and it is difficult for parents to send their children to the centres every day. Especially, during the rice planting or harvesting periods the villagers have to work in the field which is very far from their houses and so they have to take the children along with them. High absenteeism is common during that period. This is a problem for which we are trying to find a solution.

One of the basic problems in organizing and carrying out a programme for the group care of pre-school children is the difficulty of getting mothers to take interest and participate actively in its operation. One way of achieving mother's participation is to arrange for them to take turns attending the centres so that much burden does not fall upon any individual mother.

In this connection there is always a question from the parent as to why the child could not read and write after a period of time in the centre. It has to
be made clear that the centre is not really aiming at giving education but it is a place where we could reach the pre-school children and provide them with health and nutrition services.

3. Problem of supervision

For better results, supervision has to be undertaken at every level. The immediate supervisors of the attendants of Child Nutrition Centre are nurses and midwives. At provincial level supervision is carried out by staff public health nurses or nutritionists of the provincial health office. Lack of transport facilities is the major problem at this level. At the central level, supervision comes from the Nutrition Division and Material and Child Health Division. The number of central supervisors is small and such inadequate supervision will result in the deterioration of the activity.

4. Available resources

Concerning personnel, we have limited staff of just about 50 persons including the administrative staff. The annual budget is only 3 million Baht per year (approximately $150,000) which is so small that assistance from international agencies like UNICEF, USAID etc. becomes even more necessary. This is one of the reasons why work has to be integrated into the existing health services. The increase of our budget is only 4 per cent annually and we have to maximize the utilization of existing resources as much as possible.

In conclusion, I would like to point out that the implementation of nutrition programmes for pre-school child, in its nature, is not an easy undertaking. Yet our experience so far indicates that the organization of the Child Nutrition Centre which is basically a day-care centre to accommodate the children of this age group is one of the most promising means of approach. If all the pre-school children of the village can be assembled, any health service other than nutrition can easily be managed.
Applied Nutrition Programmes have been essentially educational and demonstration endeavours, carried out in rural communities, with a designated objective of enhanced local production and consumption of nutritionally desirable foods in order to improve the nutritional status in a specific community. Nutrition programmes in South East Asia were initiated because of shortages of food, lack of suitable equipment for improved food production, nutritionally inappropriate food behaviour, ignorance, and poverty. These programmes in the region have experienced a varied degree of involvement in co-ordinated activities with co-operative action of the Ministries of Agriculture, Health, Education, and Community Development. Co-ordination of activities of an Applied Nutrition Programme by a central government or local committee avoids duplication or unacceptable differences in approach. However, the executive action of the Programme's activities remains the responsibility of the separate ministries and agencies. The Programmes in the region have emphasized the exceedingly important role of the community and its involvement, as well as the family, in nutritional improvement of vulnerable groups. The most unrecognized factor has been that Applied Nutrition Programmes are long-term and of a continuous effort with adaptable objectives which are an integral part of a National Food and Nutrition Policy within the total national plans for economic and social development.

When a nutrition programme is isolated from the overall emphasis to national planning, its accomplishments can be expected to be of limited scope. Also, if food production objectives of a programme are to be achieved, an economic incentive within these objectives is desirable. With the economic incentive must also be a parallel endeavour of education in wise economic spending of some of the additional purchasing power toward improved food consumption. To achieve its objective, the nutrition programme must be supported by the Government and by the communities in which it is working.

Applied Nutrition Programmes in South East Asia have varied from—

1. comprehensive schemes of interrelated educational activities with
objectives for the improvement of food production, consumption, and
distribution within the local community with special intent to enhance
the nutrition of children and mothers,

2. single measures of practical activity which have lacked an integrated
effort of two or more Government departments.

Applied Nutrition Programmes do not have a standard format of project
formulation and development. For this reason, I am not prepared to make
comparisons of one National Programme with another in the region. The
objectives of each Programme have been established at a particular time to
meet the priorities of a particular locality and situation. Only those programmes,
which have remained flexible and realistic in their objectives as conditions have
changed, have maintained their potential as a contributor to national develop-
ment.

National Programmes are extensively variable in their approaches to local
project emphasis and implementation within a country. These variations in a
National Programme may be as great as when comparisons are made in
programmes between countries. A typical example of necessity for extensive
variation within a country would be the India Applied Nutrition Programme;
where climate, ecological conditions, native food crops, food habits and prefer-
ences, family income levels, and many other influencing factors dictate adjust-
ments to meet the local scene.

A four-stage approach to implementing and operating an Applied Nutrition
Programme is recognized:

First — feasibility survey and preliminary planning,

Second — collection of base-line data and detailed planning;

Third — programme operations in pilot zones, with evaluation and

Fourth — expansion to new zones.

To day, we look at the total scope of nutrition from these dimensions — food
production, food consumption, distribution, economics, knowledge and
solution of nutritional deficiencies.

It is the responsibility of the Ministry of Agriculture to provide an adequacy
of food nutrients by economical food production practices (crops and animals)
and importation policies to meet the nutrient needs of the national populations
The promotion of altered food production may highly depend upon the skill.
of the agriculture and home economics extension services of this ministry and
the extent of their contact to the household level.

The Ministry of Education has a unique opportunity to provide information
through teachers, whereby children develop the right opinions about nutrition
knowledge. This has been most successfully accomplished through integrated
teaching and demonstration at all ages and as a part of all subject disciplines.
Practical feeding programmes in schools not only can be a tool of education,
but their nutrition value to the child can be a substantial contribution to learning
capability.

Health agencies will always have a valuable role to play in meeting the
crises where poor nutrition has permitted in roads of many diseases. Through
education in the community health agency centres, the pre-school child as
well as the pregnant and lactating mothers are emphasized in reference to
their vulnerable position and the consequences of inadequate nutrition.

In order that I do not completely disappoint you in these ten minutes, I will
enumerate the countries of South East Asia who have Applied Nutrition
Programmes. I do not want to make comparisons of National Programmes
because of the great variations in objectives and time of implementation.

Cambodia — a nutrition survey and training programme with only health
agency involvement.

India — a wide scope of activities by many national, state, and local
agencies conducted in 21 areas of the country.

Indonesia — an integrated effort of agriculture, health, and education
presently endeavouring a realistic programming of a pilot
scheme in seven regions of the country.

Korea — a pilot programme with major efforts by agriculture.

Malaysia — a pilot project with one year of operation and involving the
co-ordination and co-operation of agriculture, health,
education, and community development.

Pakistan — a programme with a major health emphasis.

Philippines — an extensively expanded programme under the leadership of
education which has now been undertaken as a nation-wide
Applied Nutrition Programme in S. E. Asia

approach through a co-ordinated effort of the National Food and Agricultural Council with co-operation of Education, Agriculture, and Health.

Singapore — a health agency survey of nutrition problems and of dietary patterns of pre-school children.

Thailand — an emphasis of health and education through Child Nutrition Centres and teacher training for nutrition education to school children.

What is success in a National Nutrition Programme? When you have inspired the citizens of the local community to produce, distribute, and utilize proper foods in order that every member of the family is receiving their essential daily nutrients for growth, work, normal body functioning, and physical and mental well-being — then you can say that your Applied Nutrition Programme is a success.
CURRENT STATUS OF THE APPLIED NUTRITION
PROGRAMME IN THAILAND

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A pilot project of Applied Nutrition which started in Ubol in 1961 dealt on a small scale with several aspects of applied nutrition such as base-line and periodic surveys, production of protective foods including vegetables, poultry and fish by the community and primary school, education of the public, training of personnel of various levels and categories and evaluation of the programme. The programme started in 10 villages in 1961 and expanded to 39 villages in 1968.

In 1965, a second programme was undertaken, in Chengmai. Besides the original objectives, this programme had another aim viz. to improve on the methodology and approach employed in the first instance.

ANALYSIS

From gathered experience, it is possible to conceptualize as to what mechanisms are important to the effective development of ANP. Following is a brief review of such mechanisms:

1. The national food and nutrition policy

   It is almost a prerequisite that a national food and nutrition policy be established. Such policy will state the direction which the country will follow in a specified period of time.

2. The central planning and co-ordinating body

   This may be in the form of a national food and nutritional committee. It will assume the function of a central planning authority with other supportive roles as co-ordinating, providing technical advice and guidance and evaluating food and nutrition activities.
3. The secretariat office of the body

Truly indispensable and can be said to be a vital part of the central planning and co-ordinating body. The efficiency of the secretariat office will reflect in the committee’s effectiveness.

4. A master plan for food and nutrition policy

This plan states measures to be implemented, specify priorities and explain necessary mechanisms which should be created including target setting, methodology of implementation, use of resources, supervision and evaluation.

5. Definition of the problem and population in terms of priorities

This is even more important in the face of resource limitation which is characteristic of developing countries. Effort and resource should be spent in setting up priorities of the problem and toward the protection of the more vulnerable group(s).

6. Establishment of necessary infrastructure

Only through adequate infrastructure can a successful field programme be realized. This includes creating, in the event of non-existence or re-orienting the role and function of existing personnel, their positioning at village level to provide necessary continuity of contact with the people and the creation of facilities or methodology which will facilitate such contact. Adequate supervisory system is also an important contributing factor.

7. Creation of low-cost nutritious foods

It is becoming evident that food technology can play a sizeable role in filling certain gaps in the complicated process of improving nutritional status of the masses. The advantage of having low-cost protein food in hand is immense and could open up new horizons in programme designing and implementation.

CURRENT DEVELOPMENT

1. Policy development

Last October, the Government approved the national food and nutrition policy as recommended by the Ministry of Public Health and advised its
inclusion in the five-year economic development plan which is to begin in 1972. The policy emphasizes four major areas of development, that is:

a. supplementary feeding programme for the preschool child together with development of adequate infrastructure to implement such programme.

b. promotion of production of protein rich foods in rural areas, emphasizing soyabean cultivation and poultry programme.

c. development of low-cost protein foods, utilizing indigenous sources and modern technology.

d. development of high-protein, high-yielding rice varieties.

2. Co-ordinating mechanism

Thailand has had a national nutrition committee for the last two decades, but it can be said that the performance of the committee still leaves much to be desired. After the last general election (1968), new efforts are being made to reorganize the whole set up, as evident by the replacement of the old committee with a new national food and nutrition co-ordinating committee chaired by the Ministry of Education.

Together with the set up of the new committee, plans are underway to establish a secretariat office in the form of a national institute of food and nutrition.

This Institute is expected to be established in Bangkok in the next one or two years. It will be affiliated to the Ramathibodi Medical School which is the newest and one of the most progressive institutes in the country.

The key staff of the Institute will be drawn from the Ministries of Health, Education and Ramathibodi Medical School. The Institute will have four major functions among which will be the formulation of a master plan for food and nutrition development and training of workers of various categories to carry out field programmes developed by agencies in accordance with the master plan.

3. Protein problem and pre-school child feeding as a major area of concentration

At central level, marriage between nutrition and food technology occurred in 1968 in the form of a joint programme to develop protein foods by the
University of Agriculture and the Ministry of Public Health. Since then, many prototypes have been developed, among which are the soya milk and the textured protein from mung bean and other sources, fortified with amino acid, vitamins, and minerals. At present, this programme enters its promotion phase in which emphasis is given to the promotion of protein food industries and the creation of a fixed market for the foods. The latter will include child nutrition centres and school nutrition programme among others.

In the field, methodology of applied nutrition programme has been changed to put emphasis on preschool child feeding and education of mothers, with collateral development of agricultural programme in the same village. The mechanism by which preschool children are reached is in the form of a day-care centre type of establishment officially called the child nutrition centre.

The centre provides for care of the pre-school child in the village and is affiliated to the health or midwifery centre which supervises its functioning. This programme stresses not only nutrition but other aspects of child development such as physical and mental development, education and other aspects of health care.

The child nutrition centre is considered a means to reach not only the preschool child but the mothers as well. Education programme for mothers is essential and cannot be neglected. The final aim of the whole set up is to induce change in the practice of child feeding and care within the family.

The protein foods used in the centre may be low-cost protein foods developed centrally or products of the local agricultural promotion programme such as the poultry programme which emphasizes production of half-breed chicken for better meat and egg yield, better resistance to infection and simple feeding. This was started in Chingmai in 1968 by providing pure breed roasters to cross with local hens. A small number of their offspring, when grown up, is to be provided as food material to the child nutrition centre by every participating household in turn. The programme proved so successful that by the end of the same year it was extended to 40 villages in 18 provinces.

To summarize, the next decade will see in Thailand new developments which are designed to answer the three most gnawing problems in all applied nutrition activities, which are (1) Co-ordination (2) Effective utilization of existing resources and (3) How to reach the vulnerable group of population. No claim is made as to the efficacy of the designs being used in our programme, but we shall be ready to share our experience in implementing them with those who may be interested and wish for the communication.
The Philippines is a developing country of 7,100 islands with a problem of population increase so explosive that, although our country is only the thirteenth in territorial size in Asia, we rank sixth in population size. Our annual increase in population is 3.4\%\textsuperscript{a}, one of the highest in the world. One need not spell out the significance of this rapid rate of population growth in terms of food production.

Planning for the first applied nutrition project in the Philippines was made just a little over a decade ago. Last year, the author reported here at Hyderabad how our National Coordinating Council on Food and Nutrition was involved in this regard. Agreements on the role of each agency were made at the NCCFN meetings and the leadership for the implementation of the project was given to the Education Department which was the initiating ministry for these plans.

The NCCFN operates on the concept that nutrition should be the concern of all, hence its promotion should be a concerted multidisciplinary action whether one plans for a national, provincial or grassroots action programme. Any agency interested in leading an applied nutrition project can and does obtain support from other member agencies at the NCCFN. But while each of these projects are all cooperative ventures, emphasis naturally varies with the main agency’s line of interest. Thus, the Education Department’s programme centered around education and school feeding and the Health Department’s project, established later, stressed mothercraft centres with pre-school feeding. The Agriculture Department provides adequate support to both these projects while in turn stressing the attainment of national food targets in its own nutrition programme.

The school feeding aspect of the UNICEF-assisted ANP has just been discussed in detail by my colleague from the Philippines. Major changes in
curriculum have been made as a result of the impact of the programme on education, administrators and teachers, resulting in notable nutrition enrichment of most subjects at all levels especially in the teacher training field. The impact of the training of workers of all categories is even more striking. Regular five-to-six week live-in seminars, multidiscipline in types of trainees as well as course content are being undertaken. Trainees are often selected on the basis of geographic area of operations so that not only exposure to nutrition principles is accomplished but also rapport is established among these workers who will have to cooperate with each other in order to achieve a success in their nutrition programme.

Nutrition training is also now being emphasized under the expansion of this programme through the Department of Health. To supplement the multidiscipline training described above, another type of training is now being undertaken aimed mainly to sharpen the diagnostic skills and to enhance the preventive activities of health personnel. This training is centred around rehabilitation centres for third degree type of malnutrition which have been opened as separate wards in hospitals. Not only hospital personnel, but peripheral medical and para-medical field personnel undergo this type of training. To date, six out of the eight health regions into which the country has been divided have a malnutrition ward. Six more provincial malnutrition wards have also been established. Three of all these “malwards” are already in full operation as training centres.

The Department of Health is moreover presently operating a mothercraft training project where malnourished pre-school children are being given supplementary feeding. This is a USAID supported project where mothers are given nutrition education while participating in the demonstration activities involved in the feeding of their malnourished preschoolers. This project is also closely integrated with the social welfare programme of the Department of Social Welfare called “Project Tulungan”. Tulungan is a word which is difficult to translate into English and connotes “helping-each-other”. In this social welfare project, Food-for-Peace materials are utilized.

The Department of Agriculture has an intensified food production programme which is now strongly nutrition-oriented. A National Food and Agriculture Council was established by the President of the Republic for this purpose and the success of its first major venture—increasing rice production—is well known here. At present, food targets, set along recommendations provided by the Food and Nutrition Research Centre, have been established and hopefully, self-sufficiency in most food items will be in sight within the next four or five years.
As may be evident, the predominant theme around which these projects are built is COOPERATION. Cooperation is an ideal easily achieved on paper. But no amount of regulation or orders-from-above can impose real cooperation. This must come voluntarily from the heart of the individual concerned. That is why it is so difficult to attain cooperation in actual practice unless the persons involved are convinced of the cause they are involved in. It must be confessed that despite our obsession for cooperation, in planning for ANP projects, we cannot claim complete success along this line in all our endeavours. Occasionally, one sour character in a key position is enough to hamper full operations. It is for this reason that I would like to see as a starting activity for each training programme, the inclusion of what psychologists call T-group sessions. In this way, we can generate greater understanding on the part of the individuals from whom cooperation is expected.

We in the Philippines are not unfamiliar with the advantages of cooperation. It is part of our culture. When a man needs to move house, it is literally done for him by friends and neighbours who carry it on their shoulders. This is called "Bayanihan". It is now the ANP symbol adopted by the planners at the National Coordinating Council on Foods and Nutrition. We hope that in the years to come, the Bayanihan Spirit will prevail not only throughout our country, but literally throughout the world.
SYMPOSIUM ON
FOOD CONSUMPTION PATTERNS IN ASIAN COUNTRIES

Chairman: C. R. Pascual, Philippines and K. K. P. N. Rao, FAO.
Rapporteur: Soemilah Sastroamidjojo, Indonesia

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Review of food consumption surveys in Asia — ELENA QUIOGUE ... 216
The nutritive value of Asian dietaries in relation to the protein and energy needs of man — P. R. PAYNE ... 240
Food consumption patterns of pre-school children in India — AMBALINI BAILUR ... 256
Economic aspects of food and nutrition planning — L. JOY ... 267
Post-war changes in food consumption patterns in Japan — T. OTSU ... 275
It is an accepted fact that man eats not only for survival but also for the fulfillment of his other basic needs. Food is the fulcrum from which emotions like love and hate revolve. It is a channel for smooth interpersonal relationships as well as the medium for communication.

As the times change, so does man’s eating pattern. This change has been influenced by the rapid movement of people. Urbanization has altered food procurement methods from the primitive hunting and fishing stage to the purchase of food items from large centres or supermarkets.

A rough estimate of the overall food intake pattern of Asian countries can be gleaned from the food consumption survey reports. The data gathered indicate that the diets are generally lacking in calories, protein, vitamins and minerals. Total calories are often insufficient and high proportion of the calorie intake comes from rice which is the staple food of many. This also accounts for the lack of protein and of B vitamins in the diets of those who eat polished rice. The inadequate intake of milk, fruits and vegetables results in the deficiency of calcium and vitamins A and C. Iron deficiency is rampant due to the high incidence of parasitism. Altogether, the general trend in the dietary intake appears to be a deficiency both in quantity and quality.

In the determination of consumption patterns, other factors aside from availability should be taken into view. Comparatively speaking, while people have become aware of the role of socio-cultural factors in nutrition, this area until recently has received lesser attention than the role of education, the level of income and the availability of food. Comprehensive dietary surveys done in close coordination with other interested groups are a must if we intend to uncover the gaps existing between actual food intake and requirement. The information gathered, including relevant data on food habits, agricultural potentialities, economic and socio-cultural background, can be used as a basis for the planning and implementation of nation wide nutrition campaigns for better health particularly in Asia where the problems of population growth...
Food Consumption Patterns in Asian Countries

are great. It can also serve as a starting point for the laying out of national policies on food and nutrition. It does not need further explanation to say that food production targets cannot be well established unless consumption patterns are well defined.

Our understanding of the reasons for the many dietary patterns is still very limited. This timely conference is indeed a step toward better understanding and hopefully a step toward the betterment of the nutritional status for a more efficient and productive manpower in all Asia.
REVIEW OF FOOD CONSUMPTION SURVEYS IN ASIA

ELENA S. QUIogue
Food and Nutrition Research Centre,
National Institute of Science and Technology,
Manila, Philippines

This paper is a review of food consumption surveys conducted in the various countries of the Asia region over the past 12 years. I encountered varied types of surveys—from national, to regional, to small-scale partial surveys, on entire families, on specific groups, on infants and children using different methods—from food weighing, to questionnaire—interview, observation, self-recording by housewives, household budgets, menu-pattern, socio-economic surveys etc. The wide variety of methods used, however, did not allow for much objective reporting and most of the information gathered was more qualitative than quantitative, which would have permitted easier comparability of the data. Presented herein is a summary of some surveys reported in the literature.

a. NATION WIDE FOOD CONSUMPTION SURVEYS

Among the countries which have conducted and published nation wide food consumption surveys may be cited Japan, Korea, Pakistan, Iran, India and the Philippines. The most accurate estimate of actual food consumed in Japan is obtained from the National Nutrition Survey conducted by the Statistics and Survey Division of the Ministry of Health and Social Welfare (Table 1).

<table>
<thead>
<tr>
<th>Year</th>
<th>Calories</th>
<th>Protein (gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Iran</td>
<td>1962-67</td>
<td>2460</td>
</tr>
<tr>
<td>2. East Pakistan</td>
<td>1962-64</td>
<td>2202</td>
</tr>
<tr>
<td>3. Japan</td>
<td>1965</td>
<td>2184</td>
</tr>
<tr>
<td>4. West Pakistan</td>
<td>1962-64</td>
<td>2111</td>
</tr>
<tr>
<td>5. Korea</td>
<td>1970</td>
<td>2105</td>
</tr>
<tr>
<td>6. India</td>
<td>1965</td>
<td>1970</td>
</tr>
<tr>
<td>7. Philippines</td>
<td>1958-67</td>
<td>1673</td>
</tr>
</tbody>
</table>
It has been conducted every year since 1946 when it started with a limited population in some big cities, but has gradually enlarged to the present whole household population of Japan. Foods consumed are weighed and self-registered by each household for three days, and checked by investigators (nutritionists) who arrange the collected forms in food groups by household. Calorie and nutrient contents of foods are calculated from food composition tables, recommended allowances are estimated by age, sex, activity, whether pregnant or lactating, and food expenditures are calculated. Evaluation and analysis are done by the Nutrition Section of the Bureau of Public Health.

In Korea, a nationwide nutrition survey was conducted by the Ministry of Health and Social Affairs from 29 July to 15 August 1969 which included dietary, anthropometric, clinical, and socio-economic aspects. It was a very intensive survey which even included estimates of nutrient losses from cooking besides detailed characteristics of the diet in terms of calories and nutrients of the various occupational and regional groups in the population.

A nationwide nutrition survey was conducted in 1962-64 in Pakistan under the leadership of the Directorate of Nutrition Survey and Research, with the collaboration of the National Institutes of Health (U.S.A.) and the United Nations Specialized Agencies, the FAO, WHO, and UNICEF. The population sample consisted of 15,000 persons from East Pakistan and 8,000 from West Pakistan, or a total of 23,000 persons. Methods used were food weighing and interview, with clinical and biochemical surveys for nutritional status assessment.

Another survey of national scope was the National Sample Survey of Family Expenditure conducted in 250 villages in East Pakistan and 250 in West Pakistan, using the questionnaire-interview method. All aspects of food consumption including weights and prices and family composition were taken into account.

In Thailand, the 1962-63 survey of household expenditures by the National Statistical Office included quantities and costs of foods purchased and consumed by all private and non-institutional households in all regions of the kingdom, both urban and rural, and the Bangkok-Thonburi municipal areas. A total of 6,430 households were covered, 2,310 in towns and 4,120 in villages.

A few years back, very little was known about the food and nutrition situation of Iran. But from the commencement of activities of the Food and Nutrition Institute, a series of food and nutrition surveys were conducted in order to establish a baseline for future planning. Almost all the regions of the country with a variety of geographic, climatic and cultural conditions in rural and urban communities were put under survey. (Table 2).
<table>
<thead>
<tr>
<th>Country</th>
<th>Area or location</th>
<th>Year</th>
<th>Calories</th>
<th>Protein (gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Indonesia</td>
<td>Java and Madura</td>
<td>1964</td>
<td>1556</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Outer islands</td>
<td>1964</td>
<td>1931</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Ponbrogro</td>
<td>1964</td>
<td>1955</td>
<td>22.3</td>
</tr>
<tr>
<td></td>
<td>Gunung-Kidul diets</td>
<td>1957-59</td>
<td>1330</td>
<td>15.6</td>
</tr>
<tr>
<td>2. Iran</td>
<td>Gorg Tappeh and 5 other villages around it</td>
<td>1965</td>
<td>2754</td>
<td>74.8</td>
</tr>
<tr>
<td>3. Israel</td>
<td>25 towns of Israel</td>
<td>1960</td>
<td>2240</td>
<td>76.2</td>
</tr>
<tr>
<td>4. Korea</td>
<td>Farming village Southeast of Seoul</td>
<td>1962</td>
<td>1918</td>
<td>63.5</td>
</tr>
<tr>
<td></td>
<td>Various areas</td>
<td>1962-64</td>
<td>2083</td>
<td>65.8</td>
</tr>
<tr>
<td>5. Malaya</td>
<td>From different parts of Malaya residing at University campus</td>
<td>1968</td>
<td>2130</td>
<td>(1.3 gms/kg.)</td>
</tr>
<tr>
<td>6. Thailand</td>
<td>10 villages in Uthol</td>
<td>1966</td>
<td>2053</td>
<td>55.7</td>
</tr>
<tr>
<td></td>
<td>Migrant families in Doi Yaw village</td>
<td>1967</td>
<td>1913</td>
<td>48.5</td>
</tr>
<tr>
<td></td>
<td>Bangkhen, Bangkok</td>
<td>1964</td>
<td>1240</td>
<td>42.9</td>
</tr>
<tr>
<td></td>
<td>Nong-Kuai village</td>
<td>1964</td>
<td>2307</td>
<td>60.5</td>
</tr>
<tr>
<td></td>
<td>Sampee-Sue village</td>
<td>1964</td>
<td>1894</td>
<td>46.4</td>
</tr>
<tr>
<td></td>
<td>Mae-ka-chan village</td>
<td>1964</td>
<td>2280</td>
<td>54.7</td>
</tr>
<tr>
<td></td>
<td>Ban-oy Mae-ram village</td>
<td>1964</td>
<td>1999</td>
<td>52.0</td>
</tr>
</tbody>
</table>

Range of calories: 1350-2754
Range of proteins: 15.6-76.2
Philippines regional nutrition surveys have been conducted since 1958 using a three-pronged approach that include clinical, biochemical, and dietary phases. The dietary survey procedure consists of actual weighing of the household food supply for a period of three days in succession, supplemented by questionnaire-interview technique for questions on food preparation and cooking practices, infant feeding and weaning practices, beliefs and notions about food, and others. Stratified random sampling techniques have been used in these surveys and the frequency was one region each year. Thus, strictly speaking, these regional nutrition surveys are not national in scope as each region was done in a different year. For purposes of showing the whole picture for the country, however, we have come up with a summary for 9 regions (out of 10), while plans are underway for a nationwide food consumption survey shortly.

We have done some nutrition surveys (dietary, biochemical and clinical phases) in the Philippines. Allow me to show some charts and graphs that we have worked out giving more detailed analyses and evaluation of our dietary data collected from 9 regions (out of 10) during the last 10 years. They show various ways by which we have treated our data in our efforts to evaluate both the quantity and quality of our diets and the various factors that have contributed to make our diets the way they are in our particular setting.

Table 3 shows the scope of our surveys—the geographic areas covered and the period—9 regions over 10 years; number of households surveyed are 2,813 and number of persons 19,145. The average household size for the country is 6.8 members.

Table 4 shows the contribution of 12 food groups to the calorie and nutrient contents of the diet. The cereal group is the greatest contributor to calories, proteins, iron, thiamine, riboflavin, and niacin, and meats, poultry, fish to protein, fat and calcium contents of the diet.

Figure 1 shows the relative composition of the Philippine population (1960) by age and sex, compared to the composition of the population surveyed. There is a very close similarity in percent breakdown by age and sex in both populations which gives us confidence in the representativeness of our samples.

Figure 2 shows the average daily per capita food intakes in nine regions compared to per capita recommended allowances for Filipinos. Only “cereals” and “other fruits and vegetable” are shown to be adequately met, while “meat, poultry and fish” and “starchy roots and tubers” are the closest to adequate 87%. All other foods are only between 27 and 43% of recommended levels.
## Summary of nutrition surveys conducted in the Philippines by region and by population of household sample (1958-69)

<table>
<thead>
<tr>
<th>Regions</th>
<th>Date of survey</th>
<th>Number of households</th>
<th>Number of persons</th>
<th>Average household size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Metropolitan Manila</td>
<td>February—May, 1958</td>
<td>402</td>
<td>2,967</td>
<td>9.4</td>
</tr>
<tr>
<td>2. Ilocos-Mt. Province</td>
<td>April—June, 1960</td>
<td>274</td>
<td>1,614</td>
<td>5.9</td>
</tr>
<tr>
<td>3. Cagayan Valley-Batanes</td>
<td>April—June, 1961</td>
<td>293</td>
<td>1,814</td>
<td>6.2</td>
</tr>
<tr>
<td>4. Southern Tagalog</td>
<td>January—April, 1962</td>
<td>368</td>
<td>2,302</td>
<td>6.8</td>
</tr>
<tr>
<td>5. Western Visayas</td>
<td>February—May, 1964</td>
<td>512</td>
<td>3,485</td>
<td>6.8</td>
</tr>
<tr>
<td>6. Eastern Visayas</td>
<td>April—June, 1965</td>
<td>306</td>
<td>1,951</td>
<td>6.4</td>
</tr>
<tr>
<td>7. Southwestern Mindanao</td>
<td>April—May, 1966</td>
<td>225</td>
<td>1,743</td>
<td>7.7</td>
</tr>
<tr>
<td>8. Northeastern Mindanao</td>
<td>April—May, 1967</td>
<td>187</td>
<td>1,335</td>
<td>7.1</td>
</tr>
<tr>
<td>9. Bicol</td>
<td>April—May, 1969</td>
<td>246</td>
<td>9,734</td>
<td>7.0</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td>2,813</td>
<td><strong>Average 6.8</strong></td>
</tr>
</tbody>
</table>
TABLE 4

Contribution of different food groups to calories and nutrients in nine (9) regions of the Philippines: 1958-1969

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Per caput intake</td>
<td>785p</td>
<td>1573</td>
<td>47.0</td>
<td>21</td>
<td>322</td>
<td>35</td>
<td>10</td>
<td>1886</td>
<td>.74</td>
<td>.49</td>
<td>14</td>
<td>68</td>
</tr>
<tr>
<td>Cereals</td>
<td>335</td>
<td>1211</td>
<td>25.9</td>
<td>4</td>
<td>262</td>
<td>.04</td>
<td>4</td>
<td>19</td>
<td>.46</td>
<td>.19</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Starchy roots &amp; tubers</td>
<td>52</td>
<td>64</td>
<td>.5</td>
<td>—</td>
<td>16</td>
<td>.02</td>
<td>1</td>
<td>129</td>
<td>.05</td>
<td>.02</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Sugars and syrups</td>
<td>18</td>
<td>67</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.01</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Dried beans, nuts and seeds</td>
<td>7</td>
<td>18</td>
<td>1.3</td>
<td>—</td>
<td>3</td>
<td>.01</td>
<td>—</td>
<td>5</td>
<td>.03</td>
<td>.01</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Leafy and yellow vegetables</td>
<td>18</td>
<td>8</td>
<td>.6</td>
<td>—</td>
<td>1</td>
<td>.03</td>
<td>1</td>
<td>1085</td>
<td>.02</td>
<td>.04</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Vitamin C-rich foods</td>
<td>23</td>
<td>10</td>
<td>.2</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>196</td>
<td>.01</td>
<td>.01</td>
<td>—</td>
<td>—</td>
<td>12</td>
</tr>
<tr>
<td>Other fruits and vegetables</td>
<td>92</td>
<td>54</td>
<td>1.4</td>
<td>—</td>
<td>13</td>
<td>.02</td>
<td>1</td>
<td>205</td>
<td>.06</td>
<td>.04</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Meat, poultry and fish</td>
<td>76</td>
<td>124</td>
<td>14.9</td>
<td>7</td>
<td>1</td>
<td>.15</td>
<td>2</td>
<td>136</td>
<td>.06</td>
<td>.10</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Eggs</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>54</td>
<td>—</td>
<td>.02</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Milk and milk products</td>
<td>24</td>
<td>20</td>
<td>1.0</td>
<td>1</td>
<td>3</td>
<td>.04</td>
<td>40</td>
<td>.02</td>
<td>.05</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>8</td>
<td>69</td>
<td>.3</td>
<td>8</td>
<td>—</td>
<td>—</td>
<td>13</td>
<td>.02</td>
<td>.02</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>48</td>
<td>21</td>
<td>.4</td>
<td>1</td>
<td>4</td>
<td>.03</td>
<td>1</td>
<td>4</td>
<td>.01</td>
<td>.01</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

*P.E.P. but includes “miscellaneous” group.
FIGURE 1. RELATIVE COMPOSITION OF THE POPULATION OF THE PHILIPPINES (1960) AND THAT OF THE REGIONS SURVEYED.

AGE AND SEX BREAKDOWN

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>INFANTS: UNDER 1 YR.</td>
<td>2.0</td>
<td>3.4</td>
<td>5.7</td>
<td>8.6</td>
<td>10.3</td>
<td>12.0</td>
<td>13.4</td>
<td>14.7</td>
<td>15.0</td>
<td>15.1</td>
</tr>
<tr>
<td>CHILDREN: 1-6 YRS.</td>
<td>21.0</td>
<td>17.4</td>
<td>17.8</td>
<td>16.9</td>
<td>15.0</td>
<td>13.5</td>
<td>12.0</td>
<td>10.8</td>
<td>9.6</td>
<td>8.5</td>
</tr>
<tr>
<td>7-12 YRS.</td>
<td>10.2</td>
<td>9.8</td>
<td>9.5</td>
<td>9.3</td>
<td>9.2</td>
<td>9.1</td>
<td>9.0</td>
<td>8.9</td>
<td>8.8</td>
<td>8.6</td>
</tr>
<tr>
<td>TOTAL CHILDREN 0-12 YRS</td>
<td>39.2</td>
<td>37.1</td>
<td>36.8</td>
<td>36.2</td>
<td>35.7</td>
<td>35.2</td>
<td>34.8</td>
<td>34.4</td>
<td>34.0</td>
<td>33.5</td>
</tr>
<tr>
<td>ADOLESCENTS: GIRLS: 13-19 YRS.</td>
<td>7.5</td>
<td>6.9</td>
<td>6.4</td>
<td>6.0</td>
<td>5.6</td>
<td>5.2</td>
<td>4.9</td>
<td>4.6</td>
<td>4.3</td>
<td>4.0</td>
</tr>
<tr>
<td>BOYS: 13-19 YRS.</td>
<td>7.4</td>
<td>7.7</td>
<td>7.9</td>
<td>8.2</td>
<td>8.5</td>
<td>8.8</td>
<td>9.1</td>
<td>9.4</td>
<td>9.7</td>
<td>10.0</td>
</tr>
<tr>
<td>TOTAL ADOLESCENTS 13-19 YRS</td>
<td>14.9</td>
<td>14.6</td>
<td>13.3</td>
<td>12.6</td>
<td>12.1</td>
<td>11.8</td>
<td>11.5</td>
<td>11.0</td>
<td>10.7</td>
<td>10.5</td>
</tr>
<tr>
<td>ADULTS: WOMAN</td>
<td>22.1</td>
<td>23.3</td>
<td>24.0</td>
<td>24.3</td>
<td>24.5</td>
<td>24.7</td>
<td>24.9</td>
<td>25.0</td>
<td>25.0</td>
<td>25.0</td>
</tr>
<tr>
<td>20-69 YRS.</td>
<td>20.0</td>
<td>19.8</td>
<td>19.5</td>
<td>19.2</td>
<td>18.9</td>
<td>18.6</td>
<td>18.3</td>
<td>18.0</td>
<td>17.7</td>
<td>17.4</td>
</tr>
<tr>
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PHILIPPINE POPULATION, 1960
SURVEY POPULATION, 1958-1960
FIGURE 2. AVERAGE DAILY PER CAPITA FOOD INTAKES IN NINE REGIONS OF
THE PHILIPPINES (1958-1969) COMPARED TO RECOMMENDED
DAILY FOOD ALLOWANCES FOR FILIPINOS

[Bar chart showing food intakes and recommended allowances for various food groups]
Figure 3 shows the corresponding nutrient intakes compared to nutrient allowances. Calories are 83% adequate, proteins 95%. While iron, niacin and ascorbic acid seem to be adequately met, the clinical and biochemical surveys do not confirm these.

Figure 4 shows urban and rural food intakes and here we see that foods consumed in bigger amounts in urban than in rural areas are sugars, vitamin C-rich foods, fruits and vegetables, meat, poultry and fish, eggs, milk and fats; while, those consumed in bigger amounts in rural areas are cereals principally rice, starchy roots and tubers, and dried beans.

Figure 5 shows that calorie and protein intakes are slightly higher in the urban than rural areas. The same is true of vitamin A, thiamine, riboflavin and niacin. Ascorbic acid intake is slightly higher in rural areas, while calcium and iron are at the same level in both urban and rural areas.

Figure 6 shows the distribution of 2567 households in 8 regions surveyed according to their levels of adequacy in calories and protein. There are definitely greater numbers of households that did not reach the recommended calorie allowances (72%) than protein (52%).

Factors found to affect directly the calorie and protein contents of the diet are shown in the succeeding figures. As the size of household increases, the calorie and protein contents of the diet decreases (Fig. 7). As the household income level increases, so do the calorie and protein contents of the diet (Fig. 8), and as the average years of schooling of the household members increase, so do the calorie and protein contents of the diet (Fig. 9). These charts tend to point out the factors that need emphasis in nutrition policy and in planning and programming for improvement of family dietaries.

Figure 10 shows the percentage calorie breakdown of intakes, recommended allowances, and available supply. Available supplies tend to be high in carbohydrate calories and low in proteins and fats, which is also characteristic of the food intake. Recommended allowances tend to be lower in carbohydrates and higher in fats, while remaining in-between actual intakes and available supply for protein.

Figure 11 is a comparison of the recommended daily food allowances with available food supply in the Philippines, showing supplies to be adequate only with respect to cereals, starchy roots, sugars, dried beans, and fish, and inadequate in fruits and vegetables, meats, eggs, milk, fats and oils.
Figure 3: Average daily per capita nutrient intakes compared to recommended allowances in nine regions of the Philippines: 1958-1969.
Figure 4: Mean daily per capita food intakes (urban/rural) compared to recommended allowances in nine regions of the Philippines: 1966-1969

1/ Except "miscellaneous" foods not included among the recommended.
Review of Food Consumption Surveys in Asia
FIGURE 6. DISTRIBUTION OF 2567 SURVEY HOUSEHOLDS IN EIGHT REGIONS BY LEVEL OF ADEQUACY FOR CALORIES AND PROTEIN: 1958-1967

CALORIE LEVELS
NUMBER AND % OF HOUSEHOLDS

PROTEIN LEVELS
NUMBER AND % OF HOUSEHOLDS

CALORIES
2000 + ABOVE
1800 - 1999
1200 - 1599
BELOW 1200

PROTEIN (GM)
49 + ABOVE
40.0 - 49.9
30.0 - 39.9
BELOW 30
FIGURE 7. DAILY PER CAPITA CALORIE AND PROTEIN INTAKES
BY SIZE OF HOUSEHOLD IN EIGHT (8) REGIONS
FIGURE 9. PERCENTAGE OF HOUSEHOLDS MEETING RECOMMENDED ALLOWANCES FOR CALORIES AND PROTEIN BY AVERAGE YEARS OF SCHOOLING OF HOUSEHOLD MEMBERS IN EIGHT (8) REGIONS OF THE PHILIPPINES: 1958-1967

- Below 5 years (11,838 households)
- 5-10 years (11,806 households)
- Over 10 years (9,420 households)
FIGURE 10. PER CAPITA CALORIE DISTRIBUTION IN THE PHILIPPINES COMPARED TO RECOMMENDED ALLOWANCES AND AVAILABLE SUPPLY

TOTAL CALORIES

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</tbody>
</table>

- **CARBOHYDRATES**
- **PROTEIN**
- **FATS**

Elena E. Quinque
Figure 11. Comparison of recommended daily allowances with available food supply.

b. SMALL SCALE SURVEYS

Other countries have also conducted large scale surveys, but in relation to total population of the country, they are not of countrywide scope. Besides, many of these have been conducted on special population groups or for special purposes, rather than on groups representing segments of the population large enough to permit generalizations. In India, for example, a large number of diet surveys have been carried out in the various States during pre-war and post-war years, covering both urban and rural areas. These surveys, which included agriculturists, tribals, industrial workers, students, clerks, etc. number more than 1,470 and cover a lakh of persons. They have been carried out chiefly by the Nutrition Sections of the Public Health Directorate and by the National Institute of Nutrition (formerly Nutrition Research Laboratories). The patterns of food consumption in large areas which have not been surveyed, however, is largely a matter for conjecture.

Pilot surveys were reported in 1964 as having been organised by the Department of Food in India, in preparation for a nation wide food consumption survey in 52 regions to be conducted along the lines and standards provided by FAO. These pilot studies were supposed to test the schedules of inquiry, develop appropriate methodology, and train survey staff.

On the basis of careful and detailed study of available information from the National Sample Survey as well as the diet surveys of the Indian Council of Medical Research, Sukhatme concluded that at least one in every four of the Indian population does not get enough calories and that possibly as much as half the population do not have enough proteins of the requisite quality.

Nutrition surveys have been carried out in different areas of Indonesia since before the war, but mostly when there was hunger, or when the food situation is alarmingly bad, or when one or another kind of nutrition deficiency is suspected. These investigations were too small in number to make generalizations possible, but they give an idea of the general food shortages. One of the few surveys of special areas was the food consumption survey conducted in Ponorogo in 1960 by the East Java Health Service, using the food weighing method.

Food consumption surveys like the Mean-Pattern Survey and nutrition surveys were carried out by the Nutrition Institute and the Academy of Nutrition, while consumption figures were obtained from the National Socio-economic surveys. The conclusion made was that the per capita food consumption is dangerously low in Indonesia both in quantity and quality.
events confirm this, like the yearly recurrence of food shortage and consequent hunger, even chronic hunger, and the increase in the number of areas compelled to use the protein-poor cassava as staple food. The predominance of cassava as basic foodstuff in Gunung-Kidul diets had resulted in diets low in calories and protein by UN-FAO standards. Bailey recommended that extra calories be derived from maize, sorghum and legumes for the additional protein rather than from cassava which is low in protein content and deficient in sulphur-containing amino acids. The Nutrition Survey of Farmers in Japan is conducted by the Ministry of Agriculture and Food on one-fifth of the sample farm households from 1 April to 31 March the following year. Data on marketing and working activities are obtained from daily book-keeping by the sample farm households, and items of family composition and characteristics by interview. In Malaya, results of a study of diets consumed by 500 women students from different parts of Malaya and from different ethnic groups residing in residential colleges of the University of Malaya showed a satisfactory plane of nutrition and good standard of health. A household budget survey using the questionnaire-interview method was conducted by the Department of Statistics in Malaya on one-fourth of all households, or 2,760 households, of which 1,920 were rural and 840 urban, comprising Malaysians, Chinese and Indians. Items purchased and consumed from April 1957 to March 1958 were recorded and nutrient levels assessed by income group, by race, by location. In Taiwan, province-wide dietary surveys using the food weighing method were conducted on 400 households by the Sino-American Joint Committee on Rural Reconstruction in 1962. Per capita available nutrients in 1965 and 1968 show increases in calories by 9%, protein 15%, and other nutrients 10-25%, mostly due to increased production of fishery and livestock during the 3-year intervening period, although niacin and riboflavin were still considered inadequate. A dietary re-survey (of the same households surveyed in 1961-62) was conducted in ten villages in Feb.-Mar. 1966 by the Applied Nutrition Project in Ubol, Thailand on 91 families comprising 633 persons. In 1967, a food consumption survey of migrant families was conducted on 13 households comprising 87 persons in Doytow village, and on 28 households.
in 4 villages in Chiang-mai province using 24-hour recall method only. Interesting variations were found between survey areas.

Some isolated surveys conducted between 1959 and 1963 include the survey of school lunches in some schools in Bangkok and nearby areas. Detailed dietary surveys in selected villages for 1-2 or 3 days per household, using weighing method for all prepared food and left-overs was also done. The expanded nutrition project in 1962-63 included clinical, biochemical, and dietary besides economic aspects, as well as agricultural and health conditions of the villages. Results were found satisfactory. Food supply is abundant all-year round in Thailand and no serious scarcity of food ever occurs. 

In Ceylon, the Consumer Finance Survey conducted jointly by the Central Bank and the Department of Census and Statistics in 1963 found the total expenditure for food and drinks to be 50% of the income. Cereals took up 27% of the food expenditure, vegetables and fruits, 12%, and all other food groups between 5 and 9%. 

Among the surveys reported from Vietnam were a week's survey in hospitals in 1959, follow-up work on applicants for jobs of varied activities conducted by the Nutrition Laboratory, also a study of the nutritional value of the diets using the interview method. 

A survey was conducted in Laos on 17 families for two consecutive days in 1967. Food weights were taken after the women returned from the market and before preparation, and information was gathered on the intended use of food. Diets appeared to provide sufficient calories and protein but were deficient in vitamins A and C due to low consumption of fruits and vegetables. Table 2 shows per capita calorie and protein intakes in various countries of the region as reported from small-scale surveys.

C. CHILD NUTRITION AND FOOD CONSUMPTION SURVEYS

Most countries realise the importance of the vulnerable groups especially children as being the most sensitive to nutrition deficiencies. Among the child nutrition surveys conducted may be cited the following:

1. India—A survey of 4,000 children below 5 years of age showed 40% to be suffering from malnutrition; similar results were obtained on school children by the Indian Council of Medical Research. Surveys on 30 pre-school children in Hyderabad city and in several parts of the country show the bottleneck to be calories and not protein as was originally
believed.\textsuperscript{19} It was also suggested that protein deficiency in these children was to a considerable extent conditioned by the low calorie intake.\textsuperscript{20} Diet and nutrition surveys of population groups and pilot projects for the prevention of nutritional disorder and for promotion of better nutrition among the vulnerable groups such as pre-school children and expectant and nursing mothers was carried out in the field centres around Hyderabad by the field unit of the National Institute of Nutrition.\textsuperscript{21}

2. Indonesia—Protein calorie malnutrition is present in certain parts of Java, coupled with vitamin A deficiency particularly affecting pre-school children and pregnant and lactating mothers.\textsuperscript{11}

3. South Korea—In 1963, a survey of 250 weanling infants and children below two years of age showed intakes of calories, protein, calcium, iron, riboflavin, and niacin to be below 50\% of recommended dietary allowances.

4. Kuala Lumpur—A survey was done in 1959 on children 1 to 4 years of age to determine their state of nutrition in relation to socio-economic conditions.\textsuperscript{13}

5. Singapore—A report received in late 1970 from Singapore states that a food consumption survey on pre-school children is being planned.

6. Thailand—In 1966, an individual food consumption survey was reportedly conducted on 35 pre-school children.\textsuperscript{6}

7. Philippines—A nutrition survey was conducted in 1969 on 7,815 infants and pre-school children in 15 towns in Laguna province (South of Manila) with expertise from Dr. R. W. Engel of the Agency for International Development (AID). Among the survey findings were: about 53\% were afflicted by one form of malnutrition or another, and 3\% suffered severe malnutrition. Health officials believe that this pattern of malnutrition is duplicated in varying degrees in all 66 provinces of the country.

In the light of the above review on status of food consumption surveys in the region, it will be noted that applied nutrition programmes can only be as good as the basic data available which may determine the direction that these programmes should take. Unless the most objective and reliable methods of obtaining, analyzing and evaluating food consumption data are used, there
may be gaps in information so basic for social and economic development planning. The following recommendations are thus presented. Nation wide food consumption surveys are the most complementary data to national food balance sheets as they show variations in intakes between groups not otherwise revealed by the latter and should be aimed for, if and when possible.

Techniques for individual surveys should be developed and extended to the vulnerable groups, particularly pre-school children and pregnant and lactating mothers, these being most sensitive to nutritional deficiencies.

No standard methods or techniques for food consumption surveys would be suitable for all countries, but efforts can be made to determine the most appropriate amounts under the culture and conditions prevailing within the country or the particular group under study.

Objective methods of reporting would make possible international comparability of data.

There is a great need for more reliable information on food wastage particularly for determining food availability and for food planning purposes.

Studies on nutrient losses from various cooking methods can help provide more accurate information on nutrients actually available for consumption.

REFERENCES

Review of Food Consumption Surveys in Asia

The earliest estimates of protein requirements were based on studies of the diets of individuals or groups of subjects who were considered to be healthy and leading normal active lives. Thus the recommendations of Voit and of Attwater at the turn of the century were a reflection of the dietary habits of a moderately prosperous section of the working classes in Europe and America. These standards were in excess of 100 gms per day for an average man, and soon became the subject of bitter controversy; the proponents of such very high figures maintaining that they were not merely expressions of cultural and dietary patterns, but were essential for the maintenance of health and vigour. Chittenden carried out experiments over periods up to 9 months, which showed that unimpaired physical and mental performance could be maintained with daily intakes equivalent to 36 gms of utilizable protein. Chittenden's work focussed attention for the first time onto the problem which is basic to the establishment of requirement levels, and one which is still not satisfactorily resolved, namely that of specifying objective functional criteria of health in relation to nutrient intakes. The contemporary situation is that a number of authorities advocate two levels of protein, one which may be called a physiological minimum requirement, or simply a requirement level which is based upon stated criteria such as the maintenance of N balance, together with another and higher figure called a recommended intake, which is based upon no clearly defined criteria, but which may be judged 'safer' or more culturally acceptable (i.e. more in line with observed intakes).

It is worthwhile to make a critical examination of these two concepts, and of their possible applications.

**The Physiological Requirement**

Estimates of this are currently based upon maintenance of N balance, and commonly include a safety factor, to meet the needs of extra stresses, to allow for errors in techniques and for variations between individuals. Their application is primarily in assessing dietary situations i.e. as a diagnostic tool for...
defining and locating nutritional problems, individuals receiving less than the requirement being considered ‘at risk’. Another legitimate application would be in the calculation of least cost diets in subsistence situations, i.e. in planning for the best possible utilization of existing limited resources in a community.

RECOMMENDED INTAKES

These are generally based upon a number of considerations. For example that in all societies increased income results in protein intakes which rise towards an upper limit of about 12% of the calories, and that this has been accompanied by improved health standards in developed countries. Also it is sometimes suggested that protein intakes close to the physiological level may perhaps over very long periods result in detrimental changes in the relative protein levels in different tissues and organs, and that such changes might bring about a subtle deterioration of health. Whilst all of these deserve serious consideration, particularly the last, unfortunately none provide the basis for a quantitative estimate. At best they are reasons for recommending a level above that of the requirement, but how far above?

Recommended intakes are intended for use in planning food and nutrition policies, and are thus considered to be of great importance by those who view the problem of poor nutrition primarily as one of a deficit in food supply. However, the changes in the use of agricultural resources involved in an effective plan will always involve some cost to the community in terms of displacement of labour, and often a worsening of income distribution. This being the case, a recommendation about desirable protein intakes should be based upon an appreciation both of the cost and the benefits which might accrue to any particular community. In the present state of knowledge we simply do not have sufficient quantitative information upon which to base such an assessment.

THE ESTIMATION OF PHYSIOLOGICAL REQUIREMENTS

Since the factorial method of assessing requirements consists of the summation of obligatory N losses by various routes, (urine, faeces and skin), all of which are estimated separately, it is essential to know the limits of error and of variability of each of these.

Table 1 shows mean values and standard deviations of minimum urinary, faecal and skin losses of N measured in adult male and female subjects. Also shown are values for the 1 year old infant and for a 14 year old boy, which include estimates of N needed for growth. Where no direct determinations have been made, values (shown in parentheses) have been extrapolated from
those for the adult. Details of the derivation of the figures, and of the methods of extrapolation will be found in the appendix.

**TABLE 1**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Minimal N losses mg/day/kg</th>
<th>Growth N mg/kg</th>
<th>Total N</th>
<th>Protein g/kg</th>
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<td></td>
<td>Urine</td>
<td>Feces</td>
<td>Skin</td>
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<tr>
<td>1 year old child</td>
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<td>26 ± 9.3</td>
<td>(22)</td>
<td>10 ± 2.7</td>
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<td>3-4 year old child</td>
<td>34 ± 4.2</td>
<td>9.0 ± 1.1</td>
<td>(16)</td>
<td>15 ± 3.0</td>
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<tr>
<td>14 year old boy</td>
<td>35 ± 3.1</td>
<td>8.7 ± 1.4</td>
<td>(17)</td>
<td>11.8 ± 2.9</td>
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<tr>
<td>Adult male</td>
<td>34 ± 4.2</td>
<td>9.0 ± 1.1</td>
<td>15 ± 3.0</td>
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<tr>
<td>Adult female</td>
<td>25 ± 3.1</td>
<td>8.7 ± 1.4</td>
<td>11.8 ± 2.9</td>
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</table>

Figures in parentheses are calculated from Urinary N = 100 mg/Kg.
Skin N = 44 mg/Kg.
Fecal N = 0.25 mg/calorie in food.

It will be seen that in the cases of the adult male and female, the standard deviation of the figure for total obligatory N losses is close to 10%, and this is the same as the quantity accepted by the F.A.O. Committee on protein requirements as representing the range of individual variation. However it is not possible with the data available, to separate variation due to differences between individuals from that due to variation within individuals from day to day, and to experimental error. In fact true individual variation is probably small. Mueller and Cox give values for urinary N in four subjects, measured during an 18 day period on an N free diet. The standard deviations due to the daily variation for each individual were only slightly less than that between the individuals. Also basal N losses are closely related to basal metabolic rates, and these have been shown to vary between individuals by no more than 3 to 5 per cent when calculated on the basis of surface area. It seems reasonable therefore to regard the total variance around the mean value for N losses, as a measure of uncertainty, and thus to arrive at a figure which we can be confident will meet the needs of any individual, we must make an addition of two standard deviations, i.e. 20%, to the mean value. Table 2 shows the resulting estimates of physiological requirements in terms of a completely utilizable protein. The values for adults are considerably less than the F.A.O. safe practical allowance of 0.71 g/kg, the difference being largely due to the fact that the F.A.O. Committee based their estimate upon a rate of endogenous urinary loss of 2 mg N per basal calorie, a figure which is undoubtedly too high (by a factor of nearly 100% for female adults). The difference between male and female subjects is highly significant, and is consistent with the differences in basal energy metabolism. The extra allowances for pregnancy and lactation are those adopted by the F.A.O. Committee, as is also the requirement at birth.
Somewhat fortuitously the values for children are very close to the F.A.O.
average values, however, as Table 1 shows in each case, at least one of the
factorial components in children has to be obtained by extrapolation from the
adult figure, and this particularly applies to skin losses which are an important
fraction of the total. This being so, the application of the factorial method to
children is open to some doubt. However there is evidence from feeding
trials that intakes of between 1.2 and 1.25 gms. of dietary protein in the form
of egg or of cow's milk can result in normal or greater than normal growth
rates in children (chronological ages 1 to 2 years) recovering from mal-
nutrition. For the adult, the factorial estimates are fairly well established,
and as Table 3 shows are in very good agreement with long term N balance
studies in which maintenance of body weight and of various indices of health
were demonstrated.

**TABLE 2**

<table>
<thead>
<tr>
<th>Age years</th>
<th>Protein g/Kg</th>
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*Reference No. 4.

**TABLE 3**

Calculated requirements compared with N balance experiments.

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</tbody>
</table>
It may well be said that more evidence is needed of the adequacy of such intakes over much longer periods of time, comparable with individual life spans. This of course applies with equal force to estimates of requirements of all other nutrients, and the establishment of dietary levels necessary for the maintenance of optimal states of health, should be the aim of fundamental research in nutrition in the future. At the present time, it is more realistic to accept that we are not in a position to define the criteria for such an optimum, or even to be certain that these if defined, are all attainable simultaneously at a fixed level of dietary intake. Thus work with animals has shown conclusively that the fast growth and large adult size achieved with high protein diets, are incompatible with maximum life span and freedom from degenerative diseases.9,10 Again, resistance to some types of diseases, for example hookworm is increased with high intakes of protein,11 the reverse is true of others such as malaria and schistosomiasis,12,13. The initial high rate of loss of N seen upon transfer from a high to a low N intake, has in the past been interpreted as showing the existence of a body protein store, presumably fulfilling the purpose of a reserve. However, the existence of any such store is now in question, the loss of N being regarded rather as a reflection of delayed adaptation of enzymes involved in the re-cycling of amino acids.14 Certainly all attempts to show that animals with previously repleted 'stores' are in any way protected from subsequent exposure to stress, injury or radiation, have given negative results.15 Finally it is sometimes suggested that protein intakes more in line with the self-selected diets seen in richer communities, which are all between 2 and 3 times the physiological level for the adult might be safer, or nearer to some ideal optimum. This attitude arises partly from the view that individuals will instinctively choose what is best for health. In fact for most of the time period over which dietary preferences and instincts have been formed by evolutionary selection, survival of the species as a whole will have depended upon successful achievement of reproductive age, and very little upon selection of diets leading to maximum life span (an average span of less than 20 years is probably the natural condition of man) and as the rising incidence of 'diseases of affluence' in Western countries shows we cannot place much confidence in instinctive selection of diets as the best insurance for prolonged active life.

**THE RELATION BETWEEN PROTEIN AND ENERGY NEEDS**

*The average requirements of population groups*

Table 2 shows the average calorie requirements for the different age groups according to F.A.O.16. If these are combined with the protein requirements,
we have in the third column of the table, the proportions of utilisable protein expressed as calories (NDp Cal%), which should be present in adequate diets.

Assessment of diets in relation to requirements

In many situations in developing countries, there is very little quantitative data on individual intakes of food, but it is nevertheless possible to make an assessment of the protein calorie ratio on the basis of food balance sheets, or by examination of traditional diets. Evidently the crude protein in such a diet cannot be compared directly with the requirement scale, which is expressed in terms of a completely utilized protein, but must first be corrected for its quality. Ideally this should be measured as Net Protein Utilization operative (NPUop) using human subjects. However this is rarely possible, and an assay procedure using young rats is more practical. Table 4 shows the NDp Cal% (calculated as Protein Calories per cent x NPUop) of a number of staples, and of traditional meals and diets based on those staples.

TABLE 4

The utilisable protein content of a number staples and diets based on them

<table>
<thead>
<tr>
<th>Staple</th>
<th>Alone</th>
<th>Diets (No.)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sago</td>
<td>0.3</td>
<td>4.0 (7)</td>
</tr>
<tr>
<td>Cassava</td>
<td>0.9</td>
<td>4.6 (2)</td>
</tr>
<tr>
<td>Plantain</td>
<td>1.6</td>
<td>6.2 (3)</td>
</tr>
<tr>
<td>Yam</td>
<td>4.6</td>
<td>6.4 (9)</td>
</tr>
<tr>
<td>Maize</td>
<td>4.7</td>
<td>8.0 (5)</td>
</tr>
<tr>
<td>Rice</td>
<td>4.9</td>
<td>11.5 (1)</td>
</tr>
<tr>
<td>Sorghum</td>
<td>4.9</td>
<td>9.6 (4)</td>
</tr>
<tr>
<td>Pennisetum</td>
<td>5.3</td>
<td>5.9 (7)</td>
</tr>
<tr>
<td>Potato</td>
<td>5.9</td>
<td>9.2 (7)</td>
</tr>
<tr>
<td>Wheat</td>
<td>5.9</td>
<td>-</td>
</tr>
</tbody>
</table>

*NDpCal% = Net dietary protein calories % total calories. (c.f. Requirement for Adult Man 3.5%).

**The figure in parenthesis represents the number of diets assayed.

With the exception of cassava, sago and plantain, all provide sufficient utilisable protein to meet requirements after the age of 1 year. Younger infants should be receiving supplements of breast milk, the supply of which
should be sufficient provided the mother’s requirements particularly for increased calories are met.

For those who question the application to man of protein quality measured with rats, Table 5 summarises several years of careful and exacting work by Swaminathan and his associates at Mysore, and shows that very simple diets based upon cereals with minimal additions of pulses and vegetables have NDp Cal% values measured with 8 to 12 year old children which are in excellent general agreement with the rat assays.

Although these biological methods are known to give the most accurate results, an easier method of calculation from food tables is often very useful. Protein contents are relatively easy to calculate, although there are considerable variations between varieties of the same cereal, e.g. the two rice diets in Table 5.

### TABLE 5

<table>
<thead>
<tr>
<th>Cereal base</th>
<th>Protein calories per cent</th>
<th>NPUop</th>
<th>NDp Cal%</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>13.1</td>
<td>36</td>
<td>4.8</td>
<td>27</td>
</tr>
<tr>
<td>Millet</td>
<td>12.2</td>
<td>43</td>
<td>5.3</td>
<td>28</td>
</tr>
<tr>
<td>Rice</td>
<td>7.3</td>
<td>66</td>
<td>4.8</td>
<td>29</td>
</tr>
<tr>
<td>Rice</td>
<td>9.7</td>
<td>63</td>
<td>6.1</td>
<td>27</td>
</tr>
<tr>
<td>Wheat</td>
<td>10.6</td>
<td>49</td>
<td>5.2</td>
<td>30</td>
</tr>
</tbody>
</table>

However, to calculate the efficiency of utilization of the protein is more difficult, since it depends upon a number of factors:

(i) The amino acid composition: There are various techniques for arriving at a protein score, however the original method of Block and Mitchell is still probably the best available and gives scores which agree well with NPU measurements made under standardised conditions i.e. at a protein level just sufficient for maintenance.

(ii) The percentage of protein in the diet: As this rises, so the efficiency of utilization falls. This is not because the animal’s capacity for
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protein synthesis has been saturated, but because protein is used increasingly for energy purposes. Equations and nomograms are available for predicting this effect.\(^7\)

\[\text{iii) The energy intake: If the intake of energy is restricted below a certain level, the efficiency of utilization falls because protein is used primarily for energy purposes. In fact if the intake is reduced to the level of the basal metabolic rate, the efficiency of protein utilization is zero. Table 6 shows this effect measured in a diet from Iran.}\]

\[
\begin{array}{|c|c|}
\hline
\text{Energy intake expressed as percentage of basal metabolism} & \text{Net protein utilization operative} \\
430 & 55 \\
340 & 56 \\
200 & 45 \\
160 & 32 \\
110 & 20 \\
\hline
\end{array}
\]

\[\text{TABLE 6 Net protein utilization operative of an Iranian diet at different levels of energy intake}\]

\[\text{ESTABLISHING MINIMAL REQUIREMENTS FOR ENERGY}\]

The very marked effect of reduced energy intake upon the effective protein value of a diet is of great importance in assessing the nature of the nutritional problems of a community. Thus although the proportion of useful protein in a diet may appear adequate to meet the needs even of vulnerable groups in a country, if the intake of calories falls below a certain minimal figure, protein deficiency will result. It is evidently of great practical importance to establish this minimal level. Experiments have been carried out in human adults, and in animals in which N balance has been determined at a series of different levels of calorie intake.

From these measurements, it is possible to determine the minimal energy required to achieve N equilibrium. Also in experiments in which calorie balance has been measured, the minimal intake has been determined at which
it is possible to maintain a constant level of body energy content. Table 7 shows the results of such experiments in terms of calories per unit of metabolic

TABLE 7
Minimum energy intakes necessary for maintenance of body N or energy content

<table>
<thead>
<tr>
<th></th>
<th>Metabolizable energy</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k cals/Kg</td>
<td>k cals/day/Kg</td>
</tr>
<tr>
<td>Adult men</td>
<td>34</td>
<td>67</td>
</tr>
<tr>
<td>Rats</td>
<td>250</td>
<td>115</td>
</tr>
<tr>
<td>Rats</td>
<td>220</td>
<td>107</td>
</tr>
<tr>
<td>Lambs</td>
<td>70</td>
<td>105</td>
</tr>
<tr>
<td>Calves</td>
<td>42</td>
<td>107</td>
</tr>
<tr>
<td>Cows</td>
<td>22</td>
<td>104</td>
</tr>
<tr>
<td>Pigs</td>
<td>35</td>
<td>103</td>
</tr>
</tbody>
</table>

body size (body weight). Evidently the same amount of energy (close to 110 k cals/day/kg) is necessary to maintain both a constant level of body N and body energy content. Since the value for the basal metabolic rate in different species is 70 k cals/kg, we can say that 1.5 x the basal energy expenditure is the minimum energy intake needed for maintenance. In the case of children, it is possible to estimate growth requirements for energy from the slope of the line relating N balance to calorie intake, in the region where N intake is adequate, and calorie intake is the factor limiting N balance. In adult men, and in young adult rats, this value is close to 7 mg N per calorie, so that the energy cost of growth is 24 k cals for each gram of protein deposited. Adding this to the maintenance requirement estimated as 1.5 x the BMR, gives a scale of minimum energy requirements. These values can be regarded as the lower limit of adaptation to reduced calorie intake, and apply to subjects whose level of physical activity is reduced to an absolute minimum, and who are in a state of thermal neutrality. At lower intakes than these, adult subjects will be in negative N balance, and children will suffer a reduction in growth rate. Fig. 1 shows a comparison of minimal calorie requirements with the range of observed intakes in children of different ages. Evidently the requirement level coincides well with the lower ends of the ranges of intakes found in all age groups.
These estimates of minimal energy needs have been used by Sukhatme to calculate the incidence of protein and calorie deficiency in a community for which the distribution of calorie and protein intakes on a household basis is known, and to further analyse this in relation to income. Sukhatme was able to show that whilst the incidence of deficiency of protein directly due to low intakes was 34 per cent of all households sampled in Madras, and 5 per cent
in Bihar, when protein deficiency resulting from an inadequate calorie intake was included, the total incidence rates became 55 per cent and 17 per cent respectively.

**THE RANGE OF INDIVIDUAL CALORIE NEEDS**

The figures for calorie requirements in Table 2 are the average values suggested by F.A.O.\(^{15}\) as applicable to population groups. They assume for example only a moderate level of physical activity in the adult working population, whereas the range in fact extends from the minimum necessary to maintain body weight which is about 37 kcal/day for the adult man, up to between 60 and 70 kcal/day for men engaged in heavy work. In children, the range of observed calorie intakes at any one age is such that it is always possible to find two individuals, one of whom is receiving twice as many calories as the other, (Widdowson\(^{20}\), see Fig. 1). It seems very unlikely that differences in growth rates are sufficient to account for this and, as for the adult, wide differences in activity levels are the most probable explanation, together with in varying degree some capacity to burn off excess calories.\(^{21}\) There is no evidence for a similar range of protein requirements, and certainly no demonstrable extra need for protein at high levels of work output. This being the case, the safest assumption to make is that protein and calorie needs are uncorrelated, so that an individual who by force of circumstances is reduced to the minimum level of calorie intake, must still be regarded as needing the same amount of protein, and therefore a higher dietary ratio of protein to calories than someone with a higher expenditure. Thus although the NDp Cal % figures in Table 2 apply to groups of people, individuals within the group will have different dietary requirements. Fig. 2 shows the range of values for the level of Net dietary protein needed in diets by adult men, and 1 year old children at different calorie intakes. All combinations of NDp Cal % and calorie intake represented by the curves, will result in N equilibrium, and weight maintenance in the adult, and normal growth in the child. Diets in the region below the curves would result in protein deficiency, even though calories may be adequate, and diets in the region to the left of the vertical lines corresponding to minimum calorie needs, would result in both protein and calorie deficiency. It is particularly interesting to note that for example a diet having a protein value of 4.0 % will meet the needs of a normal active child, providing the calorie intake is maintained at an average level. Poor rice diets based upon low protein varieties can have values as low as this, and one has been described by Swaminathan\(^{22}\) which has been shown to result in a moderate rate of growth in 2-3 year old children but only when the calorie intakes were kept at a high level.\(^{23}\) A child fed such a diet might if healthy, active, and not subject to deprivation, continue to thrive, but any depression of food intake occasioned
by an infection, by marginal deficiency of a mineral or vitamin or by a social or economic factor, would result in a move to the left on the diagram into the region of protein inadequacy below the maintenance curve. Further depression of intake could bring about both protein and calorie deficiency in the region to the left of the vertical line. Thus a succession of normal growth, a kwashiorkor and finally marasmic condition could all arise from a diet of the same composition, through the effect on appetite of any one of many possible environmental influences.

PROTEIN AND WORLD FOOD PROBLEMS

A reduction of estimates of protein requirements, does not in any way diminish the magnitude of the task of solving food problems, but rather serves to direct attention to the fact that the main need in most parts of the world is to stimulate increased demand for foods in much the same proportions as they are consumed at present, and to match the demand by increased supplies. The staple foods and traditional diets consumed in Asia and most other parts of the world are adequate in relation to their protein content for all members of the population except infants and very young children, so that protein deficiency if it occurs is likely to be the result of an inadequate intake of food. Such low intakes imply not only a concomitant low protein intake but also a lowered efficiency of utilization. Hence protein deficiency is an indirect result of an
energy deficit and could not be corrected by addition of extra protein to the existing diet (and even less by the addition of amino acids). The much discussed 'protein gap' if it exists at all is evidently best regarded as a difference between present levels of consumption and those which may be aspired to at some future stage of economic development. Attempts to deal with such a gap as if it were a deficiency of supplies in relation to physiological needs of the whole population, by introduction of unconventional high protein foods and amino acids, are doomed to failure since they rest upon a misconception of the nature of the problem.

During the next 30 years, the population of most developing countries will double. The role of the food technologist in solving the supply problems that this will generate will be in providing cheap appetizing and nutritionally balanced foods, to relieve the monotony of diets in which the main sources of both protein and energy will continue to be the staple foods in use today. The basic problems of poor nutrition arising from maldistribution will not however be overcome by increasing the supply of specific nutrients such as protein.

APPENDIX

THE MAGNITUDES AND DEGREE OF UNCERTAINTY OF THE FACTORIAL COMPONENTS :

1. BASAL URINARY N PER DAY :

For adult males, the values given by Hawley et al., Mueller and Cox, and Young and Scrimshaw have been combined to give 19 subjects.

<table>
<thead>
<tr>
<th>mg N/Kg</th>
<th>mg N/Kg/l</th>
<th>mg N/Basal calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>34.0 ± 4.2</td>
<td>100 ± 12.3</td>
<td>1.47 ± 0.21</td>
</tr>
</tbody>
</table>

For adult females, the values given by Hawley et al., and Bricker and Smith total 31 subjects.

<table>
<thead>
<tr>
<th>mg N/Kg</th>
<th>mg N/Kg/l</th>
<th>mg N/Basal calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.3 ± 3.1</td>
<td>70 ± 7.0</td>
<td>1.10 ± 0.11</td>
</tr>
</tbody>
</table>

All measurements were made after at least 6 days on N-free diet.

Urinary N is correlated with Wt1/2 surface area or with body weight, r = 0.700, 0.620, 0.692 for males and 0.664, 0.669, 0.660 for females.

Correlations with basal calories are poorer, 0.371 for males and 0.640 for females, probably because of the greater error involved in determination of BMR, than in measurement of weight and height. There is in any case no advantage to be gained from expression as mg basal calorie, since all that is needed is a means of relating urinary N to body size.
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For 3-4 year old children Fomon et al\textsuperscript{39} for the 4th to 6th day on N-free diets give:\n\[
\begin{array}{ll}
\text{mg N/Kg} & \text{mg N/Kg}^2 \\
50 \pm 13 & 100 \pm 26 \\
& (\text{mg/basal calorie}=1.0)
\end{array}
\]

100 mg N/Kg\textsuperscript{2} has been used to obtain the extra-polated values in the Table.

2. METABOLIC FECAL N:

For adults, Young and Scrimshaw\textsuperscript{86} give 9.0 $\pm$ 1.1 mg/Kg for 8 male subjects. Bricker et al\textsuperscript{60} for 25 females give 8.7 $\pm$ 1.4 mg/Kg. Fomon et al\textsuperscript{39} give 23 $\pm$ 9.3 for 3-4 year old children, and Waterlow and Wills\textsuperscript{11} give 33 as representative of 1 year old infants.

Metabolic fecal N has been shown in a number of species to be related to the total dry matter intake in the food. Accordingly, it seems reasonable for purposes of inter-polation, to relate metabolic fecal N to calorie intake. The above values give ratios of 0.22, 0.20, 0.23 and 0.24 mg N/calorie consumed. Metabolic fecal N losses for the adolescent in the Table have been calculated on the basis of 0.25 mg N per dietary calorie (F.A.O. calorie allowance).

3. Other possible routes of N losses are:

- Integumental—skin, nails, hair, etc. Possibly some N loss as flatus (though it is not known if this may properly be regarded as of exogenous or endogenous origin).

- Sweat losses which may range from 2 mg/Kg to 6 mg/Kg for heavy work in hot conditions.

The sum total of all these possible losses is best estimated from the results of long continued N balance trials in adults. Mitchell\textsuperscript{58} gives a figure of 3.38 g N/day for 23 subjects over a 220 day period. It was suggested that in these active subjects 0.38 g could be accounted for as sweat loss above minimal levels so that excluding these greater than minimal losses, other routes accounted for 1.0 g N/day with an SD of 20%. In female subjects, Bricker et al\textsuperscript{60} together with values reported by Johnson and McMillan\textsuperscript{86} give a total of 15 subjects averaging 0.67 g/day $\pm$ 22% (a figure which includes menstrual losses). It would be expected that skin losses should be related in some degree to surface area, and in fact in both male and female groups there is a better correlation between N loss and surface area than there is with body weight. For the purposes of extrapolation for the adolescent and infants, a value of 44 mg N/Kg has been used (corresponding to the adult male value).

Sweat loss above the minimum is best regarded separately, since it evidently depends upon work output and environmental conditions. The maximum value corresponds to an extra 0.04 gms protein/day for the adult male i.e. just over 10%, an addition which could be made specially for high levels of calorie intake.

4. GROWTH REQUIREMENTS:

Rates of N gain at different ages have been calculated from figures for growth velocity\textsuperscript{46} N content of weight gains from Fomon\textsuperscript{39}.

<table>
<thead>
<tr>
<th>Age years</th>
<th>Weight gain/day/kg</th>
<th>mg N gain/day/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.89 $\pm$ 0.20</td>
<td>21 $\pm$ 4.7</td>
</tr>
<tr>
<td>3-4</td>
<td>0.35 $\pm$ 0.09</td>
<td>10 $\pm$ 2.7</td>
</tr>
<tr>
<td>14</td>
<td>0.35 $\pm$ 0.07</td>
<td>10 $\pm$ 2.1</td>
</tr>
</tbody>
</table>
INDIVIDUAL VARIATION:

The standard deviation will represent the combined variance due to experimental error, to day to day variation within subjects, as well as between subjects, variation. There is insufficient information to separate these, but it is notable that Mueller and Cox give daily values for urinary N over a 12 day period on N free diets, for four subjects. The variation between subjects was not greater than the daily variation which was about 12% (CV) over the last 6 days.

It would seem that individual variation is small compared with day to day changes and in this respect is similar to that found for BMR/sq. metre, namely 3.5% for male and 4.6% for female subjects, the total inter and intra-individual variation being 10%.  

Individual variation of the growth component is indicated by SDs shown above, and is calculated from the 3rd to 27th percentile velocity standards.

REFERENCES

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FOOD CONSUMPTION PATTERNS OF PRESCHOOL CHILDREN
IN INDIA

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Children in the age group 1 to 5 years in India are subjected to various nutritional
deficiency diseases. There is a high incidence of protein-calorie malnutrition, iron
deficiency anaemia and deficiencies of vitamins A and B-complex. Thus the
preschool children constitute one of the most vulnerable sections of the
population and immediate measures have to be adopted to tackle this grave
public health problem. Precise knowledge about the food consumption
patterns and nutrient intakes of these preschool children is an essential pre­
requisite for the implementation of any prophylactic programme.

Until recently, precise data on food consumption patterns of this section of
the population were not available. Data on preschool children were obtained
from diet surveys of general populations by use of consumption coefficients.
Also, at times standardized, uniform procedures had not been followed for
collection of data. Therefore, to fill this gap in our knowledge, a nutritional
and dietary survey of preschool children was undertaken at six different research
centres in India under the auspices of the Indian Council of Medical Research
(ICMR)\(^1\). These centres were in Delhi, Calcutta, Bombay, Poona, Hyderabad
and Vellore. Whereas the Delhi region is predominantly a wheat eating area,
the regions around Calcutta and Vellore are areas where mainly rice is consumed.
In the regions where the other 3 centres are located, a mixture of cereals and
millet is consumed.

The nutritional survey covered 3000 children of the age group 1 to 5 years
at each centre. For the survey of dietary patterns, a subsample of 300 preschool
children was taken. In the Delhi and Hyderabad regions, a rural population
was surveyed whereas in the other centres the population was urban or semi­
urban. However, in all cases, the majority of children surveyed belonged to
the lower socio-economic category with an income of less than Rs. 20/- per
capita per month.

Carefully standardized methods of population sampling and of the survey
itself were used by the 6 centres for collection of data. The method of survey

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was an oral questionnaire wherein the mother of the child was interviewed to get the previous day's food intake of the child. The accuracy of this recall method of survey had been ascertained earlier in the following manner. The field workers collected food intake data by direct observation of the preschool children for a day and the following day they collected data on the same children by the previous day's recall by the mother. Good agreement was found between the results obtained by these two methods. Dietary intake of the child was assessed by showing cups standardized in terms of volumes rather than weights of foods to the mother.

Table 1 shows the feeding habits of the children surveyed. In all the regions studied, breast feeding was continued for prolonged periods even up to the ages of 4 to 5 years. Usually pregnancy of the mother was the main reason for stoppage of breast feeding. Supplementary feeding was started between 1 to 2 years and by 4 to 5 years over 90% of children were fully weaned. In general, in the urban areas, supplementary foods were started at an earlier age and breast feeding was stopped at an earlier age also.

**TABLE 1**

Feeding habits of preschool children (1-5 years) in different regions in India

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Calcutta</th>
<th>Delhi</th>
<th>Poona</th>
<th>Vellore</th>
<th>Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 S*</td>
<td>75.6</td>
<td>75.9</td>
<td>44.7</td>
<td>67.6</td>
<td>67.7</td>
</tr>
<tr>
<td></td>
<td>19.5</td>
<td>10.5</td>
<td>8.3</td>
<td>32.3</td>
<td>5.3</td>
</tr>
<tr>
<td>2-3 W**</td>
<td>31.1</td>
<td>33.2</td>
<td>10.7</td>
<td>30.8</td>
<td>55.7</td>
</tr>
<tr>
<td></td>
<td>68.9</td>
<td>66.1</td>
<td>85.8</td>
<td>69.2</td>
<td>42.9</td>
</tr>
<tr>
<td>3-4</td>
<td>8.5</td>
<td>5.5</td>
<td>8.6</td>
<td>9.1</td>
<td>28.6</td>
</tr>
<tr>
<td></td>
<td>91.2</td>
<td>94.5</td>
<td>99.4</td>
<td>90.9</td>
<td>71.4</td>
</tr>
<tr>
<td>4-5</td>
<td>1.5</td>
<td>2.0</td>
<td>1.0</td>
<td>2.8</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>98.5</td>
<td>98.0</td>
<td>99.0</td>
<td>97.2</td>
<td>90.0</td>
</tr>
</tbody>
</table>

* S—Percentage of children having supplements.
** W—Percentage of children fully weaned.

Table 2 shows the intake of various food constituents by preschool children in different regions in India. The consumption of the various categories of foods in the different regions was essentially similar. The reasons for the higher intake of milk and milk products, other vegetables, meat, fish and eggs in Calcutta compared to the other regions could be due to the fact that the urban population studied here belonged to both the poor as well as middle classes.
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TABLE 2
Intake of foodstuffs per child (1 to 5 years) per day in different regions in India

<table>
<thead>
<tr>
<th>Food item (g)</th>
<th>Calcutta</th>
<th>Delhi</th>
<th>Bombay</th>
<th>Vellore</th>
<th>Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal</td>
<td>96</td>
<td>164</td>
<td>154</td>
<td>167</td>
<td>143</td>
</tr>
<tr>
<td>Pulses</td>
<td>13</td>
<td>8</td>
<td>12</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Milk and milk products</td>
<td>278</td>
<td>174</td>
<td>64</td>
<td>62</td>
<td>74</td>
</tr>
<tr>
<td>Green leafy vegetables</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>72</td>
<td>18</td>
<td>17</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Oils and fats</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Sugar and jaggery</td>
<td>—</td>
<td>27</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Fruits</td>
<td>—</td>
<td>15</td>
<td>13</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Flesh foods</td>
<td>56</td>
<td>—</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3 shows the calorie and protein intake of preschool children compared with the recommended allowances. The calorie intake of preschool children in the various regions ranged from about 600 to 950 which is well below the recommended allowance of 1275 calories for this age group. This deficit was of the order of 30 to 40%. The protein intake ranged from 18 to 29 g. and this, in terms of per kg. body weight, met the requirement figure of 1.75 g/kg. body weight or even exceeded it. The ICMR Expert Committee in 1968 took the net protein utilization (NPU) of Indian diets to be 50 and based the protein requirement figure on this.

The NDP Cal% of the diets was obtained from Miller and Payne’s equation.

\[
\text{NDP Cal} = \frac{\text{Score} \times (54 - P)}{(54 - Pm)}
\]

where

- \( P \) = Protein calories expressed as \% of total calories
- \( = \) Protein calories

\[
\text{Net utilisable calories} \times 100
\]

- \( Pm \) = \[\frac{400}{\text{Score}}\]
- \( \text{Score} \) = Chemical score of the protein.
- \( \text{NPU} \) under standard conditions.

If the NDP Cal\% of a diet is satisfactory in relation to requirement, then if enough of the diet is consumed to satisfy calorie needs, the protein needs are also satisfied, both qualitatively and quantitatively.

The NDP Cal\% of the diets of all regions was above the recommended value of 4.0. Thus, it is clear that though the protein of the diet appeared to be adequate, at least in terms of the existing body weights of the children, the calories were not.

Figure 1 shows the cumulative frequency distribution of preschool children according to their intake of proteins and calories. While 35% of the children...
did not get adequate protein in the diet, 92% did not get adequate calories. The 35% children whose intake of protein was inadequate, also had an inadequate intake of calories whereas 57% (i.e. 92-35) children had only an inadequate intake of calories. There was no child with adequate amount of calories but with an inadequate amount of protein intake.

**TABLE 3**

<table>
<thead>
<tr>
<th>Region</th>
<th>Total calories per child per day</th>
<th>Total protein g/child/day</th>
<th>Calories/kg body weight</th>
<th>Protein/kg body weight</th>
<th>NDpCal %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcutta</td>
<td>588</td>
<td>24.0</td>
<td>54</td>
<td>2.2</td>
<td>8.8</td>
</tr>
<tr>
<td>Delhi</td>
<td>946</td>
<td>28.5</td>
<td>89</td>
<td>2.8</td>
<td>6.0</td>
</tr>
<tr>
<td>Bombay</td>
<td>773</td>
<td>17.9</td>
<td>72</td>
<td>1.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Poona</td>
<td>813</td>
<td>22.4</td>
<td>79</td>
<td>2.2</td>
<td>6.1</td>
</tr>
<tr>
<td>Vellore</td>
<td>764</td>
<td>19.4</td>
<td>78</td>
<td>2.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>725</td>
<td>19.4</td>
<td>74</td>
<td>1.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Recommended allowances (ICMR 1968)</td>
<td>1275</td>
<td>—</td>
<td>—</td>
<td>1.75</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Figure 2 shows NDpCal % of the diets of the preschool children in the different regions compared with the recommended allowance. All the diets satisfied the recommended value of 4.0.

**Fig. 1**

CUMULATIVE FREQUENCY (PERCENTAGE) DISTRIBUTION OF PRE-SCHOOL CHILDREN (HYDERABAD REGION) BY INTAKE OF PROTEINS AND CALORIES

NUTRIENT INTAKE AS PERCENTAGE OF SUGGESTED REQUIREMENTS (ICMR, EXPERT GROUP 1968) BASED ON ACTUAL BODY WEIGHTS
From these results it is clear that since 92% of the children had calorie deficiency, the protein that they ingested, though adequate in amount, was being utilized for energy production in the body and hence became inadequate due to the primary deficiency of calories. Hence 90% of the children could be expected to have various degrees of protein-calorie malnutrition.

The vitamin and mineral intake of the preschool children is shown in Table 4. Thiamine and niacin appeared to be adequate in the diet. There was a deficiency of riboflavin, ascorbic acid, vitamin A, iron and calcium. These deficiencies were reflected in the nutritional status of the children who were seen to have a high prevalence of angular stomatitis, xerophthalmia and Bitot's spots and iron deficiency anaemia. However, there were no apparent manifestations of deficiencies of ascorbic acid and calcium in the preschool children surveyed.

From these data, it is evident that the diets of the preschool children are deficient in several nutrients especially calories, vitamin A and iron. However, these diets have enough protein in them to give an adequate NDpCal%. Therefore, if the children were consuming enough of these same diets to satisfy their energy requirements, their protein needs would be met. This is an important
consideration which has emerged from the survey of preschool children's diets and will doubtless influence decisions on food and nutrition policies. These data suggest that the first step towards preventing malnutrition in children is to correct the existing calorie gap. Protein concentrates and protein-rich foods given to children in the presence of a gross calorie deficiency would be a wasteful process. This is especially true in developing countries where economies are already strained. Therefore, if priorities have to be struck, then augmentation of the existing food supplies should be given the first priority.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Average intake</th>
<th>Recommended allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine mg/1000 Cal</td>
<td>0.53</td>
<td>0.5</td>
</tr>
<tr>
<td>Riboflavin mg/1000 Cal</td>
<td>0.30</td>
<td>0.55</td>
</tr>
<tr>
<td>Niacin equivalents mg/1000 Cal</td>
<td>9.90</td>
<td>6.6</td>
</tr>
<tr>
<td>Ascorbic acid mg/day</td>
<td>4.4</td>
<td>30-50</td>
</tr>
<tr>
<td>Vitamin A (retinol) µg/day</td>
<td>61.0</td>
<td>250-300</td>
</tr>
<tr>
<td>Iron mg/day</td>
<td>5.9</td>
<td>15-20</td>
</tr>
<tr>
<td>Calcium mg/day</td>
<td>193.0</td>
<td>400-500</td>
</tr>
</tbody>
</table>

* Based on diet survey in the Hyderabad region.

Since cereal-based diets tend to be bulky, an important question is whether the preschool children would be able to tolerate such diets taken in larger amounts. Studies were carried out at our Institute in which preschool children were fed, to satiety, diets to which they were already accustomed for a period of two weeks. It was found that these children were able to consume the food without any ill effects, in amounts which provided enough calories to meet their requirements.

However, all this does not mean that no improvement of the diets is necessary. The diets are deficient in vitamins and minerals and this situation must be rectified. This has to be done by improving the diets with the inclusion of more protective foods like milk, vegetables and fruits. This, however, will be a long term solution. The immediate step could be the overcoming of the calorie gap by providing more of the same food to which the children are already accustomed.
Improvement of protein quality of diets of population groups by means of amino acid supplementation has been under active consideration lately. We did a series of experiments to determine whether fortification of cereals with lysine would improve the protein quality of diets which, being predominantly cereal based, might be expected to be deficient in lysine.\textsuperscript{5,7,8}

Amino acid composition of the diets of preschool children from several regions in India was determined. The diets were formulated from the diet survey data and analyzed for amino acids by ion-exchange chromatography after acid hydrolysis, in the amino acid analyzer. Table 5 shows the amino acid composition of 3 diets based on wheat, rice or mixed cereals from the Delhi, Tamil Nadu and Andhra Pradesh regions respectively. The amino acid pattern of these diets is compared to that of egg, as recommended by WHO/FAO in 1965.\textsuperscript{8}

**TABLE 5**

Essential amino acid\(^{a}\) composition of diets of preschool children in different regions in India

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Egg value (\text{gAA/16gN})</th>
<th>Wheat diet (%) of egg value</th>
<th>Rice diet (%) of egg value</th>
<th>Mixed cereal diet (%) of egg value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threonine</td>
<td>5.1</td>
<td>3.1</td>
<td>61.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Valine</td>
<td>7.3</td>
<td>4.5</td>
<td>61.2</td>
<td>5.7</td>
</tr>
<tr>
<td>Methionine(^{b})</td>
<td>5.5</td>
<td>3.6</td>
<td>65.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Cystine</td>
<td>6.6</td>
<td>4.0</td>
<td>60.9</td>
<td>4.4</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>8.8</td>
<td>6.9</td>
<td>78.2</td>
<td>7.7</td>
</tr>
<tr>
<td>Leucine</td>
<td>10.0</td>
<td>6.2</td>
<td>63.0</td>
<td>7.8</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>6.4</td>
<td>4.4</td>
<td>68.9</td>
<td>4.7</td>
</tr>
<tr>
<td>Lysine</td>
<td>1.6</td>
<td>1.1</td>
<td>67.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Tryptophane(^{c})</td>
<td>10.0</td>
<td>6.2</td>
<td>63.0</td>
<td>7.8</td>
</tr>
</tbody>
</table>

\(^{a}\) Analyzed by automatic amino acid analyzer  
\(^{b}\) Protected by performic acid oxidation  
\(^{c}\) Microbiological assay on alkaline hydrolysates  
\(^{d}\) Amino acid
In the wheat diet, threonine, isoleucine and valine were equally the first limiting amino acids. The sulphur amino acids, methionine and cysteine, were second limiting and tryptophan the third limiting. However, the margin of deficit between the various amino acids was very narrow and the differences might not be significant.

Tryptophan was first limiting in the rice based diet, the sulphur amino acids second limiting and isoleucine and threonine jointly, the third limiting. In the Andhra Pradesh mixed cereal diet also, tryptophan appeared to be the first limiting amino acid, followed by isoleucine as second limiting and sulphur amino acids as the third limiting. Thus, in none of the 3 diets studied, was lysine the first limiting amino acid. Hence, fortification of wheat or rice diets with lysine might not be expected to improve their protein quality. However, since chemical composition may not necessarily reflect biological availability, a series of experiments were done to determine the effect of addition of lysine to cereals on the growth and nitrogen retention of growing rats.6,7

Figures 3 and 4 show that in the presence of dietary constraints of calories, vitamins and minerals, addition of lysine at 0.1% or 0.2%, level to either 90% rice or 90% wheat diets did not improve growth of rats significantly.
Fig. 4

EFFECT OF LYSINE ON WEIGHT GAIN OF WEANLING RATS FED 90% WHEAT DIETS ADEQUATE OR DEFICIENT IN CALORIES, VITAMINS & MINERALS

TABLE 6

<table>
<thead>
<tr>
<th>Dietary treatment</th>
<th>Dietary protein</th>
<th>Average weight gain/rat (4 weeks)</th>
<th>Average food intake/rat (4 weeks)</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casin control</td>
<td>11.6</td>
<td>87±4.4</td>
<td>247±3.6</td>
<td>1.04</td>
</tr>
<tr>
<td>Ad libitum feeding</td>
<td>11.5</td>
<td>67±2.8</td>
<td>268±2.8</td>
<td>2.18</td>
</tr>
<tr>
<td>Rice diet (RD)</td>
<td>10.8</td>
<td>66±3.1</td>
<td>272±3.3</td>
<td>2.24</td>
</tr>
<tr>
<td>RD+0.1% LMH</td>
<td>13.3</td>
<td>76±5.3</td>
<td>262±8.8</td>
<td>2.16</td>
</tr>
<tr>
<td>Wheat diet (WD)</td>
<td>13.8</td>
<td>77±2.6</td>
<td>272±2.6</td>
<td>2.05</td>
</tr>
<tr>
<td>Restricted feeding</td>
<td>11.5</td>
<td>49±1.7</td>
<td>191±3.6</td>
<td>2.22</td>
</tr>
<tr>
<td>RD+0.1% LMH</td>
<td>10.8</td>
<td>49±2.4</td>
<td>192±3.8</td>
<td>2.38</td>
</tr>
<tr>
<td>WD</td>
<td>11.5</td>
<td>57±3.4</td>
<td>192±6.0</td>
<td>2.24</td>
</tr>
<tr>
<td>WD+0.1% LMH</td>
<td>13.8</td>
<td>58±4.4</td>
<td>191±6.0</td>
<td>2.20</td>
</tr>
</tbody>
</table>

*L-lysine-mono-hydrochloride  Mean ± S.E.
Another growth study was done on rats (Table 6) in which complete, natural diets of preschool children based on rice and wheat were formulated and fed to rats ad libitum or in restricted quantities. Addition of lysine to these diets at 0.1% level of the cereal did not increase weight gain or PER.

The NPU under operative conditions (NPUop) of diets of preschool children with or without added lysine was determined (Tables 7 and 8). The procedure of Miller\(^\text{19}\) was followed with slight modifications for the determination of NPUop. The NPUop of none of the 3 diets studied showed an increase with addition of lysine to the diet.

**TABLE 7**
The net protein utilization (NPUop) of the wheat diet of preschool children fed to growing rats with or without added lysine

<table>
<thead>
<tr>
<th>Dietary treatment</th>
<th>Average weight gain/rat (10 days) g.</th>
<th>Average food intake/rat (10 days) g.</th>
<th>NPUop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein free diet</td>
<td>-13</td>
<td>59</td>
<td>—</td>
</tr>
<tr>
<td>Wheat diet (WD)</td>
<td>25</td>
<td>95</td>
<td>47±2.5</td>
</tr>
<tr>
<td>WD + 0.1% LMH*</td>
<td>23</td>
<td>92</td>
<td>45±2.2</td>
</tr>
<tr>
<td>WD + 0.2% LMH</td>
<td>29</td>
<td>94</td>
<td>49±3.0</td>
</tr>
</tbody>
</table>

* L-lysine-mono-hydrochloride
Mean ± S.E.

**TABLE 8**
The net protein utilization (NPUop) of diets of preschool children fed to growing rats with or without added lysine

<table>
<thead>
<tr>
<th>Dietary treatment</th>
<th>Average weight gain/rat (10 days) g.</th>
<th>Average food intake/rat (10 days) g.</th>
<th>NPUop SEM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein free diet</td>
<td>-10</td>
<td>56</td>
<td>—</td>
</tr>
<tr>
<td>Rice diet (RD)</td>
<td>20</td>
<td>76</td>
<td>54±2.2</td>
</tr>
<tr>
<td>RD + 0.2% LMH*</td>
<td>17</td>
<td>73</td>
<td>55±4.0</td>
</tr>
<tr>
<td>Mixed cereal diet (MCD)</td>
<td>20</td>
<td>80</td>
<td>47±3.1</td>
</tr>
<tr>
<td>MCD + 0.2% LMH</td>
<td>22</td>
<td>80</td>
<td>49±4.8</td>
</tr>
</tbody>
</table>

* L-lysine-mono-hydrochloride
* Standard error of the mean
From these data, it is evident that addition of lysine to diets of preschool children, especially under the existing patterns with deficiencies of calories, vitamins and minerals, may not be beneficial.

REFERENCES

Payne's paper has argued:

(i) that the minimum protein-calorie requirement is not a fixed number either of calories or of grammes of protein; that there is a wide range of dietaries that will just meet protein-calorie requirements, and that this range of minimal dietaries will show variations not only in the foods they include but also in the amounts of calories and proteins they contain;

(ii) that observed grain-based diets generally have adequate NDpCal\% values even where calorie intakes are minimal to meet energy requirements for growth and activity;

(iii) that for adults where NDpCal\% values of diets exceed 4.4, protein-calorie deficiency can be remedied by increasing the food intake without changing the diet pattern until calorie requirements are met;*

(iv) that increasing protein intakes where calorie intakes are less than required simply provides extra calories in protein form;

(v) that amino acid supplementation in this situation is ineffective.

These conclusions are consistent with and supported by those of Sukhatme\(^1\) and Gopalan\(^2\)\(^a\) who show that calorie intakes are less than required in a high proportion of cases of protein calorie malnutrition observed in India. Sukhatme shows that in a sample of 1022 households in Madras, 90\% of the households estimated to have intakes so low as to lead to protein-calorie malnutrition and could be brought to requirement simply by increasing the intake of their present diet. In a sample from Bihar, the comparable figure is 100\%. Gopalan refers to a nation wide study of 15000 pre-school children belonging to the poor socio-economic group in which “no children.....were found to subsist on diets that were adequate with regard to calories but deficient in proteins”.

In these cases, high protein diet supplementation is likely to prove an expensive method of providing needed calories. Where protein-calorie malnutrition

\[^*\]For children, higher NDpCal\% levels are necessary. For 1 year olds, the minimum level at which protein requirements are assured is 5.8 NDpCal\%; with higher than minimum calorie requirements, NDpCal\% could be lower.
is associated with poverty not only of the individuals concerned but of the country at large, as it is particularly in India, then it is essential to be able to identify the cheapest means of diet supplementation. This may not even be simply more of the existing diet for in some cases a fall of NDpCal\% could be tolerated so that an increase of a less protein rich—and generally cheaper—component of the diet may suffice.

The conventional method used by economists for the solution of least-cost diets is linear programming\(^4\). However, with the recognition of the fact that target dietary cannot be expressed in terms of fixed requirements of calories and proteins but are nonlinear functions of protein-calorie ratios, amino acid proportions and total calorie intakes, this method needs considerable modification. Iterative linear programming may be used to obtain least-cost diets by successive approximation. Relatively simple graphic methods may also be effective in reaching good approximations.

A clear distinction must be drawn, however, between the use of linear programming for least-cost analysis directed to the question of how an individual consumer might achieve an adequate diet at minimum cost and linear programming used to determine the least-cost attainment of national nutritional targets as, for example, in the Indian Ministry of Health’s Comprehensive Nutrition Plan. When, in the form of a linear programming model, the question is asked “what should India produce more of, and in what quantities, to make good nutritional deficiencies at least-cost?”. It is assumed not only that output can be secured of the products so indicated but, implicitly, that they will in fact be consumed by the people for whom they are intended. The Indian Comprehensive Nutrition Plan does just this and gives as an answer a plan for additional production of a number of food items intended to supplement the diets of children from 1-6 years old—as follows:

<table>
<thead>
<tr>
<th>Food item</th>
<th>Quantity 1000 tonnes</th>
<th>Estimated cost Rs. crores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseed flour</td>
<td>200</td>
<td>18.00</td>
</tr>
<tr>
<td>Bal Ahar</td>
<td>405</td>
<td>45.00</td>
</tr>
<tr>
<td>Pulses</td>
<td>1187</td>
<td>178.05</td>
</tr>
<tr>
<td>Fish protein concentrate</td>
<td>6</td>
<td>4.95</td>
</tr>
<tr>
<td>Toned milk</td>
<td>18</td>
<td>0.86</td>
</tr>
<tr>
<td>Lysine</td>
<td>2</td>
<td>3.30</td>
</tr>
<tr>
<td>Fish</td>
<td>400</td>
<td>120.00</td>
</tr>
<tr>
<td>Fresh milk</td>
<td>336</td>
<td>30.24</td>
</tr>
</tbody>
</table>
This diverse pattern of food supplements does not reflect allowances made for differences in tastes, prices or availability to different individuals or regions but that limits of feasible production increases were seen for the cheapest sources of proteins ('animal grade' and 'non-animal grade') and indeed to the second and third cheapest etc.

Quite apart from the fact that the question as posed misspecifies the problem in as much as it concentrates on protein rather than calories—and distinguishes animal grade protein as an additional requirement—the method of approach is inappropriate, and counterproductive. Among the shortcomings of this approach are those common to aggregative supply-oriented approaches including notably the balance sheet approach to the estimation of nutrition problems and to food and nutrition planning. Such approaches assume that if first an optimal production plan can be determined the devising of a plan for distribution can follow. It is a major contention of this paper that production and distribution problems must not be separated and that in practice, the most effective approach to food and nutrition planning is to work from the planning of distribution measures to the planning of supply improvement measures.

Distribution is not primarily a matter of storage and transport. It is primarily a matter of purchasing power. Dandekar et al have calculated that, in India in 1960-61, one third of the rural population and one half of the urban population were unable to produce or buy their minimum calorific requirements. Dandekar took 2250 calories per day as his average minimum per capita requirement, substantially higher than Sukhatme's 2200 calories per nutrition unit. Nevertheless, there is agreement inasmuch as Dandekar's calculation that 50% of urban populations could not afford sufficient calories coincides with Sukhatme's observation that in his Madras sample 49% did not get sufficient calories. Sukhatme's data also shows a strong positive relationship between intake and income.

While the precise relationship between income and intake might be further discussed it seems reasonable to accept Dandekar's argument that poverty is the major cause of malnutrition. It follows that even if adequate food supplies were available they might not be eaten. In particular, it follows that even were the Comprehensive Nutrition Plan's production targets achieved, the food produced might not be eaten by the children for whom it was intended. Quite apart from whether mothers will wish to feed the foods produced, they will generally not be the cheapest supplements for them to buy. Above all, mothers may be quite unable to buy any more food at all. If they cannot afford to buy more grains and pulses now, how are they to afford milk and fish?
what good is it to produce more pulses unless the increased supply depresses prices as to make them cheap enough to buy? But then, if pulse prices fall how much more would be produced?

Effective food and nutrition planning must start from the consumer. First it is necessary to identify whose intakes are inadequate and why. We need to determine the extent to which poor diets can be improved by alternative means—by education programmes, by increasing purchasing power in different ways, or by the direct provision of food—especially through institutional feeding programmes. Where diet improvement programmes rely on consumers growing or purchasing new amounts or patterns of foods the feasibility and cost of implied changes in supply patterns must be examined with a view to selecting programmes the supply implications of which are both feasible and low cost. One must work from demand to supply. To reverse the order of this reasoning is likely to lead to wholly abortive plans. Certainly, in the case of the Comprehensive Nutrition Plan, when one asks how consumers are now to be enabled and induced to eat the food to be provided for them one wonders that this question should not have been asked to start with.

Many of the underfed are to be found among farming families producing most of the food they consume. While the provision of opportunities for augmenting their incomes by promoting public works and other employment programmes might be relevant for these as well as for urban families there is the further possibility of programmes to assist them to raise their farm output. It should be noted, however, that policies to stimulate increases in total marketed farm production do not necessarily have their impact on the subsistence farmer. Where the object to farming improvement programmes is to improve food intakes of small farm families they may need to be specially designed for this purpose.

Programmes designed to increase the marketed supplies of food products may not only fail to solve the nutrition problem they may aggravate it. Fears are currently expressed that the introduction of new farming technology is creating unemployment. Whether or not this is so is by no means established, but the changes induced by the introduction of new technology are likely to create at least temporary problems of displacement, poverty and malnutrition.

*Ultimately we are concerned not with improving diets but improving physical and mental functioning and among the alternative means to be considered here are not only different nutrition programmes and policies but also health programmes and policies. The inter-dependance between these makes it imperative that they should be considered together. While this paper deals only with nutrition consideration it assumes parallel and integrated treatment of health issues also.
The danger of treating nutrition problems as primarily food production problems might be illustrated by a proposal recently encountered for a programme of introducing grade dairy cattle into a densely populated area in Africa. The proposal was supported on the grounds that it would provide milk in an area where there was much malnutrition. However, it seemed highly likely that (a) only a fraction of one per cent of the largest farmers of the area had the land to support grade dairy cows; (b) the milk they produced would mostly be sold more than a hundred miles away perhaps to people with already adequate diets; (c) the employment effects would be negligible if not adverse; (d) there was a long run danger of a pressure to absorb small holding to improve the viability of the dairy farms. Thus, locally at least, there was every reason to suppose that nutrition problems would be aggravated rather than eased by the milk production programme. In general, it is false to see production programmes as necessarily contributing to the solution of nutrition problems. Only where the demand is created can additional supply contribute to the solution—though it may be possible to stimulate supplies in ways which also stimulate the demand of those in need.

Whatever the immediate effects of new farming technologies there is likely to be an increase in the number of people in India at or below the margin of subsistence. For these people, nutrition policy must aim primarily at increasing their purchasing power. Projections of the labour force show an expected rise of about 40 million (20%) in the rural labour force and 20 million (65%) in the urban labour force in the next ten years. Perhaps the most serious question to be faced in India today is where and how this exploding labour force can be absorbed in productive employment on the earnings on which they can subsist.

At the national level, the nutrition aspects of food policy must be concerned to identify measures which achieve the best compromise—if compromise is necessary—between creating demand for food by low income groups and satisfying increasing demand not only for foods sought by those with rising incomes but also for the cheap foods bought by those with low incomes. Increasing diversion of resources to foods in demand as incomes rise may mean increasing scarcity and higher prices of foods consumed by lower income groups. For this reason, nutritionists need to be most cautious in their advocacy of improving the quality of already adequate diets and to recognise that success in this may be bought at the cost of the deterioration of already inadequate low-income diets.

These observations underline the need to avoid setting intake requirements and recommended standards of intake artificially high. While it may sound
prudent to “err on the safe side”, it must be seen that in reality the effect is not to ensure that fully adequate standards are met, but on the contrary, to make it more difficult for those at the margin of subsistence to improve or even to maintain their intakes. Moreover, it must be clear that the question of what should be recommended is not a technical question but primarily an economic one—how much we can afford to recommend. Where minimum requirements are above realised intakes we can postpone the discussion of how much beyond this it would be good to go until we have achieved the minimum.

How then would be effective food and nutrition planning proceed?

First, it would identify those whose intakes were inadequate and the nature and extent of their nutritional inadequacy. Ideally, it should identify ‘ill-health’ associated with malnutrition, making explicit reference to other interrelated health aspects such as parasites. Decisions might need to be taken about the extent to which—in specific situations—poor diet absorption, due perhaps to parasites, was to be tackled by health measures and/or by improving food intakes. Throughout, a parallel and related set of questions to examining health programme alternatives should be posed.

Second, it would attempt to predict future trends of the numbers of inadequately fed, identified geographically and by socio-economic and demographic characteristics—ideally, analysing the causes of observed trends;

Third, it would examine the alternative patterns of diet supplementation which might be aimed at especially those which would result from increasing purchasing power of low-income groups;

Fourth, it would consider alternative policies and programmes for securing or inducing diet improvements including e.g., fortification programmes, including education and/or augmenting incomes or reducing prices, also their appropriateness and cost in relation to different categories of people identified as inadequately fed;

Fifth, it would propose conclusions on how extensive a total programme could be mounted, which items could be included and which categories of people it could be addressed to—ideally, arguing the case for the choices made and the reasons for rejecting alternatives;
Sixth, it would assess the pattern of future food demand, prices and supplies taking account of the policies proposed and consider policies to stimulate production, including policies to change the pattern of food production from that which would result from the free play of market forces;

Seventh, it would conclude with an assessment of the predicted impact of the plan on the national nutrition problem.

Planning could not in fact neatly follow this step-wise sequence for there would need to be a process of iteration and adjustment not only of objectives to the feasibility and cost of their fulfilment but also between policies variously affecting demand, supplies and prices so that ultimately the plan presented was consistent in these respects.

Clearly, an approach such as that outlined above would integrate food and nutrition policy. Clearly, too, it would involve and integrate nutritional, economic and agronomic analysis—the main nutritional analysis being contributed under the first, third and fourth headings.

Were a comprehensive nutrition plan to be drawn up following the procedure suggested above, it would differ from the existing plan referred to in a number of ways:

(a) the national nutrition problem would be presented as the sum of individual group and regional problems shown to be different and requiring different treatment—at least in detail. Prognosis of trends and their relationship to other national and local development programmes and policies would also be emphasised;

(b) it would not be assumed that people would or could eat the appropriate amounts of what was thought to be the cheapest diet supplement for them; nor would it assume that the devising of a programme which ensured that they did was the responsibility of some other authority; nor, again, that diet supplementation was necessarily to be effected by the direct provision of food to the needy;

(c) it would concentrate on the means of enabling or inducing the relevant people to improve their intakes and then examine the wider implications of the success of such a programme with concern to make the demand and supply aspects of the programme consistent overall.
Almost certainly, such a plan would

(i) be more concerned, generally, for calories than proteins in its attack on protein-calorie malnutrition and would not assume that increased production would solve the problem;

(ii) be more concerned about conventional and cheap foods rather than non-conventional and dearer foods and, therefore, probably, give little emphasis to processed foods, protein concentrates and dear foods such as fish and milk except, perhaps, for institutional feeding programmes where convenience was important or for infant feeding in cases where breast milk was not available to supplement weaning foods devised from traditional local foodstuffs. Amino acid fortification also would, on the face of it, seem a non-starter; and

(iii) quite certainly, it would omit aggregative linear programming least-cost exercises of the form used in the preparation of the present plan.

The elimination of malnutrition will make demands on resources and techniques but the most challenging demand will be that made on our capacity for social organization. It is to be hoped that social scientists will be increasingly mobilised to co-operate in the study of the problem and alternative means for its solution.

REFERENCES

POST-WAR CHANGES IN FOOD CONSUMPTION PATTERNS IN JAPAN

TOSHIRO OISO

National Institute of Nutrition
Tokyo, Japan

Food consumption patterns in Japan have changed tremendously since last war. I will present the outline of these changes on the basis of the results of the Japanese National Nutrition Survey which have been carried out since 1946.

Until the beginning of the 20th century, the food consumption patterns in Japan had chiefly consisted of cereals, pulses, vegetables and fishes. The dietary habits of Japanese were formed during the period of national isolation of about 300 years. Therefore, Japanese diet primarily depended upon the foods produced within this country. Because of a fall of productive capacity since the war, self-supply of food was absolutely insufficient. All agricultural efforts were concentrated towards production increase. Increased potato and cereal consumption supported the caloric requirement of the population. Vegetables were self-supplied in each house farm, even in the urban area up to 1955.

Since 1956, the food supply started to improve and minimum calorie and protein requirements of the people were met. The efforts of persons concerned with nutrition were chiefly to increase the intake of animal protein, fats and oils, vitamins and some minerals. Also, the living style of the population changed towards westernization and many kinds of western foods appeared in the Japanese diet. As the use of bread was transitionally recommended instead of rice as a main food, the intake of the above mentioned nutrients was expected to increase. In fact, during this decade, the consumption of eggs, milk, meat, poultry, fats and oils increased year by year and per capita consumption of these animal foods increased two-fold or more. On the other hand, the consumption of potatoes and cereals except rice and barley decreased. With the disappearance of the house farms, the consumption of green vegetables decreased and other vegetables increased, on the other hand. Consumption of soyabean products and fish were almost constant throughout this decade.
Since 1966, changes in food consumption patterns were found in food selection from the standpoint of economy, taste, and sometimes of nutrition. The results of the last Nutrition Survey in 1968 showed that except vitamin A, B₁ and B₂, all the nutritional requirements of population are satisfied on an average.

The following Figures (1-7) show the changes in food consumption pattern and also compare those of the urban and rural areas.
Post-War Dietaries in Japan

Fig. 2. Annual changes in intake of protein foods.

Fig. 3. Changes in calorie ratio.
Toshio Oiso

Rice, Potatoes & Animal Food

Fig. 4. Intake of cereals and potatoes—Rural and urban areas.

Fig. 5. Intake of protein—Rural and urban areas.
Fig. 6. Intake of milk and eggs—Rural and urban areas.

Milk & Eggs

Fig. 7. Intake of vegetables and pulses—Rural and urban areas.
The Ministry of Health and Welfare began The National Nutrition Survey in 1946. In the beginning, the scale of the survey was so small that the estimation of the food consumption patterns of whole population was impossible. Then, only the comparison of data between urban and rural households was made. The average data for the whole country have been presented since 1969. The survey was conducted 4 times every year up to 1964 and each survey lasted 3 days. At present, it is once a year (May) and lasts for 5 days. The sample number of the survey is about 15000 households every year. All food consumed by all household members are weighted and recorded by a member of each household and are checked every day by a dietitian. The data collected in the nutrition surveys are given in Tables 1-6.

Food consumption patterns (whole country)
Rice, wheat, other cereals, potatoes and green vegetables (Those which decreased)
Fishes, pulses, milk, eggs, and meat (Animal protein sources)
Other vegetables, seasonings, drinks and fruits, sugars, fats and oils (Plant foods)

Nutrient intake (whole country)
Caloric ratio
Total protein, animal protein and fat
Vit. B_2 and Vit. B_3
Vit. C and calcium
Food consumption (Urban) 1946-'68
Food consumption (Rural) ,
Rice, potatoes, animal foods (Urban-Rural)
Vegetables and pulses (Urban-rural)
Seasonings, drinks, and sugars (Urban-rural)
Fish, shellfish and meat (Urban-rural)
Milk and eggs (Urban-rural)
Nutrient intake (Urban)
Nutrient intake (Rural)
Total calorie and fat (Urban-rural)
Total protein and animal protein (Urban-rural)
Vit. B_2 and Vit. B_3
Vit. C and calcium
### TABLE 1

Annual changes of food consumption
(whole country)

<table>
<thead>
<tr>
<th>Per capita consumption per day (g.)</th>
<th>1949</th>
<th>1953</th>
<th>1958</th>
<th>1963</th>
<th>1968</th>
<th>1968-69</th>
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### TABLE 2

Annual changes of nutrient intake (whole country)

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<th>Per capita consumption per day</th>
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<th>1968</th>
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<tr>
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<td>—</td>
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<td>Vitamin C (mg)</td>
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TABLE 3
Annual changes of food consumption
(Urban)

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TABLE 4
Annual changes of food consumption
(Rural)

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<td>7</td>
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<td>Animal food</td>
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### TABLE 5

Annual changes of nutrient intake  
(Urban)

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<td>88</td>
<td>75</td>
<td>80</td>
<td>122</td>
<td>—</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>253</td>
<td>270</td>
<td>381</td>
<td>401</td>
<td>519</td>
<td>532</td>
</tr>
</tbody>
</table>

### TABLE 6

Annual changes of nutrient intake  
(Rural)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorie</td>
<td>2084</td>
<td>2171</td>
<td>2152</td>
<td>2210</td>
<td>2243</td>
<td>2225</td>
</tr>
<tr>
<td>Total protein (g)</td>
<td>59</td>
<td>67</td>
<td>68</td>
<td>69</td>
<td>74</td>
<td>75</td>
</tr>
<tr>
<td>Animal protein (g)</td>
<td>17</td>
<td>20</td>
<td>21</td>
<td>27</td>
<td>29</td>
<td>—</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>13</td>
<td>19</td>
<td>23</td>
<td>36</td>
<td>39</td>
<td>—</td>
</tr>
<tr>
<td>Vitamin A (I.U.)</td>
<td>—</td>
<td>—</td>
<td>1071</td>
<td>1407</td>
<td>1325</td>
<td></td>
</tr>
<tr>
<td>Vitamin B₁ (mg)</td>
<td>1.98</td>
<td>1.58</td>
<td>1.07</td>
<td>1.00</td>
<td>1.02</td>
<td>1.00</td>
</tr>
<tr>
<td>Vitamin B₂ (mg)</td>
<td>0.71</td>
<td>0.74</td>
<td>0.69</td>
<td>0.74</td>
<td>0.82</td>
<td>0.93</td>
</tr>
<tr>
<td>Vitamin C (mg.)</td>
<td>186</td>
<td>105</td>
<td>78</td>
<td>79</td>
<td>113</td>
<td>—</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>253</td>
<td>270</td>
<td>377</td>
<td>387</td>
<td>486</td>
<td>519</td>
</tr>
</tbody>
</table>
To summarize, the following may be pointed out as recent or coming trends in food consumption pattern.

1) With the mechanisation of living and labour, the caloric intake is apt to be above the requirement. Obesity is tending to be a nutritional problem. The consumption of cereals will decrease more and more.

2) In response to the nutritional propaganda, low caloric, high vitamin foods such as green and yellow vegetables and fruits are being consumed more.

3) As a reflection of the individualization of life and the complexity of living, instant foods or pre cooked foods are gaining popularity.

4) With the popularization of the refrigerator, even perishable foods such as milk, fishes, and meat will be used in most households.

5) The quality of group feeding is becoming more nutritional and more sanitary.
SYMPOSIUM ON
NUTRITION AND FAMILY PLANNING

Chairmen : M. K. Krishna Menon, India
and
K. Ramesh Pai, India

Rapporteurs: P. E. Soysa, Ceylon

Papers:

Food, Nutrition, population and economic development
—Pitambar Pant . . 286

Family planning experiences in Mauritius 1967 to 1968
—C. C. Desilva . . 311

Population problems of less developed countries
—S. N. Agarwala . . 317

Experience with the use of oral contraceptives and
IUCD in malnourished population of India —S. Tejua . . 330

Family size and nutritional status

285
The objective of economic development in India is to provide a reasonable standard of living to all sections of the population, and its continued improvement over time. A nutritionally satisfactory diet is an essential component of good living. In the context of an already large population growing at a rapid rate, the existing high proportion of undernourished population and the limited land available per capita, the problem of providing a nutritionally satisfactory diet deserves careful consideration and assumes urgency and vital importance in India. A diet sufficient in quantity and adequate in its nutritional content is the foundation of good health and well-being. It is also an important factor in raising productivity. Penalties imposed on society as a result of general malnutrition, particularly protein deficiency during infancy and childhood, can be severe and costly in terms of loss of health and happiness, and impediment to economic development. At the same time improvement in the nutritional status of the masses of people in a large and poor country can be best considered in the context of a comprehensive and long-term view of social and economic development. This is so because of the many technical and economic problems that need to be tackled, which require simultaneous examination of many related aspects. These include the dynamics of population growth and the measures for regulating it, physiological requirements in terms of nutritional elements of diet to be reconciled with the economic demand for food, the supply prospects taking into account productive possibilities and auxiliary technologies, and assurance of minimum income to sections of people suffering from malnutrition within the framework of an expanding economy. An integrated approach covering a period of 10 to 15 years is useful to throw light on problems as may be expected to emerge and to think out a set of consistent measures by way of tackling them.

DYNAMICS OF POPULATION GROWTH:

Significant improvement in the nutritional status of large masses of poor people in India is partly a problem of nutritional education but essentially it is linked with low incomes. The solution must lie with rapid growth
of income and its improved distribution, mainly through expansion of
opportunities for productive employment to the growing labour force and
continuous increase in productivity per head. Income per capita can grow
satisfactorily only if the rate of increase in production is substantially higher
than the rate of growth of population. A right strategy for advance is to
seek reduction in the rate of growth of population while simultaneously
working for the acceleration in the rate of economic growth. Given the
possibility of deliberate control over births and deaths, and the capacity to
bring about rapid economic development through planning, higher rate of
investment, proper allocation and better management of resource, it is
considered possible to attain a fairly high rate of growth over a long period
in India. As the pattern of demand and even the pace of development
depend not only on the number of people, but also on the structure of
population as characterised by age and sex, it is necessary to study the
dynamics of population change in some detail in the perspective of the
next 15 years or so.

POPULATION GROWTH AND DEMOGRAPHIC CHARACTERISTICS:

India's population during the last 50 years, 1920-1970, increased by 120
per cent, from 251 million in 1920 to 554 million in 1970. The annual
percentage rate of growth of India's population during the decade 1920-30
was 1.06 and during the next two decades 1.35 and 1.24 respectively. There
was a sharp acceleration to 1.97 in the next decade 1950-60 and further
to 2.35 in the decade 1960-70.

While mortality has been greatly reduced in India, fertility has suffered only
a slight decline. This will be evident from the fact that while the death
rate decreased from 36.3 in 1921-31 to 15.6 in 1961-71, the birth rate in
the same period declined from 46.4 to 39.8 only.

As a consequence of the high rate of growth of population the Indian
population has a relatively high proportion of young people. Thus over
two-fifth of the population in India is below 15 years in contrast to less
than a third in developed countries, such as USA, Canada and Japan which
have a lower rate of population growth.

The Indian population is also characterised by early marriage. It is a
striking fact that 19 per cent of the female population in the age group
10-14 is married. In the rural areas the proportion was as high as 22 per
cent, while it was 7 per cent in the urban areas in 1961. The percentage
of married among females in the age group 15-44 was 86 in rural areas
and 79 in urban areas.
The general fertility rate (GFR), namely, the number of children born per 1000 women in the reproductive age group 15-44, for India is also significantly higher than the corresponding rate in countries, such as Japan and England (including Wales). It was 195 for India in 1961 as compared to 72 for Japan (1960) and 91 for England (1962). The first, second and third order births, taken together, represent 55 per cent of all births, spread nearly equally between the three. The fourth and fifth order births contribute another nearly 27 per cent. The remaining 18 per cent are births of the order of 6 and over. Seen against the background of the need for curbing population growth, this suggests the urgent need of preventing the higher order births (say over 3) and spacing out the lower-order ones.

**POPULATION PROJECTIONS:**

*Population size:* Estimates of the likely level of population up to 1985-86 have been made by an Expert Committee under the Chairmanship of the Registrar General of India on the basis of three alternative assumptions regarding fertility rates. The assumptions regarding mortality were kept the same in all cases. To the three estimates prepared by the Committee—high, medium low—we have added two more, namely (1) uncontrolled fertility and (2) very high.

It is important to draw attention to the probability of errors in such projections concerning future population growth owing to the wide range of expected future variations in both fertility and mortality. There may not be scope for wide divergence in mortality where the declining trend is assumed on the basis of parallel experience in other countries. There is, however, uncertainty as to the degree of decline in fertility which can be realistically expected as well as the timing in which the decline may occur.

The risk of using the estimates based on the data of a preceding decennial census of 1961 on the very eve of the 1971 census is all the greater. A better basis for projections will be provided by the 1971 census. When the results of the census become available in the next few months more detailed and refined studies might be possible.

Table 1 gives the decline in the GFR in 1985-6 postulated in the different variants relative to the base GFR figure of 195 for the period 1961-66.

The mid-year population estimates arising from these projections for 1975-76, 1980-81, and 1985-86 are shown in Table 2. The projection for 2000-01 is based on the simple assumption of continued growth of popul-
The difference in population between that based on the assumption of "uncontrolled fertility" and the "low" variant is 34 million in 1975-76, 87 million in 1980-81, 168 million in 1985-86, and can exceed 500 million by the year 2000. Thus a delay in effecting a reduction in the birth rate may not appear to be too serious a problem in the short run but it can give rise to an unmanageable problem of population growth in the long run.

TABLE 1

<table>
<thead>
<tr>
<th>Variant</th>
<th>GFR during 5 years preceding 1985-86</th>
<th>Percentage decrease from GFR during 1961-69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled fertility</td>
<td>195</td>
<td>0</td>
</tr>
<tr>
<td>Very High</td>
<td>142</td>
<td>27</td>
</tr>
<tr>
<td>High*</td>
<td>118</td>
<td>39</td>
</tr>
<tr>
<td>Medium*</td>
<td>100</td>
<td>49</td>
</tr>
<tr>
<td>Low*</td>
<td>84</td>
<td>57</td>
</tr>
</tbody>
</table>

*Estimates of the Expert Committee under the chairmanship of the Registrar General, India (1968).

TABLE 2

<table>
<thead>
<tr>
<th>Variant</th>
<th>1975-76</th>
<th>1980-81</th>
<th>1985-86</th>
<th>2000-01</th>
<th>GFR during preceding 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncontrolled fertility</td>
<td>644</td>
<td>750</td>
<td>871</td>
<td>1341</td>
<td>195</td>
</tr>
<tr>
<td>Very high</td>
<td>639</td>
<td>727</td>
<td>806</td>
<td>984</td>
<td>142</td>
</tr>
<tr>
<td>High</td>
<td>639</td>
<td>720</td>
<td>784</td>
<td>939</td>
<td>118</td>
</tr>
<tr>
<td>Medium</td>
<td>624</td>
<td>690</td>
<td>740</td>
<td>875</td>
<td>100</td>
</tr>
<tr>
<td>Low</td>
<td>610</td>
<td>663</td>
<td>700</td>
<td>828</td>
<td>84</td>
</tr>
<tr>
<td>Expectation of life at birth : years all variants</td>
<td>58.5</td>
<td>62</td>
<td>64</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

The "medium" projection is the one recommended for adoption by the Expert Group and actually being used for population projections up to
1985-86 by the Planning Commission. It is to be underlined that even this projection implies halving the general fertility rate during the 20 years 1965-85 (Table 1). Even with such a reduction, there is the prospect of India’s population increasing by 320 million in the next 30 years on top of the estimated 555 million in 1970.

Age structure: The age structure of the 1986 population estimate under the different assumptions is shown in Table 3.

<table>
<thead>
<tr>
<th>Age structure, 1985-86</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>0—4</td>
</tr>
<tr>
<td>5—19</td>
</tr>
<tr>
<td>20—64</td>
</tr>
<tr>
<td>65+</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

As one looks at this table from left to right it will be evident that higher the population growth rate assumed the larger will be the proportion of younger people in the population. The uncontrolled fertility projection has, for instance, 53 per cent of the population in the age group 0-19 as compared to 45 per cent in the medium projection. This means that the burden of dependency will increase, the need for providing suitable nourishment for children will be greater and there will be mounting pressure on school facilities.

A more detailed breakdown of estimated population in 1970-71, 1980-81 and 1985-86 by age group and sex, along with an estimate of number of pregnant and lactating women is given in Table 4, as the “medium” projection has been adopted provisionally by the Planning Commission for the long-term planning exercises. This kind of information is needed for working out the nutritional requirements on the basis of given norms.

Urban and Rural Distribution: A rural and urban distribution of the projected population upto 1980-81 was also attempted by the Expert Committee making use of past trends of urban population growth in different
# TABLE 4

Population (in million) by age group (Medium Projection), as on 1st October

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0—1</td>
<td>9.7</td>
<td>9.2</td>
<td>18.9</td>
<td>10.1</td>
<td>9.4</td>
<td>19.5</td>
<td>8.2</td>
<td>7.7</td>
<td>15.9</td>
</tr>
<tr>
<td>1—4</td>
<td>35.1</td>
<td>33.3</td>
<td>68.4</td>
<td>34.6</td>
<td>32.4</td>
<td>67.0</td>
<td>30.7</td>
<td>28.7</td>
<td>59.4</td>
</tr>
<tr>
<td>5—9</td>
<td>39.3</td>
<td>37.0</td>
<td>76.3</td>
<td>46.4</td>
<td>43.4</td>
<td>89.8</td>
<td>43.6</td>
<td>40.6</td>
<td>84.2</td>
</tr>
<tr>
<td>10—14</td>
<td>34.0</td>
<td>32.8</td>
<td>66.8</td>
<td>43.1</td>
<td>40.5</td>
<td>83.6</td>
<td>45.9</td>
<td>42.9</td>
<td>88.8</td>
</tr>
<tr>
<td>15—19</td>
<td>28.3</td>
<td>27.2</td>
<td>55.5</td>
<td>38.6</td>
<td>26.3</td>
<td>64.9</td>
<td>42.7</td>
<td>40.0</td>
<td>82.7</td>
</tr>
<tr>
<td>20—44</td>
<td>94.3</td>
<td>88.3</td>
<td>182.6</td>
<td>122.2</td>
<td>115.5</td>
<td>237.7</td>
<td>140.8</td>
<td>132.9</td>
<td>273.7</td>
</tr>
<tr>
<td>45—54</td>
<td>22.2</td>
<td>19.4</td>
<td>41.6</td>
<td>28.8</td>
<td>26.5</td>
<td>55.3</td>
<td>31.9</td>
<td>29.6</td>
<td>61.5</td>
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<tr>
<td>55—64</td>
<td>14.0</td>
<td>12.3</td>
<td>26.3</td>
<td>19.1</td>
<td>18.3</td>
<td>37.4</td>
<td>22.3</td>
<td>20.4</td>
<td>42.7</td>
</tr>
<tr>
<td>65+</td>
<td>8.8</td>
<td>8.7</td>
<td>17.5</td>
<td>13.4</td>
<td>12.6</td>
<td>26.0</td>
<td>16.4</td>
<td>15.2</td>
<td>31.6</td>
</tr>
<tr>
<td>All ages</td>
<td>285.7</td>
<td>268.2</td>
<td>553.9</td>
<td>356.3</td>
<td>333.9</td>
<td>690.2</td>
<td>382.2</td>
<td>358.0</td>
<td>740.2</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>22.2</td>
<td>16.6</td>
<td>12.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lactating women</td>
<td>19.9</td>
<td>16.2</td>
<td>12.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
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<tr>
<td>Andhra Pradesh</td>
<td>6217</td>
<td>8410</td>
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<td>1598</td>
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<td>2607</td>
<td>3316</td>
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<tr>
<td>Bihar</td>
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<td>6153</td>
<td>6102</td>
<td>9515</td>
<td>9091</td>
<td>11438</td>
<td>10330</td>
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<tr>
<td>Gujarat</td>
<td>5268</td>
<td>7367</td>
<td>7305</td>
<td>10219</td>
<td>9764</td>
<td>11445</td>
<td>10698</td>
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<td></td>
</tr>
<tr>
<td>Haryana</td>
<td>1296</td>
<td>1917</td>
<td>1902</td>
<td>2788</td>
<td>2664</td>
<td>3183</td>
<td>2969</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>587</td>
<td>740</td>
<td>734</td>
<td>934</td>
<td>892</td>
<td>1611</td>
<td>1590</td>
<td></td>
<td></td>
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<tr>
<td>Kerala</td>
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<td>3470</td>
<td>4786</td>
<td>4573</td>
<td>5370</td>
<td>4987</td>
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<td>Madhya Pradesh</td>
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<td>Tamil Nadu</td>
<td>8908</td>
<td>11549</td>
<td>11473</td>
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<td>14361</td>
<td>16385</td>
<td>15402</td>
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<tr>
<td>Maharashtra</td>
<td>11060</td>
<td>16055</td>
<td>15921</td>
<td>22836</td>
<td>21820</td>
<td>25825</td>
<td>24113</td>
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<tr>
<td>Mysore</td>
<td>5213</td>
<td>7362</td>
<td>7300</td>
<td>10358</td>
<td>9897</td>
<td>11284</td>
<td>10609</td>
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</tr>
<tr>
<td>Nagaland</td>
<td>19</td>
<td>28</td>
<td>28</td>
<td>42</td>
<td>41</td>
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<tr>
<td>Orissa</td>
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<td>1699</td>
<td>1685</td>
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<td>2431</td>
<td>2942</td>
<td>2712</td>
<td></td>
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</tr>
<tr>
<td>Punjab</td>
<td>2545</td>
<td>3765</td>
<td>3734</td>
<td>5476</td>
<td>5232</td>
<td>6256</td>
<td>5758</td>
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<td></td>
</tr>
<tr>
<td>Rajasthan</td>
<td>3251</td>
<td>4542</td>
<td>4504</td>
<td>6252</td>
<td>5974</td>
<td>6990</td>
<td>6716</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>9392</td>
<td>12864</td>
<td>12757</td>
<td>17577</td>
<td>16794</td>
<td>19605</td>
<td>18352</td>
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<td></td>
</tr>
<tr>
<td>West Bengal</td>
<td>9463</td>
<td>12221</td>
<td>12119</td>
<td>17512</td>
<td>16733</td>
<td>19890</td>
<td>18365</td>
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</tr>
<tr>
<td>Union Territories</td>
<td>654</td>
<td>958</td>
<td>948</td>
<td>1444</td>
<td>1399</td>
<td>1766</td>
<td>1578</td>
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</tr>
<tr>
<td>Delhi</td>
<td>2337</td>
<td>4029</td>
<td>3995</td>
<td>6671</td>
<td>6374</td>
<td>3005</td>
<td>7396</td>
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</tr>
<tr>
<td>Total</td>
<td>78210</td>
<td>111346</td>
<td>110417</td>
<td>157479</td>
<td>150469</td>
<td>177497</td>
<td>166311</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total population (million) | 435      | 559      | 554      | 720      | 690      | 784      | 740      |
Urban as % of total        | 18.0     | 19.9     | 19.9     | 21.9     | 21.9     | 22.6     | 22.4     |
categories of cities and towns grouped into 2 size classes (e.g. towns above 50,000 population and those below) and 4 functional classes (e.g. manufacturing, trade and transport service and agriculture). Using a similar method the estimate has been extended to 1985-86 to provide the approximate figures of urban population by States and Union Territories as in Table 5.

The urban population proposition rises from 18 per cent in 1960-61 to less than 22 per cent in 1980-81 and 22.5 per cent in 1985-86. In absolute numbers the increase is of the order of 90 to 100 million during the course of 1960-61 to 1985-86 corresponding to a population growth of 300-350 million depending on the choice of the ‘medium’ or ‘high’ projection.

MAGNITUDE OF THE TASK:

It is instructive to link the alternative projections made by the demographers with the quantitative increases that will be necessary in the use of corresponding contraceptive measures such as sterilisation, intrauterine contraceptive devices (IUCD) and conventional contraceptives to conform to each of the projections. Leaving out the ‘low’ variant as being outside the realm of practical possibilities, an exercise of this type has been carried out for the “medium” projection (Table 6). This exercise illustrates the magnitude of the task to be faced in terms of the increases to be achieved for sterilisation, IUCD and conventional contraceptives even to keep to the medium projection, i.e. a population of 690 million in 1980-81 and 740 million in 1985-86.

Assuming a base level of 1.4 million fresh couples covered by sterilisation in 1969-70, the exercise throws up a figure of 3.3 million fresh couples to be covered by sterilisation in 1975-76, and 6.7 million fresh couples in 1980-81. Sterilisation will have to increase, by 15 per cent annually until 1980-81, whereafter they could stabilise at 6.7 million per year. Expressed in another way, sterilisation need to increase from 3 per 1000 of population per annum at present to 5 per 1000 in 1975-76 and to 9 per 1000 in 1980-81 and each year thereafter.

On a base level of 0.48 million fresh couples covered by IUCD in 1969-70, the IUCD coverage will need to increase by 15.20 per cent annually up to 1980-81 and by 10 per cent per annum till 1985-86. This implies an increase from 1 per 1000 per annum at present to 2.4 per 1000 in 1975-76, 4 per 100 in 1980-81 and 6 per 1000 in 1985-86.
<table>
<thead>
<tr>
<th>Year</th>
<th>Female population (15-44)</th>
<th>Potential births</th>
<th>Fresh couples covered by Sterilisation</th>
<th>I.U.C.D.</th>
<th>C.C.</th>
<th>Total</th>
<th>Births (million) prevented through the use of specific means of birth control</th>
<th>Sterilisation</th>
<th>I.U.C.D.</th>
<th>C.C.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966-67</td>
<td>104.500</td>
<td>20.377</td>
<td>0.890</td>
<td>0.910</td>
<td>0.465</td>
<td>2.265</td>
<td>0.355 0.260 0.051 0.607</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>67-68</td>
<td>107.100</td>
<td>20.884</td>
<td>1.840</td>
<td>0.670</td>
<td>0.475</td>
<td>2.985</td>
<td>0.622 0.305 0.070 0.997</td>
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<td></td>
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<tr>
<td>68-69</td>
<td>109.700</td>
<td>21.391</td>
<td>1.665</td>
<td>0.480</td>
<td>0.960</td>
<td>3.105</td>
<td>1.041 0.354 0.089 1.455</td>
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<td></td>
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</tr>
<tr>
<td>69-70</td>
<td>112.500</td>
<td>21.937</td>
<td>1.430</td>
<td>0.480</td>
<td>1.550</td>
<td>3.460</td>
<td>1.380 0.344 0.166 1.891</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>70-71</td>
<td>115.300</td>
<td>22.463</td>
<td>1.644</td>
<td>0.576</td>
<td>2.015</td>
<td>4.235</td>
<td>1.659 0.309 0.249 2.218</td>
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<td></td>
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</tr>
<tr>
<td>71-72</td>
<td>118.200</td>
<td>23.049</td>
<td>1.891</td>
<td>0.691</td>
<td>2.619</td>
<td>5.201</td>
<td>1.974 0.288 0.324 2.587</td>
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<tr>
<td>72-73</td>
<td>121.300</td>
<td>23.653</td>
<td>2.174</td>
<td>0.829</td>
<td>3.405</td>
<td>6.409</td>
<td>2.332 0.298 0.422 3.054</td>
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<tr>
<td>73-74</td>
<td>124.700</td>
<td>24.316</td>
<td>2.501</td>
<td>0.995</td>
<td>4.426</td>
<td>7.923</td>
<td>2.723 0.341 0.549 3.614</td>
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<td></td>
</tr>
<tr>
<td>74-75</td>
<td>128.700</td>
<td>24.979</td>
<td>2.876</td>
<td>1.194</td>
<td>5.775</td>
<td>9.825</td>
<td>3.164 0.406 0.713 4.285</td>
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<td></td>
<td></td>
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<tr>
<td>75-76</td>
<td>131.700</td>
<td>25.681</td>
<td>3.307</td>
<td>1.433</td>
<td>7.481</td>
<td>12.222</td>
<td>3.667 0.488 0.928 5.083</td>
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</tr>
<tr>
<td>77-78</td>
<td>139.900</td>
<td>27.085</td>
<td>4.374</td>
<td>1.895</td>
<td>10.773</td>
<td>17.043</td>
<td>4.896 0.689 1.414 7.000</td>
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<tr>
<td>78-79</td>
<td>142.700</td>
<td>27.826</td>
<td>5.030</td>
<td>2.179</td>
<td>12.928</td>
<td>20.138</td>
<td>5.636 0.804 1.696 8.137</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>79-80</td>
<td>146.600</td>
<td>28.587</td>
<td>5.785</td>
<td>2.506</td>
<td>15.513</td>
<td>23.805</td>
<td>6.484 0.931 2.036 9.451</td>
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<td></td>
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<tr>
<td>Year</td>
<td>Value 1</td>
<td>Value 2</td>
<td>Value 3</td>
<td>Value 4</td>
<td>Value 5</td>
<td>Value 6</td>
<td>Value 7</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-------</td>
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<td>---------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80-81</td>
<td>150.700</td>
<td>29.386</td>
<td>6.652</td>
<td>2.382</td>
<td>18.816</td>
<td>28.152</td>
<td>7.460</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>81-82</td>
<td>154.000</td>
<td>29.386</td>
<td>6.652</td>
<td>3.171</td>
<td>20.478</td>
<td>30.302</td>
<td>8.513</td>
<td></td>
<td></td>
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<tr>
<td>82-83</td>
<td>158.500</td>
<td>30.907</td>
<td>6.652</td>
<td>3.171</td>
<td>22.525</td>
<td>32.667</td>
<td>9.465</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83-84</td>
<td>162.000</td>
<td>31.590</td>
<td>6.652</td>
<td>3.837</td>
<td>24.778</td>
<td>35.268</td>
<td>10.322</td>
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<td></td>
<td></td>
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<tr>
<td>84-85</td>
<td>165.400</td>
<td>32.253</td>
<td>6.652</td>
<td>4.220</td>
<td>27.256</td>
<td>38.130</td>
<td>11.091</td>
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<tr>
<td>85-86</td>
<td>168.600</td>
<td>32.877</td>
<td>6.652</td>
<td>4.642</td>
<td>29.882</td>
<td>41.277</td>
<td>11.773</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Notes:
1. Method of computation involves use of data/assumptions based on census and surveys relating to:
   a. age distribution of acceptors, by each mode of contraception for each year of the programme,
   b. age specific marital fertility rates,
   c. average effectiveness of each type of contraceptives and
   d. allowance for mortality, widowhood and withdrawal from reproductive age group, wife aged 15-44.
2. 1966-67 to 1969-70 figures of sterilisations (fresh), both IUCD and conventional contraceptives (C.C.) users are actuals. Three different percentage rates of increase in sterilisation, IUCD and C.C: 15, 20, 30, 13, 15, 20 and 0, 10, 10 have been assumed for the periods 1970-76, 1976-81 and 1981-86 respectively.
<table>
<thead>
<tr>
<th>Year</th>
<th>Births on reduced basis</th>
<th>Death rate</th>
<th>Birth rate</th>
<th>Growth rate</th>
<th>Population</th>
<th>Sterilisation</th>
<th>I.U.C.D.</th>
<th>C.C.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966-67</td>
<td>19,769</td>
<td>15,400</td>
<td>39,364</td>
<td>2.396</td>
<td>502,223</td>
<td>2.133</td>
<td>1.698</td>
<td>0.465</td>
<td>4.298</td>
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<tr>
<td>1967-68</td>
<td>19,886</td>
<td>14,800</td>
<td>38,638</td>
<td>2.183</td>
<td>514,677</td>
<td>3.922</td>
<td>1.853</td>
<td>0.475</td>
<td>6.250</td>
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<tr>
<td>1968-69</td>
<td>19,905</td>
<td>14,200</td>
<td>37,751</td>
<td>2.355</td>
<td>522,724</td>
<td>5.492</td>
<td>1.769</td>
<td>0.960</td>
<td>8.221</td>
</tr>
<tr>
<td>1969-70</td>
<td>20,046</td>
<td>13,600</td>
<td>37,112</td>
<td>2.351</td>
<td>510,149</td>
<td>6.757</td>
<td>1.613</td>
<td>1.550</td>
<td>9.950</td>
</tr>
<tr>
<td>1970-71</td>
<td>20,264</td>
<td>13,000</td>
<td>36,619</td>
<td>2.314</td>
<td>533,392</td>
<td>8.260</td>
<td>1.544</td>
<td>2.015</td>
<td>11.819</td>
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<tr>
<td>1971-72</td>
<td>20,461</td>
<td>12,500</td>
<td>36,090</td>
<td>2.359</td>
<td>566,936</td>
<td>9.932</td>
<td>1.604</td>
<td>2.619</td>
<td>14.155</td>
</tr>
<tr>
<td>1975-76</td>
<td>20,598</td>
<td>10,400</td>
<td>33,044</td>
<td>2.264</td>
<td>623,344</td>
<td>18.951</td>
<td>3.129</td>
<td>7.481</td>
<td>29.561</td>
</tr>
<tr>
<td>1976-77</td>
<td>20,381</td>
<td>10,000</td>
<td>31,972</td>
<td>2.197</td>
<td>637,492</td>
<td>21.990</td>
<td>3.838</td>
<td>8.977</td>
<td>34.759</td>
</tr>
<tr>
<td>1977-78</td>
<td>20,084</td>
<td>9,600</td>
<td>30,830</td>
<td>2.123</td>
<td>651,457</td>
<td>25.476</td>
<td>4.296</td>
<td>10.773</td>
<td>40.545</td>
</tr>
<tr>
<td>1978-79</td>
<td>19,688</td>
<td>9,300</td>
<td>29,603</td>
<td>2.030</td>
<td>665,087</td>
<td>29.439</td>
<td>4.968</td>
<td>12.928</td>
<td>47.335</td>
</tr>
<tr>
<td>1979-80</td>
<td>19,135</td>
<td>9,000</td>
<td>28,212</td>
<td>1.921</td>
<td>678,237</td>
<td>33.953</td>
<td>5.725</td>
<td>15.513</td>
<td>55.191</td>
</tr>
<tr>
<td>1980-81</td>
<td>18,409</td>
<td>8,800</td>
<td>26,654</td>
<td>1.785</td>
<td>693,678</td>
<td>39.110</td>
<td>6.583</td>
<td>18.616</td>
<td>64.309</td>
</tr>
<tr>
<td>1981-82</td>
<td>17,561</td>
<td>8,600</td>
<td>25,005</td>
<td>1.640</td>
<td>702,293</td>
<td>44.019</td>
<td>7.428</td>
<td>20.478</td>
<td>71.923</td>
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<tr>
<td>1982-83</td>
<td>16,901</td>
<td>8,400</td>
<td>23,694</td>
<td>1.529</td>
<td>711,301</td>
<td>49.664</td>
<td>8.294</td>
<td>22.525</td>
<td>79.483</td>
</tr>
<tr>
<td>1983-84</td>
<td>16,247</td>
<td>8,200</td>
<td>22,450</td>
<td>1.425</td>
<td>723,700</td>
<td>53.031</td>
<td>9.199</td>
<td>24.778</td>
<td>86.999</td>
</tr>
<tr>
<td>1984-85</td>
<td>15,626</td>
<td>8,100</td>
<td>21,305</td>
<td>1.320</td>
<td>733,665</td>
<td>57.084</td>
<td>10.133</td>
<td>27.236</td>
<td>94.473</td>
</tr>
<tr>
<td>1985-86</td>
<td>15,011</td>
<td>8,000</td>
<td>20,214</td>
<td>1.221</td>
<td>742,608</td>
<td>60.796</td>
<td>11.147</td>
<td>29.982</td>
<td>101.925</td>
</tr>
</tbody>
</table>
In the case of conventional contraceptives, the increase over the 1969-70 base level of 1.55 million fresh couples will need to be 20-30 per cent per annum till 1980-81 and 10 per cent annually thereafter till 1985-86. Per thousand of population this would mean increase from 3 at present to 12 in 1975-76, 23 in 1980-81 and 40 in 1985-86.

Incidentally, it has to be pointed out that even the 'very high' variant, which aims at keeping the rate of growth of population at about the current level throughout the period, implies active steps for birth control. Specifically, it implies doubling of the number of sterilisations per year by 1985-86, the quadrupling of IUCD insertions and an almost eight-fold increase in the number of conventional contraceptive users (with 1969-70 performance as the base).

Although the birth control measures consistent with the medium projection will pose a challenge to our administrative capacities, the 1985-86 targets of 90 per 1000 in sterilisations, 6 per 1000 for IUCD and 40 per 1000 for conventional contraceptives can, by no means, be considered as being unattainable. The medium projection thus offers the best basis for action. The important question is whether the necessary tempo can be mounted and sustained to the degree and within the time schedule as postulated with the existing programmes, policies, and organisational set-up for family planning. Shortfalls in year to year performance or delays in reaching the milestones in the prescribed path or birth rate reduction can significantly widen the gap between the actual and projected population in the terminal year.

Operational performance needs to be related to demographic goals by means of exercises such as the ones illustrated above. The overall targets for different contraceptive methods have to be translated into specific performance yardsticks on a regional basis and for different age groups in the reproductive population and for couples classified according to the number of children they have had. Considering that more than 60 per cent of couples in the reproductive age group (wives aged 15-44) should be contraceptive users by 1985-86, this will be a formidable administrative task. Equally important is the necessity to keep under constant appraisal the nutritional aspect, the acceptability and feasibility of different programmes, so that new experiments and approaches are tried and tested and programmes and policies are modified and adapted to changing needs and circumstances.

NUTRITIONAL REQUIREMENTS:

Proceeding on the assumption of population growth as in the 'Medium Projection' variant discussed above, the aim of planning from the nutri-
tional standpoint is to develop food production and distribution so that the nutritional requirements are met to the greatest extent possible by 1980-81 and 1985-86.

This involves, first, the assessment of the adequacy of existing consumption in comparison with scientifically defined requirements and secondly working out food production programmes and policies which will bring consumption in line with or much nearer to these levels.

*Present position*: The estimated availability of various food items in India is shown in Table 7 on per capita basis. These calculations based on total food supplies and total population provide only a general overall picture and cannot, of course, reveal the nutritional status of individual households and persons or even the wide difference within broad groups.

**TABLE 7**

Availability of food items in gms per capita per day and their average nutritive values—India, 1969*

<table>
<thead>
<tr>
<th>Items</th>
<th>Quality</th>
<th>Proteins</th>
<th>Fats</th>
<th>Estimated calories (Nos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>395</td>
<td>30.4</td>
<td>5.5</td>
<td>1244.3</td>
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<tr>
<td>Pulses</td>
<td>51</td>
<td>8.7</td>
<td>2.7</td>
<td>154.5</td>
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<tr>
<td>Sugar</td>
<td>46</td>
<td>0.4</td>
<td>—</td>
<td>164.7</td>
</tr>
<tr>
<td>Edible oils</td>
<td>10.4</td>
<td>—</td>
<td>10.4</td>
<td>91.9</td>
</tr>
<tr>
<td>Milk</td>
<td>108</td>
<td>3.7</td>
<td>4.2</td>
<td>72.4</td>
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<tr>
<td>Meat</td>
<td>3.6</td>
<td>0.5</td>
<td>0.3</td>
<td>5.4</td>
</tr>
<tr>
<td>Fish</td>
<td>7.1</td>
<td>0.8</td>
<td>0.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Eggs</td>
<td>1.3</td>
<td>0.3</td>
<td>0.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Starchy roots</td>
<td>44</td>
<td>0.4</td>
<td>—</td>
<td>35.6</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>58</td>
<td>0.6</td>
<td>0.1</td>
<td>17.4</td>
</tr>
<tr>
<td>Others (Miscellaneous</td>
<td>3.0</td>
<td>3.5</td>
<td>150.0</td>
<td></td>
</tr>
<tr>
<td>plants, animal oils, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>49.0</td>
<td>27.0</td>
<td>1943.3</td>
<td></td>
</tr>
</tbody>
</table>


The diet is primarily vegetarian with heavy dependence on cereals and pulses. The intake of various protective foods like milk and milk products, eggs, fish and meat, vegetables and fruits is relatively small. As a consequence many of the essential nutrients like calcium, iron, vitamins,
### TABLE 8

Requirements of nutrients for Indian population

<table>
<thead>
<tr>
<th>Year/unit</th>
<th>Net Calories (Numbers)</th>
<th>Protein (gm)</th>
<th>Calcium (mgn)</th>
<th>Iron (mgn)</th>
<th>Thiamine (mgn)</th>
<th>Riboflavin (mgn)</th>
<th>Nicotinic acid (mgn)</th>
<th>Ascorbic acid (mgn)</th>
<th>Folic acid (mgn)</th>
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<tbody>
<tr>
<td>1969</td>
<td>2394</td>
<td>43</td>
<td>0.45</td>
<td>22</td>
<td>1.2</td>
<td>1.3</td>
<td>16</td>
<td>46</td>
<td>90</td>
</tr>
<tr>
<td>1985</td>
<td>2393</td>
<td>45</td>
<td>0.45</td>
<td>23</td>
<td>1.2</td>
<td>1.3</td>
<td>16</td>
<td>46</td>
<td>92</td>
</tr>
</tbody>
</table>
### TABLE 9a

Food requirements on the basis of recommended balanced diet by age-groups, India 1980-81

<table>
<thead>
<tr>
<th>Items</th>
<th>Total</th>
<th>All non-vegetarian</th>
<th>All vegetarian</th>
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<td></td>
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Pritambar Pant
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**Notes:**

A—Annual requirements for human consumption in thousand tonnes.

B—Recommended allowance gms per head per day.

@ Included in green leafy vegetables.

* Included in meat, fish, etc.

(1) Based on recommended schedule of diet by the Nutrition Expert Group (1968).

(2) Men, women 19+, moderate activity status.

(3) Infants 0-1 omitted.
**TABLE 9b**

Food requirements on the basis of recommended balanced diet by age groups, India: 1985-86

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<th>Items</th>
<th>Age groups</th>
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<td>46796</td>
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<tr>
<td>A</td>
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<td>B</td>
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<td>854</td>
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Notes:—A—Annual requirements for human consumption in thousand tonnes.
B—Recommended allowances gms per head per day.
@ Included in green leafy vegetables.
* Included in meat, fish etc.
1) Based on recommended schedule of diet by the Nutrition Expert Group (1968).
(2) Men, women 19+ moderate activity status.
(3) Infants 0-1 omitted.
<table>
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<th>Age Group</th>
<th>Body weight in kg</th>
<th>Percentage of total population 1985-86</th>
<th>Protein requirements gms/day/kg body weight ref. protein net (A)</th>
<th>Gross requirements gms/day/kg body weight alternative alternative ref. protein net (A)</th>
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Average/capita/day

### Calories and Protein

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49.0  | 59.1  | 2286
thiamine, riboflavin and niacin etc., which are largely derived from non-cereal food items, and known to be deficient in varying degrees in most Indian diets.

NORMATIVE REQUIREMENTS OF FOOD AND NUTRITION:

Nutrition requirement is a function of the body weight, the environmental temperature, sex and activity status of the human being. Based on these considerations, the Nutrition Expert Group of the Indian Council of Medical Research has formulated detailed recommendations regarding dietary allowances of calories, proteins, fat, calcium, iron, vitamin A, thiamine, riboflavin, niacin, ascorbic acid, vitamin B12, folic acid and vitamin D. The recommendations are made separately for adult men and women and children and according to age group and activity status. To work out the average level of nutrition in per capita terms in any period, the recommended allowances need to be applied to the structure of the population according to age, sex and activity status in the relevant period. The structure of the population has already been investigated in an earlier section. Based on some broad assumptions of the activity status in the future, the average nutritional requirements per day can be worked out. The results are shown in Table 8.

The changing structure of the population has only a marginal effect on the levels of nutrition required in average per capita terms in India. The normative requirements of nutrition per person per day in India should comprise of 2400 calories and 45 gms. of protein, supplemented by appropriate minerals.

The dietary allowances recommended by the Nutrition Expert Group of the Indian Medical Council (1968), when applied to the 'medium population projections' give a good idea of the human consumption requirements of different items in the Indian diet in 1980-81 and 1985-86, if the recommended standards of acceptable diet are to be realized by then. The main results in terms of grams per capita per day and the total quantities required for each item of food for human consumption during the two years are summarised in Tables 9a and 9b.

Table 10 is an effort to apply the method of calculation to work out the average protein requirement suggested in Working Group’s Report on

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1 Indian Council of Medical Research—Recommended Daily Allowance of Nutrients and Balance Diets, 1968.
Food, Nutrition, Population and Economic Development 307

Protein Requirement (FAO, 1957). The age and sex distribution is from the 'medium projection'. The body weight figures are the best realistic guesses. Reference protein, average minimum requirements are the same as in the Working Group Report. Safety allowances have been applied—

(a) to allow for individual variation in requirements, multiply by 1.5;

(b) to allow for the quality of protein in the diet, multiply by 1.5 (corresponding to a protein score of 66 for a primarily cereal-pulse diet);

(c) to allow for the loss between retail stage and physical intake stage, an allowance of 10-12 per cent.

The net effect is to arrive at the 'requirement per kg of body weight' by multiplying the initial figure by 2.5 in the first variant. In variant 2, a further 20 per cent increase is allowed to compensate for the existing protein malnutrition and retarded physical growth and development as well as for the stress caused by intestinal parasites, and acute and chronic infectious diseases, which may raise the requirements for proteins. This second variant is thus derived by multiplying the initial value by 3.0. The additional protein requirements for women during pregnancy and lactation have also been added in the allowance for the relevant age group. Calculations have been made for calories also, but in this case the recommendations of the Working Group of the Indian Medical Council (1968) have been adhered to. The second variant would seem to make liberal allowance for unknown factors and could form a good basis for future effort to raise the nutritional level.

A number of interesting points are brought out, such as—

(1) The calorie requirements per capita per day for the population as a whole is 2192 in 1970-71 and 2285-86 because of the changing age structure.¹

(2) The protein requirements per capita per day for the population as a whole is 49 gms. under variant 1 and 50 gms. under variant 2 in 1985-86.¹

¹The normative requirements under variant 2 are in close accord with the standards defining an acceptable diet worked out by the Regional Analysis Division of the Economic Research Service of the US Department of Agriculture who have suggested 2200 calories and 60 gms. of protein per day, including 7 gms. of animal and 50 gms. of pulse protein for the countries of the Far East Region. It was further assumed that 15 per cent of the total calorie supply should come from fats.
(3) Children below 10 constituted 21.5 per cent of the population in 1985-86. They should consume 14.1 per cent of total calories and 15.2 per cent of total proteins.

(4) Pre-school children, roughly corresponding to age 1-6, will need 9.2 per cent of total protein consumption, about 1.1 million tonnes per year in 1985-86.

So far we have been discussing average needs on the basis of physiological or normative considerations. There is, however, another approach which derives future estimates of requirements on the basis of changes in population and per capita income. The nutritional aspect is not explicitly considered as a determining factor although the nutritional implications of such projections are usually outlined. Table 11 shows the assessment of future food needs on the basis of increase in per capita private consumption expenditure as envisaged in the long-term perspective in the Fourth Five Year Plan up to 1980-81. For the period 1980-81 to 1985-86, the economy is assumed to grow at an annual rate of 7 per cent. The requirements of different food items have been assessed, using consumption functions appropriate for each with 1969 consumption as the base.

### TABLE 11

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<th>1980-81</th>
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<th>1985-86</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gms/day</td>
<td>Calories</td>
<td>Proteins (gms)</td>
<td>gms/day</td>
</tr>
<tr>
<td>Cereals</td>
<td>440</td>
<td>1387</td>
<td>33.9</td>
<td>460</td>
</tr>
<tr>
<td>Pulses</td>
<td>75</td>
<td>227</td>
<td>12.8</td>
<td>80</td>
</tr>
<tr>
<td>Sugar</td>
<td>60</td>
<td>215</td>
<td>0.5</td>
<td>70</td>
</tr>
<tr>
<td>Edible Oil</td>
<td>14</td>
<td>124</td>
<td>—</td>
<td>16</td>
</tr>
<tr>
<td>Milk</td>
<td>166</td>
<td>139</td>
<td>5.7</td>
<td>207</td>
</tr>
<tr>
<td>Meat</td>
<td>4.3</td>
<td>7</td>
<td>0.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Fish</td>
<td>11.8</td>
<td>7</td>
<td>1.3</td>
<td>16.8</td>
</tr>
<tr>
<td>Eggs</td>
<td>2.2</td>
<td>4</td>
<td>0.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Starchy roots</td>
<td>4.7</td>
<td>38</td>
<td>0.9</td>
<td>59</td>
</tr>
<tr>
<td>Fruits &amp; vegetables</td>
<td>75</td>
<td>23</td>
<td>0.8</td>
<td>89</td>
</tr>
<tr>
<td>Others (Misc. plants, animal oils etc.)</td>
<td>150</td>
<td>3.0</td>
<td>150</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>2321</td>
<td>59.7</td>
<td>2499</td>
<td>64.8</td>
</tr>
</tbody>
</table>
The estimates for 1980-81 are as adopted at the National Food Congress, 1970. These demand forecasts show that in terms of average calorie requirements, India may not reach an adequate nutrition level even by 1980-81. The implications of these demand estimates in terms of requirements for human consumption are shown in Table 12.

**TABLE 12**

Production requirements of food items for human consumption

<table>
<thead>
<tr>
<th>Food items</th>
<th>Units</th>
<th>1980-81</th>
<th>1985-86</th>
<th>1985-86 (Sukhatme)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>mill. tonnes</td>
<td>112.2</td>
<td>126.0</td>
<td>110.3</td>
</tr>
<tr>
<td>Pulses</td>
<td>mill. tonnes</td>
<td>19.1</td>
<td>22.0</td>
<td>28.5</td>
</tr>
<tr>
<td>Starchy roots</td>
<td>mill. tonnes</td>
<td>12.0</td>
<td>13.7</td>
<td>12.6</td>
</tr>
<tr>
<td>Sugar</td>
<td>mill. tonnes</td>
<td>15.3</td>
<td>19.2</td>
<td>13.7</td>
</tr>
<tr>
<td>Fruits and vegetables</td>
<td>mill. tonnes</td>
<td>19.1</td>
<td>21.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Edible oils</td>
<td>mill. tonnes</td>
<td>3.6</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Milk</td>
<td>mill. tonnes</td>
<td>42.5</td>
<td>56.7</td>
<td>55.0</td>
</tr>
<tr>
<td>Eggs</td>
<td>thou. tonnes</td>
<td>560</td>
<td>850</td>
<td>548</td>
</tr>
<tr>
<td>Fish</td>
<td>thou. tonnes</td>
<td>3050</td>
<td>4600</td>
<td>4654</td>
</tr>
<tr>
<td>Meat</td>
<td>thou. tonnes</td>
<td>1100</td>
<td>1341</td>
<td>1976</td>
</tr>
</tbody>
</table>

Assuming a one year lag between production and consumption of agricultural commodities, the above estimates are worked out on the basis of population reaching 698 millions in 1981-82 and 750 millions in 1986-87. As may be noticed in the projections for 1985-86, the various estimates derived from different approaches will need to be analysed and reconciled so as to meet the nutritional goals within the framework of an economic plan which continues to give an important role to the market for satisfying consumer demand.

The final requirements must include appropriate provision for seed, food, other inter industry requirements and losses. This demand has to be then carefully reviewed in relation to potential for development on the basis of known technology, and feasibility of programmes and policies from various angles. It may appear that production in certain lines cannot be raised to meet the estimated demand. In that case other alternatives would have to be considered, both from the demand and supply side. It is the deeper understanding of the various related problems which will give the purpose
and strength to the final strategy which emerges from such exercises requiring the active participation and collaboration of nutrition experts, other scientists, planners, economists, administrators and policy makers. Without such joint effort and a longer integrated view, rapid, rewarding progress may not be achieved. Such exercises on long-term planning are part of the work of the Indian Planning Commission. It is now proposed to intensify these efforts and draw many others actively into the work. A preliminary exercise on the perspective of agricultural development has already been made in the Perspective Planning Division to study the implications of development as required.

The object of the paper is to raise questions as to how much we know in this field as a sound basis to work on, what are the problems, what must be the priorities, what alternative approaches must be considered, what criteria are valid to make choices for resource allocation in this field; as long as incomes are not high enough, what short cuts are possible to improve the nutrition position, what can be done to make the foods people eat more adequate nutritionally without having to wait for the effects of education and propaganda to reach every home.
I must first of all thank the President and Committee of this First Asian
Congress of Nutrition for affording me this opportunity to speak about my
rather mixed experiences in Mauritius from August 1967 to July, 1968.

Perhaps I better preface my observations by giving you a bird's and
worm's eye view, combined of the Island. It is a subtropical island situated
on the Tropic of Capricorn, 500 miles east of Malagasy. It is believed to
have emerged from the ocean bed a million years ago or more as a result
of a volcanic eruption which threw up the most fascinatingly grotesque
mountain peaks to be seen anywhere in the world. It was uninhabited by
man till the 17th century. Prior to it there is evidence that the Arabs in
ancient times and the Portuguese in the era of Vasco de Gama used it as
a watering point for their boats. The Dutch were the first to colonise the
island and to name it after Maurice, Prince of Orange, but they succumbed
soon, to a plague of rats which drove them away, unfortunately only after
they had completely liquidated its most interesting inhabitant — the DODO.
They also exploited the fine ebony trees so ruthlessly that what is left today
is worthless.

The French then stepped into the Dutch sabots and introduced sugar into
Mauritius. In order to work these plantations economically they imported
African and Madagascan slaves. There was plenty of miscegenation
between these races which resulted in a large number of creoles who were
all baptized into the Roman Catholic Faith.

The French grew rich on sugar and piracy. They so harried the British
ships and stole their merchandise with the connivance, if not the active
encouragement, of the Government of France, that the British were com­
pelled for the protection of the Indo-British trade and their ships to conquer
the island in 1810. For 20 years they had a fierce struggle with the French
planters to abolish slavery which they did in 1830. The slaves were given
the option of working on the estates for regular wages but almost to a man
they refused. No comments.
The result was the large and rather indiscriminate importation of indentured Indian labour. The conditions in which these workers were transported were often as bad as those of the slave trade from Africa to America, and from a third to a half of each boat load perished on the high seas. Not only that, many of them caught dysentery and typhoid etc., and died soon after landing. It is also alleged, though this is disputed, that the Indian labourers introduced malaria to the island which was the main cause of morbidity till the late forties. It has now been totally eradicated but, unlike in Ceylon, there has been eternal vigilance and no recurrence since.

So at present we have a heterogeneous mass of 800,000 people in 720 square miles living on a monoculture. Sugar is a highly developed and organised industry and accounts for over 96% of the exports.

The Hindus comprise just 52%; the Creoles who are nearly all Roman Catholics about 30%, the Muslims about 14% and Chinese who are either Catholics or Buddhists 3%. There are also a few French or Franco-Mauritians who are more exclusively white in their culturo-socio-economic outlook than any other community in the world, except the South Africans, the Rhodesians and the Southern whites of USA. Many of them and the lighter-skinned Creoles are now emigrating either to Australia, or to South Africa.

Mauritius is a parliamentary democracy, but prior to 1968, when she was granted Independence within the Commonwealth, the Government Ruling Party was to a very great extent dominated by the Hindus, though a minority Muslims group and a few individual Creoles held some of the ministerial posts. There was strong opposition to Independence by the party of the Creoles which had powerful financial and moral support from the Franco-Mauritians. Owing to the very marginal majority of the Hindus (52%), the political leaders particularly of the ruling party were averse to going full steam ahead for population control, especially as nearly 35%-40% of the population were Roman Catholics. However, as a result of the reports of Prof. Titmuss and of Prof. Meade from Cambridge, the per capita income falling from Rs. 1,000/- to Rs. 800/- p.a. the government at last in 1965 saw the light, and gave a contribution of Rs. 500,000/- a year to the Family Planning Association and Action Familiale in equal amounts. The latter was a Roman Catholic organization which was formed, organized and built up by the present Bishop of Port Louis, Bishop Margeot. They of course, limited their methods to temperature control and have about 5,000 patients regularly registered on their books. It is very efficiently organized, as one would expect, but there are quite
a significant number of Roman Catholic patients who attend the Family Planning Association (F.P.A.) Clinics where they ask for oral contraceptives and other methods.

When I arrived in Mauritius as a Medical Adviser to the F.P.A. I found that the Ministry of Health had an expatriate Woman Medical Officer sent by the Ministry of Overseas Development of U.K. as Director of Family Planning. There was also a junior technical officer, a young medical woman of U.K. but a native of Trinidad of Indian ethnicity. The three of us worked in close liaison with each other. When I commenced work there were 106 clinics and centres. A clinic was defined as one in charge of a doctor; most of them, if not all, had facilities for the insertion of I.U.D's, while a centre had no doctor and was run by a supervisor or a Welfare Officer and a motivator; only oral contraceptives and traditional methods like condoms, spermicidal jellies and diaphragms were issued here. I found a general lack of supervision and control over these, as some of the oral contraceptive cases had never been examined by a doctor though many had been on the registers for over 1-2 years. The total number of working sessions at the clinics and centres operating in 1967 was about 146 per month. When I left a year later there were nearly 400.

The doctors who were all part-time and paid by the Session by the F.P.A. were approximately 7 or 8 in 1967 and when I left the country we had 16. They were very well paid by Indian or Ceylon standards. We also increased the nursing staff from 7 to 16. None of them was a fully qualified nurse, but had one to two years training as nurses, and then had abandoned it for various personal or financial reasons. We were fortunate enough to enrol a "coloured" South African nurse married to a Mauritian who had a SRN from Durban. There were also 30-40 welfare workers who assisted at all the clinics and centres, but they had a very poor training course previously. The majority were certainly not satisfactory but they were poorly paid and had no incentive to do better.

We had also 106 motivators, who up to my arrival were completely untrained and were usually recruited as women with some influence in the village and used to be paid a very small salary (Rs. 10/- or Rs. 20/- per month) and a commission on each fresh coupon submitted by a new patient. There was a great deal of corruption and cheating in this and the basis of payment had to be changed several times; the M.F.P.A. also employed seven supervisors at very high salaries though they were unqualified and had no special training.

I found that most of the Mauritian women were very keen about some
measure of family planning and generally preferred O.C.s to I.U.D.s, but many women had recourse only to the condom; even the most recent returns received by me last year have shown that for 14,595 wallets of O.C.s there had been 8679 condoms issued in June 1970, while the number of I.U.D.s inserted in that month was only seven. When Dr. Speed, Dr. Mathabir and I were operating in Mauritius the monthly total of I.U.D.s rose to nearly 200. There was a lot of propaganda against the I.U.D. both in the Press and through the A.F. and M.F.P.A. too. The latter feared that with the gradual conversion of the populace to I.U.D.s from O.C.s many of the welfare workers and others might lose their jobs; so they both covertly and overtly propagandised for O.C.s against I.U.D.

With the departure of the expatriate advisors there has been a fairly rapid reversion from I.U.D.s to O.C.s. As far as I can estimate from the returns for June 1970, there is nearly a 40% drop out rate for O.C.s in a year. The drop out rate for I.U.D.s is about 15% though the numbers are much fewer than for O.C.s.

The obstruction to family planning as in most of our countries arose from the male population. When I started there had been very little propaganda levelled exclusively at the male, although the Executive Committee of the M.F.P.A. was totally male. On my recommendation, 7 male motivators were recruited who were to make home visits and talk to the husbands. Some of the Committee members and executive staff for some inexplicable reason were not convinced about the necessity for this type of personnel. They were also not given transport facilities though there were sufficient vehicles gifted by I.P.P.F. Oxfam etc., available for this purpose. Two local firms also presented two vans just before my departure from the Island.

Dr. Speed and I also initiated and organised for nearly a year a weekly T.V. talk for 20-30 minutes by political, religious and social leaders. The first talk was given by the Hon. Prime Minister, who is a medical man but rather fearful about the microscopic minority! These T.V. talks, I have evidence to believe, had a significant impact on the masses. They were given for the most part in Creole, the common language of Mauritius; one or two were in Hindi and a similar number in English and French. Every sugar estate has a social welfare centre with a T.V. set, so that a vast majority of the male population at any rate had a chance of hearing these talks. In addition we organised frequent and regular public meetings, particularly for males; Dr. Speed in addition who was very facile in the use of French spoke to the higher forms of secondary schools on Sex Education.
The Roman Catholic Church in Mauritius was very surprisingly in favour of this largely due to the influence, I believe, of Bishop Margeot.

My lack of an adequate knowledge of French was a severe handicap though I tried to improve it during my stay, as I had hoped to remain for two years, but certain circumstances made it impossible for me to ask for an extension of my contract after one year.

The demographic statistics are encouraging; in 1958 the birth rate was nearly 41 and the death rate 12 per 1000. The natural rate of increase was therefore 29/1000. In 1967 the birth rate was 31 and the death rate approximately 10; a rate of increase of 21. I gather unofficially that in 1969, the natural rate of increase was down to 19; much though not all of this fall is due to emigration, increased age of marriage and abortions. It is difficult to estimate the abortion rate as most of them were illicit. However, the two gynaecologists assured me that half their beds were nearly always occupied by complications due to abortions. There were also quite a few deaths due to tetanus and septicaemia as a result. My own estimate was that there was one abortion to two live births in 1967-1968.

It is estimated that about 25% of the women in the child-bearing age group have used one or other method of family planning though this does not necessarily mean that they were regular clients. About 52% of the total number used oral contraceptives, 20%, the rhythm method; 7%, I.U.D.s; 16% condoms and the balance 5% other traditional methods. These figures relate only to patients attending the A.F. and M.F.P.A. clinics. There is a significant number attending private medical practitioners for family planning advice. The general view was that these would account for another 3-5% of the women at risk.

The most recent information I have is that since January 1971, the government was to take over all the clinics run by the M.F.P.A. I do not know what the government's position will be to the patients who seek A.F. advice. It was Dr. Speed's and my original suggestion that the government should take over almost all the clinics. The government accepted this recommendation at the end of 1967 but rejected it a month later. I am glad that after a lapse of three years they have at last seen the logic of our arguments. I gathered that since 1969 the M.F.P.A. has employed 5 full time doctors. This is certainly more satisfactory than having a complete cadre of part-time medical practitioners paid by the
I am sure that with the Ministry of Health assuming full responsibility for family planning the results obtained will be even better.

The density of population is over 1000 per sq. mile or nearly 400 per sq. kilometre-much higher than India's or Ceylon's. Unlike in my own country there is very little new land available for cultivation. They have about 10,000 acres reserved for la chasse — or hunting the stag! These may be acquired under a Socialist Government.

Their one chance lies in the development of fisheries; they have made a beginning with regard to this though there is some competition from the Japanese.

The unit is too small for the development of many industries, and it is too far away from any big centre of population. They have started the manufacture of sunflower seed oil and Margarine.

The standard of living is higher than in India or Ceylon. The Standard of literacy is high and the quest for education is never satiated. Primary education is free and state controlled, but secondary education is private and must be paid for. Every street corner has an Eton, a Balliol or a London college! The Ministry of Education has very little control over these secondary schools.

There is a good deal of emigration but this unfortunately occurs in the most affluent, skilled and educated classes, and does not affect the masses. Unemployment and underemployment are growing menaces. Therefore population control is not only necessary but urgent. I think all the leaders are aware of this fact but for political reasons are not averse sometimes to pulling their punches. Though much has been achieved, much more remains to be done! The price of prosperity is eternal vigilance.
World's population, according to the estimates prepared by the United Nations, was slightly more than 3.6 billion in 1970. Because of the paucity of data it is not possible to obtain accurate population data for distant past. An approximate picture of world population trend can be assembled only for the past two centuries, and even these estimates are subject to considerable margin of error. (It was pointed out by the United Nations that their 1960 estimates of world population might easily have an upward or downward error of more than 50 million). They are, however, sufficiently valid to indicate that the rate of population growth was sufficiently moderate until the present century, and that great acceleration has occurred in the past two decades. The average annual growth rate was only about 0.5 per cent throughout the nineteenth century, 0.6 per cent in the first half of the twentieth century, and it suddenly increased to 1.8 per cent during the 1950's. The rate of growth of world population rose still higher during the 1960's and is currently estimated to be around 2.0 per cent per annum (Table 1). Whereas it took thousands of years for the world to attain its

<table>
<thead>
<tr>
<th>Year</th>
<th>World's population (in millions)</th>
<th>Average annual per cent increase from preceding date</th>
<th>Approximate number of years required to double at computed rate of increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1750</td>
<td>791</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1800</td>
<td>978</td>
<td>0.4</td>
<td>125</td>
</tr>
<tr>
<td>1850</td>
<td>1,252</td>
<td>0.5</td>
<td>140</td>
</tr>
<tr>
<td>1900</td>
<td>1,650</td>
<td>0.5</td>
<td>140</td>
</tr>
<tr>
<td>1950</td>
<td>2,486</td>
<td>0.9</td>
<td>78</td>
</tr>
<tr>
<td>1960</td>
<td>2,982</td>
<td>1.8</td>
<td>39</td>
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</tbody>
</table>

*Reference Numbers 5 and 6.
first billion, the second billion was added in just about 100 years. A third billion was added only in thirty years and the fourth billion can be expected around 1975, just 15 years after the attainment of the third billion. At the beginning of the present century world's population was 1.6 billion and it is estimated to cross the six billion mark before the turn of the century. The total increase in the world population of the present century to date (till mid-1970) amounts to 1822 million and nearly 58 per cent of this increase, or about 1,146 million, took place during the last 19 years. Most of this increase is due to an increase in the population of the less developed countries.

POPULATION OF DEVELOPED AND LESS DEVELOPED REGIONS:

Of the 3.6 billion inhabitants of the world in 1970, more than two and a half billion live in world's less developed regions, and about a billion in world's more developed regions. The present (1970) population of the more developed regions is five times their population two centuries previously, while the population of less developed regions, inhabited by more than 2,500 million people in 1970, increased by four and a quarter times during the same period (Table 2). The less developed regions of the world are found

TABLE 2

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (in millions)</th>
<th>Percentage of the population in</th>
<th>More developed regions</th>
<th>Less developed regions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>World's Total</td>
<td>More developed regions</td>
<td>Less developed regions</td>
<td>More developed regions</td>
</tr>
<tr>
<td>1750</td>
<td>791</td>
<td>201</td>
<td>590</td>
<td>25.7</td>
</tr>
<tr>
<td>1800</td>
<td>978</td>
<td>248</td>
<td>730</td>
<td>25.6</td>
</tr>
<tr>
<td>1850</td>
<td>1,262</td>
<td>347</td>
<td>915</td>
<td>27.7</td>
</tr>
<tr>
<td>1900</td>
<td>1,650</td>
<td>573</td>
<td>1,077</td>
<td>34.7</td>
</tr>
<tr>
<td>1950</td>
<td>2,486</td>
<td>858</td>
<td>1,628</td>
<td>34.5</td>
</tr>
<tr>
<td>1970</td>
<td>3,632</td>
<td>1,351</td>
<td>2,281</td>
<td>37.2</td>
</tr>
<tr>
<td>2000</td>
<td>6,130</td>
<td>1,642</td>
<td>4,688</td>
<td>23.7</td>
</tr>
</tbody>
</table>

*Reference Numbers 5 and 6.

in the continents of Asia, Africa and Latin America. All the countries of Asia excepting Japan and those in South West Asia are less developed. In the continent of Africa all the countries excepting those in Northern Africa.
Population Problems of Less Developed Countries

are classified as less developed. In Latin America all the countries excepting those in Temperate South America are less developed. On the other hand, all the countries of Europe, the Soviet Union, North America, Australia and New Zealand, Temperate South America, North Africa, Japan and South West Asia are more developed. Nearly 75 per cent of the world’s population resides in less developed countries, and of the world’s less developed population 75 to 77 per cent resides in Asia. Table 3 gives the esti-

**TABLE 3**

Estimated population of less and more developed regions, 1965-1985*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LESS DEVELOPED REGIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Asia excepting Japan</td>
<td>755</td>
<td>827</td>
<td>901</td>
<td>979</td>
<td>1,060</td>
</tr>
<tr>
<td>South Asia</td>
<td>981</td>
<td>1,126</td>
<td>1,296</td>
<td>1,486</td>
<td>1,693</td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Africa</td>
<td>90</td>
<td>101</td>
<td>110</td>
<td>133</td>
<td>154</td>
</tr>
<tr>
<td>Eastern Africa</td>
<td>86</td>
<td>95</td>
<td>112</td>
<td>129</td>
<td>149</td>
</tr>
<tr>
<td>Middle Africa</td>
<td>32</td>
<td>36</td>
<td>40</td>
<td>46</td>
<td>52</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>20</td>
<td>23</td>
<td>26</td>
<td>29</td>
<td>34</td>
</tr>
<tr>
<td>Latin America</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropical South</td>
<td>130</td>
<td>151</td>
<td>175</td>
<td>204</td>
<td>236</td>
</tr>
<tr>
<td>Middle</td>
<td>57</td>
<td>67</td>
<td>80</td>
<td>95</td>
<td>112</td>
</tr>
<tr>
<td>Caribbean</td>
<td>23</td>
<td>26</td>
<td>29</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td><strong>MORE DEVELOPED REGIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South-West Asia</td>
<td>67</td>
<td>77</td>
<td>90</td>
<td>105</td>
<td>122</td>
</tr>
<tr>
<td>Japan</td>
<td>97</td>
<td>103</td>
<td>110</td>
<td>116</td>
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<tr>
<td>Europe</td>
<td>445</td>
<td>462</td>
<td>479</td>
<td>497</td>
<td>515</td>
</tr>
<tr>
<td>Soviet Union</td>
<td>231</td>
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<td>256</td>
<td>271</td>
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<td>Northern Africa</td>
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<td>87</td>
<td>101</td>
<td>119</td>
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<td>Northern America</td>
<td>214</td>
<td>228</td>
<td>243</td>
<td>261</td>
<td>280</td>
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<tr>
<td>Temperate South America</td>
<td>36</td>
<td>39</td>
<td>43</td>
<td>47</td>
<td>51</td>
</tr>
<tr>
<td>Australia and New Zealand</td>
<td>14</td>
<td>15</td>
<td>17</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td><strong>World Total</strong></td>
<td>3,289</td>
<td>3,632</td>
<td>4,022</td>
<td>4,457</td>
<td>4,934</td>
</tr>
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<td>Less developed regions</td>
<td>2,252</td>
<td>2,542</td>
<td>2,875</td>
<td>3,247</td>
<td>3,659</td>
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<tr>
<td>More developed regions</td>
<td>1,037</td>
<td>1,090</td>
<td>1,147</td>
<td>1,210</td>
<td>1,275</td>
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</table>

*Reference No. 5.
mated growth of population of less developed and more developed regions of the world based on the United Nation's estimates (medium variant) for the period 1965-1985.

FUTURE GROWTH OF POPULATION:

During the period 1965-1985, the more developed regions would add to their population at an average rate of 5 per cent per quinquennium, while the less developed regions would gain at an average rate of 13 per cent per quinquennium. Because of the higher rate of population growth in less developed regions, their population in 1985 would be nearly three times of that of the more developed regions (the ratio being 2.9 to 1) whereas in 1965 the ratio was only a little over two to one (2.2 to 1).

Among the world's major areas, the largest addition to the population during 1965-1985 is expected to be in South Asia, which contains nearly one-third of the world's population. India, Pakistan and Indonesia are the main contributors to this growth. According to the United Nation's estimates, India's population is expected to increase from 555 million in 1970 to 808 million in 1985; Pakistan's from 137 million to 224 million and Indonesia's from 121 million to 184 million during the same period. The next important contributor to the growth of world's population is likely to be East Asia where Mainland China would account for most of the increase. Although Mainland China's pace of population growth is likely to be more moderate than that of India's, yet its population is expected to grow from 760 million in 1970 to 965 million in 1985. Although the rate of population growth of the continents of Africa and Latin America would be very high, higher than that of Asia, yet the absolute increase in their population would not be very substantial. Africa's population is likely to increase from 344 million in 1970 to 530 million in 1985 and Latin America's from 283 million to 435 million during the same period, an increase of 186 and 152 millions, respectively.

The 1970's may experience the highest rate of growth of world population that had ever been experienced in the history of man or is likely to be encountered in the future. The growth rate is likely to be 2.0 to 2.1 per cent annually, it will be between 1.0 and 1.1 per cent annually in the more developed regions and between 2.4 and 2.5 per cent per annum in the less developed regions. The average annual growth rate in Middle South America is likely to be 3.4 per cent, in Tropical South America 3.0 per cent, in South West Asia 3.0 per cent, in South Asia 2.8 per cent, and in Africa between 2.7 and 2.8 per cent. The more rapid rate of population
growth in less developed countries is due to their high birth rate and declining death rate (Table 4). Most of the less developed countries in Africa, Asia and Latin America have today a crude birth rate around 45 per 1,000 population and a crude death rate around 15, whereas in more developed countries the birth rate is around 19 and death rate around 9. It is indicated that the decline in the crude birth rate of the less developed regions during the period 1965-1985 would be offset by a corresponding decline in the death rate so that the rate of growth of population would remain unchanged (Table 4).

TABLE 4

Some demographic characteristics of less developed and more developed regions, 1965-1985*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>World Total</th>
<th>More developed regions</th>
<th>Less developed regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual rate of population growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965-70</td>
<td>2.0</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>1970-75</td>
<td>2.0</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>1975-80</td>
<td>2.1</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>1980-85</td>
<td>2.0</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>Crude birth rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965-70</td>
<td>33.8</td>
<td>40.6</td>
<td></td>
</tr>
<tr>
<td>1970-75</td>
<td>32.2</td>
<td>39.0</td>
<td></td>
</tr>
<tr>
<td>1975-80</td>
<td>32.1</td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td>1980-85</td>
<td>30.8</td>
<td>34.9</td>
<td></td>
</tr>
<tr>
<td>Crude death rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965-70</td>
<td>14.0</td>
<td>36.1</td>
<td></td>
</tr>
<tr>
<td>1970-75</td>
<td>12.7</td>
<td>34.2</td>
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</tr>
<tr>
<td>1975-80</td>
<td>11.6</td>
<td>32.5</td>
<td></td>
</tr>
<tr>
<td>1980-85</td>
<td>10.5</td>
<td>30.9</td>
<td></td>
</tr>
<tr>
<td>Expectation of life at birth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1965-70</td>
<td>53.1</td>
<td>49.5</td>
<td></td>
</tr>
<tr>
<td>1970-75</td>
<td>55.5</td>
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</tr>
<tr>
<td>1975-80</td>
<td>58.1</td>
<td>55.3</td>
<td></td>
</tr>
<tr>
<td>1980-85</td>
<td>60.4</td>
<td>58.0</td>
<td></td>
</tr>
<tr>
<td>Percentage age distribution of population</td>
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<tr>
<td>Age</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37.4</td>
<td>36.3</td>
<td>28.1</td>
</tr>
<tr>
<td>15—64</td>
<td>57.6</td>
<td>58.2</td>
<td>63.0</td>
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<tr>
<td>65+</td>
<td>5.0</td>
<td>5.5</td>
<td>8.9</td>
</tr>
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</table>

*Reference No. 7.
CHANGES IN AGE STRUCTURE AND OTHER FUNCTIONAL AGE GROUPS:

A striking contrast between the age structure of the population in the more developed and less developed regions is seen in Table 4. Whereas children under 15 years of age constitute 28 per cent of the total population in more developed regions, the corresponding percentage in less developed regions is 42. The more industrialised countries have an economic advantage over less developed countries in that 63 per cent of their population is of working age group, while the comparable proportion in the less developed countries is only 55. The age structure is likely to change only minimally during the period 1965-1985.

The anticipated future change in the number of various functional age groups which are of relevance to development planning are shown in Table 5. The most noteworthy is the growth of working age population, with its important implications for employment and capital requirements for industrial growth. This working age population in less developed countries is likely to grow at a higher rate than the total population, namely, at 2.6 per cent per annum during 1970-75 and 2.5 per cent per annum during 1975-1980. This growth will result in an estimated increase of working population by 404 million during the 1970-1980 decade (Table 5). Another important group is the school age population defined as belonging to ages 5 to 14. Although, the growth rate of this group would be the same as that of the general population, the absolute increase would be of the order of 182 million during the decade, while in the more developed regions, the increase would be only of 3 million.

Population of some of the countries of the world for selected years based on U.N. projections (medium variant) are given in Table 6.

SOME IMPLICATIONS OF RAPID POPULATION INCREASE:

The rapid population increase poses a serious threat to development efforts of the less developed countries. The task of providing food, schools, employment, health facilities, housing etc., for the increasing numbers is staggering. The population question is not merely quantitative but also qualitative in nature as the implications of population growth upon the quality of life and the well-being of the people are vitally important. A few illustrations are given below to bring out the social and economic effects of the perspective population growth in developing countries.

Persistent high fertility causes important health problems not only be-
TABLE 5
Expected changes in the main functional age groups, 1970-1980*
(in millions)

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>More developed regions</th>
<th>Less developed regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>3,632</td>
<td>1,090</td>
<td>2,542</td>
</tr>
<tr>
<td>1980</td>
<td>1,657</td>
<td>1,210</td>
<td>3,247</td>
</tr>
<tr>
<td>Increase</td>
<td>825</td>
<td>120</td>
<td>705</td>
</tr>
<tr>
<td>Percentage increase</td>
<td>22.7</td>
<td>11.0</td>
<td>27.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Pre-school group (0-4 years)</th>
<th></th>
<th>School-age group (5-14 years)</th>
<th></th>
<th>Working-age group (15-64 years)</th>
<th></th>
<th>Old-age group (65 years and over)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>508</td>
<td>612</td>
<td>836</td>
<td>1,021</td>
<td>2,098</td>
<td>1,089</td>
<td>189</td>
</tr>
<tr>
<td>1980</td>
<td>622</td>
<td>86</td>
<td>196</td>
<td>1,199</td>
<td>693</td>
<td>577</td>
<td>105</td>
</tr>
<tr>
<td>Increase</td>
<td>113</td>
<td>56</td>
<td>30</td>
<td>204</td>
<td>404</td>
<td>479</td>
<td>202</td>
</tr>
<tr>
<td>Percentage increase</td>
<td>20.5</td>
<td>17.0</td>
<td>21.3</td>
<td></td>
<td>28.5</td>
<td>22.8</td>
<td>28.7</td>
</tr>
</tbody>
</table>

*Reference No. 7.

cause economic improvements, which are essential for good health, get restricted but also because it poses an immediate health problem for the mother and her children. In most of the developing countries married women aged 17 to 37 suffer from continuous nutritional drain from repeated pregnancies and lactation resulting in 'maternal depletion' and increased risk of 'maternal mortality' which increases with every pregnancy
beyond the third. Premature curtailment of breast feeding and of infant care by an intervening pregnancy is an important factor contributing to high infant mortality. Again, children who survive in families where there are too many children arriving too fast are likely to be stunted prematurely in their growth and underdeveloped due to lack of nutritious food.

### TABLE 6

Population estimates for selected countries: Each Mid-year 1965-1985*

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>China (Mainland)</td>
<td>695</td>
<td>760</td>
<td>826</td>
<td>866</td>
<td>894</td>
<td>937</td>
<td>965</td>
</tr>
<tr>
<td>2</td>
<td>Japan</td>
<td>98</td>
<td>103</td>
<td>110</td>
<td>114</td>
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<td>3</td>
<td>India</td>
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<td>555</td>
<td>633</td>
<td>683</td>
<td>717</td>
<td>771</td>
<td>808</td>
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<td>4</td>
<td>Pakistan</td>
<td>116</td>
<td>137</td>
<td>162</td>
<td>179</td>
<td>191</td>
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<tr>
<td>5</td>
<td>Afghanistan</td>
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<td>17</td>
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<td>6</td>
<td>Ceylon</td>
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<td>1</td>
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<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
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<tr>
<td>11</td>
<td>Republic of Vietnam</td>
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<td>21</td>
<td>22</td>
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<td>24</td>
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<tr>
<td>12</td>
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</tr>
</tbody>
</table>

*Reference No. 5.

**POPULATION GROWTH AND FOOD SUPPLY**

In recent years there has been a growing concern about the widening gap between population growth and food supply in developing countries in view of rapid population growth. Available food supplies are inadequate...
in quantity for a healthy and active life. Growth retardation, with children often lagging behind in physical and mental development, for an average of three or four years, and persisting high mortality rates from malnutrition and infections indicate that the problem of availability of nutritious food in adequate quantity requires immediate solution. Retarded development and poor health are responsible for low stamina and low physical activity. Low physical activity results in low productivity, which in turn causes more poverty and more inadequate food supply. Unless this vicious circle is broken, future generations will have reduced stature, lower body weights, lower level of physical capacity and consequently reduced working efficiency.

It has been estimated by the United Nation's Food and Agriculture Organization that in order to provide sufficient food for the growing population and to meet progressively the needs for protective foods of the vulnerable groups of the population, the total food supply in the developing countries will have to be increased by 75 per cent during the period 1965-2000. This implies an annual rate of increase of 3.8 per cent. But this is not the only increase in the demand for food. It is felt that with increased urbanisation and increased incomes, market demand for food would further go up.

Much of the concern about food shortages arises from the question whether and in what ways it will be possible to achieve such increases. This, it may be appreciated, is not the question of ultimate productive capacity of the world, for the world as a whole is potentially capable of feeding an increasing population for many years to come. It is an immediate problem of finding adequate food supplies for the growing population of the developing countries. During the last two decades, developing countries have made praiseworthy efforts to increase food production. But the gains have largely been offset by increase in population, and therefore per capita food consumption has increased a very moderate pace as compared to the more developed countries. The “Green Revolution” in some less developed countries, notably India, has provided much needed relief and has given a breathing space, but it does not provide a long-term solution of the problem. In the context of economic development, the problem is not merely of providing adequate food, but of developing agriculture so that it might provide livelihood to a large part of the population for many years to come. Undoubtedly, reduction of population growth rates would reduce the proportion of population dependent on agriculture by facilitating a shift of population from agriculture to non-agricultural
occupations. This shift, together with the associated increase in the market of agriculture products, would make possible increase in agricultural productivity and income.

POPULATION GROWTH AND EMPLOYMENT:

Employment is another area of serious concern on account of rapid population growth. About two-thirds of the world's manpower resources are presently located in less developed countries. The working population in these areas will grow rapidly in the years to come, and is likely to double itself before the end of the century.

The sharp increase in the working population is chiefly due to the growing number of young people, but an increase in the length of working life as a result of decline in mortality is also a contributory factor. It has been estimated that in less developed countries, the average number of working years for men will increase from 35.6 in 1960 to 38.9 in 1980 and 39.3 in the year 2,000.

The need for expanding employment opportunities for the growing numbers of young people will become even more urgent in the future. The rate at which the young people are at present entering the labour force in less developed countries is such that new job opportunities have to be created for almost half of them. In the future this ratio will increase still further, and after 1980 new job-opportunities will have to be created for about two-thirds of the young people entering the labour force. It may be noted that the number of job seekers will continue to increase in the future, and the effect of a decline in birth rate will be felt only after a lapse of fifteen years.

The rapid increase of labour supply in the future would require tremendous efforts in terms of investments. A major problem will be to mobilise human resources in the countryside since the absorptive capacity of labour in agriculture is limited. Although the proportion of the working population engaged in industry rose substantially in the less developed countries in the 1950's, yet only one-fourth of the overall increment in the total working age population went into industrial development and the bulk of it remained on land making the under-employment problem more serious.

A demographic factor of considerable importance is the high dependency ratio in the less developed countries. The dependent population (children below 15 and old people above age 64) is about four-fifths of the size of
the working population, while in industrialised countries it is only three-fifth. Little decline in this ratio can be expected in the coming years in the developing countries unless a major decline in fertility takes place, and even then the ratio by the end of the century would be two-thirds, substantially higher than that prevailing in the more developed countries. There is need therefore for developing labour intensive and capital saving production methods of production and, in particular, smaller industries, labour-intensive agriculture and rural works so that larger number of people can find employment.

**POPULATION GROWTH AND EDUCATION**

Another major problem is of providing schooling to the growing number of school-going children in less developed countries. The child population in less developed countries during the 70's would be between 40 and 45 per cent of the total population, while this ratio would be around 30 per cent in more developed countries. During the period 1970-1980, the number of children of school age (5-14 years of age) will increase from 640 million in 1970 to 822 million in 1980 according to the medium projects of the United Nations, and will exceed 1,500 million by the end of the Century, or nearly triple the present number.

The educational problems are not confined to the young population only. More than one-third of all the adults are illiterate. Inspite of vigorous literacy campaigns for the adults and a decline in the percentage of illiterate adults from 43 in 1950 to 39 in 1960, the absolute number of illiterates is still increasing yearly by about 15 to 20 million, owing to rapid population growth.

**POPULATION GROWTH AND HOUSING**

Another important feature of the demographic situation in developing regions is the high rate of internal migration to urban areas, and very rapid rate of growth of cities and towns. The United Nations had estimated in early 1960s that nearly ten dwelling units per 1,000 inhabitants had to be built each year in the developing countries in order to offset obsolescence and to cope with the urban population growth throughout the decade. In many countries only one-fifth of this goal has been accomplished. The housing situation has generally deteriorated and in some cases it is on the verge of disaster.

There is a growing tendency for rural exodus to exceed employment...
opportunities generated in the urban areas by the development process. This tends to hamper economic growth because of increasing investments required for providing transport, housing and other social services. Projections made by the United Nations indicate that during the 1960-70 and 1970-80 decades, annual rate of growth of urban population in less developed regions would vary between 4.6 and 4.5 per cent whereas it will be between 2.1 and 1.9 per cent in the more developed regions. While the population of localities with 20,000 inhabitants or more would triple in the coming three decades, the rural population will only increase by about 80 per cent. Not only the housing, but problems of drinking water, sewage disposal, sanitation, transport, etc. will become more acute, and require larger investments.

The problem of developing the less developed regions of the world is not easy. Not only are the countries economically backward with very low rates of savings, but their rapid rate of population growth with higher dependency ratio, sizable unemployment and under-employment, and low level of literacy makes the task of developing these countries extremely difficult. A reduction in the rate of population growth would definitely help in accelerating the pace of economic development, but most of the countries of the less developed region are faced with the dilemma of a declining death rate and a near static high birth rate. Therefore, unless the birth rate declines substantially in the immediate future, the countries may experience an increase rather than a decline in the population growth rate. The question of birth rate decline, as such, assumes far greater importance than the mere maintenance of health of the mother and the child.

It is known that literate and urban women belonging to a higher socioeconomic group have lower fertility than those who are less educated, live in rural areas, belong to the poorer sections of the society and are more traditional in their outlook. But the task of educating the vast illiterate masses living in less developed regions of the world would not be easy and would take a couple of decades. The task of increasing the per capita income is even more complex. Whatever little progress is made by these countries is almost eaten away by the growing population. Therefore, unless the rate of population growth is reduced, economic progress is difficult, and without economic progress and higher per capita income, population control is not easy. The less developed countries of the world thus find themselves in a vicious circle which is not easy to break. Technical assistance, political stability, strong leadership, greater consciousness among the masses and viable social and economic policies etc., are some of the
factors which contribute to more rapid economic and social progress of the less developed regions.

REFERENCES

2. FAO (1963) Third World Food Survey, FFHC Basic Study No. 11. FAO, Rome.
The impact of population growth on food situation in India has pointed the dire need for the improvement in contraceptive technology. Research efforts in this direction the world over, have led in the past decade, to the use of newer methods including oral hormonal contraceptives and intrauterine contraceptives devices.

I shall deal first with the hormonal contraceptives.

As you are all aware, prior to 1938 no form of oral hormonal contraception was possible as none of the then available hormones was active when taken orally. The era of oral contraception commenced with the reports of Pincus in 1958. The contraceptive pills used today contain a synthetic estrogen (mestranol which is 3 methyl ether of 17 ethinyl estradiol or ethinyl estradiol itself), and a progestogen which could be a derivative of progesterone or nortestosterone. Common derivatives of progesterone which are active orally and have been used for contraceptive purposes are drugs like medroxy progesterone acetate, megestrol acetate and chlormadinone acetate. Changes in the testosterone molecule give rise to compounds such as dimethisterone, norethindrone, ethynodiol diacetate, norethynodrel etc. It is remarkable that the numerous progestogen-estrogen combinations available for use, have similar basic contraceptive effects despite varied pharmacological properties of individual ingredients.

Hormonal contraceptives to date have been used in the following regimens:

(i) Combined estrogen/progestogen formulations, i.e.

(a) 20-21 day scheme, wherein pills are taken every month for 20-21 days starting day 5 of the menstrual cycle;

(b) One-pill-a-month, on day 7 of menstrual cycle;
Contraceptives in Malnourished Populations

(c) One-month intramuscular injection, on day 7 or 8 of menstrual cycle;

(ii) sequential formulations — In this regimen the natural hormonal sequence of events in the menstrual cycle is maintained, i.e. estrogens are followed by estrogen-progestogen combination.

(iii) progestogen alone.
   (a) depot intramuscular injection every month or every 3 months;
   (b) slow release of progestogen from subcutaneous silastic implants, intravaginal rings, intrauterine and intracervical devices.

(iv) estrogens administered postcoitally.

Some of these methods are, however, still in the experimental stage.

MODE OF ACTION:

Most of the oral combined and sequential preparations in use at present, have their contraceptive action by preventing ovulation through the suppression of gonadotrophic hormones. It is, therefore clear, that formulations which contain doses high enough to inhibit ovulation would be 100 per cent effective if taken as prescribed. Pregnancy rates with the sequential have been reported to be a little higher as ovulation occurs in a small percentage of cases.

There are some indications that these contraceptives also act directly on the ovary and reduce their sensitivity to gonadotrophins. Search for the effect of these hormones on reproductive processes other than inhibition of ovulation has shown that low dose of progestogens alone, lead to adverse changes in the cervical mucus and hinder sperm transport; bring about subtle changes in the development of the endometrium that hinder implantation, and induce changes in the transport of the fertilized ovum and its subsequent degeneration. Thus the continued assurance of contraceptive effect in the absence of inhibition of ovulation has been a major advance in contraceptive technology.

SIDE-EFFECTS:

Contraceptive steroids have been in use in India since 1962 and there has been ample evaluation of the so called minor side effects with the use of these contraceptives. Side effects with combined preparations such as
nausea and vomiting, as reported by various investigators, has been experienced by 0.2 to 27.3 per cent women. This being maximum during first few cycles of use. Menstrual irregularities in the form of breakthrough bleeding, spotting, reduced flow and amenorrhoea have been reported to have been experienced by 3.0 to 13.2 per cent of the women. Reduced flow with these preparations would appear to be advantageous since haemoglobin levels in women taking these drugs has been shown to rise. This rise would have positive significance especially in anaemic women. Gain in weight has been reported by 15 to 30 per cent women — significance of this symptom is however debatable. Lactating women who have used this mode of contraception have by and large reported a decrease in milk secretion. Significance of this in a country like India where breast feeding forms a major nutritional source for the infant is apparent. Some of the steroids have been shown to be excreted in breast milk and it has been universally recommended that lactating mothers should preferably avoid the use of contraceptive steroids while lactating. Pregnancy rate due to method failure has been reported to be zero per 100 women years. Rate of discontinuation has, however, been high (25 to 50 per cent). Most of the women having discontinued because of minor side-effects and trouble of remembering and taking a pill daily.

With sequential preparations incidence of nausea, vomiting, dizziness etc., has been reported to be lower (0.9 to 10 per cent). Menstrual irregularities have also been lower (0.3 to 3 per cent). However, pregnancy rate was higher, approximately 5 per 100 women years, and drop out rate was the same as for combined preparations (25 to 50 per cent). The latter could be attributed to insecurity from pregnancy and the problem of taking a pill every day.

Experience with the low dose daily progestogen pill has shown a very low incidence of nausea and vomiting (0.2 to 2 per cent). Incidence of menstrual abnormalities has been reported to be 15-50 per cent and pregnancy rate between 3-8 per 100 women years. Drop out rate with this regime has been 20 to 57 per cent. Similar has been the experience with depot injections of progestogens alone. It is, therefore, clear, that with the experience available, we still do not have the right dose and compound in a regime which would give minimum side-effects and maximum protection. Further research in this direction is definitely indicated.

METABOLIC EFFECTS:

As pointed out earlier, contraceptive steroids are not natural substances and quantitative and qualitative differences are known to exist between
natural and synthetic steroids. Despite the wide array of steroid molecules synthesized as a result of modern chemical ingenuity, very little is known of their metabolic effects in the human. Until recently, the metabolic effects of contraceptive steroids have been inadequately investigated or ignored. Data accumulated suggest that no tissue or organ system is free from their biological and functional effect. These include effects on the liver, cortisol, carbohydrate, lipid, protein metabolisms etc.

Results of metabolic studies the world over and limited studies in India have shown the following effects:

LIVER FUNCTION:

Liver is probably the only organ which is affected with more regularity and intensity by sex hormones than any other extragenital organ.

Sex hormones have been shown to significantly influence the synthesis of hepatic DNA, RNA, total protein including hepatic cell enzymes, serum enzymes and circulating plasma proteins of various types. Extensive effects on hepatic lipid and lipoprotein formation, intermediary metabolism of carbohydrates have been demonstrated. These hormones further alter the rate of chemical transformation and conjugation of drugs and other substrates; have important influences on the formation and composition of bile and effect the transport of biliary secretion of numerous endogenous and exogenous substances.

CORTISOL METABOLISM:

Higher serum cortisol levels have been reported but no interference with the diurnal pattern of cortisol secretion has been shown. An increase in the protein bound fraction mediated via an increase in hepatic synthesis of transcortin has been shown to be definitely estrogen dependent. Inactivation of cortisol in the liver has been reported to be decreased in women taking these steroids.

A majority of the side-effects including weight gain, fluid retention, headache etc., have been attributed to changes in cortisol levels.

CARBOHYDRATE METABOLISM:

Considerable data has accumulated regarding the effect of synthetic sex steroids on glucose and insulin metabolism. Longitudinal studies of plasma
glucose, non-esterified fatty acids, insulin and blood pyruvate levels during oral and intravenous glucose tolerance tests, show that although fasting plasma glucose levels are not altered in a majority of the users of these contraceptives, both tolerance to oral and intravenous glucose were impaired. Apart from the hyperglycaemic alterations, changes in blood levels of other substances have also been reported. These include changes in insulin levels, increased plasma non-esterified fatty acids, serum pyruvate and lactate levels. In other words the metabolism of a non-obese individual tends to become that of an obese and that of the obese towards that of a diabetic.

**LIPID METABOLISM:**

Longitudinal studies on lipid metabolism have demonstrated raised fasting serum cholesterol, triglyceride and low density lipoprotein levels in women on oral contraceptive therapy. Although no detailed studies of the effects of glucocorticoid therapy on serum lipid levels have been reported as such, changes in tryglyceride and serum cholesterol levels have been attributed to the increase in plasma cortisol levels. However, a definite relationship between the dose and structure of the estrogen component and changes in lipid metabolism has not been established. Enzyme changes at the cellular level altering fat synthesis could also be responsible for the gain in weight reported by these women.

**TRYPTOPHAN METABOLISM:**

Recent investigations have shown that the use of oral contraceptives, and the administration of estrogens alone are accompanied by changes in the metabolism of the amino acid tryptophan.

Some of the neuropsychiatric side effects such as depression, reported by users of these contraceptives, could be related to be low in these individuals. This, in conjunction with high excretion levels of N-methylnicotinamide reflect the enhanced capacity of the conversion of L-tryptophan to nicotinic acid derivatives under the influence of these steroids.

**OTHER EFFECTS:**

The occurrence of hypertension, usually reversible, has been reported in a proportion of women taking oral contraceptives. Studies indicate that in these women there is an increase in plasma levels of renin, angiotensin and aldosterone. Hypertension could also be secondary to the rise in the glucocorticoid level.
An increase in haemoglobin concentration, serum iron and serum iron binding capacity has been reported.

A definite estrogen dependent relationship has been established with the state of hypercoagulability seen in these women. Changes in the clotting factors, platelet function and physical state of the blood vessels has been shown to be related to the dose of estrogen taken.

By and large, the metabolic and other effects just mentioned are based on studies done in women with normal nutrition. A large number of diet surveys carried out in various States in India by the National Institute of Nutrition and the Nutrition Sections in Public Health Directorates in some States, indicate that taking into account the distribution of persons in different ages, sex and activity in various States of India, (a) the average per capita requirement of calories is about 2,000. As against this, the All India average consumption of calories is about 1,890 per person per day; (b) the average per capita requirement of protein is about 44.0 gms. per day, and the All India average intake is about 53 gms. per day. The protein requirement appears to be satisfactory because of a high consumption of cereals; (c) the consumption of protective foods such as milk, flesh foods, leafy vegetables and fruits was rather low in most of the States.

Although these are average figures it is obvious that malnourished populations with specific deficiencies must exist within these States as also among the group of women taking oral contraceptives. Very few metabolic studies have been reported on malnourished women in India taking these drugs. One experimental study on the rhesus monkey has failed to show any deleterious effect of malnutrition on metabolic effects produced with hormonal contraceptives. Another isolated study in the human has shown enhanced hepato-toxic effects in women taking diets low in protective foods. However, information available indicates that malnutrition per se may lead to—

(a) lowered carbohydrate tolerance;
(b) low serum protein content;
(c) altered albumin globulin ratio; and
(d) lower blood cholesterol values.

In normal women there appears to be a challenge to the physiologic reserve with the use of the combined/sequential preparations containing estrogens. When ample reserve exists, the effects are less marked; but when the reserve is decreased for any reason including malnourishment, these women would perhaps show increased signs of metabolic stress and derangements. Further
studies are positively needed to either prove or disprove this. Many of these changes appear to be reversible after short periods of treatment, but it is impossible to judge the reversibility of some of these changes during prolonged administration.

The most difficult question to answer is the cause-effect relationship and the seriousness of such changes more so in malnourished populations. Majority of the alterations are of a small magnitude and may not be of consequence to most persons taking these drugs. However, certain questions need further elucidation. These include questions such as—whether women on oral contraceptives with abnormal glucose tolerance curves would definitely be liable to the complication of diabetes; whether elevation of certain of the clotting factors definitely implied an increased risk to thromboembolism or whether other effects were equally responsible; and whether alteration of serum lipid profile predisposed these women to atherosclerotic cardiovascular diseases.

There are many more questions, definite answers to which we do not have today despite modern research technology especially since these changes are known to be reversible.

Most of the information available today is on combined/sequential formulations containing estrogens. Majority of the side effects have been linked with the estrogen content of these pills. Metabolic effects of progestogens alone both orally and parenterally are only beginning to be studied and very little information has been published. It would be interesting to know how women in India react to these drugs metabolically. A search for such effects in my opinion, would be most fruitful as these metabolic effects may not be the same as in Western women where overnutrition seems to be the problem.

**INTRAUTERINE CONTRACEPTIVE DEVICES:**

Another method used for contraception is the intrauterine contraceptive device (IUCD). Although the idea of intrauterine contraception has a long history, the devices made of polyethylene and other synthetic materials have been in use only in the last decade. In India this method was introduced in 1962 and approximately 3 million women have used the device. Results of studies done in India show that a majority of acceptors of this method were below 30 years of age and had borne on an average 5 children, indicating family limitation as the chief problem rather than family spacing.
Among the reversible methods of contraception, the IUCD is unique in that it provides a long-term effect on the basis of a single procedure. This advantage is evident from the analysis of studies with a six-year follow up indicating approximately 50 per cent continuation rate. With each successive year, the incidence of symptoms leading to the removal or expulsion of the device has been reported to decline. Thus by the third year of use, the annual continuation rate approaches 90 per cent and pregnancy rate 1 per 100 women years, and this rate continues to decline in subsequent years. Main reasons for the discontinuation of this method in various reports has been disturbance in menstrual pattern (17 to 40 per cent), pregnancy (2 to 5 per cent), vaginal discharge, backache etc. (2 to 15 per cent). The commonest of all complications that follow the insertion of an IUCD is vaginal bleeding (20-50 per cent). This could be immediate post insertion bleeding or in the form of menorrhagia or irregular bleeding; in fact, there is no set pattern and vaginal bleeding may become profuse 2-3 years after the device has been in use (2-10 per cent). However, there appears to be a definite direct relationship between this bleeding and the acceptability rate of the method. Persistent increase in blood loss acquires a greater significance in a country like India, where the average haemoglobin level is lower as compared to women in Western countries. Despite its wide use the world over, very few reports have appeared regarding anaemia and the use of an IUCD and only two studies have been reported from India.

In one study, correlating haemoglobin levels in women using the device over a period of four years, and the pattern of vaginal bleeding, the authors observed a mean haemoglobin concentration in the control group of 11.7 ± 0.14 gm/100 ml. as compared to 13.4 gm/100 ml. in Western countries. At the end of three months of IUCD use this level dropped to 11.0 gm/100 ml. and subsequently improved after 1 year use. A second fall in haemoglobin level occurred after the device had been used for three years. Heavy menstrual flow was experienced by 42.4 per cent women after 3 months and at the end of 3 years 30.1 per cent women experienced heavy periods. As expected, there was a direct relationship between menstrual flow and haemoglobin level. An interesting feature of the study was the fact that variations in haemoglobin levels over the years were not found to be statistically significant and in no woman did the haemoglobin level fall more than 1.4 gm/100 ml.

Apparently, the loss of blood that occurs during menstruation was made up during the subsequent menstrual period and symptoms such as lethargy and weakness complained by about 46 per cent women using these devices were not secondary to the blood loss but perhaps due to other factors in-
cluding high parity and poor nutrition per se. However, it stands to reason that where medical manpower permits, a full blood investigation should be carried out in patients intending to use an IUCD and supportive iron therapy be given to women with low haemoglobin levels, since heavy bleeding in these women would tend to tip the balance towards symptoms of iron depletion.

Another study where the IUCD had been inserted post partum, no change in haemoglobin level was noted.

Very few studies have appeared on the subject from Western countries. In these reports, control haemoglobin levels were 13.4 gm/100 ml. One study reported no change in haemoglobin level whereas approximately 40 per cent women showed a drop of 1.5 gm/100 ml after one year use in another study. It is evident that more work on the effect of an IUCD on malnourished women is indicated.

Despite wide investigations, the reasons for heavy bleeding are not known. Immediate post insertion bleeding could be considered traumatic, but reasons for delayed bleeding episodes are far from established. Histological examination of endometria obtained from such women indicate hyperestrogenism but this needs further investigation.

The use of various preventive and curative measures such as belladonna derivatives, antihistaminics etc., has not been successful. Incorporation of metallic copper to an IUCD has shown in preliminary studies, a definite decrease in the incidence of bleeding. This effect has been attributed to the hemostatic effect of copper. Pregnancy rates with the copper device have also been lower.

The contraceptive efficacy of the IUCD including copper appears to be secondary to leucocytic infiltration since a definite correlation has now been established between the antifertility effect of the device and leucocytic infiltration induced in many species, including the human. Further research, however, to elucidate the etiology of bleeding is definitely indicated. Whether the new copper device is the answer still remains to be seen.

Prevention and subsequent reduction in the incidence of bleeding would certainly improve the acceptability of the method. With its other advantages such as 'One-time' motivation, low cost and low pregnancy rate, the IUCD still has a strong place in the family planning programme of the country.
Children below the age of 5 years constitute a major vulnerable segment of the population from the nutritional standpoint. They account for over 15% of India's population as against 6-8% in the advanced countries of the West or East (Table 1). About 40% of the total deaths in India occur in this age group as against 3-7% in the advanced countries of the West. Though there has been a steady decline in the infant mortality rate in India over the last 20 years, there has been little change in the pre-school child mortality rate, which has remained more or less stationary (Tables 2 and 3). A considerable proportion of India's child population never reaches adulthood and this situation is apparently an important motivation for large families, especially among the poor segments of the population. A vicious cycle of malnutrition leading to high child mortality and this, in its turn motivating large families resulting in a further aggravation of malnutrition is thus set up.

### Table 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Under five years</th>
<th>5-14 years</th>
<th>15 years and above</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>India (1961)</td>
<td>15.2</td>
<td>26.4</td>
<td>58.4</td>
<td>100.0</td>
</tr>
<tr>
<td>U.K. (1965)</td>
<td>8.8</td>
<td>13.1</td>
<td>78.1</td>
<td>100.0</td>
</tr>
<tr>
<td>U.S.A. (1965)</td>
<td>10.5</td>
<td>17.5</td>
<td>72.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>


### Table 2

Proportional mortality in children of age 0-3 years in India and developed countries

<table>
<thead>
<tr>
<th>Year</th>
<th>U.S.A.</th>
<th>U.K.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951-56</td>
<td>1957-64</td>
<td>1964</td>
</tr>
<tr>
<td>39.2</td>
<td>38.5</td>
<td>6.4</td>
</tr>
</tbody>
</table>

K. Visweswara Rao and C. Gopalan

TABLE 3

Infant and toddler mortality in India

<table>
<thead>
<tr>
<th></th>
<th>India 1951-56</th>
<th>U.K. 1957-64</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(1964)</td>
</tr>
<tr>
<td>Infant mortality*</td>
<td>116</td>
<td>86</td>
</tr>
<tr>
<td>Toddler mortality**</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>

*Per 1000 live births.
**Per 1000 mid-year population of 0-5 years.

Apart from high mortality among Indian children, the nutritional status of many of the children who survive is most unsatisfactory. Analysis of the hospital records show that in the pediatric hospitals in the southern and eastern parts of the country, nearly 15% of the hospital beds are taken up by frank cases of malnutrition, prominent among them are protein-calorie malnutrition, hypovitaminosis A and anaemia. A recent survey covering 18,000 children in different parts of the country showed a very high incidence of nutritional disorders among them (Table 4).

TABLE 4

Percentage prevalence of nutrition deficiency signs in Indian preschool children

<table>
<thead>
<tr>
<th></th>
<th>Hyderabad</th>
<th>Vellore</th>
<th>Poona</th>
<th>Delhi</th>
<th>Bombay</th>
<th>Calcutta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number surveyed</td>
<td>3115</td>
<td>3000</td>
<td>3000</td>
<td>3029</td>
<td>3037</td>
<td>3102</td>
</tr>
<tr>
<td>Anaemia</td>
<td>51</td>
<td>56</td>
<td>55</td>
<td>79</td>
<td>61</td>
<td>31</td>
</tr>
<tr>
<td>Angular stomatitis</td>
<td>6</td>
<td>15</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Bitot Spot</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Xerosis of conjunctiva</td>
<td>7</td>
<td>1</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Marasmus or kwashiorkor</td>
<td>1.6</td>
<td>1.8</td>
<td>4.5</td>
<td>2.6</td>
<td>0.4</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Source: ICMR Studies on preschool children, National Institute of Nutrition, Hyderabad.

Another equally important and vulnerable segment of the population is expectant women and nursing mothers. It is estimated that there are approximately 25 million pregnancies per year today in India. A great majority of these pregnant women subsist on diets grossly inadequate in many nutrients both during pregnancy and lactation, contributing considerably to both maternal mortality and morbidity. The maternal morta-
Family Size and Nutritional Status

Maternal mortality rates in different countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Maternal mortality rates (Per 100,000 live births)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>19.6</td>
</tr>
<tr>
<td>England and Wales</td>
<td>25.9</td>
</tr>
<tr>
<td>Australia</td>
<td>32.7</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>33.1</td>
</tr>
<tr>
<td>India</td>
<td>253.0</td>
</tr>
</tbody>
</table>


An intensive programme of family planning has been launched in India with twin objectives:

(i) limitation of family size to three or less children; and

(ii) substantial enhancement of spacing between births.

It is of course obvious that for any given level of family income, particularly among the low socio-economic groups, the larger the family size, the poorer will be the nutritional status. However, the profound impact which a programme aimed at limiting the family to three or less children, can make on the nutritional situation in India, is perhaps not fully appreciated.

In the present study, an attempt has been made to assess the beneficial effects of family planning on the nutritional status of the vulnerable segments — pregnant women and pre-school children, both important from the nutritional standpoint.

RELATIONSHIP BETWEEN FAMILY SIZE AND DIETARY STATUS

Limitation of family size to a smaller number of children especially among poor socio-economic groups, may be expected to increase the quantum of disposable income and volume of food available to each member of the family.
The calorie and protein contents of the diets of about 500 families of textile workers surveyed in the two industrial cities of Ahmedabad in the north and Coimbatore in the south are given in Table 6. The subjects belonged to a homogenous socio-economic group and their family income was below Rs. 250/- per month. Families with varying number of children were considered for study. The diets were assessed by the seven-day weighment method of raw foodstuffs. The protein and calorie intake per adult consumption unit was assessed for each group. The families were broadly classified into three groups as indicated below:

(a) families of 2 adults with 1 to 3 and 4 or more children;
(b) families of 3 adults with 1 to 3 and 4 or more children; and
(c) families of 4 adults with 1 to 3 and 4 or more children.

<table>
<thead>
<tr>
<th>Family size</th>
<th>Protein per day g</th>
<th>Calories per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 + 1 to 3</td>
<td>73.0</td>
<td>2875</td>
</tr>
<tr>
<td>2 + 4 and above</td>
<td>60.0</td>
<td>2550</td>
</tr>
<tr>
<td>3 + 1 to 3</td>
<td>68.3</td>
<td>2735</td>
</tr>
<tr>
<td>3 + 4 and above</td>
<td>58.7</td>
<td>2383</td>
</tr>
<tr>
<td>4 + 1 to 3</td>
<td>62.1</td>
<td>2490</td>
</tr>
<tr>
<td>4 + 4 and above</td>
<td>56.2</td>
<td>2295</td>
</tr>
<tr>
<td>NAC Recommend Allowances (1958)</td>
<td>55.0</td>
<td>2400</td>
</tr>
</tbody>
</table>

The results set out in Table 6 show a striking inverse relationship between family size and nutrient intake. Families with three or less children were observed to have better intake of calories and proteins than families with four or more children. The difference in calorie intake per adult unit between families with three or less children and those with four or more...
Family Size and Nutritional Status

The difference in protein intake was of the order of 10 gm. daily. In most families, differences of this order implied a difference between deficiency and adequacy. These results show that limitation of family size to three or less children would have enabled practically all the families surveyed to afford an adequate dietary allowance even within their current economic means.

Nutritional Status of Pregnant Women

Incidence of Anaemia:

One of the most important causes of ill-health and mortality among women of child bearing age in India is anaemia.

The results of haemoglobin studies carried out by our Institute on 460 pregnant women during the last trimester of pregnancy, analysed by order of pregnancy are provided in Table 7. Severity of anaemia was judged by haemoglobin levels. It can be noted that the incidence of severe anaemia was significantly different between women having three pregnancies or less and those with four pregnancies or more. Thus about 8.5% of all women whose order of pregnancy was four or more had severe anaemia with less than 8 gm % haemoglobin while only 3% of women whose order of pregnancy was three or less had severe anaemia. The average haemoglobin levels were also significantly different between these two groups of women. On an average, more than 65% of severe or moderate anaemia exists among those pregnant women having higher number of pregnancies. This indicates that if the number of pregnancies are limited to three or less there can be a 65% reduction in the incidence of anaemia. This incidence can be further reduced, if the spacing between pregnancies is increased.

Nutritional Deficiency Signs:

The results of a comprehensive nutrition survey carried out among pregnant women in the rural areas around Hyderabad city are provided in Table 8. The incidence of nutritional deficiency signs like angular stomatitis, glossitis, paraesthesias and burning feet were significantly higher in pregnant women who had more than three pregnancies than those who had three or less. Just by restricting the number of pregnancies to three or less, there can be at least 60% reduction in prevalence of nutritional deficiency signs among pregnant women, even under the present standards of living.
Prevalence of anemia in pregnant women of third trimester

<table>
<thead>
<tr>
<th>Details</th>
<th>Order of pregnancies</th>
<th>Level of significance between two groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample studied</td>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td>Haemoglobin levels</td>
<td>280</td>
<td>17.6%</td>
</tr>
<tr>
<td>Prevalence of anemia (&lt;10 g. Hb levels)</td>
<td>11.5±0.21*</td>
<td>10.7±0.25</td>
</tr>
<tr>
<td>Severe anemia (&lt;8 g. Hb levels)</td>
<td>17.5%</td>
<td>27.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mean±S.E.

Percentage prevalence of nutrition deficiency signs in pregnant women by gravida

<table>
<thead>
<tr>
<th>Order of pregnancy</th>
<th>With deficiency signs*</th>
<th>Anemia</th>
<th>Glossitis</th>
<th>Angular stomatitis</th>
<th>Paracenthesia</th>
<th>Burning feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. 1 to 3</td>
<td>28.3</td>
<td>7.0</td>
<td>19.0</td>
<td>10.0</td>
<td>17.0</td>
<td></td>
</tr>
<tr>
<td>II. 4 and above</td>
<td>50.6</td>
<td>22.0</td>
<td>28.4</td>
<td>31.0</td>
<td>21.0</td>
<td>8.6</td>
</tr>
<tr>
<td>Level of significance between I and II</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.01</td>
<td>P &lt; 0.05</td>
<td>P &lt; 0.05</td>
<td>P &lt; 0.60</td>
<td>P &lt; 0.05</td>
</tr>
</tbody>
</table>

*One or more signs.

NUTRITIONAL STATUS OF PRE-SCHOOL CHILDREN

INCIDENCE OF KWASHIORKOR ACCORDING TO BIRTH ORDERS:

In the general population, children of birth orders three and below constitute 54%. Analysis of the records of the out-patient department of the Niloufer Hospital, Hyderabad, showed that children belonging to birth orders four and above accounted for 34% of total admissions as against 66% accounted for by children of birth orders 1 to 3. The large number of children of the earlier birth orders attending the out-patient department of the hospital is partly a reflection of the large number of children of earlier birth orders in the general population and partly an indication of the fact that mothers seek hospital admission and treatment more readily.
for their first few children. However, analysis of 872 cases of severe forms of protein-calorie malnutrition, kwashiorkor, investigated as inpatients in the hospital showed that of these children, only 39% belonged to birth orders three or below, while 61% belonged to birth orders four or above. It is obvious that in spite of preponderance of children of earlier birth orders in the out-patient department of the hospital, the great majority of the cases of kwashiorkor was among the children of latter birth orders.

This would suggest that even under the current economic and living conditions, mere limitation of family size to three or less children would bring down the incidence of severe forms of protein-calorie malnutrition—kwashiorkor, by at least 60%. This may turn out to be an underestimate if the possible impact of countrywide family planning on the medical care, general economic status and food resource position in the country is also taken into consideration.

NUTRITIONAL DEFICIENCY SIGNS:

The incidence of nutritional deficiency signs in children according to birth orders was also studied and is shown in Table 9. These are based

<table>
<thead>
<tr>
<th>Table 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage prevalence of nutritional deficiency signs by birth order in pre-school children</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Birth orders</th>
<th>With any nutritional deficiency sign</th>
<th>Severe PCM</th>
<th>Mild PCM*</th>
<th>Angular stomatitis</th>
<th>Vitamin deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1—3</td>
<td>17.0</td>
<td>0.8</td>
<td>4.4</td>
<td>5.5</td>
<td>6.7</td>
</tr>
<tr>
<td>2. 4 and above</td>
<td>32.0</td>
<td>2.8</td>
<td>11.0</td>
<td>7.0</td>
<td>12.6</td>
</tr>
<tr>
<td>Level of significance between</td>
<td>I &amp; II P &lt; 0.001</td>
<td>P &lt; 0.02</td>
<td>P &lt; 0.001</td>
<td>P &lt; 0.30</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Sample covered by birth order 1—3</td>
<td>900</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 and above</td>
<td>570</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Severe PCM—Marasmus and Kwashiorkor
**One or more mild signs, like moonface, hair changes etc.,

on 1500 children surveyed in the rural areas around Hyderabad city. It shows that incidence of severe or mild forms of protein-calorie malnutrition and other nutritional deficiency signs were significantly higher in children of higher birth orders than those of lower birth orders. Thus, while 32% of children of birth orders four and above exhibited various signs of nutritional deficiencies, only 17% of children of the earlier birth orders—one to three, showed such evidence. In other words, deficiency signs appear in one out of every six in the children of earlier birth orders and in one in

...
every three children in latter birth orders. These data would show that nearly 65% of the poor nutritional status prevalent in the child population is encountered in the children of birth orders four and above and only 35% in children of lower birth orders. The differences in birth orders are even more striking with regard to specific nutritional deficiencies such as marasmus, kwashiorkor or vitamin A deficiency.

GROWTH STATUS OF PRE-SCHOOL CHILDREN:

Height and weight have been suggested to be indicators of growth and nutritional status. The mean values of height and weight of 1400 children by age, sex and birth orders are presented in Table 10. The results reveal that children of lower birth orders I-3 are seen to be taller by 4 cm. and heavier by 1.5 kg. These results are also in agreement with relations observed between anthropometric measurements and family size. The anthropometric measurements showed a negative correlation with family size, i.e., among the same socio-economic groups, children of larger families (more than 3 children) tended to have lower measurements than children of comparable ages belonging to smaller families.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Sex</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Average family size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—3</td>
<td>M</td>
<td>77.5</td>
<td>73.1</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>76.1</td>
<td>73.3</td>
<td>9.0</td>
</tr>
<tr>
<td>4—5</td>
<td>M</td>
<td>90.8</td>
<td>86.4</td>
<td>12.8</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>88.9</td>
<td>83.6</td>
<td>12.2</td>
</tr>
</tbody>
</table>

**Note**: The differences in mean heights and weights between birth orders of I and II were significant (P<0.001).

FAMILY SIZE AND LIVING CONDITIONS OF PRE-SCHOOL CHILDREN:

The health and living conditions of pre-school children by family size are provided in Table 11.

As we compare in Table 11, the levels of living conditions of children in families with larger number of children and those families with smaller number of children, it was observed that the various health conditions like hygiene,
Family Size and Nutritional Status

over-crowding, low weight for age, diarrhoea and multiple illness were significantly different. The inverse relationship between family size and living conditions of the pre-school children is apparently evident.

TABLE 11

Health and living conditions of pre-school children by family size

<table>
<thead>
<tr>
<th>Health condition</th>
<th>3 or less</th>
<th>4 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor hygiene</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>Over-crowding</td>
<td>10%</td>
<td>75%</td>
</tr>
<tr>
<td>Low weight for age</td>
<td>15%</td>
<td>45%</td>
</tr>
<tr>
<td>Recurrent diarrhoea</td>
<td>27%</td>
<td>68%</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>Multiple illnesses</td>
<td>20%</td>
<td>54%</td>
</tr>
</tbody>
</table>

FUTURE STATUS OF POPULATION COMPOSITION

In many of the advanced countries like Japan in the East and U.S.A. or U.K. in the West, there have been secular trends in height and weight. This perhaps may be due to various environmental influences. One of the best associated environmental influences is the proportion of live births by birth orders three or less. They range from 71% to 98% in the developed countries, while in developing countries, they range from 38% to 54% (Table 12). This ratio is observed to have a very good association with many of the indicators of health and nutrition.

TABLE 12

Percentage of births by birth order in Asia and other countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Birth orders</th>
<th>Total</th>
<th>Birth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>India (1960)</td>
<td>53.8 46.2 100.0</td>
<td>41.0</td>
<td></td>
</tr>
<tr>
<td>Malaysia (1963)</td>
<td>46.6 53.4 100.0</td>
<td>39.4</td>
<td></td>
</tr>
<tr>
<td>Philippines (1963)</td>
<td>53.7 46.3 100.0</td>
<td>50.0</td>
<td></td>
</tr>
<tr>
<td>Thailand (1961)</td>
<td>51.7 48.3 100.0</td>
<td>42.0</td>
<td></td>
</tr>
<tr>
<td>U.A.R. (1961)</td>
<td>38.0 62.0 100.0</td>
<td>42.0</td>
<td></td>
</tr>
<tr>
<td>Japan (1963)</td>
<td>95.0 5.0 100.0</td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>U.S.A. (1964)</td>
<td>71.0 29.0 100.0</td>
<td>21.0</td>
<td></td>
</tr>
<tr>
<td>England (1964)</td>
<td>85.0 15.0 100.0</td>
<td>18.7</td>
<td></td>
</tr>
<tr>
<td>Poland (1965)</td>
<td>98.0 2.0 100.0</td>
<td>18.1</td>
<td></td>
</tr>
</tbody>
</table>

It seems that limitation of the family to three or less children will bring a substantial improvement in the health and nutritional status of the vulnerable segments.

The above observations provide clear indication of the impact of family size on nutritional status. Frequent pregnancies in women subsisting on marginally adequate diets impair their health status and impose additional burden on child-care. The observations presented here reveal that even under the existing economic conditions and given the present food resources, limitation of the family to three or less children will significantly improve the nutritional status of pre-school children and reduce maternal ill-health and mortality.

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ASPECTS OF PROTEIN NUTRITION

Chairmen: N. Shimazono, Japan
and
A. Sreenivasan, India

Rapporteur: L. K. Ramachandran, India

Papers:

Protein requirements of pre-school children - G. ARROYAVE . . 350

The minimum protein requirements of adults—E. KOPRANYI . . 358

Human amino acid requirements and protein quality
—D. M. HEGSTED . . 365

Regulation mechanisms in protein metabolism and their
bearing on human nutrition—H. N. MUNRO . . 377

Evaluation of protein quality—M. SWAMINATHAN . . 392
Before discussing in more detail the protein requirements of children of pre-school age, I would like to make some considerations about protein requirements in general.

First, we must make a clear distinction between requirements and allowances. Requirement is a physiological term. The amount of protein necessary to compensate for the obligatory losses of nitrogen from the body, plus, in the child, the nitrogen required to accumulate the amount of protein compatible with normal growth. In pregnancy and lactation additional proteins are necessary to permit the increase in mass and normal milk production respectively. The components of this equation are the urinary losses, the fecal losses, the skin and integumental losses plus the growth or milk production need.

Nobody will disagree with the fact that the values given to those components are estimates whose error is in most cases only vaguely known. Nevertheless, they are the best we have, and furthermore, they are subject to revision, as better information becomes available. Here, I want to emphasize that these values will not be improved significantly by discussion only, but instead research will determine the extent to which they are in error.

The result of the application of this so-called “factorial approach” by the National Research Council of the U.S. (NRC) is shown in Table 1. You may notice the last column in which 30% of the average requirement has been added. This I believe, is an appropriate time to define allowances. Allowances are suggested intakes proposed mostly on the basis of practical considerations. They are the result of policy decisions which modify the average requirement figure to make their applicability

* Partially supported by Grant 4208-510 of the World Health Organisation
Protein Requirements of Pre-School Children

<table>
<thead>
<tr>
<th>Age</th>
<th>Daily weight gain (g)</th>
<th>Protein gain (g/kg)</th>
<th>Basal Metabolism (Cal/kg)</th>
<th>Maintenance protein (g/kg)</th>
<th>Average requirement of &quot;Ideal Protein&quot; (g/kg)</th>
<th>Average requirement of &quot;Ideal Protein&quot; +30% (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.0 months</td>
<td>8.3</td>
<td>0.12</td>
<td>61.5</td>
<td>1.23</td>
<td>1.35</td>
<td>1.75</td>
</tr>
<tr>
<td>21.0 months</td>
<td>8.8</td>
<td>0.12</td>
<td>53.4</td>
<td>1.07</td>
<td>1.19</td>
<td>1.55</td>
</tr>
<tr>
<td>2.5 years</td>
<td>6.7</td>
<td>0.08</td>
<td>48.3</td>
<td>0.97</td>
<td>1.05</td>
<td>1.37</td>
</tr>
<tr>
<td>3.5</td>
<td>6.8</td>
<td>0.07</td>
<td>42.8</td>
<td>0.86</td>
<td>0.93</td>
<td>1.21</td>
</tr>
<tr>
<td>4.5</td>
<td>7.1</td>
<td>0.06</td>
<td>40.1</td>
<td>0.80</td>
<td>0.86</td>
<td>1.12</td>
</tr>
<tr>
<td>5.5</td>
<td>8.3</td>
<td>0.06</td>
<td>39.8</td>
<td>0.80</td>
<td>0.86</td>
<td>1.12</td>
</tr>
<tr>
<td>6.5</td>
<td>9.9</td>
<td>0.07</td>
<td>39.5</td>
<td>0.79</td>
<td>0.86</td>
<td>1.12</td>
</tr>
<tr>
<td>7.5</td>
<td>10.7</td>
<td>0.06</td>
<td>39.6</td>
<td>0.79</td>
<td>0.85</td>
<td>1.11</td>
</tr>
<tr>
<td>8.5</td>
<td>10.0</td>
<td>0.05</td>
<td>37.1</td>
<td>0.74</td>
<td>0.70</td>
<td>1.03</td>
</tr>
<tr>
<td>9.5</td>
<td>11.1</td>
<td>0.05</td>
<td>35.1</td>
<td>0.70</td>
<td>0.75</td>
<td>0.97</td>
</tr>
<tr>
<td>10.5</td>
<td>11.7</td>
<td>0.05</td>
<td>33.1</td>
<td>0.66</td>
<td>0.73</td>
<td>0.92</td>
</tr>
<tr>
<td>11.5</td>
<td>12.8</td>
<td>0.05</td>
<td>31.1</td>
<td>0.62</td>
<td>0.67</td>
<td>0.87</td>
</tr>
<tr>
<td>12.5</td>
<td>16.9</td>
<td>0.06</td>
<td>29.2</td>
<td>0.58</td>
<td>0.64</td>
<td>0.83</td>
</tr>
<tr>
<td>13.5</td>
<td>17.0</td>
<td>0.05</td>
<td>29.3</td>
<td>0.59</td>
<td>0.64</td>
<td>0.83</td>
</tr>
<tr>
<td>14.5</td>
<td>13.5</td>
<td>0.04</td>
<td>28.5</td>
<td>0.57</td>
<td>0.61</td>
<td>0.81</td>
</tr>
<tr>
<td>15.5</td>
<td>11.4</td>
<td>0.03</td>
<td>27.7</td>
<td>0.53</td>
<td>0.56</td>
<td>0.73</td>
</tr>
<tr>
<td>16.5</td>
<td>9.4</td>
<td>0.02</td>
<td>25.8</td>
<td>0.52</td>
<td>0.54</td>
<td>0.70</td>
</tr>
<tr>
<td>17.5</td>
<td>5.5</td>
<td>0.01</td>
<td>25.0</td>
<td>0.50</td>
<td>0.51</td>
<td>0.66</td>
</tr>
<tr>
<td>Adult</td>
<td>—</td>
<td>—</td>
<td>25.0</td>
<td>0.50</td>
<td>0.50</td>
<td>0.65</td>
</tr>
</tbody>
</table>

"safer" under specific circumstances. For example, to cover 97.5% of the population the NRC proposed the mentioned addition of two standard deviations, one standard deviation being accepted as 15% of the mean. WHO/FAO, using older supporting data had considered one standard deviation as 10%. The variability factor, therefore, was set by them as 20%2. Further modification of the requirements to transform them into allowances applicable to a particular situation, comes from the introduction of a correction factor for the per cent utilization of the dietary protein when this is not reference or ideal protein which by definition is 100% utilized. These utilization factors are mostly derived from experiments in rapidly growing rats and their applicability to humans, and even more, to humans of all ages, is fairly open to serious question.

The second part of my presentation is intended to illustrate the most of the trouble with the figures proposed as requirements does not lie in
the figures themselves, but rather on their interpretation and use. Table 2 shows the estimated protein requirements of infants. We notice general agreement in the early part of infancy, but the agreement is somewhat disrupted later. Some of the NDpCal % resulting from these estimates are markedly lower than that for human milk, but I am not prepared to say how wrong they may be.

Let us instead look at Table 3. Using the factorially determined average protein requirements and the average FAO caloric requirements, I have calculated the ratio of protein calories to total calories, (expressed as NDpCal % values) given in the second column from the right. The magnitude of the figures is in reasonably good agreement with those proposed by Payne and Miller1. But let us see what happens if we take the initial steps to make them into allowances by adding the variability factor. The result is the higher figures on the last column. It may be observed that these figures of NDpCal % are markedly higher than 4 which is the value estimated by Payne and Miller for maintenance2. The fact is that these higher values are erroneous because for the numerator of the fraction, the protein requirement already increased by the addition of the variability factor of 30% has been used, while for the denominator, the plain average calorie requirement has been taken. This overlook has led to unjust criticism of the protein requirements derived by the "factorial method".

**TABLE 2**

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>NRC</th>
<th>ICMR</th>
<th>FAO—OMS</th>
<th>Swaminathan</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(1)</td>
<td>(2)</td>
<td>2.3—120</td>
<td>2.3—120</td>
</tr>
<tr>
<td>1</td>
<td>2.2—120</td>
<td>(3)</td>
<td>(7.2)</td>
<td>(7.7)</td>
</tr>
<tr>
<td>2</td>
<td>2.2—110</td>
<td>(7.2)</td>
<td>1.8—110</td>
<td>1.8—110</td>
</tr>
<tr>
<td>3</td>
<td>(6.6)</td>
<td>(6.6)</td>
<td>(7.6)</td>
<td>(7.6)</td>
</tr>
<tr>
<td>4</td>
<td>(7.2)</td>
<td>(4)</td>
<td>1.8—100</td>
<td>1.5—110</td>
</tr>
<tr>
<td>5</td>
<td>1.8—100</td>
<td>(4)</td>
<td>(5.0)</td>
<td>(5.4)</td>
</tr>
<tr>
<td>6</td>
<td>(7.2)</td>
<td>(4)</td>
<td>1.5—100</td>
<td>1.3—100</td>
</tr>
<tr>
<td>7</td>
<td>(4.2)</td>
<td>(5.2)</td>
<td>(6.0)</td>
<td>(6.0)</td>
</tr>
</tbody>
</table>

(1) Gram protein/kg/d. (2) Calories/kg/d. (3) NDpCal % (4) NPU—70%


**Protein Requirements of Pre-School Children**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Weight (kg)</th>
<th>Calorie requirement</th>
<th>Protein Req (g)</th>
<th>NDp Cal %</th>
<th>NDp Cal % + 30 %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M F M F M F Both sexes Both sexes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>11.43 11.11 101 104</td>
<td>1.27 1.38</td>
<td>5.2 6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>13.61 13.43 96 97</td>
<td>1.05 1.16</td>
<td>4.6 6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>15.56 15.38 93 94</td>
<td>0.93 1.06</td>
<td>4.3 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>17.42 17.46 89 89</td>
<td>0.86 0.99</td>
<td>4.2 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>20.26 19.96 82 85</td>
<td>0.86 0.97</td>
<td>4.4 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td>23.22 20.64 80 90</td>
<td>0.86 0.94</td>
<td>4.3 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>25.90 25.04 75 78</td>
<td>0.85 0.90</td>
<td>4.6 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.5</td>
<td>28.62 27.67 73 76</td>
<td>0.79 0.86</td>
<td>4.4 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>31.30 30.44 72 74</td>
<td>0.75 0.82</td>
<td>4.3 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.5</td>
<td>33.93 33.79 69 70</td>
<td>0.71 0.79</td>
<td>4.3 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>36.74 37.74 68 66</td>
<td>0.67 0.74</td>
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<td>4.3 5.6</td>
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<td>0.50 0.50</td>
<td>4.4 5.6</td>
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</table>

Based on average NDp Cal % of 4.3

Table 4 shows the problems one may get into when playing with figures. Combining caloric requirements from FAO or NRC with average protein requirements, body weight, and NDpCal %, we introduce more variability and more confusion. One may, however, make a choice and select among these data, one of them, either because it may be a favourite or simply for the sake of argument. Table 5 is self-explanatory of what happens and presents a theoretical puzzle.

The next part of this paper is intended to emphasize the point made earlier in this talk, that is, the need for research, especially of ultimately testing the proposed requirement figures as directly as possible, on the subjects who are to consume them, and not only in rats or chicks. I will describe briefly work which is going on in INCAP's laboratories for this purpose.

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TABLE 4

Effect of Expert Groups on the NDpCal % and Protein and Calorie requirement of adults

<table>
<thead>
<tr>
<th>Body weight (kg)</th>
<th>Calorie Requirement Per day kg/day</th>
<th>Reference Protein Requirement (g/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td><strong>MEN</strong></td>
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<tr>
<td>FAO-OMS</td>
<td>65</td>
<td>3200</td>
</tr>
<tr>
<td>NRC</td>
<td>70</td>
<td>2800</td>
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<tr>
<td>FAO-OMS/NRC</td>
<td>—</td>
<td>—</td>
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<tr>
<td>PAYNE-MILLER/FAO</td>
<td>65</td>
<td>3250</td>
</tr>
<tr>
<td>PAYNE-MILLER/NRC</td>
<td>70</td>
<td>3500</td>
</tr>
<tr>
<td><strong>WOMEN</strong></td>
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<td></td>
</tr>
<tr>
<td>FAO-OMS</td>
<td>55</td>
<td>2300</td>
</tr>
<tr>
<td>NRC</td>
<td>58</td>
<td>2000</td>
</tr>
<tr>
<td>FAO-OMS/NRC</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>PAYNE-MILLER/FAO</td>
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<td>2750</td>
</tr>
<tr>
<td>PAYNE-MILLER/NRC</td>
<td>58</td>
<td>2900</td>
</tr>
</tbody>
</table>

Underlined figures used as bases for calculation.

FIG. 1

GRAPHIC REPRESENTATION OF TWO TYPICAL DIETARY PERIODS OF TWO WEEK; EACH, SAMPLING FOR BLOOD AND URINE

<table>
<thead>
<tr>
<th>Day of the week</th>
<th>U</th>
<th>S</th>
<th>U</th>
<th>S</th>
<th>U</th>
<th>S</th>
<th>U</th>
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<tr>
<td></td>
<td>0.25 g/kg/d</td>
<td></td>
<td>0.50 g/kg/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

U  Caporal midmorning urine specimens
B-B-B  Three consecutive 24 hour urine and fecal collections
S  10 ml venous blood sample
TABLE 5

Average requirement of ideal protein for a 70 kg man. 35 g/d (NRC, 1968) 0.50 g/kg/d
From that figure one can calculate his ideal energy expenditure or calorie requirement, based on a NDp Cal % = 4.0

\[
\frac{100 \times 0.50 \times 4}{X} = 4; \quad X = 50 \text{ Cal/kg}
\]

70 \times 50 = 3500 \text{ Cal/day}

Presently, NRC requirement is 2800 Cal/day.

Conclusion: The man has to either consume a diet much more concentrated in protein (higher NDp Cal %) or increase his consumption of the diet with NDp Cal % of 4.0. In the latter case he would have to increase his physical activity about 75% if he does not want to get obese.

Fig. 2. Effect of level of protein intake on the serum non-essential/essential (NE/E) amino acids and on the nitrogen balance (+positive nitrogen balance, —negative nitrogen balance).
Children 2-3 years of age in an adequate state of nutrition were interned in the metabolic ward. They had normal weight for height and fully developed muscle mass as judged by a creatinine/height index \(^*\) of over 95%. At the start they were free of any clinical evidence of disease.

They were fed formula diets supplying variable levels of whole egg protein ranging from 0.25 to 2.5 grams of protein per kg per day, in 8 steps of 15 days duration each. Two typical periods are shown in Figure 1. In the first study, which I am going to report here, 4 children were studied, two in descending and two in ascending manner. Some physical and
biochemical measurements were made frequently throughout. I shall submit to your consideration the results of the plasma amino acid ratio and of the nitrogen balance.

These results are given in Figures 2 and 3. At the lower protein intakes, the ratio of non-essential to essential amino acids tends to rise to abnormally high levels. As the protein intake surpasses 1.00—1.25 the ratio clearly tends towards normality. Furthermore, 14 out of 16 nitrogen balances done at levels of 1.25 g/kg/d or higher were positive.

The data indicate responses of clear discriminating power between the low and the high protein levels and suggest that a range of intakes of reference protein around 1.25 g per kilo per day is the land-mark on either side of which the children are on an adequate or an inadequate protein intake. Two features are rewarding about these results: (1) They agree well with those previously reported by Waterlow et al.; (2) They confirm that the general magnitude of the average protein requirement obtained by the factorial method for this age group is correct although our experimental values seem somewhat higher (see Table 1).

In conclusion, I would like to emphasize the need to test, by direct experiment, the validity of the figures of protein requirements which have been proposed on the basis of the total endogenous nitrogen losses from the body.

REFERENCES

THE MINIMUM PROTEIN REQUIREMENTS OF ADULTS

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For more than ten years in the Max-Planck-Institute of Nutrition in Dortmund research has been done to find out the conditions under which exactly reproducible results can be obtained about the protein requirement of adults. Now our long term N-balances enable us to obtain reproducible results within $\pm 1.47\%$ deviation with the same test person. But to get such results the following conditions are necessary:

1. Not only is the excretion to be analyzed but also all ingredients of the food-intake. It is not sufficient to take figures from food composition tables.

2. The caloric requirement has to be covered, otherwise the protein will be misused for energy metabolism. This leads to misinterpretations. Therefore the bodyweight has to be constant or has to increase a little. Calorie sources are cornstarch, fat, sugar and articles of food which are free from nitrogen. This makes the food very monotonous. The diet contains 35% of the calories from fat, about 60% from carbohydrates and the rest from protein.

3. Supplements of vitamins and minerals are given in the amount needed.

4. Agar-agar and cellulose are incorporated in some diets to ensure peristaltic movement and stool formation.

5. The length of each test is 21 to 28 days. It is known that many experiments are done for only one week. This may be sufficient for small animals like rats, but it is not long enough for humans. The nitrogen balance during the first part of a test period shows strongly negative balances. This part takes about 7 to 11 days. Only during the subsequent 10 to 13 and 13 to 17 days does the organism attain an equilibrium between protein requirement and protein consumption. Only values of this part of the test period with a steady state are used for calculation.
6. Last but not the least, I want to mention the test persons. These are adult healthy males. They are accommodated in the institute, where they eat and sleep. They are allowed to carry out their normal daily occupations. Mostly, they are students of "Teachers Training Colleges."

The mutual obligations, the fee and the rule of the house are exactly fixed. The individuals are contracted for the duration of a test series, that means for 6 to 12 months. An accuracy of $\pm 1.47\%$ is achieved only after following the above six recommendations.

The fundamental research in protein requirements of adults had been done before by Kraut and Muller-Wecker. They tested proteins of mixed food on normal working and heavy working. Fortunately I and my coworker Jekat could take into account their experience and could apply the technique. Kraut and Muller-Wecker also estimated the nitrogen loss from skin peeling, nails and hair, which accounts for 7 to 10% of the daily nitrogen output.

For the measurement of the minimum requirements we apply the nitrogen balance test i.e., if the nitrogen intake is higher than the output, we obtain a positive balance, if the output is higher than the intake, the balance is negative. Only the figures of steady state, when equilibrium is achieved can be used for calculation of the minimum requirement. Before I show the results of our experiments I would like to explain the definition of the biological value. Thomas in 1909 was the first who defined biological value; his definition was, the number of parts of body nitrogen which can be replaced by 100 parts of food nitrogen. But we define it as follows: the biological value is the reciprocal of the minimum requirement of protein when equilibrium is constant. The biological value of whole egg is set equal to 100. This definition is implicit in the earlier definitions, but it suits the modern methods better, because what we are really determining is the minimum requirement and not the protein increasing rate. The correct determination of the protein increasing rate is a troublesome task and implies the slaughter and the analysis of the test animals. For human subjects only nitrogen balance tests are possible.

The knowledge about the biological value of single proteins is not very useful for human nutrition, because the normal food always consists of mixed proteins. But the biological values of single proteins in mixtures influence each other very much. This remarkable influence we found in all cases, with two different plant proteins, or with two different animal proteins, or with one vegetable protein and one animal protein.
In figure 1 we see that milk has a higher biological value than wheat, but the mixture of 75 milk-N plus 25 wheat-N has a distinctly higher value than milk by itself. The curve we obtained is quite astonishing, it consists of two straight lines which intersect at the deepest point. If you choose the biological value (instead of the minimum requirement) as the ordinate in the diagrams, you do not obtain straight lines but branches of hyperbolas.
Minimum Protein Requirements of Adults

Fig. 2. Biological value of potatoes and wheat.

(fig. 2). Up to now we have no explanation for the fact that straight lines always appear when we choose the minimum requirement for the ordinate.

The results of other tests with mixed proteins of two different sources can be seen in figure 3. There are two figures with the same coordination system. The left one shows mixtures of milk plus wheat, egg plus beans, egg plus rice, egg plus soya, egg plus potatoes and beans plus maize. The figure on the right side shows (for comparison) egg plus potatoes again and also egg plus wheat, egg plus maize, egg plus algae as well as meat plus potatoes.

Wheat protein alone has the lowest biological value, a special mixture of egg plus potato protein the highest. With only 0.37 gram protein per kg bodyweight the protein requirement is covered, i.e., about 25 g protein per
day for an adult man. By this combination the nitrogen output through the kidneys also achieves the lowest level. The daily nitrogen output in the urine was 8.8 gram with wheat alone, 5.6 gram with egg alone, 3.9 gram with egg plus potato mixture. Therefore the optimal mixture of 36% egg-N plus 64% potato-N has also aroused medical interest. At the Medical Policlinic of the University of Freiburg, Kluthe provided a diet for patients with chronic kidney insufficiency based upon this optimal mixture. Twenty-eight patients, twelve of which had an artificial kidney, were treated with the diet alone. With the diet alone the urea in the serum could be brought to normal level in 11 patents, to nearly normal level in 13, and only 4 remained too high and the patients had to be dialysed. The time however between dialysis could be stretched.

The mixture of beans plus maize is also very interesting. Neither of the two vegetable products have a high biological value, but the best mixture of both almost reaches the value of whole egg. This mixture is 56% bean-N plus 44% maize-N. That means a weight proportion of the raw articles of about one third of beans and two thirds of maize. Kreyler distributed a mixture of ground beans and maize among the undernourished children in the village of Bumbuli in Tanzania (Africa). He was able to obtain a marked improvement in their clinical status.
Minimum Protein Requirements of Adults

Figure 4. Biological value of egg protein, particularly replaced by ammonia nitrogen, in humans and rats.

Figure 4 shows the minimum requirement again on the ordinate. On the abscissa is shown the percentage of egg-N replaced by ammonium nitrogen. What would the curve look like if one essential amino acid (of the whole egg) was limiting? You would get from the beginning an increase at an angle of 45°. That is true with rats (curve B) — but it is quite different with humans (curve A). You can replace two thirds of the egg protein by ammonia without changing the biological value. Only the addition of more ammonia than that causes the curve to increase. That means, the
biological value is becoming low. This finding seemed to be so important that it was confirmed on 5 test persons. It does not matter whether ammonium citrate, glutamic acid or aspartic acid is given. Only glycine alone is not very good, you have to mix it with another amino acid. As you can see in figure 4, rats react quite differently from humans when determining the biological value. Therefore, tests on rats are not useful for estimation of the biological value.

After discussions with some Indian guests in our institute in Dortmund we began experiments with chick-peas plus rice. We do not have the final results yet with these mixtures. However, perhaps we can take with us suggestions about other proteins growing in Asian countries. May be we will have a new chance to find out similar mixtures of high value as we could find for Tanzania.

REFERENCES
HUMAN AMINO ACID REQUIREMENTS AND PROTEIN QUALITY

D. M. Hegsted

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Harvard School of Public Health
Boston, Mass., U.S.A.

Proteins differ in nutritive value. This can be shown in many ways, by feeding animals diets that have equal quantities of different proteins, by nitrogen balance studies at equal intakes, etc. It is also clear that this difference must be related to the essential amino acid content of the proteins. Since in every case that has been investigated, the nutritive value of those proteins which show poor quality can be improved by the addition of one or more essential amino acids. This knowledge alone, however, is of limited use unless we can quantitate the relative value of different proteins. That is, if the protein in diet A is of lower quality than that in diet B, we have to know how much lower in order to make appropriate decisions.

Since most tissue proteins are constantly catabolized and resynthesized, it would seem clear that proteins cannot be synthesized unless all the amino acids required are present at the sites of synthesis in appropriate amounts. The basic assumption has therefore been made that it makes no difference which of the essential amino acids is limiting in a dietary protein, the effect will be the same. That is to say, if there is only one-half enough lysine or one-half enough tryptophan supplied, the effect on protein utilization will be the same. Furthermore, it has often been assumed that if any essential amino acid is completely lacking in the diet, protein synthesis will be impossible. That is, a protein lacking an essential amino acid should be equivalent to no protein at all. These basic assumptions, which have provided the basis for all the methodology and theoretical considerations in this area, are not correct. The likelihood that they were not really true has been apparent for a long time but we have only recently begun to realize the actual situation.

For many years Biological Value (BV) as defined by Mitchell et al was the best method available for determining protein quality. In this method the "nitrogen retained" is determined as the difference in urinary nitrogen between that excreted when the test protein is fed and when a nitrogen-free diet is fed. This is expressed as a percentage of the "nitrogen absorbed", this being the dietary nitrogen less the difference in fecal nitrogen on the
D. M. Hegsted

Net Protein Utilization (NPU) was revived some years ago by Miller and Bender. It is similar to BV except that "nitrogen retained" is determined by carcass analysis of rats fed the test diet and the nitrogen-free diet. The denominator in this case is the total nitrogen eaten rather than the nitrogen absorbed.

Since both BV and NPU are the ratio y/x where y is nitrogen retained and x is nitrogen eaten or absorbed, these are by definition the slope of a line relating y to x (Fig. 1). If BV and NPU are constant values, characteristic of a protein, then this line must be straight, i.e., there must be a linear relationship between y and x. A few years ago, therefore, we proposed a slope-ratio assay for evaluation of protein quality. This is essentially an extension of the measurement of NPU. Rather than making the tacit assumption that the slope is constant, this is actually measured. Protein quality is proportional to the slope. Having, presumably, a valid biological assay the potency of the test material and the error of the estimated potency can be estimated according to Finney. Since the hand calculation of the errors in the estimate of potency is tedious, a computer programme was developed to yield the values desired.

As we have indicated in several papers this method seemed to work reasonably well. However, we were puzzled to find that quite frequently the assay was not "ideal," i.e., the regression lines did not meet at the same point, the point defined by the group which received the protein-free diet. It is worth emphasizing that although statistical evaluation clearly revealed that the assay did not meet the criteria of an "ideal" assay, the slope of the regression line was not greatly affected whether or not the "blank" (zero protein group) was included in the calculation.

With small weanling rats it is difficult to investigate this area of the curve, i.e., the area below maintenance. The weight loss is relatively small compared to the variability in weight within groups of animals. We turned therefore to studies with larger animals with which more prolonged studies are possible. These studies show clearly that with certain proteins the regression line clearly deviates from that expected (Fig. 2). The true line must curve since it has to eventually reach the point indicated by the protein-free group.

We then turned to amino acid mixtures and fed diets in which each essential amino acid was varied from levels above maintenance to diets free of the amino acid. These studies confirmed our expectations. There were large differences in weight loss on diets lacking various amino acids.
Fig. 1. Biological Value (BV) by definition is the slope of the line between \( x, y \) and \( x_1, y_1 \).

\[
BV = \frac{y}{x} = \text{slope}
\]

(Fig. 3). With some amino acids — threonine, isoleucine and the total sulfur containing amino acids — the loss of tissue is nearly comparable to that obtained with a protein-free diet. At the other extreme are lysine and
leucine-free diets with which tissue losses were minimal and deficiencies of the other amino acids produce losses intermediate between these extremes.

![Graph showing response of rats to lactalbumin compared to gluten from Said and Hegsted. Open circles indicate animals fed a nitrogen-free diet. It is clear that there must be curvature in the gluten response line.]

The only possible explanation of these results would appear to be that there are specific mechanisms which allow for varying degrees of conservation of the essential amino acids. Since none of these amino acids are particularly toxic when added in some excess to well balanced amino acid mixtures, they obviously do not accumulate to any great degree. Thus, the ratio of destruction (or changes in ability to conserve) must be subject
Fig. 3. Response of adult animals to varying levels of each of the essential amino acids. Solid circles indicate response of animals fed a nitrogen-free diet. Note that only with complete deficiencies of threonine and isoleucine and total sulfur amino acids (latter not shown) does response approach that with the nitrogen-free diet. From Said and Hestøl.9

to some kind of feedback control. This is another way of saying that the amino acid requirement to achieve varying degrees of adequacy is not proportional among the essential amino acids.
I want to point out that such limited data as are available on man confirm these findings. The balance studies with varying levels of tryptophan and lysine in young women indicate that much less loss of nitrogen is sustained at zero lysine intake and zero tryptophan intake. Unfortunately, most of the other data available on man do not lend themselves to this kind of examination.

The implications of these findings are several:

(a) It would appear that the general concept of a Chemical Score based upon a protein with an ideal amino acid composition cannot be strictly true. In a rapidly growing animal, such as a young rat, where a very high proportion of the protein consumed is deposited as new tissue, the amino acid requirements must be dominated by these requirements. This does not mean that the requirements will be proportional to those deposited in tissue since we cannot assume an equal efficiency of conversion of each amino acid into tissue protein. However, since at levels of intake above maintenance to those which allow near maximum growth (Fig. 4), the new tissue formed is proportional to intake, the relative requirements for the various amino acids must be approximately constant in this region of intake.

(b) I believe the data clearly demonstrate some difference in the proportions of essential amino acids required for maintenance and for growth. If one compares the curves for threonine and lysine (Fig. 4), the ratio of these would appear to change substantially at different levels of performance. Obviously, from what I have already said, one cannot extend these lines very far above maintenance.

(c) Figure 3 indicates the method of estimating amino acid requirements, i.e., where the regression line crosses the maintenance line. The accuracy of these estimates is a function of the scatter of the data on the x axis. It is clear that lines with a low slope such as are obtained with lysine will result in estimates with a relatively poor degree of accuracy. It is much more difficult to estimate amino acid requirements for lysine using this technique than it is for threonine, for example.

(d) Finally, it should be clear that the determination of NPU at levels near maintenance and below, NPU (st) of Miller and Payne—the level they assumed would yield a constant NPU agreeing with Chemical Score—is exactly the region of intake where NPU is least constant. The change in NPU within the area of intake in which response is governed by protein
intake is due primarily to the curvature at low levels of intake, not to curvature above maintenance. Curvature does occur, of course, as the intake approaches the amount required for maximum growth.

![Chart comparing lysine and threonine dose-response lines](chart.png)

**Fig. 4.** Comparing the dose-response lines for lysine and threonine from Fig. 3. The ratio apparently varies markedly depending upon the level of response.
I should make clear here that the system for evaluation of protein quality proposed by Miller and Payne is based on several erroneous assumptions. Some of these are (a) the assumption that NPU (st) is a constant; (b) the assumption that NPU (st) yields a value similar to Chemical Score; (c) their assumptions as to the way NPU changes as the intake is increased. With regard to the latter, the change with intake is clearly a function of the growth potential of the animal. This is very different even for young rats and infants and children and completely different for young animals with higher protein needs and adult animals. Finally, one cannot assess the quantity or quality of anything by a biologic assay unless the response being measured is a function of the material being tested. The scheme of Miller and Payne is of historical interest and stimulated thought and work. However, it yields erroneous results and should be abandoned.

Now turning to amino acid requirements of man, the major data available are still the estimates on young infants of Holt and Snyderman, the data on school children of Nakagawa et al, the data of Rose on adult man, and that of Liverton and associates on adult women. Like most of the data on human requirements, it is almost impossible to evaluate the accuracy of these various estimates. The data on young women, however, were obtained in such a manner that an estimate of the relative accuracy is possible. Some years ago I plotted these data as shown in Figs. 5 and 6 and calculated the error of the estimated x (intake) when y (nitrogen balance) was zero. Table 1 is a summary of the conclusions of the various authors mentioned above converted to a mg/kg basis assuming the children studied by Nakagawa et al weighed 26 kg, the young women were 58 kg, and the men were 70 kg. It must be emphasized that these data have all been obtained with limited number of subjects and with the exception of the data on adult women, the value selected was a value judgment of an amount which seemed likely to be enough to cover the needs of the subjects examined. I do not wish to be overcritical — this may be the best value we can arrive at — but the fact remains that we have no real basis to judge the accuracy of the estimate.

Generally speaking, Table 1 indicates a fall in the requirement per unit body weight with age. However, if one compares the values for infants and children, the estimated lysine need of the children is about 40% that of the infants whereas the tryptophan value is only 15%. Similarly, the values for adult women compared to infants vary from 4% (methionine) and 5% (phenylalanine) to 10% (valine) and 13% (tryptophan). The question, of course, is whether these differences are real or happenstncial.
Human Amino Acid Requirements and Protein Quality

TABLE 1
Estimates of Amino Requirements

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<th></th>
<th>Infants (1)</th>
<th>Children (2)</th>
<th>Adult Male (3)</th>
<th>Adult Female (4)</th>
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<tr>
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<td>mg/kg</td>
<td>mg/kg</td>
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</table>

1. Taken from Reference 14.
2. Taken from References 14, 15 and 16. Children 10-12 years of age, 26 kg assumed weight.
3. Taken from Reference 17. Assumed to be 70 kg in weight.
4. Taken from Reference 18. Assumed to be 58 kg in weight.
5. Taken from Reference 19. Recalculation of data reviewed by Leverton in 18.

If one tries to look at the proportions of amino acids (Table 2), we have to realise that the accuracy of a ratio is determined by the accuracy of both the numerator and the denominator. If we happen to select a relatively inaccurate figure for one of these, the ratios will be changed markedly. In Table 2, I have calculated the ratios of the values in Table 1 using either threonine or tryptophan as the denominator. These give a quite different impression. Note that the estimated lysine need relative to tryptophan is 4.7, 13.3, 3.1, 4.0 and 3.2 for the various groups whereas the lysine: threonine ratio is 1.2, 1.6, 1.6, 1.8 and 1.4. These differences in part reflect the difference in the tryptophan: threonine ratios. In spite of the fact that early judgments were made that these data indicated a constant pattern of requirements, it is easier to reach the opposite conclusion.

One can make some value judgments. I suspect that the estimates of tryptophan requirements for infants and children are on the low side, for example, but this only a suspicion. I do conclude that we should be careful that we do not overwork these estimates and we should be careful that we do not attach great reliability to them.
Fig. 5. Nitrogen balance at various levels of lysine in young women (dark circles) and in men (open circles). Estimated requirement for balance and range of the standard error of the estimate, based on dark circles, are shown.

Fig. 6. Nitrogen balance in young women (dark circles) and men (open circles) at various levels of tryptophan. Estimated requirement for balance and the range of the standard error of the estimate are shown.
**TABLE 2**

Proportion of Amino Acids Required
(Data from Table 1)

|                | Infants | Children |  | Adult Male |  | Original | Calculated |
|----------------|---------|----------|  |           |  |          |            |
|                | Tr* Th**|          |  |            |  |          |            |
| Histidine      | 1.5     | 0.4      |  |  |  |          |            |
| Isoleucine     | 5.4     | 1.4      |  | 8.5 1.0    | 2.8 1.4 | 2.9 1.6   | 3.3 1.5    |
| Leucine        | 6.8     | 1.7      |  | 12.6 1.5   | 4.5 2.3 | 4.0 1.8   | 3.2 1.4    |
| Lysine         | 4.7     | 1.2      |  | 11.3 1.6   | 3.1 1.6 | 4.0 1.8   | 3.2 1.4    |
| Methionine     | 3.6     | 0.9      |  |      |  | 2.1       | 1.1 0.5    |
| Total S        | 5.7     | 1.4      |  | 6.6 0.8    | 4.5 2.3 | 3.2 1.8   | 4.1 1.8    |
| Phenylalanine  | 4.1     | 1.0      |  |      |  | 0.8       | 1.5 0.7    |
| Total A        | 5.6     | 0.8      |  |      |  | 6.6 0.8   | 4.5 2.3    |
| Threonine      | 3.9     | 1.0      |  | 8.5 1.0    | 1.9 1.0 | 1.8 1.0   | 2.2 1.0    |
| Tryptophan     | 1.0     | 0.25     |  | 1.0 0.12   | 1.0 0.51 | 1.0 0.56  | 1.0 0.45   |
| Valine         | 4.8     | 1.2      |  | 7.6 0.9    | 3.1 1.6 | 4.0 2.2   | 3.7 1.7    |

*Proportion relative to Tryptophan
**Proportion relative to Threonine

Another approach which may be used to estimate amino acid requirements is to attempt to explain minimal protein needs with various proteins on the basis of their amino acid content as originally proposed by Harte and Travers. Whether this may be any more satisfactory than feeding amino acids I am unprepared to say at this time. It is worth pointing out that as has been emphasized by Almquist in chicks at least it is fairly clear that the amount of amino acid required per unit protein appears to rise as protein intake is raised.

The conclusions that must be reached, I believe, are that our information and basic understanding of amino acid requirements and the relationship of these to protein quality is generally less satisfactory than most people believe or than the publications of FAO/WHO or the Food and Nutrition Board have led many to believe. It is unfortunate that the research effort in this area at this time is also far below that required to reach solutions to the problems in the near future.

**REFERENCES**

In order to survive, animals must have the capacity to adapt to changes in both the external and internal environments. Thus metabolism and cell function must be able to respond to such variations in the external environment as heat and cold, and especially to the intermittent availability of food. In consequence of these demands, the cells of the body have to be equipped to make both short-term and long-term adaptive metabolic reactions. Thus, the transient physiological adaptations of protein metabolism to intermittent intake of meals account for a large part of the diurnal variations in protein metabolism of the mammal. Among long-term adaptive reactions are those that occur when there is a decrease in availability of an essential nutrient in the diet. The regulatory mechanisms through which the animal makes adjustments in metabolism to suit these situations usually involve changes at the subcellular level and also integrated cooperation between tissues, frequently including secretion of hormones. A comprehensive description of these adaptive reactions is given elsewhere. In the present survey, we shall consider the participation of some of these adaptive mechanisms in regulating the response of the body to changes in protein intake.

**REGULATION OF LIVER PROTEIN METABOLISM IN RESPONSE TO INTAKE OF PROTEIN:**

Dietary protein is presented to the tissues in the form of free amino acids, which are then utilized by numerous metabolic pathways. For purposes of simplification, however, amino acid utilization can be reduced to three distinct types of function (a) protein synthesis, (b) the synthesis of small nitrogenous molecules, such as creatine, and (c) pathways of amino acid catabolism. Changes in these various routes of amino acid utilization are illustrated by the events occurring in the liver after consuming a meal containing protein. Following such a meal, the liver is subjected to a much greater increase in free amino acid supply than other tissues because of the
considerably greater increase in free amino acid levels in the portal blood than in the systemic circulation. The role of the liver in determining how much of this incoming load of amino acids is destroyed or retained in the liver, or transformed into plasma proteins, has been measured with some precision by Elwyn. Using dogs with cannulas in the portal vein, the splenic artery (to represent arterial blood going into the liver by way of the hepatic artery) and the hepatic vein leaving the liver, he was able to monitor continuously the exchange of amino acids across the liver during a 24-hour period after feeding a large meal of meat to his animals. The meal was absorbed during the first 12 hours, and 57% of the amino acid nitrogen was transformed to urea as it passed through the liver; a further 6% of the incoming amino acid load was secreted from the liver as plasma proteins during the 12-hour period, 14% was retained in the liver as protein, and only 23% entered the general circulation as free amino acids and was thus available to the tissues generally. These data indicate that, when large amounts of protein are fed, the systemic circulation is protected against excessive changes in free amino acid concentration by metabolic changes occurring within the liver as it monitors the incoming flow of amino acids received from the portal vein. A major question not answered by these studies is whether the proportion of amino acids catabolized to urea by the liver diminishes when a diet lower in protein is fed, so that more of the incoming amino acids are allowed to pass into the general circulation.

The changes in the liver following a meal of protein are not simply the result of mass action due to increased intracellular concentrations of amino acids, but involve complex adaptive changes. These mechanisms of adaptation have been explored by many investigators. As Elwyn concluded from indirect evidence, they involve a transient accumulation of liver protein during absorption that is later dissipated during the post-absorptive period. This effect of amino acid supply on liver protein synthesis has been amply substantiated by direct evidence. For example, we fed rats by stomach tube on amino acid mixtures that were either nutritionally complete or lacked tryptophan, and killed both groups of animals one hour later. Microsomes prepared from the livers of animals fed the complete mixture showed a greater capacity for in vitro protein synthesis than did microsomes prepared from animals fed the tryptophan-deficient amino acid mixture (Table 1). Since microsomes function in protein synthesis because of aggregates of ribosomes (polysomes) present in this cell fraction, these studies were repeated using the abundance of polysomes in liver as the criterion of change. When fasting rats were given the amino acid mixture that was nutritionally complete, the large polysome aggregates on which liver proteins are made were increased and the populations of monosomes and disomes
diminished by comparison with the profiles obtained from fasting animals (Fig. 1). However, when an amino acid mixture lacking tryptophan was fed, there were fewer polysomes than seen in the livers of the fasting rats, and monosomes and disomes were more numerous. This disaggregation of polysomes after feeding the tryptophan-deficient mixture could be rapidly reversed by administering an amino acid mixture containing tryptophan. It can be concluded that the polysome system responsible for protein synthesis in the liver is sensitive not only to changes in the amounts of amino acids arriving at the liver but also to variations in the nutritional quality of the mixture, and that these responses of liver protein synthesis to amino acid supply occur very rapidly.

**TABLE 1**

*In vitro* uptake of $^{14}$C-leucine by microsomes from rats fed one hour before death with either a complete or tryptophan-deficient amino acid mixture. Some animals were pretreated with actinomycin D.*

<table>
<thead>
<tr>
<th>Actinomycin</th>
<th>Incubation time (min.)</th>
<th>Counts/min/mg. Microsome Protein</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Incomplete Amino acids</td>
<td>Complete Amino acids</td>
</tr>
<tr>
<td>None</td>
<td>10</td>
<td>3690</td>
<td>4630</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>4600</td>
<td>5580</td>
</tr>
<tr>
<td>Pre-treated</td>
<td>10</td>
<td>2020</td>
<td>2540</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>2520</td>
<td>3550</td>
</tr>
</tbody>
</table>

*Taken from Reference 5.

The intracellular site of the response to amino acids has been examined. Rats were pre-treated with actinomycin D before feeding the amino acid mixtures, and the capacity of the liver microsomes to incorporate $^{14}$C-leucine and the polysomes obtained from their livers were then examined as before. The response of both of these parameters to the complete and to the tryptophan-deficient amino acid mixtures was still obtained in the actinomycin-treated animals (Table 1). This indicates that the response of the liver protein-synthesizing mechanism to amino acid supply is independent of an increased formation of messenger RNA in the nucleus, which is prevented by treatment with actinomycin. Consequently, the mechanism involved is likely to be cytoplasmic in nature, and it should be possible to construct a cell-free cytoplasmic system that mimics the changes in protein synthesis and in polysome aggregation when amino acid supply is varied. We have in fact been able to do this.* An *in vitro* system for incorporating
labelled amino acids into peptide chains was constructed from liver poly-
somes, tRNA, activating and transferring enzymes. ATP and GTP. The
predicted changes in rate of amino acid incorporation were obtained when
a complete mixture of amino acids was added to the system, but deletion
of any one of the amino acids from the mixture resulted in failure of amino
acid incorporation. Using the same in vitro system, it was possible to
demonstrate that polysome aggregation was also dependent on the provision
of a complete supply of amino acids.

![](image)

**Fig. 1:** Changes in liver polysome profiles caused by feeding fasting rat with either a
complete amino acid mixture (.........) or a mixture lacking tryptophan (..........)
and killing one hour later. The dashed line (-----) represents the profile in fasting
animals. (From Wunner, Bell and Munro, 1966).

These studies with the reconstructed cytoplasmic system for protein
synthesis confirm that changes in polysome profile can be brought about
by alterations in amino acid supply and that the participation of the nucleus
is not essential. There is, however, one difference between the cell-free
system and the intact animal in their responses to amino acid supply.
Further study of polysome aggregation in intact rats has demonstrated that
feeding amino acid mixtures deficient in essential amino acids other than
tryptophan fails to produce the disaggregation of polysomes characteristic
of tryptophan deficiency. It has therefore been suggested that the special
sensitivity to tryptophan of the polysome population in the liver of the
intact rat occurs because tryptophan is normally the least abundant amino acid in the free amino acid pool of the liver and thus limits the rate of protein synthesis. The considerable recycling of amino acids as a result of protein turnover maintains the levels of free amino acids even in the liver of the fasting animal. In contrast, the cell-free system for amino acid incorporation can be depleted of any amino acid to trace amounts, and thus each amino acid can be made rate-limiting in vitro. Recently, we have been able to show changes in liver polysome patterns related to the dietary supply of other amino acids than tryptophan if the rats are first depleted of liver protein to reduce recycling within the liver cell, and are then fed severely imbalanced amino acid mixtures. Under these conditions, polysome changes dependent on availability of threonine and of isoleucine were observed. This would appear to strengthen the concept that the least abundant free amino acid can be rate-limiting for liver protein synthesis. 

Along with these changes in liver polysome aggregation, amino acid supply appears to be responsible for alterations in RNA turnover in the liver cell. Rats deprived of a complete supply of amino acids show not only more monosomes in the cells of their livers, but also accumulate ribosomal subunits. This appears to increase the rate of breakdown of RNA, presumably by activating ribonuclease. This has been confirmed by recent studies on the effect of protein intake on the rate of breakdown of liver RNA. From these various pieces of evidence we can construct a picture of the adaptive changes in protein and RNA metabolism in the liver that occur after eating a meal containing protein (Fig. 2). Liver protein synthesis is accelerated by the supply of amino acids passing up the portal vein; at the same time, rate of protein degradation is slowed because enzymes involved in amino acid metabolism are stabilized by excess of their substrates. In addition, RNA breakdown is retarded, so that the amounts of protein and of RNA in the liver show a parallel increase. When the absorption of dietary amino acids ceases, the stimulus to protein synthesis ceases and the liver loses both protein and RNA at an accelerated rate.

In view of the observations just described, it is not surprising to find that there are diurnal variation in liver protein metabolism which appear to be mainly related to the intermittent consumption of protein in meals. In contrast, it would appear that plasma amino acid concentrations undergo an independent diurnal cycle that is related to nutritional factors in a more complex fashion. We have recently correlated the diurnal cycles in liver polysome aggregation and in the activity of the liver enzyme tyrosine aminotransferase in the case of rats subjected to a 12-hour alternating cycle.
Fig. 2: Scheme showing interrelationship of amino acid supply to protein synthesis and turnover and to RNA turnover in the liver cell. (From Munro, 1970).

of light and dark. Under these circumstances, the rats adopt a feeding pattern that begins towards the end of the lighting period, reaches a maximum during the early hours of darkness, and slows down again before the light comes on. Figure 3 shows that polysome aggregation is least in the middle of the light period, then starts to increase as feeding begins, reaches a maximum in the middle of the dark period, and by the beginning of the next light period shows extensive disaggregation once more. The activity of tyrosine aminotransferase, an enzyme initiating the degradation of tyrosine, follows an essentially parallel diurnal pattern. A detailed discussion of these diurnal changes in liver protein metabolism has been provided by Wurtman, who shows that the cyclical changes in aminotransferase activity are, like the polysome patterns, likely to be due to intermittent intake of tryptophan in each meal.
Fig. 3: Diurnal rhythms in polysome profile and tyrosine amino-transferase activity in rats subjected to 12 hours of darkness and 12 hours of light. Note that spontaneous eating occurs towards the end of the light period and terminates in the middle of the dark period. (Fishman et al., 1969).

ADAPTIVE CHANGES IN AMINO ACID METABOLISM IN RESPONSE TO DIFFERENT AMINO ACID INTAKES:

From the experiments just described with liver tyrosine transaminase and from many other published studies, there is abundant evidence to show that the enzymes of amino acid metabolism are subject to adaptive changes related to intake of amino acids. In view of the studies of Elwyn described above, in which a large excess of dietary protein resulted
in extensive amino acid degradation in the liver, it would be interesting to know whether increases in the levels of enzymes degrading essential amino acids only occur when an excess of a given amino acid over requirements is present in the diet. Harper\(^5\) has described studies of liver enzymes in rats receiving different levels of dietary casein from insufficient up to excessive quantities which would seem to support this concept. Threonine-serine dehydratase activity in the liver remained low until the casein content of the diet reached 20%; at higher casein intakes, enzyme activity rose steeply (Fig. 4). On the other hand, a transaminase handling the non-essential amino acid glutamic acid increased linearly in proportion to the intake of casein over the whole range of casein intakes. While these observations satisfy the prediction that essential amino acids will be conserved until consumed in excessive quantities, the picture is probably more complex than these data suggest. In the first place, at least some of the liver enzymes involved in amino acid catabolism, including threonine-serine dehydratase, show changes in activity related to intake of tryptophan and not to intake of their substrate\(^1\). Second, a few of the principal degradative enzymes for the essential amino acids are not confined to the liver, notably those for the branched-chain amino acids which occur in highest amount in muscle\(^6\). More comprehensive surveys of the response to protein intake of enzymes involved in amino acid catabolism must therefore be undertaken before this interesting hypothesis can be accepted.

Another aspect of the relationship between adequacy of essential amino acid intake and their metabolic fate is provided by studies of plasma amino acid levels. It is well known that the administration of a diet low in one essential amino acid results in a depression in the plasma level of the deficient amino acid without corresponding changes in the plasma levels of other amino acids\(^5\). Several investigators\(^7\) have extended this type of study by adding increasing amounts of the limiting essential amino acid to a deficient diet and observing the changes occurring in the free amino acid levels in the blood as the intake of the limiting amino acid progressed from insufficient to excess. Figure 5 shows that in the case of lysine which is required by growing chicks, the plasma level of this amino acid did not rise appreciably until the lysine intake represented 0.8% of the diet, after which there was a sharp rise in plasma lysine concentration\(^7\). Maximal growth rate was also attained when the lysine content of the diet reached 0.8%. This means that the dietary concentration of lysine at which the plasma level of that amino acid begins to rise sharply is an indicator of adequacy of lysine intake. These authors made similar studies with arginine and valine. These observations suggest an approach that could prove useful in measuring the amino acid requirements of human
subjects. Indeed, Young et al. have recently examined the effect of giving increasing levels of dietary tryptophan to young adults on the free tryptophan content of their plasma and on their N balances. This confirmed the relationship between adequacy of essential amino acid intake and blood levels. At intakes of tryptophan below 3 mg per kg., the plasma levels of tryptophan were low and constant. Between intakes of 3 and 5 mg tryptophan per kg., plasma tryptophan concentration rose sharply but at intakes beyond 5 mg it reached a second plateau at a much higher level. The sharp increment at 3 mg. intake was taken to mean that the requirements of the subjects had been met at this point. Presumably the second plateau represents induction of tryptophan pyrrolase in the liver. Nitrogen balance measurements showed that they attained N equilibrium between 2 and 2.6 mg tryptophan per kg., however, the authors point out that no allowance was made for integumental and sweat losses in measuring N balance, and in all probability the true N equilibrium was not attained until an intake of about 3 mg. tryptophan per kg. body weight had been
Interrelationships Between Hormones and Amino Acid Metabolism:

Some years ago, we showed that, when a meal consisting of carbohydrates is eaten, there is a rapid fall in the levels of free amino acids in the plasma. This effect does not occur after fat administration. All the essential amino acids and most of the non-essential amino acids show a reduced concentration after carbohydrate administration. In later labelling studies, Munro et al. demonstrated that glucose administration causes an increase in muscle uptake of amino acids. In order to obtain this deposi-
tion, the secretion of insulin is required. Since most meals contain large amounts of carbohydrate, blood amino acid levels can sometimes be depressed instead of being raised following a meal if it contains only limited amount of protein. This carbohydrate phenomenon contributes considerably to diurnal variations in plasma amino acid levels, and in consequence, these plasma rhythms are quite distinct in timing and in mechanism from the rhythms occurring in the liver enzymes of amino acid degradation. In addition, the utilization of protein given in the same meal is affected by dietary carbohydrate. It seems that deposition of the incoming amino acids in muscle as a result of the stimulus of the carbohydrate of the meal reduces their rate of degradation in the liver.

The above studies of the action of carbohydrate indicate that hormonal secretion can mediate the response of protein metabolism to diet. Recent work shows that the levels of free amino acids in plasma may well influence rates at which growth hormone, adrenocortical hormones, and glucagon, as well as insulin, are secreted. All of these hormones are extensively involved in the metabolism of amino acids, so that changes in their secretory rate in response to alterations in blood amino acid levels would suggest some sort of feedback regulatory mechanism. Indeed, Felig et al. have found that the plasma levels of the branched-chain amino acids as well as tyrosine and phenylalanine are permanently raised in obese subjects, and that insulin level is also elevated. From these observations, they propose (Fig. 6) that these plasma amino acids act as feedback regulators stimulating insulin secretion in an attempt to accelerate the passage of plasma amino acids into muscle. Since obese people suffer from resistance to this action of insulin, the level of amino acids in the plasma remains elevated and the secretion of insulin is persistently stimulated.

REGULATION OF AMINO ACID METABOLISM IN RELATION TO MAMMALIAN BODY SIZE:

Mammals vary in mature body size from a few grams to thousands of kilograms. In general, intensity of metabolism per unit of weight is profoundly affected by size of species, becoming progressively less with increasing body weight. Table 2 shows representative data for the effect of body size on some metabolic parameters. It has long been recognized that energy metabolism decreases in intensity with increasing species size. Thus, in relation to body weight, the rat has an energy metabolism five times as intense as the energy metabolism of man. The greater need of the rat for energy causes the rat to consume five times more food per kg of body weight; consequently, the rat also eats five times more protein per kg.
of its weight than does man. Thus the daily flux of dietary protein and of amino acids is much more intense in the case of the rat than in the case of man.

The rate of synthesis of body proteins also declines with increasing size of species. Thus, turnover of plasma albumin decreases from a half-life of about 1 day in the mouse down to 21 days in the case of the cow (Table 3). In view of this systematic slow-down of the rate of protein synthesis with increasing size of animal, the RNA contents of the livers of various animals from the mouse to the cow were measured. It was found that the RNA content per unit of liver DNA fell progressively with increasing body size\(^2\). This indicates that the liver cells of larger mammals have less protein-synthesizing apparatus coincident with the slower rate of protein formation by these cells. It can also be concluded that the requirement for amino acids to carry out protein synthesis is proportionately less in larger animals. It is accordingly not surprising that requirements for essential amino acids show the expected relationship to body size in the few cases in which suitable data on more than one species are available. For example, the requirement for threonine and for methionine per kg. of body weight is about four times smaller in man than in the rat (Table 2).

![Feedback mechanism proposed for regulation of insulin secretion in response to increased amino acid levels in the blood of obese subjects (Felig et al, 1969).](image)
Protein Metabolism and Human Nutrition

TABLE 2
The Influence of Body Size on Protein and Energy Metabolism and Amino Acid Requirements*

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Amount of metabolic component per kg of body weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For 200 gm rat</td>
</tr>
<tr>
<td>Basal energy metabolism (Kcal/day)</td>
<td>308</td>
</tr>
<tr>
<td>Total energy metabolism (Kcal/day)</td>
<td>190</td>
</tr>
<tr>
<td>Threonine requirement (mg/day)</td>
<td>28</td>
</tr>
<tr>
<td>Methionine requirement (mg/day)</td>
<td>56</td>
</tr>
<tr>
<td>Total body protein synthesis (mg N/day)</td>
<td>1010</td>
</tr>
</tbody>
</table>

*Taken from Reference 25.

TABLE 3
Plasma Albumin Turnover, Liver Cell Composition per Milligram DNA, and Composition of Liver Microsomes of Different Mammals Arranged in Ascending Order of Weight*

<table>
<thead>
<tr>
<th>Species</th>
<th>Half-life of plasma albumin (days)</th>
<th>Whole liver composition</th>
<th>Microsome fraction (% of total dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RNA DNA Phospholipid</td>
<td>RNA DNA Phospholipid</td>
<td>DNA DNA DNA Protein Phospholipid</td>
</tr>
<tr>
<td>Mouse</td>
<td>1.2 4.45 14.2</td>
<td>86 9.6 24.2</td>
<td></td>
</tr>
<tr>
<td>Rat</td>
<td>2.5 3.05 9.8</td>
<td>60 7.3 22.9</td>
<td></td>
</tr>
<tr>
<td>Rabbit</td>
<td>5.7 2.44 11.6</td>
<td>77 6.2 22.2</td>
<td></td>
</tr>
<tr>
<td>Dog</td>
<td>8.2 1.69 9.4</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>20.7 1.29 8.7</td>
<td>47 5.9 31.3</td>
<td></td>
</tr>
</tbody>
</table>

*Taken from Reference 26.
In view of this systematic reduction in protein synthesis rate with increasing body size, it might be assumed that the free amino acid levels in the plasma and tissues of man would be lower than in the body of the rat. However, comparison of the plasma amino acid levels in different species shows that there are no consistent changes related to size of animal\(^6\). As pointed out above, the intake per kg. body weight of both total protein and of individual amino acids is much less in man than in smaller animals (Table 3). Consequently, the rate of replacement of the free amino acid pool by the dietary amino acids must be progressively slower in animals of increasing body size. Comparison of the total daily intake of essential amino acids by different mammals with the total pool of free essential amino acids in their tissues shows that the body pool of free amino acids is small in relation to the amino acid intake of smaller species but considerable in the case of larger species\(^6\). This must have a significant buffering effect on the impact of dietary amino acids consumed by the larger mammals.

In conclusion, these studies emphasize the considerable effect of species size on intensity of protein metabolism. These findings have some importance when comparisons are made between data on small animals such as the rat with results obtained on large mammals such as man.

REFERENCES

EVALUATION OF PROTEIN QUALITY

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The primary function of dietary proteins is to provide amino acids in appropriate patterns for the synthesis of tissue proteins during growth and reproduction, for the replacement of the endogenous losses of tissue proteins and for other metabolic needs. The nutritive value of a dietary protein is an expression indicating its ability to meet the protein needs of the body. In evaluating the quality of proteins, we have to take into consideration the following: (i) The essential amino acid content and availability of amino acids; (ii) Factors which affect the quality of proteins and (iii) Methods for evaluating protein quality.1-3 Among the factors which affect protein quality, the most important are (i) Amino acid content and availability of amino acids; (ii) Amino acid imbalance; (iii) Interference of non-available carbohydrates in digestion and absorption; (iv) Interference by trypsin and growth inhibitors in absorption and utilization and (v) Influence of heat processing on protein utilization.4,5 In view of the complex factors mentioned above, the nutritive value of the proteins present in a food or diet will have to be assessed by (i) animal experiments and (ii) by experiments on human subjects.1,3 Among the several biological methods available for the evaluation of protein quality, the following two methods are widely used: (i) Determination of protein efficiency ratio by rat growth method and (ii) Determination of net protein utilisation (NPU) of the protein. The Committee on protein malnutrition of the Food and Nutrition Board, National Academy of Sciences, U.S.A.3 has stressed the need for conducting growth and nitrogen metabolism studies in infants and children for assessing the quality of dietary proteins. In addition, it will be desirable to assess the value of certain protein rich foods of vegetable origin such as oilseed meals and legumes in the treatment and prevention of protein deficiency states in children as compared with standard protein like milk proteins, since protein-calorie malnutrition occurs widely among pre-school children in the developing countries.6,7

ESSENTIAL AMINO ACID CONTENT AND AVAILABILITY OF AMINO ACIDS

Determination of essential amino acid contents of proteins:

The first step in the evaluation of a protein is the determination of the content of essential amino acids. The methods used for determining the
Evaluation of Protein Quality

Contents of individual essential amino acids in proteins are, chemical, microbiological and chromatography. The chemical methods yield accurate results only for some of the essential amino acids. The microbiological methods yield reliable results for all essential amino acids and have been widely used for this purpose. Methods based on chromatographic separation of amino acids using ion-exchange resin columns have proved quite accurate and rapid. Automation of the procedures was first introduced in 1958 by Spackman, Stein and Moore and several models of automatic amino acid analysers are being manufactured by some firms. Such instruments are widely used during recent years for the determination of the amino acid contents of dietary proteins.

Determination of the amino acid content is usually done by acid hydrolysis of the proteins. During this process, tryptophan is almost completely destroyed while partial destruction of some of the other amino acids viz. cystine, methionine, threonine may take place. The conditions for conducting the acid hydrolysis with minimal destruction of the essential amino acids have been studied by several workers. For the assay of tryptophan, alkaline hydrolysis of the protein is resorted to. During alkaline hydrolysis racemisation of amino acids takes place and appropriate corrections will have to be made if microbiological assays are used. The amino acids commonly deficient in certain dietary proteins are lysine, sulphur amino acids, threonine and tryptophan. The contents of these amino acids in some foods are given in Table 1.

Chemical Score:

The nutritive value of protein depends on the quantity of essential amino acids present in it. If one or more essential amino acids are not present in adequate amounts, the nutritive value of the protein will be low depending on the degree of deficiency. Egg proteins contain all essential amino acids in adequate amounts and possess the highest nutritive value among dietary proteins. Block and Mitchell assigned a chemical score of 100 to egg proteins and evolved a system of chemical score for rating the nutritive value of other dietary proteins, by expressing the quantity of most limiting amino acids in different food proteins as a percentage of the same amino acid present in egg proteins. The chemical scores of some dietary proteins are given in Table 1.

Determination of Availability of Amino Acids:

A number of methods have been standardized for determining the amino acid availability from proteins present in different foods. These can be
### TABLE 1

<table>
<thead>
<tr>
<th>Protein source</th>
<th>Most limiting amino acids</th>
<th>Lysine</th>
<th>Methionine</th>
<th>Cystine</th>
<th>Total Sulphur</th>
<th>Threonine</th>
<th>Tryptophan</th>
<th>Chemical Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg, Hens</td>
<td></td>
<td>6.4</td>
<td>3.1</td>
<td>2.3</td>
<td>5.4</td>
<td>5.0</td>
<td>1.7</td>
<td>100</td>
</tr>
<tr>
<td>Milk, Cow's</td>
<td>S</td>
<td>7.9</td>
<td>2.5</td>
<td>0.9</td>
<td>3.4</td>
<td>4.7</td>
<td>1.4</td>
<td>63</td>
</tr>
<tr>
<td>Milk, Human</td>
<td>S</td>
<td>8.6</td>
<td>2.4</td>
<td>2.0</td>
<td>4.4</td>
<td>4.5</td>
<td>1.7</td>
<td>80</td>
</tr>
<tr>
<td>Beef, Muscle</td>
<td>S</td>
<td>8.7</td>
<td>2.5</td>
<td>1.3</td>
<td>3.8</td>
<td>4.5</td>
<td>1.2</td>
<td>70</td>
</tr>
<tr>
<td>Fish</td>
<td>TRY</td>
<td>8.8</td>
<td>2.9</td>
<td>1.3</td>
<td>4.2</td>
<td>4.3</td>
<td>1.0</td>
<td>60</td>
</tr>
<tr>
<td>Rice Milled</td>
<td>LYS, THRE</td>
<td>3.9</td>
<td>2.2</td>
<td>1.8</td>
<td>4.0</td>
<td>3.3</td>
<td>1.2</td>
<td>60</td>
</tr>
<tr>
<td>White wheat</td>
<td>LYS</td>
<td>2.2</td>
<td>1.2</td>
<td>2.2</td>
<td>3.4</td>
<td>2.6</td>
<td>1.1</td>
<td>33</td>
</tr>
<tr>
<td>Corn Meal</td>
<td>TRY</td>
<td>2.9</td>
<td>1.9</td>
<td>1.3</td>
<td>3.2</td>
<td>5.0</td>
<td>0.6</td>
<td>40</td>
</tr>
<tr>
<td>Soya flour</td>
<td>S</td>
<td>6.3</td>
<td>1.1</td>
<td>1.8</td>
<td>3.1</td>
<td>3.9</td>
<td>1.4</td>
<td>57</td>
</tr>
<tr>
<td>Peanut flour</td>
<td>S, LYS, THR</td>
<td>3.6</td>
<td>0.9</td>
<td>1.5</td>
<td>2.4</td>
<td>2.7</td>
<td>1.1</td>
<td>44</td>
</tr>
<tr>
<td>Sesame seed</td>
<td>LYS</td>
<td>2.6</td>
<td>2.6</td>
<td>2.2</td>
<td>5.0</td>
<td>3.1</td>
<td>1.5</td>
<td>40</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>LYS, S</td>
<td>4.3</td>
<td>1.4</td>
<td>1.6</td>
<td>3.0</td>
<td>3.5</td>
<td>1.2</td>
<td>60</td>
</tr>
<tr>
<td>Peas</td>
<td>S</td>
<td>11.4</td>
<td>1.3</td>
<td>1.2</td>
<td>2.5</td>
<td>4.9</td>
<td>0.7</td>
<td>45</td>
</tr>
<tr>
<td>Navy bean</td>
<td>S</td>
<td>7.9</td>
<td>1.2</td>
<td>1.0</td>
<td>2.2</td>
<td>5.2</td>
<td>0.7</td>
<td>42</td>
</tr>
</tbody>
</table>
mainly classified as (i) Chemical methods; (ii) Enzymic methods; (iii) Microbiological methods; and (iv) Animal assays.

(i) **Chemical methods:**

A chemical method for determining the availability of lysine from protein has been standardized by Carpenter employing Sanger’s reagent (fluorodinitrobenzene). It makes use of the reaction of fluorodinitrobenzene (F-DNB) with the free E-amino group of lysine in proteins. E-dinitrophenyllysine (E-DNP-lysine) released after subsequent hydrolysis is measured colorimetrically. The results obtained by this method showed good agreement with those of biological assays on a wide range of processed foods like milk powder, fish flour and cottonseed flour.

(ii) **Enzymic methods:**

Enzymic *in vitro* analytical procedures for determining the availability of amino acids have been developed by some workers. Sheffner et al. described a method for determining the amino acid index of different proteins. This index combines the pattern of essential amino acids released by *in vitro* pepsin digestion with the amino acid pattern of the remainder of the protein to produce an integrated index. It has been called the Pepsin-Digest-Residue (P.D.R.) amino acid index. The method of Sheffner et al is however quite laborious since 10 amino acids have to be determined in the acid hydrolysate as well as in the pepsin digest. Mauron et al. determined the availability of tryptophan, methionine and lysine by *in vitro* digestion with enzymes with simultaneous dialysis. The procedure was applied to heat-processed milk and the results were in good agreement with the protein efficiency ratio determined with albino rats. This method like that of Sheffner et al is long and cumbersome and cannot be adopted as a routine technique for the evaluation of protein.

(iii) **Microbiological methods:**

Ford has used the organism *Streptococcus zymogenes* NCDC 592 for estimating the availability of different amino acids in a variety of food proteins. The organism is vigorously proteolytic and requires exogenous methionine, leucine, isoleucine, histidine, tryptophan and valine. Values obtained for available methionine, tryptophan, leucine and arginine closely correlated with the rat assay values. This method was successfully adopted by Carpenter et al. and Narayana Rao et al. for determining the available methionine in freeze-dried herring press cake processed under different conditions and in casein-glucose reaction mixtures, respectively.
(iv) **Animal assays:**

Methods to estimate *in vivo* availability of individual amino acids have been developed by several authors using albino rats as the experimental animal. Kuiken and Lyman and Kuiken studied the availability of 10 essential amino acids in different foods (Table 2). Calculations were based on determinations of the amino acids in the food and faeces. Corrections for the metabolic amino acids in the faeces were made from control period in which a low-protein egg ration was fed. Schweigert and Guthneck determined the availability of lysine and methionine based on weight recovery of protein depleted rats. Deshpande et al. evaluated the availability of isoleucine using growth response in young rats. Gupta et al. measured the availability of amino acids on the basis of growth response and amino acid determination in food and faeces of rats. The draw back in the above methods is the difficulty to differentiate the amount of amino acids in the faeces, contributed separately by the intestinal bacteria and by the diet.

<table>
<thead>
<tr>
<th>Name of Foods</th>
<th>Name of amino acids</th>
<th>Availability %</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>10 essential amino acids</td>
<td>92-100</td>
<td>19</td>
</tr>
<tr>
<td>Peanut</td>
<td>Lyserine</td>
<td>49-98</td>
<td>20</td>
</tr>
<tr>
<td>Roasted beef</td>
<td>Methionine</td>
<td>48-83</td>
<td>20</td>
</tr>
</tbody>
</table>

### FACTORS AFFECTING PROTEIN QUALITY:

In addition to the essential amino acid contents and availability of amino acids, several other factors affect the nutritive value of the proteins. These are discussed below:

**Amino acid imbalance:**

Recent studies have shown that certain amino acids when present in excessive amounts increase the requirements of one or more amino acids and affect adversely the growth of experimental animals. A well known
Example is the imbalance between leucine and isoleucine in maize and sorghum.\textsuperscript{23,26}

Trypsin and growth inhibitors and other toxic factors:

Trypsin and growth inhibitors such as haemagglutinins present in various legumes exert a deleterious effect on the utilisation of protein for promoting the growth of animals.\textsuperscript{3}\textsuperscript{22,27,28} Optimal heat treatment has been found to inactivate the inhibitors and haemagglutinins and improve the quality of the proteins for promoting growth (Table 3). The mechanism of action of these inhibitors is however not fully known.

\textbf{TABLE 3}

Effect of inactivation of trypsin and growth inhibitors by optimal heat treatment on the growth promoting value of soyabean and blackbean proteins

\begin{tabular}{|l|c|}
\hline
Name of Foodstuffs & Growth of albino rats (g) \\
\hline
Soyabean, Raw & 10.6 \\
Soyabean autoclaved at 14 lbs. pressure for 30 minutes & 44.6 \\
Blackbean (Phascolus vulgaris), Raw & Loss in weight \\
Blackbean autoclaved at 16 lbs pressure for 30 minutes & 45* \\
\hline
\end{tabular}

* Reference No. 70

Effect of heat processing:

Heat processing produces both beneficial and deleterious effects on the nutritive value of proteins.\textsuperscript{3}\textsuperscript{30,31} The beneficial effects are due to the inactivation by heat of the trypsin and growth inhibitors, hemagglutinins, and other toxic factors present. The adverse effects are due to the decrease in availability of certain essential amino acids, such as lysine and methionine, as a result of reaction with reducing sugars and carbonyl compounds present in the food. This mechanism (Maillard reaction) has been extensively studied.\textsuperscript{32} The loss of amino acids depends on the severity of heat treatment and the moisture content of the food. In general, foods containing trypsin and growth inhibitors, such as legumes, show marked improvement in the nutritive value of their proteins on heat processing.\textsuperscript{30,31,32}

Severe heat processing of cereals, such as toasting, puffing and gun explosion techniques (Table 4) have been reported to cause drastic reduction in the nutritive value of the proteins.\textsuperscript{3}\textsuperscript{32} Less severe heat treatment as in cooking or baking, does not have this effect.\textsuperscript{32} The proteins of most legumes...
show marked improvement in their nutritive value as a result of heat processing, such as pressure cooking, toasting, or puffing, whereas the same treatment results in a decrease in the nutritive value of oilseed and nut proteins. Mild heat treatment, as in screw pressing, brings about slight improvement in the nutritive value of peanut proteins and marked improvement in that of soybean protein. It does not affect appreciably the proteins of coconut, cottonseed, sunflower and sesame.

ML. Swaminathan

TABLE 4

Effect of heat processing on the nutritive value of proteins

<table>
<thead>
<tr>
<th>Name of Food</th>
<th>Per</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cake mixture (wheat flour, egg white and lactalbumin)</td>
<td>3.4*</td>
</tr>
<tr>
<td>Cake (baked in the usual fashion and dried in the radiator overnight)</td>
<td>2.4</td>
</tr>
<tr>
<td>Rusk prepared from the cake (drying at 60°C overnight and toasted at 100-120°C for 30 minutes)</td>
<td>0.8</td>
</tr>
<tr>
<td>Whole wheat</td>
<td>1.8</td>
</tr>
<tr>
<td>Puffed wheat</td>
<td>Negative</td>
</tr>
</tbody>
</table>

* Reference No. 32

Non-available carbohydrates:

Whole cereals, legumes, nuts and oilseeds and vegetables contain varying amounts of carbohydrates such as cellulose, hemicelluloses, galactans, mannans, gums and pectin, which are unavailable to man, and are mainly excreted in the feces. Present mostly in the cell walls, they may also prevent the access of digestive juices to the proteins in the cells. Nitrogen balance studies with human subjects with whole cereals and millets containing fair amounts of unavailable carbohydrates indicate that the digestibility of the proteins is low, presumably due to the incomplete digestion of the proteins in the bran. Experiments with albino rats have shown that the digestibility coefficient of proteins of dehydrated leafy vegetables is low, whereas that of the protein concentrates prepared from leaves and grasses is high, since the latter are practically free from unavailable carbohydrates. The studies of Pretorius and Venter have shown that when carob flour rich in gums and mucilages was added to milk, the percentage of N absorption from milk was reduced from 81 to 59 (Table 5).

Level of protein in diet:

It is generally recognised that as the level of protein in the diet is increased beyond the optimal level there is a steady decline in the percentage of utiliza-
Evaluation of Protein Quality

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The level at which a food protein possesses the maximum nutritive value will depend on the essential amino acid composition of the protein. A complete protein like egg protein possesses the highest nutritive value at about 9-10% protein level beyond which there is a rapid decline in the nutritive value of the proteins. A protein with a medium nutritive value like peanut protein possesses the maximum nutritive value at about 15% protein level beyond which there is a steady decline in its nutritive value. Evaluation of protein quality is generally carried out at 10% protein level with foods containing 11% or more of proteins but in the case of foods containing less than 10% protein eg., some cereals and diets based on them, it is carried out at a level nearest to the protein content of the food or diet. In the case of protein foods meant for the treatment of protein malnutrition, it is necessary to assess the nutritive value of the proteins at 10, 15 and 20% levels as the food will have to be fed at a higher protein level, i.e. 15 to 20% for the treatment of protein malnutrition.

TABLE 5

Effect of non-available carbohydrates on the absorption of proteins

<table>
<thead>
<tr>
<th>Name of Food</th>
<th>Non-available carbohydrates %</th>
<th>Digestibility Coefficient %</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole meal bread</td>
<td>4.6</td>
<td>86</td>
<td>35</td>
</tr>
<tr>
<td>White bread</td>
<td>1.6</td>
<td>91</td>
<td>34</td>
</tr>
<tr>
<td>Ragi diet</td>
<td>6.8</td>
<td>68</td>
<td>34</td>
</tr>
<tr>
<td>Rice diet</td>
<td>1.6</td>
<td>83</td>
<td>72</td>
</tr>
<tr>
<td>Milk</td>
<td>-</td>
<td>81</td>
<td>37</td>
</tr>
<tr>
<td>Milk + Carob flour</td>
<td>-</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>

Effect of rate of release of essential amino acids on protein quality:

For the optimal utilization of proteins all the essential amino acids must be digested and absorbed at the same time. Melnick et al attributed the low growth rate of rats on raw soybean diet to the slow release of methionine as compared to the other essential amino acids by the proteolytic enzymes in the intestinal tract. They showed that methionine is released more rapidly from heat processed soybean than from raw soybean.

Effect of calorie intake on protein utilization:

Restriction in calorie intake affects adversely the utilization of dietary proteins. The data presented in Table 6 show that restriction of calorie intake to 66%, and 50% respectively brings about a marked decrease in the
NPU and NPR of casein. Similarly the supplementary value of a protein food to ragi diet is very much reduced (Table 7) when the calorie intake is restricted to 75% and 50% respectively.

**TABLE 6**

Effect of Calorie restriction on NPU & NPR of Casein
(8 males per group—Experimental period 10 days)

<table>
<thead>
<tr>
<th>Calorie intake</th>
<th>NPU</th>
<th>NPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kcal/day/rat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>59.3</td>
<td>3.53</td>
</tr>
<tr>
<td>24</td>
<td>44.8</td>
<td>2.25</td>
</tr>
<tr>
<td>16</td>
<td>19.8</td>
<td>0.74</td>
</tr>
</tbody>
</table>

**TABLE 7**

Effect of calorie restriction on the supplementary value of Indian Multipurpose Food to poor ragi diet

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Mean daily food intake (g/day)</th>
<th>Gain in body weight (g/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basal diet</td>
<td>MPF</td>
</tr>
<tr>
<td>I</td>
<td>8.0</td>
<td>—</td>
</tr>
<tr>
<td>II</td>
<td>7.2</td>
<td>0.8</td>
</tr>
<tr>
<td>III</td>
<td>6.0</td>
<td>—</td>
</tr>
<tr>
<td>IV</td>
<td>5.2</td>
<td>0.8</td>
</tr>
<tr>
<td>V</td>
<td>4.0</td>
<td>—</td>
</tr>
<tr>
<td>VI</td>
<td>3.2</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Effect of vitamin and mineral deficiencies in the evaluation of protein quality:

Studies on the evaluation of protein quality in diets based on different cereals have revealed that (1) the diets based on rice, wheat, pearl millet and sorghum are deficient in certain vitamins and minerals, besides protein and hence give a low PER; (2) if the deficiencies of vitamins and minerals are made up by the addition of salt mixture and vitamins premix, the PER is increased to a marked extent and the supplementary value of added
protein or limiting essential amino acids could be observed\(^a\) (Tables 8 and 9).

### TABLE 8

Effect of supplementation with vitamins, minerals and lysine on protein efficiency ratio of Sorghum and ragi diet\(^a\)

<table>
<thead>
<tr>
<th>Protein content</th>
<th>Increase in body weight (g/4 weeks)</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Percent a</td>
<td>Percent b</td>
</tr>
<tr>
<td>Poor Sorghum Diet (PSD)</td>
<td>9.8</td>
<td>26.5</td>
</tr>
<tr>
<td>PSD + Lysine</td>
<td>10.0</td>
<td>32.4</td>
</tr>
<tr>
<td>PSD + Lysine + Thr.</td>
<td>10.1</td>
<td>37.5</td>
</tr>
<tr>
<td>Poor Ragi Diet (PRD)</td>
<td>7.8</td>
<td>34.1</td>
</tr>
<tr>
<td>PRD + Lysine</td>
<td>7.9</td>
<td>52.8</td>
</tr>
<tr>
<td>PRD + Lys. + Thr.</td>
<td>7.9</td>
<td>63.0</td>
</tr>
</tbody>
</table>

(a) Without vitamins and minerals.
(b) With added vitamins and minerals.

### TABLE 9

Effect of supplementation with vitamins, minerals and redgram on the protein efficiency ratio of Sorghum and Ragi diets\(^a\)

<table>
<thead>
<tr>
<th>Protein content</th>
<th>Increase in body weight (g/4 weeks)</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Percent a</td>
<td>Percent b</td>
</tr>
<tr>
<td>Poor Sorghum diet (PSD)</td>
<td>10.3</td>
<td>33.5</td>
</tr>
<tr>
<td>PSD + Redgram</td>
<td>12.9</td>
<td>62.7</td>
</tr>
<tr>
<td>Poor Ragi diet (PRD)</td>
<td>8.1</td>
<td>37.1</td>
</tr>
<tr>
<td>PRD + Redgram</td>
<td>10.8</td>
<td>70.4</td>
</tr>
</tbody>
</table>

(a) Without vitamins and minerals.
(b) With added vitamins and minerals.

**Effect of stress on protein utilization:**

Different types of stresses such as infection, fever, injury, climatic extremes and psychological stress have been found to affect protein utilisation and requirements.\(^3\) They act either by interfering with the digestion and absorption of protein or by increasing the endogenous metabolism of tissue proteins.\(^4,5\) In the evaluation of protein quality using animals and human
subjects, care should be taken to see that the animals and human subjects are free from stresses likely to affect protein metabolism.

**BIOLOGICAL METHODS USING EXPERIMENTAL ANIMALS:**

A number of methods (Table 10) have been proposed by various workers for the evaluation of protein quality. Only a few of them measure the overall nutritive value of the protein e.g. PER, NPU and Biological value. Most of the other methods measure the protein needs of depleted animals or the protein needs for certain specific functions such as liver or blood protein regeneration (Table 10).

**TABLE 10**

Methods Available for the Evaluation of Protein Quality

<table>
<thead>
<tr>
<th>Methods Based on Growth and Body Weight Changes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein efficiency ratio</td>
</tr>
<tr>
<td>Net protein ratio</td>
</tr>
<tr>
<td>Gross protein value</td>
</tr>
<tr>
<td>Rat repletion method</td>
</tr>
<tr>
<td>Nitrogen growth index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods Based on Carcass Nitrogen Analysis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen retention method</td>
</tr>
<tr>
<td>Net protein utilization</td>
</tr>
<tr>
<td>Rat repletion methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods Based on Nitrogen Balance:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen balance</td>
</tr>
<tr>
<td>Digestibility coefficient, biological value and net utilization of dietary proteins</td>
</tr>
<tr>
<td>Nitrogen balance index</td>
</tr>
<tr>
<td>Egg replacement method</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods Based on Regeneration of Blood and Liver Constituents:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver protein regeneration</td>
</tr>
<tr>
<td>Blood protein regeneration</td>
</tr>
<tr>
<td>Regeneration of liver enzymes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Determination of Availability of Amino Acids:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical methods</td>
</tr>
<tr>
<td>Enzymatic methods</td>
</tr>
<tr>
<td>Microbiological methods</td>
</tr>
<tr>
<td>Animal assays</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous Methods:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma amino acid levels</td>
</tr>
<tr>
<td>Microbiological methods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical Scoring Methods:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical score</td>
</tr>
<tr>
<td>Essential amino acid index</td>
</tr>
<tr>
<td>Simplified chemical score</td>
</tr>
</tbody>
</table>
Evaluation of Protein Quality

During recent years only two methods viz., PER and NPU have been recommended as the most suitable methods for the evaluation of the quality of dietary proteins. A brief account of these two methods is given below:

**Protein Efficiency Ratio:**

The growth method has gained much popularity as it is easy to carry out the test and at the same time yields reliable results. Osborne *et al.* first described a method for assessing the nutritive value of the proteins based on the growth of rats. The ratio between the increase in body weight in grams and the protein intake in grams was considered as the index of the nutritive value of the protein. This is known as protein efficiency ratio (PER). Chapman *et al.* and the American Association of Official Agricultural Chemists have described standardised procedures using rats aged 21-28 days and with an experimental period of 28 days. Hegsted and Worcester made a critical study of the growth method. They observed a high correlation between gain in weight and PER for a number of proteins and concluded that little additional information is gained by the calculation of PER. However, the Rutgers collaborative study demonstrated clearly that the variation between laboratories was reduced by approximately 50% by taking food consumption into account and calculating the PER. The A.O.A.C. method was subjected to collaborative assay in eleven laboratories and the results obtained in the different laboratories were in good agreement.

**Net Protein Ratio (NPR):**

This method introduced by Bender and Doell is a modification of the PER method. In this method an allowance is made for the protein requirements for maintenance. The method consists in feeding a group of weanling rats on a diet containing 10% of the test protein and another comparable control group on a non-protein diet for a period of 10 days. The NPR is calculated by adding the loss in weight of the control group to the gain in weight of the test group and dividing the total weight (g) by the quantity (g) of protein consumed by the test group according to the following formula:

\[
\text{NPR} = \frac{\text{Gain in wt. (g) of the test group} + \text{loss in wt. (g) of the non-protein group}}{\text{Protein intake (g)}}
\]

NPR values have been reported to correlate closely with NPU values.

**Net Protein Utilization (NPU):**

Mitchell introduced the term Net Utilization of dietary proteins which is a product of the digestibility coefficient and biological value divided by
Miller and Bender developed a direct method of estimating this using young albino rats and termed it ‘Net Protein Utilization, (NPU). The method is briefly as follows: Groups of albino rats 28 days old are used. One group is fed on a non-protein diet while the other groups are fed on the test diets containing different proteins at 10% level for a period of 10 days. The food intakes of the animals are measured. The animals are killed at the end of 10 days and the body nitrogen determined by Kjeldahl method on a sample of dried and powdered carcass. The NPU is calculated according to the following formula:

\[ \text{NPU} = \frac{\text{Body N of the test group} - \text{Body N of the non-protein group} + \text{N consumed by non-protein group}}{\text{N consumed by test group}} \]

The main advantage of determining NPU of a food or diet is that it helps in the calculation of the net available protein (which is the same as Reference Protein) of the diet. A comparative statement of the PER, NPU and Chemical Score of some dietary proteins is given in Table 11. It will be seen that there is good correlation between the PER, NPU and Chemical Score.

TABLE 11

<table>
<thead>
<tr>
<th>Protein source</th>
<th>Most limiting amino acids</th>
<th>PER as % of egg protein</th>
<th>Chemical score as Egg protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg, Hen's</td>
<td>--</td>
<td>4.5</td>
<td>91</td>
</tr>
<tr>
<td>Milk, Cow's</td>
<td>S</td>
<td>3.0</td>
<td>67</td>
</tr>
<tr>
<td>Milk, Human</td>
<td>S</td>
<td>4.0</td>
<td>67</td>
</tr>
<tr>
<td>Beef, Muscle</td>
<td>S</td>
<td>3.0</td>
<td>67</td>
</tr>
<tr>
<td>Fish</td>
<td>TRY</td>
<td>3.0</td>
<td>67</td>
</tr>
<tr>
<td>Rice, milled</td>
<td>LYS</td>
<td>2.0</td>
<td>44</td>
</tr>
<tr>
<td>White wheat flour</td>
<td>LYS</td>
<td>1.0</td>
<td>22</td>
</tr>
<tr>
<td>Corn meal</td>
<td>TRY</td>
<td>1.2</td>
<td>26</td>
</tr>
<tr>
<td>Soy flour</td>
<td>S</td>
<td>2.4</td>
<td>53</td>
</tr>
<tr>
<td>Peanut flour</td>
<td>S</td>
<td>1.7</td>
<td>38</td>
</tr>
<tr>
<td>Sesame seed</td>
<td>LYS</td>
<td>1.7</td>
<td>38</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>LYS</td>
<td>2.1</td>
<td>47</td>
</tr>
<tr>
<td>Peas</td>
<td>S</td>
<td>1.7</td>
<td>38</td>
</tr>
<tr>
<td>Navy bean</td>
<td>S</td>
<td>1.7</td>
<td>38</td>
</tr>
</tbody>
</table>

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**Evaluation of Protein Quality**

**Application of PER method for assessing protein quality in poor cereal diet:**

The PER method has been used for assessing the effects of supplementation of poor cereal diets with the limiting amino acids lysine and threonine or with a legume on the PER of the diets. The results are given in Tables 8 and 9.

The data indicate that (i) sorghum diet is deficient in certain vitamins and minerals and supplementation with vitamins and minerals brings about a marked increase in the PER; (ii) the supplementary effects of limiting amino acids (lysine and threonine) are observed only after the vitamins and mineral deficiencies are made up, and (iii) ragi diet is not deficient in vitamins and minerals and hence responds to supplementation with limiting amino acids or red gram even without the addition of vitamins and minerals.

**PER and NPU of Reference Protein:**

Since egg proteins possess the highest nutritive value, having an NPU(st) of 100, it has been chosen as a reference protein by the FAO/WHO Expert Group on protein requirements for expressing human protein requirements. The Expert Group, however, stated that "there is good reason to believe that in both human milk and egg proteins, the proportions of essential amino acids are higher than that required for older children and adults although the physiological reason for this is not clear." It was, therefore, considered of interest to find out the effect of dilution of egg protein with a non-essential amino acid on the PER and NPU. The results are given in Tables 12 and 13.

**TABLE 12**

<table>
<thead>
<tr>
<th>Protein level</th>
<th>NPU</th>
<th>Gain in weight</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>96.7</td>
<td>4.73</td>
<td>4.74</td>
</tr>
<tr>
<td>8.5</td>
<td>95.8</td>
<td>3.78</td>
<td>4.74</td>
</tr>
<tr>
<td>7.5</td>
<td>97.2</td>
<td>3.39</td>
<td>4.72</td>
</tr>
<tr>
<td>6.3</td>
<td>96.3</td>
<td>3.25</td>
<td>4.64</td>
</tr>
<tr>
<td>5.0</td>
<td></td>
<td>2.44</td>
<td>4.84</td>
</tr>
</tbody>
</table>
TABLE 13
Effect of dilution of egg proteins with L-glutamic acid (G.A.) on the PER and NPU

<table>
<thead>
<tr>
<th></th>
<th>Hen's Egg 10%</th>
<th>Egg 8.5% GA 2.5%</th>
<th>Egg 7.5% GA 4.2%</th>
<th>Egg 6.5% GA 5.8%</th>
<th>Milk 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Score</td>
<td>100</td>
<td>85</td>
<td>75</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td>NPU</td>
<td>96.7</td>
<td>89.0</td>
<td>78.8</td>
<td>70.4</td>
<td>79.6</td>
</tr>
<tr>
<td>PER</td>
<td>4.74</td>
<td>4.05</td>
<td>3.33</td>
<td>3.12</td>
<td>3.49</td>
</tr>
<tr>
<td>PER as % of egg proteins</td>
<td>100</td>
<td>85</td>
<td>74</td>
<td>66</td>
<td>74</td>
</tr>
<tr>
<td>Lysine</td>
<td>6.40</td>
<td>5.44</td>
<td>4.80</td>
<td>4.16</td>
<td>7.80</td>
</tr>
<tr>
<td>Threonine</td>
<td>5.10</td>
<td>4.34</td>
<td>3.83</td>
<td>3.32</td>
<td>4.60</td>
</tr>
<tr>
<td>Sulphur amino acid</td>
<td>5.50</td>
<td>4.68</td>
<td>4.13</td>
<td>3.58</td>
<td>3.30</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.60</td>
<td>1.36</td>
<td>1.20</td>
<td>1.04</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Table 12 shows that the NPU and PER values of egg protein are nearly of the same order for diets containing varying levels of egg protein i.e. 10, 8.5, 7.5 and 6.5% levels. Table 13 shows that dilution of egg protein with varying levels of glutamic acid progressively reduces the PER and NPU. For obtaining a PER of 3.53, the levels of some of the important essential amino acids required are as follows: Lysine 4.8; Sulphur amino acids 4.13; threonine 3.83 and tryptophan 1.20. These results indicate the optimal levels to which the above amino acid levels should be raised in poor cereal diets consumed by children, either by amino acid supplementation or by mutual supplementation with other proteins for increasing the PER of the proteins to about 3.0.

CLINICAL EVALUATION OF PROTEIN QUALITY USING HUMAN SUBJECTS:

The clinical evaluation of protein quality using human subjects is essential when new protein foods have to be used for feeding infants or for supplementing the diets of children and other vulnerable sections of the population and for assessing the protein adequacy of the diets consumed by the people. The WHO Protein Malnutrition Committee suggested that it is necessary to take into consideration the following factors for the evaluation of a protein supplement:

1. The essential amino acid content of the product;
2. The possible presence of toxic factors;
3. The need for having exact specifications for the final product and for its components;
4. Low cost and good keeping quality;
5. Acceptability of the product to the consumers;
6. Evaluation of protein quality using experimental animals;
7. The suitability of the product for feeding infants, weaned infants and pre-school...
Evaluation of Protein Quality

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children. Only after a product has been found to possess high nutritive value and safe for human use according to the above criteria, experiments with human subjects should be undertaken. The type of products that will require testing with subjects may be broadly grouped as follows: (i) Milk substitutes of vegetable origin and dried infant foods based on vegetable proteins; and (ii) Protein foods for supplementing the diets of weaned infants and pre-school children and expectant and nursing mothers in the developing countries and for the treatment of protein malnutrition.

Studies with human subjects may be broadly grouped under three heads (1) Growth studies with infants and children; (2) Nitrogen balance studies with infants, children and other age groups; and (3) Treatment of protein-calorie malnutrition in children. These studies can be supplemented, if necessary, with some biochemical measurements such as, serum proteins, serum free amino acids, blood urea, urinary excretion of creatinine and sulphur compounds.

Growth Studies:

Studies with Infants:

Measurements of growth rate of infants fed on new types of infant foods based on vegetable proteins as compared with that of infants fed on cow’s milk is a practical method of evaluating the adequacy of the vegetable proteins for infants growth. It is essential to make sure that the infants selected for the study are in good health and free from ailments which are likely to affect growth adversely. A large number of experiments dealing with the growth of infants fed on milk substitutes and dried infant food have been carried out during recent years.[3,5,6] Table 14 shows the results of studies of Fuman et al.[2] on infants 4-6 months of age fed soybean milk. Four infants were fed for periods of 38 to 73 days ad libitum a soybean milk formula which contained 1.14 g protein/100 ml (6.8% of the calories supplied by protein) and the mean intake of protein by infants was 1.7 g/kg/day. The amounts of methionine (mean intake 38 mg/kg/day) and tryptophan (mean intake 14 mg/kg/day) supplied by the formula were slightly less than the currently accepted minimal requirements of these amino acids for infants. The gain in weight of the infants was within the normal range (21.3 g/day) as compared with mean gain in weight of 19 g/day obtained for 5 infants fed pasteurised human milk. The results of these studies are of considerable interest to developing countries where soybean is available and animal milk production is low.

In Table 15 the results of studies of Pereira et al.[8] with an infant food based on peanut flour and skim milk powder as compared with a milk food
are given. The protein content of the food was 22% of which 60% was derived from peanut, 30% from milk and 10% from wheat. The infants were allotted sequentially to two groups at the age of 6 months and fed on peanut infant food and milk respectively, for a period of 10 months. Data regarding the height (body length) and weight of the children were maintained. The results showed that there was no significant difference in the mean increases in height and weight between the two groups. The results indicate that an infant food containing a mixture of 60% peanut protein, 30% milk protein and 10% wheat protein can be used for feeding infants in place of milk food. This again is of considerable importance to several developing countries where milk production is inadequate and peanut is available in large quantities.

### TABLE 14

<table>
<thead>
<tr>
<th>Name of milk</th>
<th>No. of infants</th>
<th>Protein intake g/kg/day</th>
<th>Mean gain in wt. g/kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean milk formula</td>
<td>4</td>
<td>1.7</td>
<td>21.3</td>
</tr>
<tr>
<td>Pasteurised human milk</td>
<td>5</td>
<td>1.5</td>
<td>19.0</td>
</tr>
</tbody>
</table>

### TABLE 15

Mean increase in height and weight of infants on peanut infant food and milk food supplements (duration of experiment—10 months)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Height (cm)</th>
<th>Increase ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>Children on peanut infant food (12)</td>
<td>64.39</td>
<td>74.75</td>
</tr>
<tr>
<td>Children on milk food (12)</td>
<td>63.47</td>
<td>73.56</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children on peanut infant food (12)</td>
<td>6.41</td>
<td>8.39</td>
</tr>
<tr>
<td>Children on milk food (12)</td>
<td>6.06</td>
<td>7.88</td>
</tr>
</tbody>
</table>

**Studies with weaned infants and pre-school children:**

Since the diets consumed by a large majority of weaned infants and pre-school children are inadequate both in quantity and quality, studies have been carried out by various workers to assess the supplementary value of
legumes and processed protein foods based on oilseed meals and legumes to their diets. The results of two of the studies are given in Tables 16 and 17.

**TABLE 16**

The effect of supplementing the diet of poor pre-school children with pulse or processed protein foods on the NDpCal % and growth rate of preschool children in India (Duration of Experiment—6 months)

<table>
<thead>
<tr>
<th>Diets</th>
<th>Basal diet</th>
<th>Basal diet + high protein food</th>
<th>Improved basal diet</th>
<th>Improved basal diet + high protein food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group (years)</td>
<td>2-5</td>
<td>2-5</td>
<td>2-5</td>
<td>2-5</td>
</tr>
<tr>
<td>Experimental period (months)</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Mean body weight (kg)</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Calorie intake (Kcal)</td>
<td>1129</td>
<td>1129</td>
<td>1215</td>
<td>1215</td>
</tr>
<tr>
<td>Protein intake (g)</td>
<td>18.8</td>
<td>38.9</td>
<td>23.9</td>
<td>46.0</td>
</tr>
<tr>
<td>Dietary protein calories (%)</td>
<td>6.7</td>
<td>13.8</td>
<td>7.9</td>
<td>15.1</td>
</tr>
<tr>
<td>NPU*</td>
<td>55</td>
<td>45</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>NDpCal %</td>
<td>3.6</td>
<td>6.2</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Increase in wt. (kg)</td>
<td>0.06</td>
<td>1.27</td>
<td>1.24</td>
<td>1.31</td>
</tr>
<tr>
<td>Increase in ht. (cm)</td>
<td>1.62</td>
<td>3.78</td>
<td>3.48</td>
<td>4.70</td>
</tr>
</tbody>
</table>

* Calculated according to Miller and Payne from 'Chemical Score'.

**TABLE 17**

Daily intake of calories and proteins and increase in height and weight of weaned infants and preschool children fed on vegetable protein diet and mixed diet containing skim milk powder

<table>
<thead>
<tr>
<th>Group and Age</th>
<th>Calorie intake (KCal)</th>
<th>Protein intake (g)</th>
<th>NDpCal %</th>
<th>Mean increase in Height cm</th>
<th>Weight kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable protein group :</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-24 months</td>
<td>950</td>
<td>25</td>
<td>5.2</td>
<td>5.4±0.20</td>
<td>1.90±0.10</td>
</tr>
<tr>
<td>25-36</td>
<td>970</td>
<td>29</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37-48</td>
<td>1060</td>
<td>33</td>
<td>6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49-60</td>
<td>1260</td>
<td>35</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skim milk group :</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-24 months</td>
<td>910</td>
<td>25</td>
<td>6.6</td>
<td>6.4±0.19</td>
<td>1.79±0.08</td>
</tr>
<tr>
<td>25-36</td>
<td>870</td>
<td>29</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37-48</td>
<td>970</td>
<td>33</td>
<td>8.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49-60</td>
<td>1130</td>
<td>35</td>
<td>8.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The studies of Dumm et al41 with pre-school children have yielded valuable results (Table 16). The control cereal diet provided daily about 18.8 g. protein and NDpCal % of 3.6 and did not promote any increase in body weight. Addition of 20 g. extra protein from a high protein food based on peanut protein isolate raised the NDpCal % to 6.2 and promoted excellent growth. In a second experiment, they found that increasing the calorie intake by about 85 calories and protein intake by 5 g. by adding legumes, raised the NDpCal % to 4.0 and promoted fairly good growth. The increase in growth rate is due to the combined effect of increased calorie and protein. Addition of 20 g. extra proteins to this improved basal diet in the form of high protein food based on peanut protein isolate raised the NDpCal % to 6.0 and caused a further increase in height. These results indicate that a NDpCal % of 4.0 can meet the minimum protein needs of pre-school children promoting moderate growth while a diet providing NDpCal % of 6.0 contains liberal amounts of protein to promote excellent growth.

The results of studies carried out by Ganapathy et al65 are given in Table 17. In this experiment supplementary value of legumes as compared with skim milk powder to the basal diet consumed habitually by pre-school children aged 1-5 years was assessed over a period of 9 months: In the first diet cereals contributed about 40% and pulses about 60% of the proteins while in the second diet cereals contributed about 40% and skim milk powder 60% of the proteins. The mean daily protein intake of the children of different age groups on the two diets was as follows: (a) 12-24 months, 25 g; (b) 25-36 months, 29 g; (c) 37-48 months, 33 g, and (d) 49-60 months 38 g. The quantity of legumes consumed ranged from 54 g. for the age group 12-24 months to 100 g. for the age group 37-48 months and of skim milk powder from 33 g. for the age group 12-24 months, to 71 g. for the age group 37-48 months. No significant differences were observed in the mean increase in height and weight between the two groups but the increase was significantly greater than those observed in a similar group of control children subsisting on their home diet (Table 17). The NDpCal % of the diets containing cereals and legumes ranged from 5.2 to 6.3, thus indicating that the protein intake was adequate.

**Nitrogen Balance:**

Nitrogen balance methods yield data regarding the suitability of the protein to meet the requirements of the individual. It has the advantage that it can be completed in a shorter period as compared with growth methods. The minimum period for which satisfactory timed collection of faecal collections can be made is 3 days. Balance studies on each experimental diet for three successive three-day balance period after a suitable period of initial adaptation are essential for the evaluation of protein quality.
Extreme care must be taken to exclude interfering factors such as intercurrent infections and psychological stresses which may completely vitiate the results.\textsuperscript{44,45} Nitrogen losses through the skin are not taken into account in most of these studies as it is difficult to measure them. Since nitrogen losses in sweat may be large in tropical countries, N-balance studies reported from tropical countries should be corrected for such losses before they can be properly interpreted.\textsuperscript{44,45} As pointed out by Wallace\textsuperscript{4} the errors in N-balance studies are additive and tend to increase N-balance. N-intakes tend to be over-estimated because of unrecognised food losses, and N-output underestimated because of incomplete collection of excreta. Further, as N losses through skin are usually not determined, these are additional factors for increasing the N-balance. Hence N-balances should be interpreted with great caution after making due allowances for the losses through skin.

In spite of the above drawbacks N-balance studies carried out on a group of individuals over a period of some months on different dietary regimens under comparable conditions do throw light on the adequacy or otherwise of the diets to meet the protein needs of the individual.\textsuperscript{61} It has proved to be a sensitive method in the evaluation of (i) milk substitutes and infant foods based on vegetable proteins in feeding infants; (ii) effects of supplementation with limiting amino acids in improvements of the quality of dietary proteins in children; and (iii) adequacy of dietary protein to meet the protein needs of children.\textsuperscript{3,4,61}

\textit{N-balance Studies in Infants:}

The studies of Forman and his coworkers\textsuperscript{58} have shown that N-balance in infants fed soybean milk providing 1.7 g. protein/kg was of the same order as that observed in infants fed on pasteurised human milk providing 1.5 g. protein/kg thus providing evidence that soybean milk could meet the protein needs of infants for satisfactory growth.

\textit{N-Balance in pre-school children:}

Scrimshaw and his coworkers\textsuperscript{60,70} studied the effect of supplementation of corn and wheat proteins with limiting amino acids on N-retention in pre-school children. The results showed that supplementation of the corn diet with lysine, tryptophan and isoleucine and of wheat diet with lysine brought about a marked increase in N-retention, indicating thereby that amino acid supplemented corn and wheat proteins are adequate to meet the protein needs of pre-school children. DeMaeyer and Vanderborgh\textsuperscript{72} determined the NPU of some dietary proteins in children aged 3 to 6 years by N balance method. The results are given in Table 18. The results show that the
NPU values of the foods obtained with children agree well with NPU values determined with albino rats reported in the literature.

**TABLE 18**

Values of Net Protein Utilisation Standardized of some proteins measured on children and growing rats.

<table>
<thead>
<tr>
<th>Protein</th>
<th>Children</th>
<th>Growing rats*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole egg</td>
<td>87</td>
<td>100</td>
</tr>
<tr>
<td>Human milk</td>
<td>95, 85, 95</td>
<td>100</td>
</tr>
<tr>
<td>Cow's milk</td>
<td>81, 79, 81</td>
<td>80</td>
</tr>
<tr>
<td>Sesame flour</td>
<td>54, 53</td>
<td>54</td>
</tr>
<tr>
<td>Peanut flour</td>
<td>57, 53, 52</td>
<td>47</td>
</tr>
<tr>
<td>Cottonseed flour</td>
<td>51, 47</td>
<td>59</td>
</tr>
</tbody>
</table>

* The same preparation was used for the assays on the children and the rats.
* Literature values.

**N-Balance in School Children:**

Studies on the effect of supplementation of diets based on rice, ragi and sorghum with limiting amino acids on N retention and NPU of dietary proteins have been carried out at Central Food Technological Research Institute (CFTRI), Mysore. The results are given in Table 19. The data indicate that supplementation with lysine brings about a significant increase in N retention and NPU in children on diets based on ragi and sorghum. In the case of rice diet, supplementation with lysine and threonine brings about a marked improvement in N-retention and NPU.

**N-Balance studies with pregnant and lactating women:**

The nitrogen balance technique has been successfully used for assessing the protein requirements of pregnant and lactating women. Table 20 shows the results of studies with pregnant women receiving 60,84, 106 and 118 g. of protein. On 60 g. protein intake, 50% of the women were in slight positive balance and the remaining retained 1.5 g to 3.4 g. nitrogen per day. The N retention increased when the protein intake was increased. The authors concluded that the optimal daily protein intake for these subjects to be about 84 g.

Narasinga Rao et al found that the N retention in lactating women was low on protein intake of 60 g. and optimal on a protein intake of 99 g. The protein needs of lactating women would be near about 99 g/day.
**TABLE 19**

Effect of supplementation with limiting amino acids on NPU of ragi and rice diets and N retention in children (Six girls aged 9-10 years)

<table>
<thead>
<tr>
<th>Diet</th>
<th>Nitrogen Intake g/day</th>
<th>Retention NPU (op) g/day</th>
<th>Protein intake g/kg</th>
<th>Net available protein g/kg</th>
<th>NDepCal %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ragi</td>
<td>4.75</td>
<td>0.28</td>
<td>45.5</td>
<td>1.31</td>
<td>0.60</td>
</tr>
<tr>
<td>Ragi + Lysine</td>
<td>4.78</td>
<td>0.64</td>
<td>52.7</td>
<td>1.32</td>
<td>0.70</td>
</tr>
<tr>
<td>Ragi + Lysine + Threo</td>
<td>4.87</td>
<td>1.04</td>
<td>59.3</td>
<td>1.34</td>
<td>0.80</td>
</tr>
<tr>
<td>Rice</td>
<td>4.11</td>
<td>0.39</td>
<td>52.9</td>
<td>1.34</td>
<td>0.71</td>
</tr>
<tr>
<td>Rice + Lysine</td>
<td>4.22</td>
<td>0.53</td>
<td>54.8</td>
<td>1.38</td>
<td>0.76</td>
</tr>
<tr>
<td>Rice + Lysine + Threo</td>
<td>4.22</td>
<td>0.80</td>
<td>63.4</td>
<td>1.34</td>
<td>0.85</td>
</tr>
<tr>
<td>Sorghum</td>
<td>4.79</td>
<td>0.41</td>
<td>49.3</td>
<td>1.31</td>
<td>0.64</td>
</tr>
<tr>
<td>Sorghum + Lysine</td>
<td>4.87</td>
<td>0.65</td>
<td>52.0</td>
<td>1.33</td>
<td>0.69</td>
</tr>
<tr>
<td>Sorghum + Lysine + Threo</td>
<td>4.96</td>
<td>1.08</td>
<td>59.8</td>
<td>1.35</td>
<td>0.81</td>
</tr>
</tbody>
</table>

**TABLE 20**

Nitrogen retention in pregnant and lactating women in varying levels of protein intake

<table>
<thead>
<tr>
<th>Subjects and Number</th>
<th>Period</th>
<th>Calorie Intake</th>
<th>Protein intake (g/day)</th>
<th>Mean N intake (g)</th>
<th>Retention (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant women 6</td>
<td>I</td>
<td>2200</td>
<td>60</td>
<td>9.61</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>2300</td>
<td>84</td>
<td>13.46</td>
<td>3.48</td>
</tr>
<tr>
<td>Lactating women 6</td>
<td>I</td>
<td>2938</td>
<td>61</td>
<td>9.81</td>
<td>0.24*</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>2991</td>
<td>99</td>
<td>15.88</td>
<td>4.03</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>2999</td>
<td>114</td>
<td>18.09</td>
<td>4.86</td>
</tr>
</tbody>
</table>

* 1 subject in negative balance.
** Reference No. 76.
* Reference No. 75

**TREATMENT OF PROTEIN-CALORIE MALNUTRITION IN INFANTS AND CHILDREN:**

During recent years a large amount of work has been carried out on the use of proteins of oilseeds, nuts and legumes in the treatment of protein-calorie malnutrition in children. The results have shown that blends of oilseeds and legume proteins or oilseed proteins and milk proteins can be successfully used in the treatment of protein-calorie malnutrition. It may be concluded that it can be used safely for supplementing the diets of weaned infants and pre-school children. The results of some of these studies are given in Tables 21 to 23.
### TABLE 21
Rise in serum albumin in cases of kwashiorkor treated on different dietary regimes

<table>
<thead>
<tr>
<th>Number studied</th>
<th>Source of protein</th>
<th>Level of protein g/kg</th>
<th>Calorie per kg</th>
<th>10th day</th>
<th>30th day</th>
<th>Serum albumin g/100 ml increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>Skim milk</td>
<td>6</td>
<td>140</td>
<td>0.50</td>
<td>1.31</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Skim milk</td>
<td>3.5-4.0</td>
<td>140</td>
<td>0.35</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Groundnut protein isolate</td>
<td>6</td>
<td>140</td>
<td>0.32</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Groundnut protein isolate + skim milk (2 : 1)</td>
<td>6</td>
<td>140</td>
<td>0.48</td>
<td>1.37</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 22
Increase in serum albumin in cases of kwashiorkor treated with 2 : 1 blend of peanut protein isolate and skim milk powder

<table>
<thead>
<tr>
<th>Number of cases</th>
<th>Name of protein food</th>
<th>Protein intake g/kg/day</th>
<th>Increase in serum albumin in 4 weeks g/100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>2 : 1 blend of peanut protein isolate + skim powder</td>
<td>5.0</td>
<td>1.52</td>
</tr>
<tr>
<td>18</td>
<td>Skim milk powder</td>
<td>5.0</td>
<td>1.67</td>
</tr>
</tbody>
</table>

### TABLE 23
Nitrogen retention in cases of kwashiorkor treated with 2 : 1 blend of peanut protein and skim milk powder

<table>
<thead>
<tr>
<th>Name of protein food</th>
<th>No. of cases</th>
<th>No. of N balance study</th>
<th>N intake g/day</th>
<th>Retention as % of intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 : 1 blend of peanut protein isolate and skim milk powder</td>
<td>4</td>
<td>I</td>
<td>6.74</td>
<td>3.03</td>
</tr>
<tr>
<td>2 : 1 blend of peanut protein isolate and skim milk powder</td>
<td>4</td>
<td>II</td>
<td>7.63</td>
<td>3.48</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>4</td>
<td>I</td>
<td>6.40</td>
<td>3.75</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>4</td>
<td>II</td>
<td>7.28</td>
<td>3.39</td>
</tr>
</tbody>
</table>
Evaluation of Protein Quality

Table 21 shows the results of studies carried out at the National Institute of Nutrition, Hyderabad during 1960-62. The results clearly indicate that a mixture of 2 parts of peanut protein isolate and 1 part of skim milk powder is almost as effective as skim milk powder in the treatment of protein-calorie malnutrition in children, while peanut protein isolate by itself is inferior to skim milk powder for this purpose.

Table 22 shows the results of studies reported from the Christian Medical College, Vellore on the same product. These results are in agreement with the results given in Table 23. The N retention in children receiving the protein blends was nearly of the same order as that observed in children receiving skim milk powder.

Scrimshaw and his coworkers have reported a protein food based on corn and cottonseed meal (INCAP 9B) was highly effective in curing cases of protein malnutrition in pre-school children. Though the food was effective in bringing about clinical improvement, the rate of regeneration of serum albumin was slow and less than that observed in children receiving skim milk powder (Table 24).

TABLE 24
Nitrogen retention in young children recovered from kwashiorkor and fed on INCAP mix. 9 and milk

<table>
<thead>
<tr>
<th>No. of children</th>
<th>Protein intake (g/kg/day)</th>
<th>N absorbed as % of intake</th>
<th>N retained as % of intake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milk</td>
<td>INCAP 9</td>
<td>Milk</td>
</tr>
<tr>
<td>2</td>
<td>4.0</td>
<td>4.0</td>
<td>84.4</td>
</tr>
<tr>
<td>11</td>
<td>3.0</td>
<td>3.0</td>
<td>84.9</td>
</tr>
<tr>
<td>48</td>
<td>2.3</td>
<td>2.3</td>
<td>82.6</td>
</tr>
<tr>
<td>13</td>
<td>1.2</td>
<td>1.2</td>
<td>78.1</td>
</tr>
</tbody>
</table>

Dean reported that biscuits containing about 20% protein and made out of a blend of peanut kernel 41 parts; skim milk powder 15 parts, wheat flour 6 parts; corn flour 20 parts; cottonseed oil 6 parts; and sugar 10 parts, was highly effective in the treatment of protein-calorie malnutrition comparing well with skim milk powder both in bringing about clinical improvement and in the regeneration of serum proteins (Table 25).
TABLE 15
Treatment of protein-calorie malnutrition with Biscuit 15 U based on peanut and skim milk powder

<table>
<thead>
<tr>
<th></th>
<th>Protein intake (g/kg/day)</th>
<th>Period I</th>
<th>Period II</th>
<th>Gain weight (g/day)</th>
<th>Increase in serum protein (g/100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Albumin:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Period I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Period II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.35</td>
</tr>
</tbody>
</table>

AMINO ACID PATTERN OF PROTEINS USED IN THE TREATMENT OF KWASHIORKOR AS COMPARED WITH MILK PROTEINS:

The contents of lysine, sulphur amino acids, threonine and tryptophan in the protein foods used in the treatment of kwashiorkor is given in Table 26 along with values for the protein efficiency ratio. It is apparent that the protein foods based on vegetable proteins contain lesser amounts of the above mentioned amino acids and possess a lower PER than milk proteins. Nevertheless, at the levels they were administered to cases of protein malnutrition (4.5 to 6 g protein/kg body weight), they have proved almost as good as milk in effecting cure and in the regeneration of serum proteins. This is of particular importance to developing countries where milk production is highly inadequate, while oilseed proteins are available in large quantities.36,37

TABLE 26
The content of some essential amino acid (g/16 gN) in some protein foods and skim milk powder used for the treatment of protein malnutrition

<table>
<thead>
<tr>
<th>Protein food</th>
<th>Lysine</th>
<th>Total sulphur amino acids</th>
<th>Threonine</th>
<th>Tryptophan</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut protein isolate + skim milk powder (2 : 1)</td>
<td>4.4</td>
<td>2.9</td>
<td>3.1</td>
<td>1.16</td>
<td>2.3</td>
</tr>
<tr>
<td>Biscuit 15 U</td>
<td>4.7</td>
<td>2.8</td>
<td>3.3</td>
<td>1.20</td>
<td>2.3</td>
</tr>
<tr>
<td>INCAP-9</td>
<td>4.8</td>
<td>3.4</td>
<td>3.5</td>
<td>1.00</td>
<td>2.3</td>
</tr>
<tr>
<td>Skim milk powder (SMP)</td>
<td>7.9</td>
<td>3.4</td>
<td>4.7</td>
<td>1.44</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Evaluation of Protein Quality

CONCLUSION:

It is evident from the foregoing account that the problem of evaluation of the quality of dietary proteins is a complex one involving the use of chemical, microbiological, biological and clinical methods. The chemical, microbiological and biological assays should be completed and data regarding the nutritive value of the protein and the safety of the food for human beings obtained, before the studies with human subjects are undertaken. It must be emphasized that studies on human subjects are necessary to ascertain the adequacy of the protein to meet the needs of various age groups. Growth studies in infants with infant foods and in children with supplementary foods will provide data regarding the adequacy or otherwise of the protein food under study for promoting optimal growth. Nitrogen balance studies will provide convincing data in children, expectant and nursing mothers and adults regarding the adequacy of the protein in meeting the body requirements. In the interpretation of the N balance data obtained in tropical climates, due allowance should be made for N losses through the skin which is usually not measured in most of these studies.

REFERENCES

50. Cooperative determinations of the amino acid content and the nutritive value of six selected protein food sources (1930), Bureau of Biological Res., Rutgers University.
SYMPOSIUM ON

ROLE OF FOOD TECHNOLOGY IN COMBATING MALNUTRITION

Chairmen: K. P. Mathrani, India
and
S. Varadarajan, India
Rapporteur: P. R. Krishnaswamy, India

Papers:

Chairman's remarks — K. P. Mathrani . . 422

Protein-rich food from plant sources:
  Nutritional and technological considerations.
  — A. S. Aiyar AND A. Sreenivasan . . 427

Approaches to amino acid and vitamin enrichment
  programmes in Japan — H. Mitsuda . . 457

New development of infant and weaning foods
  — H. A. B. Parpia . . 472

Operation flood — Milk marketing and dairy
  development — R. P. Aneja AND P. T. Jacob . . 490

Problem of food additives and contaminants
  — K. K. G. Menon . . 496
CHAIRMAN'S REMARKS FOR THE SYMPOSIUM ON "ROLE OF FOOD TECHNOLOGY IN COMBATING MALNUTRITION IN ASIA"

K. P. MATHRANI
Ministry of Food and Agriculture
(Department of Food)
Government of India, New Delhi.

The subject of this morning's symposium is "Role of Food Technology in combating Malnutrition in Asia." In my opening remarks I shall however make some observations on the general question of processing of foodstuffs and allied matters with a special reference to malnutrition. Further, in view of our experience I shall from time to time touch on the problems noticed in India and the manner in which we have tried to tackle them.

New developments in technology have brought a revolution in many fields. Recent advances in the application of technology in the field of agriculture have ushered in the green revolution. I am sure this will be followed by a rapid application of food technology, not merely to preserve and conserve the food supplies but also to render them into foods of high nutritive value for meeting the special needs of the vulnerable groups and for the complete elimination of under-nutrition and malnutrition. It is appropriate that eminent scientists have taken up this matter and are discussing such important problems as the augmentation of protein-rich foods from plant and other sources, enrichment and fortification programmes, developments in infant and weaning foods and the use of food additives and contaminants.

From time immemorial, mankind was faced with the problem of preserving food and making it fit to eat and had in process invented cooking, grinding, milling, pickling and the use of salt and other basic approaches for prolonging the storability and use of food. From the primitive technology developed processing industries with increased capacity and improved techniques, making the processing operations economical, preservation longer and foodstuffs richer in quality. Further advances in research and knowledge in recent years have contributed to the present-day development of highly sophisticated processing industries.

With urbanisation and industrialisation, food has to be handled, processed and transported and has to be treated in some form or the other. Several of
the foodstuffs found even in the village market have undergone some treatment or other, though the processing in the rural set up involved only relatively simple way; but in the modern urban market even in developing countries one finds a variety of products of modern technology such as breakfast foods, pasteurised milk, refrigerated products, canned and bottled preparations, convenient foods and ready-to-eat preparations.

A large number of people subsist on nutritionally inadequate diets. Malnutrition may be due to many deficiencies in the diet, but reports indicate that the most important cause of malnutrition is the deficiency of protein. The Indicative World Plan studies underscore the large gap that exists between the developed and the developing countries in regard to the availability and consumption of proteins. The data made available clearly emphasised the necessity of adopting measures to encourage the general use of low-cost new protein sources, which are at present inadequately exploited. These comprise proteins from oilseeds, fish protein, and even single cell proteins from petroleum products. With proper planning and adequate effort, there is every hope that real and substantial progress in increasing protein supplies can be expected from these sources.

Some of the action programmes initiated by the Food and Nutrition Board of the Department of Food in bridging the protein gap relate to the production of edible groundnut flour, soyabean products, cotton-seed flour, etc. A beginning has been made with 'Bal Ahar', a food for school feeding programmes, from a blend of whole wheat flour, edible groundnut flour, skimmed milk powder and suitably fortified with essential vitamins and minerals. A precooked weaning food called 'Bal Amul' is also under development. A project with considerable potentialities in augmenting the milk supplies and making available low cost toned-milk, utilising groundnut protein concentrates is also under development. These developments are being promoted in close collaboration with the Central Food Technological Research Institute and other national institutions concerned.

Apart from protein deficiency, the people in the developing countries suffer from lack of other nutrients, leading to deficiency diseases. Judging from the experience of India, people suffer from deficiency of vitamins like vitamin A, vitamins of the B complex group and also of minerals like calcium and iron. Of these, deficiency of vitamin A and iron has indeed serious effects; the former is recognised as the main cause of night-blindness and the latter as the cause of anaemia which is prevalent in India and other developing countries, particularly among expectant and nursing mothers. Fortification and enrichment may be elegant approaches for a rapid elimination of these maladies.
Some losses of nutrients occur during processing and preparation of foods. Modern technology has discovered techniques for restoring these losses through fortification and enrichment. Fortification and enrichment which requires little change in eating, cooking or purchasing habits may be our brightest hope at least in the short run for quickly providing a large number of people better nutrition at little cost. It is in this context that the Government of India is considering the possibility of fortifying certain commodities which are consumed on a large scale.

The Government of India have established the public sector Modern Bakeries and introduced a massive programme of fortification of bread. They have similarly undertaken a programme for the fortification of whole wheat flour by incorporating the needed essential nutrients. Likewise, a large number of projects such as production of multi-purpose foods, experiments on fortification of rice, fortification of salt with mineral nutrients, etc. have been sponsored.

Dr. M. S. Swaminathan, in his talk indicated the efforts being made in India in regard to increasing the production of foodgrains and introducing genetic improvement in their quality. Side by side with these programmes, facilities have to be developed for improving marketing, storage, transportation, preservation by cold storage, dehydration, canning, processing and other methods of conservation. Utilisation of industrial and agricultural wastes has also to be promoted. An interesting example of this type which I saw in the United States was the manufacture of proteins from whey which would otherwise have been wasted. If all the paddy could be milled adopting modern techniques, an additional quantity of about two million tonnes of rice would be available in India. The oil seeds, particularly groundnut, cottonseed and soya beans, when properly processed yield valuable proteins to combat protein malnutrition. Promotion of fruit and vegetable preservation industry, protein food industry, potatoes, tapioca and sweet potatoes processing industry and cold storage industry are important components of a programme for conserving foodstuffs, avoidance of losses and diversification of the dietary.

Special measures have to be promoted to ensure that the available food is properly distributed in nutritionally balanced proportions for adequately meeting the special needs of infants, pre-school children, school-going children, adolescents, expectant women, nursing mothers and the convalescent and the aged. As malnutrition in childhood is a major deterrent in future social and economic development and the worst sufferers are the children of pre-school age, special action programmes have to be initiated and promoted. One of the most effective ways of meeting nutrition of the vulnerable groups is supplementary feeding.
In modern food technology numerous substances are added to food for a variety of purposes such as, to make processing easier, to improve the appearance, texture, taste and cooking and to increase storability. The Central Committee on Food Standards of the Ministry of Health of the Government of India which looks after food laws, is fully conscious of the important role of the industry and has rationalised its approach through formulation of food standards which fit in with the recent advances in food technology and which afford the industry an opportunity to play its important role in combating malnutrition. There has been a substantial growth of food industries in the country in recent years. However, much still remains to be done, both from quantitative and qualitative point of view.

I would here refer to the keenness shown by the industry in India in the formation of the Protein Foods Association. Such bodies will have important contributions to make in guiding the application of food technology through right channels. In this connection, I would also allude to the creation of a high-powered committee on rational development of food industries in the country initiated by the Department of Industrial Development of the Government of India.

Here we are considering only the measures for increasing the availability of nutritious foodstuffs and for improving the nutritional quality of food. There are several other aspects of the problem which have to be solved and coordinated, such as increasing the purchasing power, eradication of poverty and other steps. These are fundamental problems concerning economic growth and development. As far as India is concerned, we do hope that with the Five-Year Plans and other efforts being promoted by the Government, the per capita income would necessarily increase and poverty and unemployment will be greatly reduced, if not eradicated, increasing the purchasing power of the people so as to enable them to overcome undernutrition and malnutrition.

The Department of Food of the Government of India have given a lead in utilising food technology for combating malnutrition. They have established a number of pilot studies and action programmes for the conservation and effective utilization of available foodstuffs. The first unit in the country for processing of maize into various products is under erection. A plant for the processing of soyabean for human consumption would also be set up shortly. The future programmes include pilot projects for modernisation of pulse milling industry, processing of sweet potatoes and fortification of Sago. Training programmes in the field of food technology and allied subjects are already in progress. Five foodcraft centres have already come up. An international centre for training in food technology has been started in collaboration with the
Council of Scientific and Industrial Research. A Rice Process Engineering and Technology Training Centre has similarly been started in collaboration with the Ministry of Education and the Ford Foundation at the Institute of Engineering Technology at Kharagpur.

Pioneering contributions have already been made towards a systematic development but a great deal of ground still remains to be covered. While I have referred only to our experience in India, a considerable amount of work in this regard will also have been done in other countries. We shall no doubt learn more about it in this symposium and mutually share our knowledge and experience. There is a promise that programmes could be undertaken for a massive attack on malnutrition which may not have been possible earlier, just as programmes were undertaken to eradicate diseases like malaria and smallpox. In this, the use of modern technology by the food processing industry can play, and I hope will play, a crucial role. I am sure the deliberations in this symposium and the contributions of the scientists and technologists participating in it would lead us rapidly to this goal.
Food needs and population trends:

While population practically everywhere is on the increase, the pace of food production reflects divergent trends in different areas of the world as of today. Thus, in countries such as the U.S.A. and Canada, the production potential of farm land is so restricted that there is generally no surplus produce. In others, as in several European countries, agricultural technology has been directed towards an increase in livestock production with corresponding improvement in quality of diets by way of increased consumption of animal proteins. However, in many areas of the world—the so called developing nations—representing a majority of mankind, progress in agricultural production has not been commensurate with population increases. Therefore, it frequently happens that, while there arise periodical gluts of food in certain areas of the world, there are others where a majority of the people do not have enough to eat. Such disparities in the per capita availability of food between the rich and the poor nations are totally lost sight of when one concerns himself only with food supplies and needs on a global basis.

Notwithstanding efforts by various international agencies at ensuring enough for all, it has been estimated that, at the present time, more than half the world’s population suffers from hunger and malnutrition. The problem of providing food for the future is even more vexing if the runaway growth in world population is reckoned against the lag in food production. It needs to be realised that, while it has taken hundreds of thousands of years of man’s existence on this planet for his population to reach the current figure of over three billion, it would, judged by present trends, have nearly doubled itself before the turn of this century. Most of this increase will occur in Asia, Africa and Latin America, areas which are finding it difficult to feed even their present populations. The present population and estimated figures for 2000 A.D. for various regions of the world are depicted in Fig. 1.

The ‘protein gap’ and its consequences:

The problem of total food shortage or caloric insufficiency in the developing
EXPECTED POPULATION GROWTH BETWEEN 1967 AND 2000

**Fig. 1.** Expected population and growth between 1967 and 2000: Reproduced from "Lives in peril—protein and the child", FAO, Rome, 1970.
countries is frequently magnified by the existence of protein malnutrition with correspondingly more serious consequences. It has been estimated that, in these regions, nearly eighty per cent of the population exist on sub-optimal levels of protein intake and suffer from various degrees of protein deficiency. The statistics on dietary protein intake for several regions of the world, taken from information compiled by international agencies (Fig. 2), reveal that the total available protein varies from about 100 g. per capita per day to about half this figure; and with the level of protein, so goes the percentage of animal protein even more markedly. It should further be reckoned that just as global averages obscure disparities between nations, so do the statistical figures for a nation between different economic strata of its society. The protein intake of the poorer segments of the population are often far below the national average. Geographic distribution studies of clinically identifiable protein deficiency diseases, particularly in the more sensitive elements of the population, indicate that these are also the known areas of low protein supply.

PROTEIN CONSUMPTION PATTERNS-MAJOR AREAS OF THE WORLD

<table>
<thead>
<tr>
<th>PROTEIN CONSUMPTION PATTERNS-MAJOR AREAS OF THE WORLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(gm. per capita per day)</td>
</tr>
<tr>
<td>PLANT PROTEIN</td>
</tr>
<tr>
<td>ANIMAL PROTEIN</td>
</tr>
</tbody>
</table>

Fig. 2. Protein consumption patterns—Major areas of the world: Based on data collected by International agencies.

The two severe forms of protein-calorie malnutrition, kwashiorkor and nutritional marasmus, are now well recognised syndromes. In less marked degrees, their prevalence is much greater, probably a hundred-fold. In these
conditions of dietary protein inadequacy, attendant bacterial infections and parasitic diseases add to their severity and lead to high mortality. Growing concern over protein-calorie malnutrition of early childhood as a major nutritional public health problem is spurred by the recognition that prolonged undernourishment will result in retardation of intellectual, psychological and neurological developments and give rise to population segments with chronically poor health and productivity. In our own country, it is estimated that out of the nearly 90 million children in the 1-5 age group, nearly 50% suffer from protein insufficiency. This vicious cycle relationship raises the spectre of generations of substandard and under-privileged mankind which in turn will seriously handicap the social and economic development of these nations.

With the protein gap still increasing, the Food and Agriculture Organisation of the United Nations has targeted a total of 112 million tons of proteins as the world requirement by 1975 as against the current production of about 85 million tons. Finding ways and means to fill this gap in a comparatively short period is a formidable problem of immense proportions, and one that undoubtedly requires all of man’s ingenuity and concerted attack for successful solution.

Increasing food supplies:

Man is dependent for his food supply, almost exclusively, on the products of land and water. It is in the practical development, improvement and prudent exploitation of these natural resources of both plant and animal origin as well as in the conservation of the produce that man must seek the solution. A co-ordinated approach, involving the total application of science and technology, for more efficient and complete use of these resources, and the elimination of practices that reduce productivity or are wasteful in nature, can alone ensure significant success.

Efforts are currently being made in several directions, with varying degrees of success, with the common objective of meeting the challenge of quantitative and qualitative improvement of man’s food. These avenues, vary widely in their potential, timeliness and feasibility and their success is further conditioned by social and cultural factors prevalent in various regions of the world.

Animal proteins versus plant proteins:

In any discussion of protein needs, a question that inevitably crops up relates to the comparative merits of vegetable and animal proteins from the points of view of quality, cost, availability and acceptability.
Protein-rich Plant Foods

Current consumption levels of animal proteins are outstandingly low in the developing countries. The estimated 25 million tons of high quality animal protein available yearly at the present time are almost monopolised by one-sixth of the world's population living in the prosperous nations. The remaining over 80 per cent of the population are mainly dependent upon cereal grains—wheat, rice and corn—for the satisfaction of both the caloric and protein needs. It would appear, at first sight, that the long-term solution to the protein deficiency problem in the developing nations could lie in rapid improvements in animal husbandry, to make available larger amounts of the more nutritive animal proteins.

Opinions on the nutritional irreplaceability of animal proteins by plant proteins are outdated and misconceived in the light of our current knowledge of protein and amino acid nutrition. While it is true that proteins from animal sources are more concentrated and have a more balanced essential amino acid content than those from plant sources, from the nutritional point of view the two should not be differentiated. This arises from the fact that the quality of a protein, determined by its essential amino acid make-up, can be improved, in practice, by supplementation with other proteins or fortification with the deficient amino acids.

Animals are notoriously inefficient at converting feed to meat since almost 90 per cent of what they consume is used up mainly for maintaining body warmth and other energy requirements. A large proportion of total calories, therefore, needs to be sacrificed to gain a few additional grams of animal protein and in the immediate future, there is little scope for diverting large quantities of calories, already in short supply, to feed animals in the developing countries.

More than thirty years ago, Kunkel, among others, pointed out the extreme inefficiency of producing food through a lengthy chain, that is, the series of steps in the transformation of materials by living organisms, which is necessary to convert nutrients to easily assimilable forms. Animals interpose links which considerably lengthen the food chain, thereby greatly decreasing the total availability of nutrients and considerably increasing their cost (Fig. 3). It is obvious, therefore, that one of the readiest ways of increasing the efficiency of food production is to shorten the food chain by placing greater reliance on plant products.

Yield per unit land is one measure of relative cost of proteins from different sources. While it must be remembered that yield of protein cannot be the sole criterion where other nutrients and produce of commercial value are also provided by the crop, animals provide the lowest yield of protein while grasses
PHOTOSYNTHESIS
16,000 MILLION TONS OF
"ORGANIC MATTER" ON LAND

2000 MILLION TONS
USED AS
ANIMAL FEED

4000 MILLION TONS
OF UNUTILISABLE
WASTE

2000 MILLION TONS
PROCESSED
FOR FOOD

NET EFFICIENCY
OF CONVERSION = 3%

360 MILLION TONS
OF "FOOD"

300 MILLION TONS
OF "FOOD"

EFFICIENCY OF PRODUCTION OF HUMAN FOOD FROM
PLANT AND ANIMAL SOURCES

Fig. 3. Efficiency of production of human food from plant and animal sources:
Direct utilization of plant products would yield at least five times more food for mankind than is possible through animal conversion.

and leaves the highest. Figures for the latter are, no doubt, as yet academic since economic methods for obtaining isolated protein suitable for human consumption are still being developed. With the recent introduction of high yielding varieties, soyabean provides 7 to 8 times more protein per unit land than milk and eggs and about 15 times that of beef.

The wasteful nature of over-dependence on animal products is also brought out by a comparison of the differences in primary calories consumed in India and the U.S.A. The Indian consumes his grain almost directly and uses about 2400 primary calories to get his 2000 actual calories. The average American, enjoying the luxury of animal conversion of cereals into protein consumes almost 11,000 calories to produce an average diet level of 3,150 calories; his demands on the earth's agricultural ecosystem is over four times that made by one living in the poorer countries (Fig. 4).

No matter how it is analysed, it is apparent that the cost of animal proteins is materially greater than the cost of vegetable proteins (Table 1) and the
Protein-rich Plant Foods

COMPARATIVE PER CAPITA CONSUMPTION OF FOODS IN U.S.A. AND INDIA

(FRM. PER DAY)

![Chart showing comparative per capita consumption of foods in U.S.A. and India.]

Fig. 4. Comparative per capita consumption of foods in U.S.A. and India:
Based on data collected by International agencies.

TABLE 1

'Nutrient economics' of proteins from selected raw material sources

<table>
<thead>
<tr>
<th>Source of protein</th>
<th>Protein content</th>
<th>PER</th>
<th>Approx. cost Rs/kg gain in body wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain sorghum</td>
<td>10.0</td>
<td>2.0</td>
<td>4.00</td>
</tr>
<tr>
<td>Groundnut</td>
<td>25.0</td>
<td>1.5</td>
<td>5.00</td>
</tr>
<tr>
<td>Wheat</td>
<td>12.0</td>
<td>1.3</td>
<td>6.50</td>
</tr>
<tr>
<td>Rice</td>
<td>8.0</td>
<td>1.7</td>
<td>10.00</td>
</tr>
<tr>
<td>Legumes</td>
<td>20.0</td>
<td>1.2</td>
<td>10.50</td>
</tr>
<tr>
<td>Chicken</td>
<td>26.0</td>
<td>2.0</td>
<td>11.50</td>
</tr>
<tr>
<td>Prawn</td>
<td>20.0</td>
<td>1.8</td>
<td>12.00</td>
</tr>
<tr>
<td>Fish</td>
<td>19.0</td>
<td>1.8</td>
<td>12.50</td>
</tr>
<tr>
<td>Egg</td>
<td>13.0</td>
<td>3.8</td>
<td>13.00</td>
</tr>
<tr>
<td>Mutton</td>
<td>18.5</td>
<td>2.1</td>
<td>15.50</td>
</tr>
<tr>
<td>Milk</td>
<td>4.0</td>
<td>2.5</td>
<td>16.50</td>
</tr>
</tbody>
</table>

Data on protein content and PER have been compiled from 'Amino acid content of foods and biological data on proteins', FAO, Rome, 1968 and 'The Nutritive Value of Indian foods and the planning of satisfactory diets', Indian Council of Medical Research, New Delhi, 1963.

Cost calculations are based on the average retail price of the produce prevailing in Bombay during 1969.
prospects of increasing food supplies from plants are in many ways brighter than from domesticated animals. Today, the developing nations in the tropical and sub-tropical regions, because of climate characteristics, soil composition, available resources of land, economic structure and cultural factors, could more easily develop their agriculture for the production of needed protein from vegetable sources rather than develop, to any significant extent, animal husbandry and the facilities required for an adequate utilisation of its products. Even two- to five-fold increases in the current levels of consumption of animal proteins would have negligible impact in satisfying the protein needs in most such countries; and exceptional economic progress and technical development are necessary to achieve this modest target.

**Increasing the availability of plant proteins:**

With the recognition that major efforts at narrowing the protein gap have to be concentrated on increasing the availability of plant proteins, the application of science and technology to both pre- and post-harvest practices are being attempted.

Throughout man's history, his efforts to obtain his food needs have been primarily directed towards increased agricultural production by bringing more land under cultivation. Since there is, indisputably, only a maximum measurable extent of cultivable area and as per capita availability of land is fast diminishing, particularly in the developing countries, man has turned his attention to improvements in conventional agriculture to increase yields per unit land.

**The 'green revolution':**

Cereals, occupying more than 70 per cent of the world's cropland, produce more than a half of man's direct energy intake. The need for increased production of cereals, to meet caloric requirements, has been recognised for many years, but it is only in recent years that cereals have come to be considered as a valuable source of protein. This arises from the fact that, despite the relatively low concentration of protein in most cereals, the quantities consumed are so enormous that they account for more dietary proteins than all the other sources combined.

Many national and international research centres throughout the world are actively engaged in attempts at increasing the yield of cereals and there is sufficient ground to believe that rapid responses in meeting protein needs are indeed possible in this direction. The achievements in the past three or four
years in increasing total cereal production have been most gratifying, even making allowance for the influence of favourable climatic conditions. This sudden breakthrough, the 'green revolution', has resulted almost entirely from the extensive application of modern plant breeding techniques; several hundred known genes have been manipulated to obtain desired combinations governing efficiency of photosynthetic utilisation of solar energy, sensitivity to photoperiod, productivity, stability of performance, capacity to withstand droughts and flood, tolerance to cold, resistance to diseases and pests, early maturity and responsiveness to fertilizers.

The combination of various desirable traits has enabled multiple cropping in tropical and sub-tropical regions where water supplies are adequate, enabling the harvesting of up to 4 crops in a year. Yields per unit of land have increased dramatically in many countries; in India, the yield barrier that had not been penetrated for nearly 30 years has been broken. Outstanding progress has been achieved with rice, wheat, millet, sorghum and other crop plants in various countries and these developments, coming in the relatively short history of plant breeding, are pointers that science and technology, properly exploited can enable man to meet the challenge of alleviating the protein crisis.

**Qualitative improvement of plant proteins:**

The 'green revolution' has so far signified mostly a self-sufficiency in quantity as increased yield was often found to cause a qualitative loss in nutritive value. In other words, while the increased cereal production held out the promise of abolishing hunger, it also threatened to increase malnutrition. This arose from the fact that in his prime objective of increasing yield, the plant breeder had paid little or no attention to manipulating the germ plasm to achieve higher protein content or protein of better quality to make it nutritionally more acceptable.

An improvement in protein content and composition in cereals, through genetic upgrading has the obvious advantage of being a permanent measure and, hence, offers one of the most promising approaches to bridging the protein gap. The results available today give indication that a combination of high yield, high protein and a protein of increased nutritive value is indeed possible in several of the major cereal crops.

A significant milestone in this direction has been the discovery of 2 natural mutants, opaque-2 and floury-2, of corn, a cereal deficient in both lysine and tryptophan. The introduction of the opaque-2 gene increases the content of both the deficient essential amino acids, that of lysine by as much as 70%; floury-2, additionally increases methionine.
The outstanding advances made with corn have not only been of great direct value, but have helped to focus attention on the eminently obvious possibilities of similar achievements with other major cereal grains. Many of these studies have already confirmed expectations of its vast potential. Only recently, it has been established that genes are present in barley which promote high protein and high lysine. In India, efforts are underway to develop varieties of crops such as high-lysine, low-leucine sorghum; high-protein and high-lysine wheat; high-methionine legumes and others.

The role of technology:

Significant as these developments are, no less exciting are the attempts to upgrade existing protein sources for human consumption by the development of several successful technologies; some of these are capable of immediate application while the commercial exploitation of many others will have to await further research and development.

Utilisation of oil seeds as source of protein:

Proteins from oilseeds offer an attractive possibility for greatly ameliorating the severity of the protein deficiency in the developing countries. Oilseeds constitute some of the most concentrated forms of food in nature and contain fairly large amounts of protein besides the oil. The protein content of oilseeds is much higher than that of other plant sources of protein such as cereals and range from about 20 to 45%. Extraction of oil and the removal of seed coats or hulls concentrates the protein in the residual meal to levels approaching in effect that of meat.

The quality of protein in oilseeds is generally good, many of them, particularly soyabean and to a lesser extent cotton seed, being rich sources of lysine (Table 2). This is a most favourable coincidence since in combination with cereals they could ideally mask the deficiency of lysine in the latter. The methionine content of oilseeds is in general low with the exception of sesame which contains high amounts of this amino acid. The nutritive value of oilseed proteins is in general good and soy protein in particular compares favourably with that of animal proteins (Table 3). The nutritive value of oilseed proteins can be further enhanced by judicious mixing with one another.

Among the different constituents of oilseeds, only the oil has for a long time been considered of value for human consumption and the oilcake residues left after extraction have been used mainly as livestock feed or manure. Extensive researches during the past decade in several parts of the world have shown that the oilseed meal, if properly prepared and processed, can serve as a valuable source of edible protein to serve human needs.
Protein-rich Plant Foods

TABLE 1
Essential amino acid content of major oilseed proteins g./g. N

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Groundnut</th>
<th>Cottonseed</th>
<th>Sesame</th>
<th>Coconut</th>
<th>Soyabean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.23</td>
<td>0.28</td>
<td>0.17</td>
<td>0.24</td>
<td>0.40</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.06</td>
<td>0.08</td>
<td>0.08</td>
<td>0.07</td>
<td>0.08</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>0.31</td>
<td>0.33</td>
<td>0.37</td>
<td>0.28</td>
<td>0.30</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.06</td>
<td>0.08</td>
<td>0.18</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.17</td>
<td>0.21</td>
<td>0.23</td>
<td>0.18</td>
<td>0.24</td>
</tr>
<tr>
<td>Leucine</td>
<td>0.40</td>
<td>0.37</td>
<td>0.52</td>
<td>0.43</td>
<td>0.48</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>0.24</td>
<td>0.21</td>
<td>0.25</td>
<td>0.24</td>
<td>0.32</td>
</tr>
<tr>
<td>Valine</td>
<td>0.28</td>
<td>0.29</td>
<td>0.29</td>
<td>0.32</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Data on amino acid content compiled from sources as indicated in Table 1. Figures in rectangles denote content of the most limiting amino acid.

TABLE 3
Nutritive value of some oilseed proteins

<table>
<thead>
<tr>
<th>Oilseed protein</th>
<th>Biological value</th>
<th>Digestibility</th>
<th>Net protein utilisation</th>
<th>Protein efficiency ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td>54.5</td>
<td>86.6</td>
<td>42.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Soyabean</td>
<td>72.8</td>
<td>90.5</td>
<td>61.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Coconut</td>
<td>69.0</td>
<td>79.5</td>
<td>55.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>67.2</td>
<td>79.6</td>
<td>52.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Sesame</td>
<td>62.0</td>
<td>81.7</td>
<td>53.4</td>
<td>1.8</td>
</tr>
<tr>
<td>Beef (for comparison)</td>
<td>74.3</td>
<td>99.3</td>
<td>66.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Data compiled from sources as indicated in Table 1.

It is fortunate that oilseeds are grown extensively in the developing countries, where protein deficiency is most prevalent (Table 4). Existing technology is adequate to produce oilseed meals suitable for simple low-cost protein rich mixtures as human food in sufficient quantities.

Soyabean, cottonseed and groundnut are the three major oilseeds in that order and together offer a potential of furnishing almost as much protein annually for man as that available from all the animal sources of protein. There has been the argument that the diversion of a traditional animal feed such as oilseed cake and residue for human food would necessitate the provision

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of alternate protein source in animal feeds. This can indeed be achieved by utilising other inferior sources of protein as yet not rendered suitable for human consumption such as leaf and grass proteins which can be produced with a high yield per unit land. Recent evidence would indicate that a good portion of the nitrogen requirements of cattle could, in fact, be provided in the form of comparatively inexpensive chemical sources of nitrogen such as urea.

The economics of traditional oilseed processing depended entirely on the maximum extraction of oil from the seeds with no attention being paid to the cake. This resulted in residues that were very poor in quality due to the excessive temperatures and pressures employed. With increasing realisation of the potentialities of oilseed proteins, pressing is being carried out under carefully controlled conditions to yield meals with highly satisfactory biological value of the proteins. Solvent extraction is also being increasingly employed and in this process the protein suffers little or no heat damage.

A major development for the simultaneous extraction of both oil and protein from oilseeds is the wet rendering process (Fig. 5). The oilseed is dispersed in aqueous medium at optimum pH when the three major constituents, viz., oil, protein and starch fibre tend to separate from one another because of differences in specific gravity.

It is possible to obtain by this process, protein isolates containing over 90 per cent protein. Such isolated vegetable proteins have certain advantages over the parent raw materials in that they are free from: (i) insoluble and indigestible carbohydrates which may swell and interfere with digestion and utilisation of the protein; (ii) odoriferous and bitter principles present in natural materials which may affect palatability; and (iii) trypsin inhibitors, phytates,
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haemagglutinins and other toxic factors which may affect nutritive value. Further, protein isolates are 2-4 times as concentrated as the protein source and possess a bland taste, thus permitting ready blending with other natural foodstuffs for increasing their protein content without affecting palatability.

Cottonseed protein could play a very important role in overcoming the deficit in needed quantity and quality of protein existing in the world today. Some of the advantages in the use of cottonseed as a source of protein are (a) high protein content of good quality; (b) availability of cottonseed as an indigenous crop in practically all areas of the world with a dietary protein deficit; (c) low cost, since the crop is grown primarily for its fibre and oil; and (d) using recent technology it can yield a product adequate for human use.

![Diagram of wet rendering process for the simultaneous extraction of oil and edible protein from oilseeds]

Fig. 5. General principle of wet rendering process for the simultaneous extraction of oil and edible protein from oilseeds: The process has been adapted for various oilseeds to suit specific requirements imposed by differences in their characteristics.

The problems in its utilisation stem from the presence in the seed of a pigment known as gossypol, which in addition to its toxicity, renders a good portion of the lysine unavailable and imparts a chrome yellow colour to the seed meal limiting its acceptability. Most of the research and development work in the processing of cottonseed have been directed towards removal or inactivation of this toxic pigment. The different methods developed for this purpose fall under one of the following categories.

(i) treatment with controlled heat in presence of water to bind gossypol to other substances in cottonseed; this however reduces digestibility and nutritive value due to loss of some lysine through binding;
(ii) application of chemicals such as calcium or ferrous ions, alkali, SO₄
ammonia and others; the separation of the chemical-gossypol complex
is often costly;
(iii) solvent extraction using acetone, benzene, ether, alcohol, aliphatic
hydrocarbons etc; the operating problems on a large scale have not
been fully solved;
(iv) liquid cyclone method using a non-polar solvent such as hexane which
is inert with respect to the protein and has no solvent effect in rupturing
pigment glands;
(v) air classification in which comminuted cottonseed containing intact
glands are subjected to separation into components;
(vi) fermentative degradation of gossypol using rumen microorganisms.

The methods for separating the intact glands by liquid cyclone or air
classification have been remarkably successful and are of great significance in
developing food grade protein; in India studies on the liquid cyclone method
are being conducted by Dorr-Oliver who originally developed the liquid cyclone.

Getting rid of gossypol can also be tackled by another way which, in fact,
represents a major breakthrough and is likely to make the other methods of
academic interest only. Since it is known that gossypol is contained in a
special gland, efforts have been underway for some time on the selection and
breeding of glandless varieties of cottonseed. Such varieties have been success-
fully developed and grown on large scale in recent years. Yield and quality of
fibre obtained from the glandless varieties are, in most cases, markedly superior
to or about equal to that from the glanded variety. The glandless seed can be
processed by simple solvent extraction using hexane to yield high quality oil
as well as meal with superior nutritive value (PER of 2.8 as against 2.1 for glanded
variety) and excellent colour making it suitable for use in food formulations.
With the increased availability of the glandless seed, the door will be wide
open for a fuller utilisation of this valuable vegetable protein source. It is
expected that by 1980, all cotton crop in the United States will be of the glandless
variety.

Edible cottonseed protein, containing less than 0.06% free gossypol, is being
utilised for human consumption, notably in Latin America where it is
incorporated as a major ingredient in 'Incaparina'. This formulation,
representing one of the earliest high protein mixes from vegetable sources, has
been fed successfully to thousands of children.

Soyabean, the world's most abundant oilseed, has been a source of protein
for humans for thousands of years. Because of its low cost and high nutritive
value resulting from the presence of the essential amino acids in good proportion, soyabean is one of the best and cheapest sources of food in terms of protein per unit cost of production.

The greatest obstacle to the general use of soyabean as a source of human food products is the bitter, beany taste and objectionable odour and colour of such products; additionally, the presence of several physiologically active proteins raise problems of toxicity. The ancient civilisations resorted to several empirical extractions, fermentation and cooking practices to destroy or remove these deleterious factors; modern technology has provided additional procedures.

Though soyabean grows well in temperature climates, it has not as yet been grown extensively in tropical countries like India. In recent years extensive efforts have been made to grow the crop in India and there are several reports of remarkable success. Due to the emergence of high yielding varieties and the acceptance of improved agricultural practices, spectacularly high yields of soyabean per acre are reported from northern India where, in 1969, between 15-20000 acres were cultivated. It is forecast that by 1974, one million acres will be under soyabean and could yield us great new source of protein of very high quality.

Soyabean is generally processed into one of five different categories of products; full fat soy flour; defatted soy flour; 60-70% protein concentrate; protein isolate; and extended milk or milk substitutes. The various products represent different degrees of separation of the protein component from oil, which is itself commercially valuable, carbohydrates, some of which like raffinose and stachyose cause flatulence, fibre and others.

In the production of soya flour, the temperature, moisture content and time in each operation of the process have to be carefully controlled so that the biological value of the product as a protein is retained, at the same time removing the growth inhibitors present in the raw bean. It is indeed fortunate that all the deleterious factors present in the soyabean can be inactivated by simple heating procedures.

The development of a special process has resulted in the production of a nutritious soy protein isolate that is completely bland. The light cream coloured bland powder is at least 90% water-dispersible and at least 50 per cent water-soluble. It has interesting emulsifying, thickening, gelling, film forming and water binding properties making it a versatile supplement that could go into a variety of solid and liquid foods. Soy protein has been used in high protein formulations for use in weaned children.
Soyabean milk is one of the earliest vegetable milk substitutes that was successfully developed. The soy protein has been used either alone or in combination with other vegetable proteins such as from sesame, coconut and others. It has also found use in the preparation of 'extended' milks in which soy protein replaces a part of milk protein, thereby stretching the availability of milk.

Groundnuts are another major oilseed crop. India is the major producer with an annual production of about 5 million tons (in shell), yielding about 1.5 million tons of the pressed cake, containing 50 per cent protein, as a byproduct. A major part of the product is used as manure and only a relatively small amount goes for animal feeding. With greater care and attention to the kernel, prior to and during the extraction of the oil, an entirely edible quality groundnut meal can be readily had.

Groundnut protein is deficient in three essential amino acids, lysine, methionine, and threonine, but could be used in combination with other proteins, both of animal and vegetable origin to give mixtures of satisfactory nutritive value.

There are no special problems involved in the processing of groundnuts by either pressing or solvent extraction. The wet rendering process could be used to advantage in getting a good quality protein isolate suitable for incorporation into foods specially designed for the vulnerable groups. Apparently there are no major obstacles to acceptance of the product, neither any manufacturing problem.

There has been some concern regarding possible contamination by aflatoxin, a mold metabolite, since the alarming death of young turkeys reared on groundnut meal in England, almost ten years ago. However, sensitive tests for these toxins have since been developed and progress is also being made in developing detoxification methods and in improving drying and storage whereby the development of these toxins may be prevented.

The mold does not appear to attack the kernel while they are still developing and where the moisture content is 30 per cent or more. But once the kernels mature, they become susceptible to contamination. As the kernels dry out, they once again become less susceptible and no contamination occurs at moisture levels lower than 9 per cent.

Based on intensive investigations, the following procedures are recommended for minimising the risk of contamination with aflatoxin:

(i) crop must be harvested as soon as it is mature and care should be taken to avoid damage during lifting
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(ii) damaged pods should be promptly isolated and destroyed
(iii) pods must be rapidly dried, avoiding unnecessary handling that could lead to cracking of the pod
(iv) dry storage of kernels after removal from pods.

While it is reasonably safe to assume that flour from good quality kernels will be free of this toxin, the defatted meal may be further subjected to a continuous extraction process with methanol for complete elimination of aflatoxin, ensuring against health hazards in the large scale use of the meal.

Groundnut protein is finding use in a number of high protein formulations developed in India for the vulnerable groups. More recently, a simulated milk product, in different flavours, has been developed for commercial distribution.

The uniqueness of sesame lies in its unusually high content of methionine, which makes the protein from this source ideal for supplementation with other oilseed proteins such as groundnut which are generally low in this essential amino acid. India produces considerable quantities of this oilseed and the isolation of protein from this source should be most desirable. The main problem in its utilisation is that the skin contains high quantities of oxalic acid and fibre. To get good quality edible meal, it is necessary that the skin be removed before pressing. This can be achieved either by a wet method involving soaking or by dry toasting. Sesame protein together with wheat germ has been formulated into a new protein beverage powder.

Coconut is among the more important oil-bearing fruits in world trade. Though some of it is consumed as fresh nuts, the chief products of commerce are oil and copra, the dehydrated kernel. Copra analyses to about 65 per cent fat and only 9 per cent protein. Economically, the extraction of oil is the prime consideration and the protein in the coconut meal is not, at present, utilised for human food. The technique of ‘wet rendering’ is particularly advantageous for the processing of coconut since the fibre content is high. Starting with fresh coconuts and using this process, very good quality of oil that does not require further refining has been obtained. Coconut meal protein has a satisfactory nutritive value, particularly when used as a supplement in diets with other proteins.

Mustard is also an important oil-seed crop of India. The presence of sinigrin, a thioglucoside, makes the meal unpalatable and toxic. Sinigrin can be hydrolysed by an enzyme contained in the seeds to give glucose, inorganic sulphate and allyl isothiocyanate. The last-named compound, responsible for the unpalatable taste, being a volatile oil can be removed by distillation.
This compound has a number of industrial, pharmaceutical and agricultural uses and as such is a valuable byproduct.

Among the other important oilseeds being studied in various parts of the world for their possible utilisation as a source of protein are sunflower seeds, rape seed and crambe. The problems associated with the utilisation of proteins from major oilseeds and methods for overcoming them are briefly summarised in Table 5.

<table>
<thead>
<tr>
<th>Oi1seed</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed</td>
<td>Gossypol toxicity</td>
<td>Removal by air or liquid cyclone classification, breeding of glandless variety</td>
</tr>
<tr>
<td>Soyabean</td>
<td>Physiologically active proteins, flatulence factor</td>
<td>Controlled heat treatment; fractionation of protein</td>
</tr>
<tr>
<td>Groundnut</td>
<td>Aflatoxin toxicity</td>
<td>Careful harvesting of pods and storage of kernels; methanol extraction of meal</td>
</tr>
<tr>
<td>Sesame</td>
<td>High oxalic acid and fibre content of skin</td>
<td>Skin removal by soaking or dry-toasting</td>
</tr>
<tr>
<td>Mustard</td>
<td>Sinigrin toxicity</td>
<td>Enzymatic hydrolysis and distillation</td>
</tr>
</tbody>
</table>

Increasing availability of proteins by supplementation:

Another practical measure for improvement of nutritive value of limited resources of plant proteins is by enabling the utilisation of the protein contained in them to the maximum. This can be done by devising suitable blends in such a manner that the constituent amino acids add up to mask individual deficiencies of essential amino acids to a significant extent. The complementary nature of the cereal proteins on one hand and the legume and oilseed proteins on the other with respect to the content of the limiting essential amino acids, lysine and methionine, is an excellent example of such a possibility (Table 6). In fact various civilisations have, from time to time, practised such supplementation to a surprising degree though on a purely empirical basis.
TABLE 6

Lysine and methionine deficiencies in plant proteins—possibilities of mutual supplementation g./g. N

<table>
<thead>
<tr>
<th>Cereals</th>
<th>Rice</th>
<th>Wheat</th>
<th>Maize</th>
<th>Ragi</th>
<th>FAO Ref. protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.23</td>
<td>0.14</td>
<td>0.17</td>
<td>0.18</td>
<td>0.27</td>
</tr>
<tr>
<td>Methionine</td>
<td>9.18</td>
<td>0.12</td>
<td>0.12</td>
<td>0.19</td>
<td>0.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Legumes</th>
<th>Oilseeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>Lentil 0.38, Peas 0.98, Groundnut 0.23, Cottonseed 0.28, Soyabean 0.40</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.04, 0.07, 0.06, 0.08, 0.08</td>
</tr>
</tbody>
</table>

Data compiled from sources as indicated in Table 1. Figures in brackets denote deficiency.

These considerations make legumes an indispensable crop for supplementing the protein content of diets based on cereals or starchy roots and tubers. Many varieties of legumes contain inhibitors or toxins which put an upper limit on their use; the deleterious substances include proteolytic inhibitors, cyanogenic glucosides, saponins, alkaloids, haemolytic factors, goitrogens, haemagglutinins, lathyrus factor and others. Although present knowledge suggests that most of these are present only in the raw grain and are eliminated by ordinary methods of preparation such as adequate soaking and boiling, it may be desirable to devise specific methods to ensure their total absence. Indeed, a genetic approach, similar to the development of the glandless variety of cottonseed to eliminate the gossypol hazard, may be practicable in many of these situations; efforts to develop varieties of Lathyrus sativus free of the toxin, β-N (oxalyl), α, β-diamino propionic acid, have already shown success.

In the absence of availability of animal proteins, international agencies such as FAO, WHO and UNICEF have a joint programme for a phased approach to the development of blended plant protein foods, specifically for use at weaning. Considerable effort has already resulted in the development of a variety of high...
protein foods based on locally available plant proteins. Among the notable examples are: *Incaparina*, composed of corn and cottonseed (variants with soyabean and sorghum have also been developed); *CSM*, containing corn, soyabean and a small amount of skimmed milk; *Bai Ahar*, made up of wheat and groundnut; *Bal Amul*, a commercial product based on wheat, soyabean and green gram. Examples of various protein food mixtures developed in different parts of the world are shown in Table 7.

### Table 7

<table>
<thead>
<tr>
<th>Product</th>
<th>Country</th>
<th>Composition</th>
<th>Protein content (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incaparina</td>
<td>Guatemala</td>
<td>Maize, cottonseed flour, vitamin A, lysine, calcium carbonate</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>Colombia</td>
<td>Same—plus defatted soyabean flour</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>Mexico</td>
<td>Same—plus defatted soyabean flour but without cottonseed flour</td>
<td>27.5</td>
</tr>
<tr>
<td>Fortifex</td>
<td>Brazil</td>
<td>Maize, defatted soyabean flour, vitamin, dl-methionine, calcium carbonate</td>
<td>30.0</td>
</tr>
<tr>
<td>Pronutro</td>
<td>South Africa</td>
<td>Maize, skim milk powder, groundnut, soyabean, fish protein concentrate, yeast, wheat germ, vitamins, niacin, sugar, iodized salt</td>
<td>22.0</td>
</tr>
<tr>
<td>Protone</td>
<td>United Kingdom</td>
<td>Maize, skim milk powder, yeast, vitamins, minerals</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>Congo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arlac</td>
<td>Nigeria</td>
<td>Groundnut flour, skim milk powder, salts and vitamins</td>
<td>42.0</td>
</tr>
<tr>
<td>Lac-Tone</td>
<td>India</td>
<td>Groundnut flour, skim milk powder, wheat and barley flour, vitamins, calcium</td>
<td>26.0</td>
</tr>
<tr>
<td>Aliment de</td>
<td>Senegal</td>
<td>Millet flour, groundnut flour, skim milk powder, sugar, vitamins, calcium</td>
<td>20.0</td>
</tr>
<tr>
<td>sevrage</td>
<td>United States</td>
<td>Maize (precooked), defatted soyabean flour, skim milk powder, sugar, vitamins, calcium</td>
<td>20.0</td>
</tr>
<tr>
<td>Supro</td>
<td>East Africa</td>
<td>Maize or barley flour, torula yeast, skim milk powder, salt, condiments</td>
<td>24.0</td>
</tr>
</tbody>
</table>


**Amino acid fortification—potentials and problems:**

Protein impact of plant foods can also be raised by fortification with the deficient essential amino acids; principally lysine for wheat, lysine alone or
with threonine for rice, lysine with tryptophan for corn etc. While only about half the protein in wheat is utilisable (Protein score 47) because of its inadequacy mainly with respect to lysine and to a smaller extent tryptophan, its protein score can be boosted to nearly that of fish (Protein score 71) by enriching with lysine to the extent it comes up to the level of the second limiting amino acid. Likewise, the nutritive value of several oilseed proteins can be significantly enhanced by supplementation with methionine, the most limiting essential amino acid. e.g. the PER of groundnut flour and soyabean meal can be increased by 30-35%. Amino acid fortification affords greater manoeuverability than is generally possible by supplementation with protein concentrate since the missing amino acids can be added in the right proportion to bring the quality of any protein of plant origin into the range of those of animal proteins.

The method has several advantages and promises to become a major means of bridging the protein gap. Technical progress in recent years has made it possible to produce lysine and methionine by fermentation or by chemical synthesis at relatively low cost. There are good prospects that with increasing demand, the price of the two other major limiting amino acids, tryptophan and threonine, will also come down making complete fortification of major cereals a practical proposition. Since fortification involves the upgrading of staple cereals and cereal products, already being widely consumed, it can be instituted with minimum delay and the benefits made available to large numbers of people. It would also appear to be the least expensive method of increasing protein availability. It has been estimated that fortification could increase the cost of cereals by 2-10% and, reckoned on the basis of the increased protein made utilisable, it would still be 10-20 times cheaper than the provision of an equivalent amount of animal protein.

Japan has made the most progress in this field and has an active fermentation industry manufacturing several amino acids. Lysine fortified foods are widely marketed and investigations are underway to develop suitable techniques for fortification of rice. The biggest lysine fortification programme in the world is being carried out in this country where government bakeries are producing fortified bread. Other avenues of fortification such as whole grains and atta are also being tried and salt and tea have also been considered as possible carriers to reach large number of people. The various high vegetable protein mixes developed for weaning children, and referred to earlier, are also fortified with lysine and/or methionine with attendant advantages.

In spite of all these developments and the widespread interest in fortification with synthetic amino acids for the past several years, actual progress has been slow and limited. The economic factor remains the primary obstacle for, in
spite of the availability of synthetic amino acids at low cost, even minor increases in price of staple cereal food would seriously affect the economically lowest segment of the population. There are also technical difficulties to be overcome especially in areas where cereals are not processed in centralised large scale facilities.

Before the adoption of amino acid fortification on a large scale, it is also desirable to ensure its need and efficacy in specific locations. This arises from the fact that although lysine is certainly the most limiting amino acid in cereals taken alone, in the quantities in which cereals are consumed in a poor diet, the total intake of lysine would often exceed the daily requirement of this amino acid. Furthermore, it has been found that all average national diets, even from countries where protein deficiency is prevalent amongst the children the first limiting amino acid is methionine. More recent figures, computed from FAO statistics on characteristic regional diets, also reveal a primary deficiency of the sulfur containing amino acids. These observations emphasise the need to recognise the fact that most people eat mixed diets, in assessing the usefulness of amino acid fortification programmes.

There is also the very real danger of the creation of an amino acid imbalance and consequent deleterious effects as a result of improper fortification. Amino acid imbalances are most readily created in diets that are low in protein by supplementing with any amino acid other than the most limiting one. Pellagra, a public health problem of considerable magnitude in the millet eaters of the Deccan Plateau has been shown to result from an amino acid imbalance caused by an excess of leucine. It is in this context that efforts are underway to develop varieties of this crop with lower leucine content and higher amounts of the limiting amino acids.

Sophistication in foods—the need and the development:

At one time it was firmly believed that animal proteins are far superior to protein isolates from vegetable sources. It is now increasingly being brought home that vegetable protein isolates are not only pure and concentrated but can also be further processed, modified, enriched and combined so as to make something equal or superior to animal proteins in nutritive value.

Despite this general realisation of their nutritional adequacy as well as economic advantage, the acceptance of plant protein products is often limited by a lack of appeal. This raises the question of human preferences as a crucial and important factor in promoting new foods. It is, doubtless, possible to promote acceptability through changes brought about by culinary skill, but this will not, in itself, suffice.
The maxim that ‘man eats what he wants, not what he is told to’, underscores the need to engineer desirable qualities of colour, flavour, texture and appearance into the new protein products. In the past decade or so, the food processing industry has assumed its burden of responsibility in fighting protein malnutrition by developing a variety of aesthetically attractive protein foods. This represents an enormous break-through in the evolution of foods and even if the products are initially beyond the reach of the poorer sections, increasing production will in time enable their penetration to the lower economic levels.

**Plant protein beverages:**

Protein beverages based on plant proteins are one fine example of such products that have great potential for popular acceptance and could contribute significantly to betterment of protein nutriture of large numbers of people.

Essentially three different kinds of beverages have been developed: ‘extended’ milks, simulated milks and soft drink type beverages.

The ‘extended’ milks, as their name signifies, permits increased availability of milk, which is in extremely limited supply in most developing nations, by ‘toning’ it with groundnut, soyabean, cottonseed or other plant proteins that are indigenously available. The success in developing these products has depended mainly on the skill in making stable homogeneous emulsions.

When the plant proteins themselves are homogenised, with or without addition of a suitable fat, to a milky suspension, a variety of simulated milks is obtained. These are offered as attractively flavoured drinks; one such is ‘Milpro’ based on groundnut protein and recently made commercially available in India.

Vegetable protein beverages can also be made in the form of soft drinks which have around 3 per cent protein and are as nutritive as milk but are more or less clear. The pioneering product in this class is ‘Vitasoy’, based on soyabean, which is extremely popular and is the largest selling soft drink in Hong Kong. Other such flavoured drinks formulated from soy protein and marketed commercially include ‘Puma’ in Guyana and ‘Saci’ in Brazil. A reconstitutable protein drink, ‘Frescavida’, based on proteins of sesame and wheat germ, is also available in powder form in El Salvador. These new protein beverages are priced as competitive as other soft drinks. More recently carbonated protein drinks are also being developed.

**Textured vegetable protein products:**

An important element of aesthetic quality in foods, apart from colour and
flavour, is texture. This is what distinguishes properly processed foods from structureless ones and makes them desirable, e.g., leavened bread from wheat flour. The technologists have an important role in conceiving and evolving processes for transforming inexpensive plant proteins into entirely new and highly suitable forms, just as the animal does, but at much less cost. When this goal is attained, status in foods need not be limited to those of animal origin or to the more expensive; cost and original source could lose their value as determining factors in the choice of food.

A most promising beginning has been made in the past few years in creating plant protein products which will satisfy equally all that a human looks for in a food of choice. Protein isolation processes and synthetic fibre technology have offered a means of obviating the inefficiencies involved in meat production by providing directly with vegetable proteins a novel series of foodstuffs possessing textural homogeneity and nutritional excellence hitherto associated only with animal protein. In addition to economy, these foods offer greater stability, uniformity, nutritional control and organoleptic variety.

Several methods of preparing textured foods have been developed, based on the original process of Robert Boyer proposed over 15 years ago. A typical commercial process begins with the isolation of a bland protein of over 95 per cent purity from any of the plant sources, by extraction with mild alkali followed by refining. This isolate is dispersed and the resulting dope is extruded through spinnerettes into a coagulating bath when filaments of 1 to 30 microns diameter are formed. By changing the conditions in the bath, the character of the filaments can be varied from that of tender delicate fibrils to tough strands. The toughness is also controlled, to an extent, by the amount of stretching the filaments undergo when taken up by a series of rolls revolving at increasing speeds. The final product is made to simulate meat, poultry or sea-food by taking advantage of process variables such as number of filaments in a bundle as well as the nature and amount of various additives such as binder, fat, colour and flavour. Products have also been developed having different zones simulating the appearance of lean and non-lean portions analogous to bacon, pastrami, corned beef and the like. Additional nutritive value can be imparted to the products by incorporation of supplemental nutrients like vitamin concentrates, amino acids and others to bring them close to that of animal proteins (Table 8).

A non-spinning process to produce a shredded texture has also been developed which yields a meat-like texture and appearance in products subjected to elevated temperatures as in deep-fat frying, roasting and boiling. The process involves rapid orientation and heat coagulation of the protein in a substantially unendangered, finely divided, hydrated state under conditions which produce a
Protein-rich Plant Foods

shred-like structure. This material maintains its structure even during dehydration and rehydration or freezing and thawing.

TABLE 8
Essential amino acid content of some textured vegetable proteins

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Beef Muscle</th>
<th>'TVP'</th>
<th>'Textrasoy'</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/g</td>
<td>mg/g</td>
<td>mg/g</td>
</tr>
<tr>
<td>Iso-leucine</td>
<td>20.0</td>
<td>27.1</td>
<td>24.0</td>
</tr>
<tr>
<td>Leucine</td>
<td>30.2</td>
<td>29.3</td>
<td>40.0</td>
</tr>
<tr>
<td>Lysine</td>
<td>33.2</td>
<td>30.7</td>
<td>33.0</td>
</tr>
<tr>
<td>Methionine, cystine</td>
<td>15.6</td>
<td>13.4</td>
<td>13.0</td>
</tr>
<tr>
<td>Phenylalanine, tyrosine</td>
<td>26.4</td>
<td>48.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Threonine</td>
<td>17.2</td>
<td>19.6</td>
<td>20.0</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>3.9</td>
<td>7.1</td>
<td>7.3</td>
</tr>
<tr>
<td>Valine</td>
<td>19.8</td>
<td>29.9</td>
<td>24.0</td>
</tr>
</tbody>
</table>

'TVP' and 'Textrasoy' are brand names of textured plant protein products made by Archer Daniels Midland Co., Decatur, Ill., U.S.A. and H. B. Taylor Co., Chicago, Ill., U.S.A. respectively and data on the amino acid composition of the products are as given by the manufacturers.

Using such procedures a range of commercial products that imitate such distinctively flavoured and textured meats as fried chicken, roast beef, smoked ham and barbecued steak, among others, have been prepared and are on sale in the United States; their market share, as yet, is minimal but is showing signs of rapid improvement. The market penetration in Japan, where a variety of such products is available, has been more than satisfactory.

More recently, the costly step of preparing the protein isolate prior to spinning, has been avoided by directly obtaining protein fibres from safflower seed meal.

Though the textured vegetable protein technology has been developed essentially for soy protein, the technical principles are similar for proteins from other oilseeds such as groundnut, cottonseed or others. In Japan, spun and textured products based on wheat protein or a mixture of soy and fish protein have been commercially marketed. Combinations of gluten and soy protein are also under development; the two proteins potentiate each other both with respect to physical properties and nutritive value. The evolution of similar products in specific areas will depend on, in addition to local availability of raw material, special economic and nutritional situations.
Proteins from foliage, seaweeds and algae:

A class of plant proteins that has, in general, a nutritive value that is superior to those of cereals but which has not as yet been exploited to any significant extent are the leaf proteins. The proteins contained in the cells of leaves are largely inaccessible to animals other than ruminants because of their inability to digest the cell walls. The major problems in obtaining protein from foliage relate to aspects of technology and economics.

Attempts have been made with varying degrees of success to break cell walls to free the protein and the most efficient method seems to be to extract the protein by mechanical or chemical rupturing of the cells and pressing out the liquid contents. About a third of the protein separates out, the remainder being closely held by the lignins and hence unsuitable even as cattle feed.

In spite of the problems of acceptability at the present time, there can be no doubt that leaf proteins offer a long term potential in meeting human protein needs. It would be highly economical to produce leaf proteins, particularly in countries with large populations and limited land resources, if one considers that the amount of protein that could be obtained from land as leaf protein is 2-3 times that of the heaviest producer among cereals, 6 times that of milk and almost 10 times that of meat.

Seaweeds and algae also contain high amounts of protein of relatively good quality in their cells. A variety of techniques have been used to break open the cell wall—these include heating, ultrasonic disintegration and mechanical crushing. The crude protein obtained has a somewhat unpleasant appearance, taste and odour. The green algae gives a green coloured product which can be decolourised and made more palatable by chemical bleaching, but the nutritive value is adversely affected. Acceptable products can be currently obtained only by the use of fairly expensive processing techniques.

Cultured under optimal conditions, Chlorella attains a protein content of up to 60% on dry basis and the quality of the protein is comparable to those of yeast and groundnut. An annual yield of 17.5 tons of chlorella per acre is possible with our present technological knowledge. The production of different algae such as Chlorella, Spirulina and others is being attempted on pilot as well as commercial scales in Mexico, Czechoslovakia, Rumania, U.S.A. and Japan.

Since algae need only atmospheric carbon dioxide as a carbon source and in view of the fact that the efficiency of conversion of inorganic nitrogen into protein through photosynthetic energy is high, a technological breakthrough in its
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processing holds considerable promise of providing an abundant source of good quality protein.

Single cell proteins:

The protein potential of microorganisms has only recently been recognised and the future holds forth hope that vast additional quantities of single cell protein may be produced by the utilisation of waste carbohydrates as well as petroleum hydrocarbons. No major differences exist between protein derived from microorganisms and proteins of other plants or animals and sufficient information has been accumulated to indicate that single cell protein is readily utilised by animals and man.

Since protein content of most microorganisms is very high (moulds: 10-40%, yeast: 30-60% and bacteria: 40-80% of dry weight), the latter can be used as such without extraction of the protein. The proteins are generally fairly rich in lysine, somewhat deficient in methionine and sometimes also in tryptophan.

Though in principle, microorganisms such as bacteria, yeast and molds are like animal converters of organic material, they offer the unique economic advantages of rapid growth and simpler nutritional requirement. While the mass doubling time for beef cattle is about 5 years, for pigs 4 months, for chicken 4 weeks and for higher plants 1-4 weeks, it is only 1-6 hours for bacteria; in other words, while beef cattle synthesise about 0.4 kg. protein in 24 hours, in the same period an equivalent amount of yeast, grown on ammonium salts as a source of nitrogen, can produce about 50,000 kg. protein.

The production of yeast from the effluents of various industries producing organic waste has been practised successfully in numerous countries in recent years. The cultivation of yeast is especially advantageous when use is made of *Torulopsis utilis*, which is rich in protein, fat and vitamins. Conversion of industrial wastes such as waste sulfite liquor, molasses, whey distillery slops and hydrolysed cellulose into yeast would also solve serious waste disposal problems in these industries. Pilot scale production of yeast using waste carbohydrates as substrate has begun in India and a British commercial unit is studying the production of yeast on byproducts from milling of wheat.

Interesting studies are also underway on the fermentation of starchy foods such as cassava with molds and the possible use of incompletely fermented material without separation of the mold from the residual starch.

One of the more significant process developments of recent years is the utilisation of hydrocarbon materials to produce protein by single cell production.
FLOWSHEET FOR PRODUCTION OF
SINGLE CELL PROTEIN

PETROLEUM CRUDE

OXYGEN FROM AIR

GROWTH OF BACTERIA, YEAST

MINERAL NUTRIENTS

DEWAXED OIL TO REFINERY

CENTRIFUGE

CELL SLURRY

WASHING

CELL SLURRY

CENTRIFUGE

CELLS

DRYING

POWDERING

ANIMAL FEEDING

ANIMAL PROTEIN

Fig. 6. Flow-sheet for production of single cell protein:
In view of the limitation in human acceptability, the product holds potential mainly as an animal feed at the present time. With the development of suitable technology, direct utilisation as human food may become possible.
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The cells, yeast or bacteria, can be grown either on high purity alkane substrates (C_{12}~C_{19}) obtained by extracting petroleum crude with urea or molecular sieves or on gas oil itself which enables dewaxing and protein production to occur simultaneously. Starting with a high purity substrate offers the advantage of doing away with costly separation steps.

Both yeasts and bacteria have been successfully utilised. The yeasts being larger simplify recovery, grow at a lower pH thereby lessening chances of contamination and have a protein with a higher lysine content. On the other hand, bacteria have higher protein content, faster growth rate and simpler nutritional requirements and are also more palatable.

In addition to the petroleum hydrocarbons which serve as the main substrate, the organisms also require a source of nitrogen, which for reasons of economy is usually an ammonium salt, and critical amounts of selected mineral nutrients such as potassium, sulphur and phosphorus, for rapid growth.

Though the full potential of single cell protein as a source of protein for human use, will have to await further research and developmental efforts, considerable interest in these products has been apparent in recent years. According to one estimate, 3 million tons of protein per year could be produced as food yeast by growing them on 1 per cent of the world’s annual production of 700 million tons of crude paraffinic petroleum.

The Petroles BP in France use a paraffinic gas oil fraction as nutrient for their yeast, and large scale animal feeding trials with the product have been successfully completed. Shell oil in England have grown the microorganisms on methane gas, often a waste product of refinery processes. ESSO use a highly purified fraction as raw material, eliminating the need to remove impurities from the final product. Feeding tests with this product have indicated it to be an acceptable sole source of protein.

Need for economy in utilisation of food resources:

While recent advances in science and technology have helped avert a major food crisis for mankind, there can be no room for complacency. The food potential of the earth, though not fully utilised today, is certainly limited and, therefore, there can be no alternative to population control as an ultimate solution. The recognition of the finite nature of the earth’s resources also necessitates their prudent exploitation by man.

Sir Peter Medawar, the scientist-philosopher, recently remarked: “We
shall have to abandon a style of economy marked by profligate production, consumption and waste for something more like a space-ship economy marked by frugality, recycling and above all by forethought. While these remarks indeed apply to all aspects of production, their relevance and wisdom are particularly apparent in the context of man's attempts to feed himself. Even today, the world can sustain only a fraction of the present population, if everyone were to depend for his food on wasteful animal conversion of nutrients as obtaining in the more prosperous nations. Our efforts have to be necessarily directed at providing better nutrition for large numbers by more efficient means.

The nutritionist has a central role to play in such efforts. Since efficient utilisation of food resources demand greater reliance on plant proteins, the nutritionist must precisely define the needed qualitative improvements in their order of importance. With the availability of such knowledge, the agriculturist and the plant breeder can focus their attention on environmental and genetic methods of upgrading the proteins of major plant crops. The technologist can supplement these efforts not only by improving nutritive value further by suitable processing but also by building aesthetic appeal into the foods. Together they can provide mankind with attractive and highly nutritious foods from plant sources that are available at the present time only at considerable cost through the intervention of animals.
It might be unnecessary to emphasize here that the protein-calorie balance of the diets is inadequate for even the present world population and the accelerated population growth in developing countries will, in time result in a serious food problem. Hunger and malnutrition have an endemic character at present but are becoming challenges to the prosperity and welfare of humanity at large. The food problem, in large measure is a protein problem. It is thus needed to find out all possible ways of increasing protein supplies and, in addition, to provide entirely new sources of protein, hitherto not employed either for human or animal nutrition. We are placing our hope on the potentiality of single cell proteins, for example, microbial isolated protein (MIPRON) as one of new protein sources from human nutrition.

Hunger and malnutrition are widespread in Asia and bring on many socio-economic problems. The food problem is certainly complex and no single approach will solve it entirely. A potential augmentation of agricultural production will be achieved by coupling modern agricultural technologies with improved high-protein or high-yielding varieties. There are however many stumbling blocks for this type of solution. The so-called "Green Revolution" is a long range goal and thus cannot be an appropriate solution to the problem we are confronting today. We have to find out short-term approaches to the food problem or to postpone the solution until we can uproot every source of the problem.

Fortification of cereal staples with deficient nutrients is one of the short-cuts to alleviating the food problem. There is certainly a need to examine whether it is possible to employ carriers other than staple cereals for the nutrients fortification. With due regard to the basic idea of fortification, it is quite possible to supply at least staple cereals as nutritionally well-balanced foods after being fortified with deficient nutrients at their source, just as city water is distributed after being sterilized at its source. Fortification programmes have to be carried out on a national basis, so that the people, rich or poor, intellectual or ignorant, can improve their nutrition without making any particular effort.
by themselves. We believe, fortification of foods should not destroy the original flavor or texture, nor saddle the consumers with much additional expense, but desirably endow a favourable character to the foods.

As often said, the major source of calories and protein in the world for human nutrition are the cereals, and so is it in Japan. As shown in Fig. 1, rice consumption had been about 350 gram per capita per day. Even as recently as 1967, it was over 320 gram, which amount of rice provided 50% of total caloric intake, 26% of protein and 37% of vitamin B₁. From these figures, one can

FIG. 1

DEPENDENCY ON RICE GRAIN AS NUTRIENTS SOURCE IN JAPAN (after National Nutrition Survey).
understand how rice grain bears an important role in the nutrition of the Japanese. The nutritive value of rice grain varies depending on many factors. One of the most critical factors among them is the milling procedure. Table 1 shows changes in calories, protein, and vitamin $B_1$ and $B_2$ contents of rice kernels caused by polishing. Rice grain is consumed mostly in completely polished form in Japan. Among the nutrients which are often found deficient in the diets of Japanese people, vitamin $B_1$ and lysine are two of the most significant. This is due to the fact that vitamin $B_1$ and lysine content of rice grain as consumed are too low to satisfy the nutritional requirements.

### TABLE 1

<table>
<thead>
<tr>
<th>Extent of polishing</th>
<th>Calories (cal)</th>
<th>Protein (g)</th>
<th>Vitamin $B_1$ (mg)</th>
<th>Vitamin $B_2$ (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown</td>
<td>334</td>
<td>7.4</td>
<td>0.40</td>
<td>0.10</td>
</tr>
<tr>
<td>Half</td>
<td>345</td>
<td>6.9</td>
<td>0.30</td>
<td>0.07</td>
</tr>
<tr>
<td>Under</td>
<td>150</td>
<td>6.6</td>
<td>0.25</td>
<td>0.05</td>
</tr>
<tr>
<td>Complete</td>
<td>151</td>
<td>6.2</td>
<td>0.07</td>
<td>0.01</td>
</tr>
</tbody>
</table>

As the living standard elevates, people prefer more refined foods (i.e., highly processed foods for their increased palatability and for the convenience of their preservation and transportation. Processing or refining of foods is likely to change their composition. When the content of a certain nutrient in the staple changes by these procedures to a level appreciably lower than found in its natural state, a certain nutritional hazard would occur among the people who live on it. Beriberi is one of the typical examples of this type of nutritional hazard. It had been widely prevalent and long been believed to be an endemic disease, until Takaki, in 1885, provided the first experimental evidence that beriberi is a food-originated form of malnutrition. Following the discovery of an anti-beriberi factor in rice bran, underpolished or germ-retaining rice was recommended as an adequate food item for the prevention of beriberi. Underpolished rice was actually rationed during the war time. Distribution of underpolished rice was however discontinued after the war primarily due to its low palatability. Fig. 2 shows that the mortality from beriberi could be decreased to a certain extent by conducting these operations, but even more effectively by the introduction of vitamin $B_2$-enriched rice.
Changes in Annual Mortality from Beriberi in Japan

Approach to food fortification in Japan commenced without taking a definite form as in USA. As to rice fortification, it may be traced back to 1948, when we gave a scientific basis for the development of a vitamin B₁-enriched rice. Vitamin B₁-enriched rice was produced and made available to the public in 1949.

Through enactment of the Nutritional Improvement Law in 1952, enriched foods have been officially recognized as a means of improving national nutritional status. Since then various foods have been fortified with vitamins, calcium, lysine and other materials which are often found deficient in Japanese diets. Table 2 is a summary of minimum enrichment standard levels required for enriched foods of cereal origin. Fortification of cereal foods with amino acids became feasible comparatively recently. Enrichment standards for lysine as listed in Table 2 were adopted in 1962.

Now we would like to refer to some details on enriched cereals and their products and the nutritional impact brought about by them. This part will be given by one of my colleagues, Dr. B. Tonomura.
TABLE 2
Minimum fortification standards required for enriched foods of cereal origin (mg/100 g)

<table>
<thead>
<tr>
<th></th>
<th>Vitamin B&lt;sub&gt;1&lt;/sub&gt;</th>
<th>Vitamin B&lt;sub&gt;2&lt;/sub&gt;</th>
<th>Calcium</th>
<th>Lysine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>100</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressed barley</td>
<td>1.2</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat flour</td>
<td>0.5</td>
<td>0.3</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Bread</td>
<td>0.3</td>
<td>0.2</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Noodles (boiled)</td>
<td>0.2</td>
<td>1.0</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Noodles (dried)</td>
<td>0.5</td>
<td>0.5</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Noodles (instant)</td>
<td>0.5</td>
<td>0.5</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Gluten cake</td>
<td>4.0</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cornflakes</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crackers</td>
<td>0.3</td>
<td>0.2</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Biscuits</td>
<td>0.3</td>
<td>0.3</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>Wafers</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Enrichment of Rice

Before the cost of synthetic vitamin B<sub>1</sub> came down to the level of food additives, major efforts were made to increase or to restore the vitamin content of white rice by processing rough or brown rice prior to milling in a manner so as to cause transfer of the vitamins from germ and bran to the edible endosperm portion.

Parboiling of rough rice:

Parboiling of rough rice is a primitive method for producing rice kernels of relatively high vitamin B<sub>1</sub> content. One of the improved processes for parboiling, which is believed to have originated in India, is as follows: rough rice is soaked in water at normal temperature for a day and subsequently at 60° to 70°C for 10 to 15 hr. The resultant wet grain is dried by heating, and then husked and polished as usual. The white rice obtained by this process contains 150 to 300 μg of vitamin B<sub>1</sub> per 100 g. of kernels. This process is not practical, however, due to the cost of drying and the production of unfavourable cooking characteristics, brownish color, and spoiled grain-like odor, in the products.

Parboiling of brown rice:

The second method for fortifying rice kernels with vitamin B<sub>1</sub> is to parboil...
brown rice instead of rough rice after soaking the grain in an acidic medium. The vitamin content of white rice obtained from this acid-parboiling process is three times that of ordinary white rice. By employing 1% acetic acid solution instead of fresh water as the soaking medium, palatability and cooking quality of the enriched rice are improved significantly.

Vitamin-enriched rice in premix formula:

Although acid-parboiling of brown rice is a unique process for increasing vitamin B₁ content in the endosperm, one of its serious limitations is that a limited amount of the vitamin is available even from whole grain. It is theoretically impossible to produce enriched rice for premix formula by the parboiling method. To overcome this difficulty, the third method was developed as an extension of the acid-parboiling process. Figure 3 shows a flow sheet for the manufacture of enriched rice. Either brown or polished rice is soaked in a 1% acetic acid solution containing enrichment ingredients such as synthetic vitamins, minerals, and amino acids for a period of 12 to 24 hr. After draining off the solution, the wet kernels are steamed briefly to convert the surface starch into

![Flow Sheet for Manufacture of Enriched Rice](image-url)
<form, and the steamed grains are then dried to moisture content of 12 to 13%.
Rice is usually washed with water before cooking to remove fine bran fractions
and other contaminations which occur in storage and transport. The \( \alpha \)-starch
layer formed by the steaming process confines the enrichment ingredients within
the kernel and thus prevents their loss during washing.

Enriched rice thus produced containing vitamin \( B_1 \) at 120 to 150 mg%,
has been in the Japanese market since the beginning of 1951. The acid-soaking
method is different in principle from the coating method developed by Kik and
Williams. Figure 4 compares the structures of enriched kernels as produced
by the respective methods. The "enriched rice" contains the ingredients
within the kernel and has a rinse-resistant layer made of \( \alpha \)-starch at the surface
of the kernel, whereas "premix rice" is produced by spraying the ingredients
on the surface of the kernel and then forming a rinse-resistant coat made of
zein. The enriched rice available today in Japanese market is almost exclusively
the product of the acid-soaking method.

![Diagram of rice structures](image)

**STRUCTURE OF VITAMIN \( B_1 \)-ENRICHED RICE GRAINS**

The process of soaking in an acidic medium is apt to cause cracks in the
grain, and the cracked kernels lose the enrichment ingredients much more
easily in washing. In order to eliminate these defects and to make the process
simpler and more economical, a soaking process in organic solvents was
developed. Various physiologically active derivatives of vitamin B₁ with low solubility have been synthesized and some of them are sanctioned as food additives. By combining organic solvents as soaking media and these water-insoluble derivatives of vitamin B₁ as the enrichment ingredients, the loss of enriched vitamin in washing and cooking can be almost completely eliminated. Steaming, which was originally adopted to prevent the cracking, can be left out in this process.

Enrichment with lysine:

Rice is generally acknowledged to be among the best of the cereals in terms of nutritive quality of its protein. However, it is also well known that the protein quality of rice can be further improved by supplementation with lysine. Rice kernel enriched with lysine by means of a premix formula has been commercialized only recently. This appears to be due to the technical difficulty of applying a relatively large amount of this ingredient to the intact grain.

The soaking method developed for the production of vitamin-enriched rice can be effectively employed for this purpose too. By employing a 1% acetic acid solution saturated with lysine as soaking medium, one can produce rice enriched with lysine up to 66 mg per gram of kernel. The steaming process is effective in preventing loss of lysine in washing. Threonine, the second limiting

![Fig. 5. Penetration of Mixture of Lys. and Thr. into Polished Rice Soaking medium: 90% Lys HCl+5% Thr]
PREPARATION OF LYSINE- AND VITAMIN B₁-ENRICHED RICE BY DOUBLE SOAKING METHOD

![Diagram of the double-soaking method for enriching rice with lysine and vitamin B₁.](image)

It appears that blending ordinary white rice with the enriched rice containing 60 mg of lysine per gram of kernels at a ratio of 100 to 1 is practical.

**Artificial rice premix:**

Some approaches have been made to provide premix granules which simulate rice kernels. To make such granules, dough consisting of wheat flour as binder, rice flour, and the enrichment ingredients are either extruded through a macaroni press or a noodle-making machine. Loss of the ingredients from this artificial rice in washing and cooking are unfortunately too high to put them to practical use, and to make the matter worse, they tend to spoil the palatability of boiled rice. Simulated fortification granules containing lysine and threonine are now being tested in Thailand.
Enrichment of wheat products

Wheat flour:

It seems unpractical in our country, Japan, to enrich all wheat flour at the mill, since the ratio of decomposition of the enrichment ingredients is found to be significantly high during storage and transport, especially in the summer season. Also, the flour is processed in various ways. One of the exceptions to this is the flour used for school lunch bread. This flour has been enriched at the mill with vitamins since May 1953. The standards prescribed for the flour enrichment as amended on March 10, 1964, is 500 I.U. of vitamin A per 100 g of flour, 0.6 mg of vitamin B₁, and 0.3 mg of vitamin B₂. In the mill, the enrichment mixture is dispensed at the rate of 1 part to 5,000 parts of flour by using feeders which are commonly employed for dispensing bleaching chemicals. Finely powdered calcium salts are used as carriers for the vitamins. A small portion of the flour used in homes is enriched at the mill.

Bread:

Enrichment of bread at the bakery level is widely practiced in Japan. Mixtures of synthetic vitamins and enrichment tablets suitable for this purpose are available. Decomposition rates of vitamins in baking, around 15 to 20% for vitamins B₁ and B₂, are generally taken into account so as to obtain bread enriched with more than 0.3 mg% of vitamin B₁ and 0.2 mg% of vitamin B₂.

Bread fortified with lysine was tested on school children in order to assess the nutritional significance of lysine supplementation. The loss of lysine in baking has been known to be significant. Bread is enriched with 0.80 g of L-lysine-HCl per school lunch serving so that at least 0.5 g of L-lysine is available to each child. It was found that loss of lysine could be reduced by baking at slightly lower temperature and for a longer time than usual, or by making bread with lower crust content.

Noodles:

On a flour basis, consumption of noodles is higher than that of bread in Japan. This situation suggests an important role for noodles in improving the quality of the national diet. In the early years of enrichment, it appeared wasteful to enrich noodles with the water-soluble vitamins; loss of vitamin B₁ from noodles in cooking amounts to 50 to 70% when one employs hydrochloric acid salts as enrichment ingredients. One of the special techniques developed to overcome this difficulty is to embed the enrichment ingredients in the central...
Enrichment Programmes in Japan

portion of noodle at the dough stage. Loss of vitamin $B_1$ from this type of noodle in cooking is still around 30%. Currently noodle-makers extensively employ the insoluble forms of vitamin $B_1$ derivatives, their loss being less than 10% after processing.

Lysine enrichment offers another difficulty for noodle-makers. No water-insoluble derivative of lysine is yet available. Consequently, efforts are being made to develop techniques for preventing losses of lysine during the boiling process.

Enrichment of barley

Formerly blending of milled barley with milled rice up to several tenths of total amount was recommended. This was originally aimed at alleviating food and vitamin $B_1$ shortages. Palatability of the blend was lower for the majority of consumers in comparison with that of plain white rice, thus this practice was discontinued. Barley is generally milled to a kernel yield of 50 to 60%, and by doing so its palatability is improved, but at the expense of loss of vitamin $B_1$. Milled barley enriched with vitamin $B_1$ applied as a premix formula is on the market. This product is manufactured by spraying the enrichment mix on the surface of milled barley.

Nutritional improvements brought about by enriched cereals:

Enrichment of rice with vitamin $B_1$ is most desirable since this vitamin is indispensable for carbohydrate metabolism. It is thus quite natural to expect a great impact of rice enrichment on national nutrition status. A reciprocal relationship has been demonstrated between the number of deaths from beriberi and the annual output of enriched rice as shown in Figure 7. Beriberi had previously been one of the major causes of deaths in Japan. However, after the introduction of rice fortification, beriberi has become only a minor cause. This is one of the most significant success stories of enriched foods in our country.

Statistics show that one third of consumers allow the dealers to blend the premix into their rice ration. Rice dealers have their own blenders of "enriched rice adders" for this purpose which provide thorough mixing of 1 part of the premix with 200 parts of ordinary white rice. And yet Table 3 shows that physical symptoms pertaining to vitamin deficiencies are still often found in Japan. More foods enriched with vitamins are necessary to clear up these national symptoms of vitamin deficiency.
Relationships among Deaths from Beriberi, Avitaminosis and Other Metabolic Diseases, and Annual Output of Enriched Rice.
TABLE 3
Annual changes in vitamin-related physical symptoms detected by National Nutrition Survey (%)-a-

<table>
<thead>
<tr>
<th>Year</th>
<th>Anemia</th>
<th>Hyperkeratosis</th>
<th>Cheilosis</th>
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<tr>
<td>1949</td>
<td>2.7</td>
<td>1.1</td>
<td>5.9</td>
</tr>
<tr>
<td>1950</td>
<td>3.3</td>
<td>1.7</td>
<td>7.4</td>
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<td>1951</td>
<td>2.8</td>
<td>1.8</td>
<td>7.1</td>
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<td>1952</td>
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<td>2.2</td>
<td>4.5</td>
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<td>2.5</td>
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</tr>
<tr>
<td>1958</td>
<td>2.7</td>
<td>3.5</td>
<td>6.3</td>
</tr>
<tr>
<td>1959</td>
<td>2.4</td>
<td>2.9</td>
<td>5.7</td>
</tr>
<tr>
<td>1960</td>
<td>2.3</td>
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</tr>
<tr>
<td>1964</td>
<td>1.8</td>
<td>3.1</td>
<td>3.5</td>
</tr>
<tr>
<td>1965</td>
<td>1.9</td>
<td>2.7</td>
<td>2.1</td>
</tr>
<tr>
<td>1966</td>
<td>1.8</td>
<td>2.9</td>
<td>3.1</td>
</tr>
<tr>
<td>1967</td>
<td>1.7</td>
<td>2.4</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Annual changes in vitamin-related physical symptoms detected by National Nutrition Survey (%)-b-

<table>
<thead>
<tr>
<th>Year</th>
<th>Loss of knee jerk reflex</th>
<th>Edema</th>
<th>Pain in calves</th>
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</thead>
<tbody>
<tr>
<td>1949</td>
<td>7.6</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td>1950</td>
<td>8.0</td>
<td>1.2</td>
<td>-</td>
</tr>
<tr>
<td>1951</td>
<td>7.0</td>
<td>1.1</td>
<td>-</td>
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<tr>
<td>1952</td>
<td>7.3</td>
<td>2.0</td>
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<td>1953</td>
<td>7.4</td>
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<td>1954</td>
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<tr>
<td>1956</td>
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<td>9.3</td>
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<tr>
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<td>9.1</td>
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<td>1964</td>
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<tr>
<td>1967</td>
<td>8.0</td>
<td>2.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Benefits from use of lysine as a means of improving protein quality of Japanese diets have been demonstrated in various experiments. Data shown in Figure 8 were obtained by providing lysine tablets together with bread at the time of serving lunch at the school. Growth rate of children is significantly improved by administering even 0.5 g of L-lysine per day. On the basis of these as well as other results, the Essential Amino Acid Research Committee of Japan initiated a survey for feasible ways for lysine enrichment of foods and to assess their practical nutritional effects. Feeding tests were continued from 1964 to 1966 with a total of 3,000 pupils in elementary schools by providing bread.
enriched with lysine in the school lunch. Physical conditions of test groups became, in general, better than those of control groups: increase in body height and weight were significant with test groups in the rural areas. Based on these results, a recommendation was made to the Government in December 1966 for executing a policy for lysine fortification in the school lunch programme. From April 1969 lysine fortified bread is being provided as a regular item in the school lunch in more than ten prefectures.

Improvement in the physique of the younger generation has been significant after World War II in Japan. This may be a reflection of elevated national living standards but it is also definitely related to the school lunch system, by which pupils are fed bread enriched with vitamins and lysine.

We sincerely hope that our experience in fortification programmes will contribute to the improvement of the food problem existing in other Asian countries.
NEW DEVELOPMENT OF INFANT AND WEANING FOODS

H. A. B. PARPIA

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Mysore-2A, India.

Nearly seventy percent of the world population lives in technologically less advanced countries of the world. Of this, about 20% consists of infants and children below the age of six. Due to various reasons such as low income, low level of literacy and low agricultural productivity, the diets of majority of infants and children are deficient in calories, proteins, certain vitamins and minerals. The degree and the extent of this problem is shown in Table 1.

<table>
<thead>
<tr>
<th>Country</th>
<th>Age (Months)</th>
<th>Calories (g)</th>
<th>Mean intake protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>24</td>
<td>731</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>444-533</td>
<td>18-25</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2-5</td>
<td>380</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>8-11</td>
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<td>13-24</td>
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<td>17.7</td>
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<td>31-36</td>
<td>950</td>
<td>21.9</td>
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<td>24-36</td>
<td>868</td>
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<td>984</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>48-60</td>
<td>856</td>
<td>22</td>
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<tr>
<td>Requirements 1-5</td>
<td>1100-1500</td>
<td>30-40</td>
<td></td>
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</table>

Solution of this problem requires a sound policy and its effective implementation. Towards this objective food science and technology can make a substantial contribution which would not only help to solve the problem of protein-calorie malnutrition but contribute to the overall improvement of health and economic progress. Only with the realisation of these factors, adequate resources would be made available for research and development to solve the problem through proper utilisation of available protein supply.

Protein available in the world and in India is considerably more than the actual consumption (Table 2). Thus, if the available protein resources can be effectively utilised, protein malnutrition could be overcome to a large extent. In the development of protein-rich supplements, due consideration should be given to various factors such as food habits, income levels, marketing and distribution problems.

The objective of this paper is to mention briefly the efforts made in the past and to discuss, in some detail, the new developments which have taken place during recent years.

TABLE 2
Production of Food Materials and protein in the world (1968) and in India (1969-70)

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Production (Million tons)</th>
<th>Protein produced (million tons)</th>
<th>Protein availability per capita/day (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>World @</td>
<td>India @</td>
<td>World</td>
</tr>
<tr>
<td>Cereals</td>
<td>1171.2</td>
<td>87.8</td>
<td>124.80</td>
</tr>
<tr>
<td>Pulses</td>
<td>42.7</td>
<td>11.7</td>
<td>9.69</td>
</tr>
<tr>
<td>Oil seeds</td>
<td>100.2</td>
<td>7.0</td>
<td>28.25</td>
</tr>
<tr>
<td>Milk</td>
<td>395.3</td>
<td>24.6**</td>
<td>14.35</td>
</tr>
<tr>
<td>Meat, eggs and fish*</td>
<td>159.1</td>
<td>2.8**</td>
<td>30.06</td>
</tr>
</tbody>
</table>

*Per capita consumption of protein per day in India—53 g.

---

@ Production Year Book, FAO, Rome, Vol. 23, 1969.
@ Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, 1970.
"State of Food and Agriculture, FAO, Rome, 1969, 139.
"World population is taken as 3570 million in 1968 and population of India as 520 million in 1969.
Available resources of protein

As already pointed out in Table 2, the availability of animal protein is very limited, being as low as 6 g per capita per day in India. Besides, its cost can be 5-10 times higher than the vegetable protein, as its production per kg requires 5 times more land and 8-10 times more water. It is obvious, therefore, that on this account alone, the production of animal protein will be far beyond the reach of a large majority and also when the population is rising very rapidly.

A very successful effort was made in India to develop an infant food based on buffalo milk which was considered to be difficult to digest as compared to cow's and human milk. The product has proved very successful commercially. Its average production at present amounts to 10,000 tonnes and it saves foreign exchange equivalent to 90 million rupees ($12 million) in India. Although its production is increasing, it is evident that this milk-based product cannot reach most of the low income groups. On the other hand, vegetable protein resources are substantially larger; the availability of oilseed proteins alone being nearly 1.8 million tonnes in India as compared to 0.75 million tonnes from milk. The quality of the latter can be upgraded to the level of animal proteins through mutual supplementation as well as by fortification with vitamins and amino acids to meet the acute shortage of infant and weaning foods.

Realising the situation, efforts have been made over the last two decades to develop various types of protein foods and concentrates to overcome the dietary deficiencies. Some of the earliest products which have promising results and paved the way for newer developments are INCAPARINA based on cottonseed flour, American Multipurpose Food (MPF) based on soyabean and Indian Multipurpose Food (MPF) based on low fat peanut flour and grain legumes.

Some of the most promising vegetable protein sources like oilseeds, oilseed meals and legumes have also been used in making protein-rich weaning and infant foods and also for extending the supplies of animal-based foods. Likewise, in countries with plentiful supplies of fish available at low prices, there is scope for the use of fish protein concentrate such as making balanced protein foods. Tables 2 and 3 give the production of oilseeds in India and countries of Far-East and per capita availability of protein from oilseeds.

Improvement of protein quality by mutual and amino acid supplementation

Oilseed proteins are partially deficient in one or more essential amino acids (Table 4). Their protein efficiency ratios are also lower than that of milk.
### TABLE 3

Production of major oilseeds and milk in South-East Asia (including India) (000 tonnes)

<table>
<thead>
<tr>
<th>Country</th>
<th>Peanut (in shell)</th>
<th>Cotton-seed</th>
<th>Sesame</th>
<th>Copra</th>
<th>Sunflower</th>
<th>Soya-bean</th>
<th>Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burma</td>
<td>336</td>
<td>22</td>
<td>83</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>482</td>
</tr>
<tr>
<td>Ceylon</td>
<td>7</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>183</td>
</tr>
<tr>
<td>China (Taiwan)</td>
<td>106</td>
<td>1</td>
<td>28</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>750</td>
</tr>
<tr>
<td>India</td>
<td>4476</td>
<td>1892</td>
<td>414</td>
<td>274</td>
<td>—</td>
<td>—</td>
<td>21272</td>
</tr>
<tr>
<td>Indonesia</td>
<td>455</td>
<td>6</td>
<td>2</td>
<td>553</td>
<td>—</td>
<td>—</td>
<td>50</td>
</tr>
<tr>
<td>Japan</td>
<td>122</td>
<td>—</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>168</td>
</tr>
<tr>
<td>Pakistan</td>
<td>106</td>
<td>1058</td>
<td>399</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>12950</td>
</tr>
<tr>
<td>Philippines</td>
<td>15</td>
<td>—</td>
<td>—</td>
<td>1290</td>
<td>—</td>
<td>—</td>
<td>31</td>
</tr>
<tr>
<td>Far-East</td>
<td>5869</td>
<td>3310</td>
<td>593</td>
<td>2564</td>
<td>—</td>
<td>—</td>
<td>1161</td>
</tr>
<tr>
<td>North America</td>
<td>1153</td>
<td>4209</td>
<td>4</td>
<td>—</td>
<td>102</td>
<td>30269</td>
<td>61217</td>
</tr>
<tr>
<td>World</td>
<td>12034</td>
<td>21202</td>
<td>1628</td>
<td>3223</td>
<td>9944</td>
<td>43613</td>
<td>395316</td>
</tr>
</tbody>
</table>


### TABLE 4

Essential amino acid content of the proteins of certain oilseeds and nuts compared with milk proteins (g/16gN)

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Coconut</th>
<th>Peanut kernel</th>
<th>Sesame</th>
<th>Soya-bean</th>
<th>Sunflower seed</th>
<th>Cotton seed</th>
<th>Cow's milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine</td>
<td>12.11</td>
<td>10.70</td>
<td>8.75</td>
<td>7.15</td>
<td>8.74</td>
<td>11.2</td>
<td>3.73</td>
</tr>
<tr>
<td>Histidine</td>
<td>1.75</td>
<td>2.43</td>
<td>1.94</td>
<td>2.38</td>
<td>2.16</td>
<td>2.7</td>
<td>2.69</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>4.50</td>
<td>4.11</td>
<td>4.18</td>
<td>5.38</td>
<td>4.70</td>
<td>3.8</td>
<td>6.51</td>
</tr>
<tr>
<td>Leucine</td>
<td>6.70</td>
<td>6.08</td>
<td>7.38</td>
<td>7.71</td>
<td>6.40</td>
<td>5.9</td>
<td>10.02</td>
</tr>
<tr>
<td>Lysine</td>
<td>3.79</td>
<td>3.57</td>
<td>2.56</td>
<td>6.32</td>
<td>3.20</td>
<td>4.3</td>
<td>7.94</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.76</td>
<td>0.88</td>
<td>2.80</td>
<td>1.34</td>
<td>1.63</td>
<td>1.4</td>
<td>2.30</td>
</tr>
<tr>
<td>Cystine</td>
<td>1.53</td>
<td>1.50</td>
<td>2.18</td>
<td>1.78</td>
<td>1.71</td>
<td>1.6</td>
<td>0.91</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>4.34</td>
<td>5.06</td>
<td>6.4</td>
<td>4.94</td>
<td>4.50</td>
<td>5.2</td>
<td>4.94</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>2.53</td>
<td>3.58</td>
<td>4.12</td>
<td>3.18</td>
<td>2.38</td>
<td>—</td>
<td>5.20</td>
</tr>
<tr>
<td>Threonine</td>
<td>3.22</td>
<td>2.69</td>
<td>3.10</td>
<td>3.94</td>
<td>3.36</td>
<td>3.5</td>
<td>4.70</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.83</td>
<td>1.10</td>
<td>1.46</td>
<td>1.38</td>
<td>1.26</td>
<td>1.2</td>
<td>1.44</td>
</tr>
<tr>
<td>Valine</td>
<td>5.30</td>
<td>4.98</td>
<td>3.90</td>
<td>5.25</td>
<td>4.99</td>
<td>4.9</td>
<td>7.01</td>
</tr>
</tbody>
</table>

protein. Recent investigations have shown that by mutual supplementation of two or more proteins and by incorporation of limiting amino acids, it is possible to produce blends containing proteins of high nutritive value comparable to milk protein.

**Mutual supplementation of proteins** : The proteins of legumes, oilseeds, nuts, milk, fish and leaves supplement those of cereals. The proteins of sesame and sunflower seeds supplement those of soyabean and legumes and those of coconut supplement, to a significant extent, chickpea and peanut proteins (Table 5).

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Name of the foodstuff</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Groundnut</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Groundnut + Soyabean</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Groundnut + Sesame</td>
<td>2.4</td>
</tr>
<tr>
<td>II</td>
<td>Soyabean</td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>Sesame flour</td>
<td>1.80</td>
</tr>
<tr>
<td></td>
<td>Soyabean + Sesame</td>
<td>2.70</td>
</tr>
<tr>
<td>III</td>
<td>Wheat</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Wheat + Soyabean</td>
<td>2.37</td>
</tr>
<tr>
<td></td>
<td>Wheat + Sesame + Soyabean</td>
<td>2.62</td>
</tr>
</tbody>
</table>

*Reference No. 11.

**Amino acid supplementation of proteins** : The nutritional value of the diets based on cereals and millets can be improved markedly by supplementation with lysine. Fortification with methionine increases markedly the PER of legumes, soyabean and milk proteins, with lysine that of sesame proteins and with lysine, methionine and threonine those of cottonseed and peanut proteins (Table 6).

**Removal of deleterious factors present in oilseeds and legumes**

Haemagglutinins and growth inhibitors present in soyabean and legumes can be inactivated by optimal heat processing. Aflatoxin present in fungus infected peanuts, can be eliminated by (1) hand picking or electronic sorting.
of fungus infested kernels and (2) by treatment of the suspension of peanut in water with \( \text{H}_2\text{O}_2 \) under optimal conditions.\(^{12}\) Gossypol present in cottonseed could be removed by extraction with solvent mixtures.\(^{13}\)

**TABLE 6**

Effect of supplementation with limiting amino acids on the nutritive value of oilseed protein (at 10% protein level in the diet)*

<table>
<thead>
<tr>
<th>Protein source</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed</td>
<td>2.39</td>
</tr>
<tr>
<td>Cottonseed + lysine + methionine + threonine</td>
<td>3.04</td>
</tr>
<tr>
<td>Peanut flour</td>
<td>1.65</td>
</tr>
<tr>
<td>Peanut flour + L-lysine + DL-methionine</td>
<td>2.07</td>
</tr>
<tr>
<td>Peanut flour + L-lysine + DL-methionine and DL-threonine</td>
<td>2.54</td>
</tr>
<tr>
<td>Sesame</td>
<td>1.50</td>
</tr>
<tr>
<td>Sesame + lysine</td>
<td>2.91</td>
</tr>
<tr>
<td>Soyabean flour</td>
<td>2.37</td>
</tr>
<tr>
<td>Soyabean flour + methionine</td>
<td>3.21</td>
</tr>
<tr>
<td>Soyabean flour + methionine hydroxy analogue</td>
<td>3.20</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>3.00</td>
</tr>
<tr>
<td>Skim milk powder + methionine</td>
<td>3.80</td>
</tr>
</tbody>
</table>

*Reference No. 11.

**Infant foods based on soyabean and peanut**

*Products based on soyabean and blends of soyabean and peanut*: Dried milk substitutes based on blends of soyabean and peanut have been developed and some of them like ‘Soyalac’ and ‘Mullsoy’ are being marketed in USA.\(^{14}\) A product known as ‘Saridele’ based on soyabean and sesame, was manufactured in Indonesia with UNICEF aid and used for feeding infants and children.\(^{11}\) Dean developed a process for the preparation of a dried malted soya milk.\(^{19}\)

Spray dried infant foods based on soyabean and peanut have also been developed at the Central Food Technological Research Institute, Mysore.\(^{17}\) The composition and PER of the products are given in Tables 7 and 8. A new method for the preparation of dried soya milk from decuticled soyabean, including a hot water extraction step to prevent the development of beany flavour, has been developed by Hand et al.\(^{16}\) The adoption of this improved process should help in improving the acceptability of infant foods based on soyabean.
## TABLE 7
The chemical composition of infant foods based on blends of soyabean, peanut and buffalo milk (values per 100 g.)

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Infant food based on peanut protein flour and skim milk powder</th>
<th>Infant food based on soyabean and skim milk powder</th>
<th>Infant food based on coconut honey, peanut protein isolate and skim milk powder</th>
<th>Infant food based on soyabean and peanut protein isolate</th>
<th>Full fat milk powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g)</td>
<td>2.8</td>
<td>2.7</td>
<td>2.9</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Protein (N × 6.25) (g)</td>
<td>26.2</td>
<td>26.1</td>
<td>26.8</td>
<td>26.5</td>
<td>26.4</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>18.4</td>
<td>18.2</td>
<td>17.8</td>
<td>18.2</td>
<td>18.2</td>
</tr>
<tr>
<td>Ash (g)</td>
<td>5.3</td>
<td>4.8</td>
<td>5.7</td>
<td>6.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>(by diff.)</td>
<td>47.3</td>
<td>48.2</td>
<td>46.8</td>
<td>47.0</td>
</tr>
<tr>
<td>Calcium (g)</td>
<td>0.95</td>
<td>0.94</td>
<td>0.92</td>
<td>0.59</td>
<td>0.95</td>
</tr>
<tr>
<td>Phosphorus (g)</td>
<td>0.73</td>
<td>0.60</td>
<td>0.82</td>
<td>0.73</td>
<td>0.75</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>—</td>
<td>5.2</td>
<td>5.8</td>
<td>—</td>
<td>6.0</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
<td>0.9</td>
<td>0.6</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>1.5</td>
<td>1.0</td>
<td>1.4</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>6.0</td>
<td>6.0</td>
<td>5.7</td>
<td>6.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Vitamin A (I.U.)</td>
<td>1500</td>
<td>1500</td>
<td>1450</td>
<td>1500</td>
<td>1480</td>
</tr>
<tr>
<td>Vitamin D (I.U.)</td>
<td>400</td>
<td>400</td>
<td>380</td>
<td>—</td>
<td>390</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>—</td>
<td>30.0</td>
<td>29</td>
<td>—</td>
<td>30</td>
</tr>
</tbody>
</table>

— indicates data not available.

## TABLE 8
The protein efficiency ratio of spray dried infant food based on soyabean and a blend of soyabean and groundnut protein isolate (10% level of protein in diet duration of experiment 4 weeks**

<table>
<thead>
<tr>
<th>Series I</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant food based on soyabean</td>
<td>Infant food + dl-methionine</td>
<td>Skim milk powder</td>
<td>Infant food based on soyabean + groundnut protein isolate</td>
<td>Infant food + dl-methionine</td>
<td>Skim milk powder</td>
</tr>
<tr>
<td>PER</td>
<td>PER corrected*</td>
<td>PER</td>
<td>PER corrected*</td>
<td>PER</td>
<td>PER corrected*</td>
</tr>
<tr>
<td>2.47</td>
<td>2.48</td>
<td>2.92</td>
<td>2.93</td>
<td>2.99</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Series II:

<table>
<thead>
<tr>
<th>Infant food based on soyabean + groundnut protein isolates</th>
<th>Infant food + dl-methionine</th>
<th>Skim milk powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>PER corrected*</td>
<td>PER corrected*</td>
<td>PER corrected*</td>
</tr>
<tr>
<td>2.34</td>
<td>2.19</td>
<td>2.85</td>
</tr>
</tbody>
</table>

* Corrected taking PER of skim milk powder as 3.00.
The feeding trial conducted by Dean with infants and preschool children has shown that 50% of the cow’s milk in the diet of infants (upto 12 months age) could be replaced by malted soyabean milk without affecting their growth. There was little difference in the growth rate of preschool children receiving supplement of cow’s milk and those receiving malted soyabean milk containing 10% skim milk solids. Glaser and Johnstone reported that 42 infants fed a soyabean formula (Mull Soy) from the first month until 5-9 months of age showed satisfactory growth. Collins-Williams found that 24 infants fed a soyabean formula (Sobee) showed satisfactory weight gain. Fomon reported that infants grew well when fed soyabean milk providing 1.7 g protein per kg body weight and the growth and nitrogen retention were satisfactory comparing well with infants receiving human milk. Omans et al found that out of three commercial soyabean milk preparations tested, one promoted nearly as good growth as a cow’s milk food while two proved inferior when fed as the sole food to premature infants.

Products based on peanut flour or peanut protein isolate and skim milk

A process for infant foods based on peanut protein isolate and skim milk powder was developed at CFTRI. The product promoted good growth in infants. More recently, an infant food based on peanut flour and skim milk powder has been developed. Sixty percent of its total protein content is derived from peanut, 30% from milk and 10% from cereals (Fig. 1).

The chemical composition, PER and the overall growth promoting value of this product are shown in Tables 7, 9 and 10. The results of studies of Pereira et al (Unpublished data) with this infant food as compared with a milk food of similar composition are given in Table 11. In this study the infants were allotted sequentially to two groups at the age of 6 months and fed on peanut infant food and milk respectively for 10 months. The results showed that there was no significant difference in the mean increase in height and weight between the two groups. These results show the importance of the product to several developing countries where milk supply is inadequate and oilseed proteins are available in large quantities.

Vegetable toned milk (Miltone, Lac-Tone)

In order to overcome shortage of milk, especially in the urban areas, the Government of India started a programme of toning milk. For this purpose, nearly 20 million rupees worth of skim milk powder is imported. Pasteurised toned milk consists of 50% buffalo milk and 50% reconstituted skim milk powder. In order to substitute imported milk powder, the CFTRI has
developed protein isolate from peanuts. Blended with carbohydrates like sugar or liquid glucose, vitamins and minerals, it substitutes the reconstituted skim milk powder for toning of buffalo milk. The product known as Miltone.
Development of Infant and Weaning Foods

(Lac-Tone) has met with a considerable amount of success. Tables 12 and 13 give the composition and essential amino acid content of the product. It is being manufactured on a pilot plant scale in Bangalore Dairy and one thousand litres of the product are prepared daily. Figure 2 outlines the process. It is marketed and also distributed for feeding of children in certain low income areas. The production of Miltone is proposed to be scaled up to nearly 2,000 litres with the support of UNICEF and the Food and Nutrition Board. It will also be produced in other urban areas of the country. Feeding trials on infants have shown that it promotes growth comparable to that of toned milk made with skim milk powder. This product opens a new potential for extending the available milk supply and also for reducing the cost to meet the protein requirements of the needy. Several commercial organisations are beginning to show interest in marketing sterilised Miltone as its cost is comparable to that of aerated waters being produced in large quantities at present in the country.

### TABLE 9

<table>
<thead>
<tr>
<th>Name of food</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant food</td>
<td>2.4</td>
</tr>
<tr>
<td>Skim milk powder</td>
<td>3.0</td>
</tr>
</tbody>
</table>


### TABLE 10

<table>
<thead>
<tr>
<th>Name of food</th>
<th>Gain in body weight (g/wk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant food based on groundnut flour</td>
<td>26.9</td>
</tr>
<tr>
<td>Infant milk food</td>
<td>19.9</td>
</tr>
</tbody>
</table>

TABLE 11
Mean increase in height and weight of infants on peanut infant food and milk food supplements (duration of experiment 10 months)*

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Initial</th>
<th>Final</th>
<th>Increase S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children on peanut infant food (12)</td>
<td>64.39</td>
<td>74.75</td>
<td>10.36 ± 0.384</td>
</tr>
<tr>
<td>Children on milk food (12)</td>
<td>63.47</td>
<td>73.56</td>
<td>10.09 ± 0.483</td>
</tr>
<tr>
<td>Children on peanut infant food (12)</td>
<td>6.40</td>
<td>8.39</td>
<td>1.98 ± 0.176</td>
</tr>
<tr>
<td>Children on milk food (12)</td>
<td>6.06</td>
<td>7.88</td>
<td>1.82 ± 0.213</td>
</tr>
</tbody>
</table>


TABLE 12
Chemical composition of Miltone (g/100 g.)*

<table>
<thead>
<tr>
<th></th>
<th>Total solids</th>
<th>Fat</th>
<th>SNF (Solids-not-fat)</th>
<th>Proteins</th>
<th>Lactose</th>
<th>Glucose &amp; Maltodextrine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11.5</td>
<td>2.0</td>
<td>9.5</td>
<td>4.0</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*Data from CFTRI, Mysore.

TABLE 13
Amino acid composition of protein of Miltone and cow's milk (g/16gN)

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Miltone*</th>
<th>Cow's milk**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>5.8</td>
<td>7.94</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.9</td>
<td>2.30</td>
</tr>
<tr>
<td>Total s. amino acids</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>4.7</td>
<td>4.94</td>
</tr>
<tr>
<td>Leucine</td>
<td>8.2</td>
<td>10.02</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>4.6</td>
<td>6.51</td>
</tr>
<tr>
<td>Valine</td>
<td>5.6</td>
<td>7.01</td>
</tr>
<tr>
<td>Arginine</td>
<td>8.5</td>
<td>3.73</td>
</tr>
<tr>
<td>Threonine</td>
<td>4.0</td>
<td>4.70</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.2</td>
<td>1.44</td>
</tr>
</tbody>
</table>

*Reference No. 25.
Development of Infant and Weaning Foods

Fig. 2: Flow sheet for the production of Miltone.

- Peanut cake water alkali
- Extraction and Centrifugation
- Protein liquor
- Detoxification with H₂O₂ and removal of H₂O₂ by catalase
- Precipitation at isoelectric pH
- Wet protein isolate
- Peptisation and dispersion in water at neutral pH

Liquid glucose, Buffer salt, Vitamin premix → Protein liquor
Standardised milk → Blending

New types of weaning foods

Bal-Ahar: During acute food shortage due to crop failures in 1965 in the States of Rajasthan and Bihar, an urgent need was felt to protect the infants and children against malnutrition. Therefore, immediate action was taken to formulate several mixtures based on cereals, oilseed and other proteins fortified with vitamins and minerals under the generic name of "Bal-Ahar".

The most acceptable Bal-Ahar consists of a blend of wheat flour, peanut
flour and chickpea flour, fortified with vitamins and calcium carbonate (Table 14). It was at first produced with the support of the Department of Food and utilised successfully. Reports indicated that the product was very effective in overcoming malnutrition. This convinced the Government of the value of such products in improving the nutrition of children. The Food Corporation of India has been manufacturing it for use in meeting distress needs as well as in feeding programme for infants and children at various levels. At present, the CARE organisation in India is also using it in their school feeding programmes. The product can be fed as a porridge or gruel and also in the form of various traditional preparations to supplement the diet.

**TABLE 14**

Approximate chemical composition of Bal·Ahar and pre·cooked weaning food (values per 100 g.)**

<table>
<thead>
<tr>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrates (g)</th>
<th>Calcium (g)</th>
<th>Phosphorus (g)</th>
<th>Iron (mg)</th>
<th>Vitamin A (I.U.)</th>
<th>Vitamin D (I.U.)</th>
<th>Thiamine (mg)</th>
<th>Riboflavin (mg)</th>
<th>Niacin (mg)</th>
<th>Ascorbic acid (mg)</th>
<th>PER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bal·Ahar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22-25</td>
<td>4-5</td>
<td>55-60</td>
<td>0.5-0.6</td>
<td>0.5-0.6</td>
<td>4-6</td>
<td>3000</td>
<td>200</td>
<td>0.5-0.6</td>
<td>0.5-0.7</td>
<td>8-10</td>
<td>—</td>
<td>2.0</td>
</tr>
<tr>
<td>Precooked</td>
<td>22-25</td>
<td>55-60</td>
<td>0.8-1.0</td>
<td>0.6-0.7</td>
<td>4-6</td>
<td>3000</td>
<td>400</td>
<td>0.5-0.6</td>
<td>0.6-0.7</td>
<td>5-6</td>
<td>40-50</td>
<td>2.4</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.0</td>
<td>2.0</td>
<td>55.69</td>
<td>3.0</td>
<td>8.8</td>
<td>6.0</td>
<td>3000</td>
<td>3000</td>
<td>0.7</td>
<td>1.1</td>
<td>7.0</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>II*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Data from CFTRI, Mysore.
* Contains peanut protein isolate.

**Precooked roller-dried weaning food**: With the growing consciousness to meet the needs of the vulnerable groups, the Government as well as the industry began to show keen interest in manufacturing and marketing weaning foods. Intensive product development research was, therefore, undertaken on behalf of several interest organisations at the CFTRI. The flow-sheet of the processing of a typical weaning food formulation** is given in Fig. 3. One of the products based on soya, cereals and legumes was developed for a leading co-operative. It is a roller-dried product having 22-25% protein and full complement of
vitamins and minerals. It is estimated that a daily consumption of 50 g of this product by a child would meet half the requirements of protein and almost the full requirement of vitamins and minerals (Table 14). The supplementary effects of this food to weaned infants is given in Table 15. Another product based on peanut protein isolate, legumes and cereals has been developed for a leading manufacturer of foods (PER 2.4). The composition of this product is also given in Table 14.

Fig. 3: Flow sheet for the preparation of precooked weaning food formulation

Edible groundnut cake
Chick-pea Green gram
Wheat or Corn

--- Flour Mill

Mixer ← Fortification premix

Dispersion ← Boiling water

Colloid Mill

Roller drying

Granulator

Packaging

Weaning food

The population of children below the age of 6 is nearly 110 million in India. Even if an attempt is made to reach 10% of this population at the rate of 50 g of weaning food per day, the total dietary requirements per day would be about 550 tonnes. This shows the potential for the development of an industry. The approximate ex-factory cost of production of vegetable protein based weaning foods is Rs. 3.30 per kg. (Table 16).
TABLE 15

Effect of supplementing the diets with a weaning food (PWF) on the growth of infants*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Weight (kg.) Mean ± ISD</th>
<th>Weight (cms) Mean ± ISD</th>
<th>Increase</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
<td>Mean ± ISD</td>
<td>Final</td>
</tr>
<tr>
<td>Control (10 children)</td>
<td>6.16 ± 0.56</td>
<td>7.05 ± 0.54</td>
<td>64.25 ± 3.09</td>
<td>70.07 ± 3.77</td>
</tr>
<tr>
<td>Experiment I (10 children)</td>
<td>5.98 ± 0.65</td>
<td>6.95 ± 1.08</td>
<td>63.71 ± 2.54</td>
<td>68.89 ± 3.28</td>
</tr>
<tr>
<td>Experiment II (10 children)</td>
<td>6.28 ± 0.76</td>
<td>7.34 ± 0.78</td>
<td>63.51 ± 1.60</td>
<td>69.35 ± 2.29</td>
</tr>
</tbody>
</table>

Period of experiment, 6 months. Age of infants at start of experiment, 6 months. Basal diet of infants, breast milk + ragi gruel; in addition, control group was given 50 g. of milk food; those of experimental group I, 50 g. of PWF; those of experimental group II, PWF + methionine.

*Sheila Pereira et al. (Personal communication).

TABLE 16

Manufacturing cost of precooked weaning food

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Weaning</th>
<th>Bal-Ahar</th>
<th>Manufacturing cost per kg. (in rupees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed capital</td>
<td>Rs. 10,75,000</td>
<td>Rs. 2,65,000</td>
<td></td>
</tr>
<tr>
<td>Production capacity (1 shift/day)</td>
<td>3 tonnes</td>
<td>3 tonnes</td>
<td></td>
</tr>
<tr>
<td>(A) Raw materials</td>
<td>1.29</td>
<td>1.21</td>
<td></td>
</tr>
<tr>
<td>(B) Container and packaging</td>
<td>0.70</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>(C) Conversion cost</td>
<td>0.57</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>(D) Commission (20% of A, B &amp; C)</td>
<td>0.51</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>(E) Freight</td>
<td>0.24</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Total cost (ex-factory)</td>
<td>3.31</td>
<td>2.82</td>
<td></td>
</tr>
</tbody>
</table>

Price of commercial foods Rs./kg.

20.00

If dl-methionine is added, the weaning food costs Rs. 0.18/kg. more.
Other supplementary foods for weaned infants

**Protein-rich biscuits**: Total production of biscuit in India has increased from 25,872 tonnes in 1965 to 66,500 tonnes in 1968 (Table 17). This shows the importance of biscuits as a media for supplying protein to the vulnerable groups of population. The Nutro-biscuits containing 16-17% protein derived mainly from low fat edible groundnut flour is already well-known to the industry. A recent development at CFTRI is the high protein (25-28%) sweet biscuits containing peanut protein. This could be used as a supplement to weaned infants. The composition of protein-rich biscuits which are now being manufactured commercially is given in Table 18.

**TABLE 17**

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (in metric tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>25,872*</td>
</tr>
<tr>
<td>1966</td>
<td>50,230**</td>
</tr>
<tr>
<td>1967</td>
<td>57,360**</td>
</tr>
<tr>
<td>1968</td>
<td>66,500**</td>
</tr>
</tbody>
</table>


**TABLE 18**

Proximate composition of the high protein biscuit developed at CFTRI, Mysore*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>2.3</td>
</tr>
<tr>
<td>Protein (N x 6.25 %)</td>
<td>25-28</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>13</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2-9</td>
</tr>
<tr>
<td>Lysine (g/100 g. protein)</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*G. S. Bains, CFTRI, Mysore.

**Fortified bread**: Another product which offers good potential for supply of protein to the vulnerable groups is bread. Recently, 9 Modern Bakeries have been set up in India. The bread produced by them has been fortified with protein isolate, vitamins, minerals and lysine. If peanut protein isolates and concentrates can be added at 2-3\% level, the amount of protein in the diet of urban population can be raised substantially.
Summary

1. The cost of production of animal protein is very high. Also, the resources available for increasing it are limited. The availability of vegetable proteins is substantial which can meet to a large extent the dietary deficiencies which exist amongst vulnerable groups of population. Its cost is low.

2. Acceptable infant foods, milk substitutes and weaning foods based on oilseeds and oilseed meals have been developed. The consumer acceptance, nutritive value as well as marketing potential of these products has been demonstrated with significant success.

3. There is need for taking policy decisions, allocating greater resources and setting up proper machinery for further development of this industry and utilisation of the product.

4. There is need for realisation that this effort will raise the mental and physical productivity and lead to much faster progress.

Acknowledgement

The assistance of Dr. M. Swaminathan and Dr. J. V. Shankar is acknowledged with thanks.

REFERENCES

Development of Infant and Weaning Foods

OPERATION FLOOD—MILK MARKETING AND DAIRY DEVELOPMENT

R. P. ANEJA and P. T. JACOB
National Dairy Development Board, Anand, Gujarat State, India.

There is, in practically every part of our country, an increasing demand for food products, which is caused by the increase in the population and also partly because of the increasing per-capita income, which normally leads to a higher consumption of these products. The statistics show that a considerable gap exists with regard to growth rates between production and demand. We are now confronted with the question if and how it will be possible to close this gap. The complexity of the problems involved are staggering.

As long as the gap between protein food supplies and requirements remains a major problem and as long as milk remains the main source of protein of the required high biological value, essential for health and full mental and physical development of children—the future citizens of the country—just that long must the milk production potential be dealt with as a national problem. However, for the foreseeable future the highest priority must be given to increasing protein production by orthodox agricultural means if requirements are to be met.

Thirty-five to 40% of the total population of the country being vegetarians, have to depend entirely on milk and milk products for their only source of animal protein. In this respect things do not look bright at all. For all practical purposes the country’s cattle population can be said to be a little more than 230 million, including 52 million breedable cows and 25 million breedable buffaloes. Annual milk production is said to be over 20 million tons. There are a large number of milk plants operating in the country. However, most of the urban milk plants supplying liquid milk have capabilities far below the requirements of the market. On the whole, the livestock industry in the country is inefficient due to a number of factors, such as poor management, insufficient feeding and unsatisfactory hygienic conditions. As long as such obstacles are allowed to remain, the task of bridging the gap between supply and demand will remain well nigh hopeless. The time for a realistic approach to such problems is long overdue.
The number of cattle kept in the four major cities of the country—Bombay, Calcutta, Delhi and Madras—has increased dramatically over the past thirty years. Nearly 1,00,000 high-yielding milch animals, imported from the country’s best breeding tracts are estimated to be in these cities. The unnatural, unhealthy surroundings and the irrational mechanics of city milk production make propagation of these animals impossible. As soon as the mother is trained to let-down milk without suckling the calf, the calf is destroyed, frequently by inhuman methods because rearing the calves in the cities is not at all economical. Prohibitive costs of maintaining dry cattle in city, make it uneconomical to get the animals in calf and keep them till they freshen again. As a result 30 to 40% of these animals are slaughtered, after a single lactation. An estimated 1 lakh animals of good genetic strains are lost to the nation this way each year in the cities.

However, about 75 to 100 crores rupees worth of milk and milk products are being consumed in these cities annually. Due to the high purchasing power of consumers milk and milk products fetch better prices in these cities than elsewhere in the country. These four major cities are therefore, considered as the magnets for milk and milk products. The dominance of the traditional milk traders, the scarcity of supplies and the limitations of the processing capacity available to the organised dairy sector, have prevented the stabilisation and rationalisation of the country’s milk production, processing and marketing activities.

The common man is the ultimate loser in all these cases. In the city, he finds milk getting thinner and more expensive each year, due to the dominance of the traditional vendors. In the countryside, the milk producer finds his best animals going to the city for premature slaughter. And the milk produced from the remaining low-yielding animals fetches him only a small share of the rupees, which the city consumers pay for that milk.

“Operation Flood” conceived by the National Dairy Development Board and to be implemented by the Indian Dairy Corporation, set up by the Government of India, for the purpose seeks to reverse this current anti-dairy development cycle. One of the major avowed aims of the project is to enable the city cattle-keepers to resettle their animals in rural milk-shed areas where they could be provided with enough feed and fodder. This will permit greater scope in milk production, thus enabling more economical milk production. By preventing the destruction of a lakh of animals in the four major cities each year, by resettlement in rural milk-shed areas, it is estimated that by the eighth year, there will be about 10 lakh animal in production in those milk-shed areas. When all these animals come into production, it would literally cause
a flood of milk in the areas of the country. It is from this design for creating a flood of this indigenously produced rural milk in the four major cities that the project derived its name “Operation Flood”.

The purpose of the project is to augment and restructure the daily complexes serving the major cities and to speed up dairy development by increasing milk procurement and production in rural areas which supply milk to the cities. Operation Flood has three major objectives, which are based on the investments which have already been made in the dairy industry in the four cities. The first objective of the project is to improve the milk marketing by enabling the organised dairy sector to obtain a commanding share—anything above 70%—of the market in the four major cities. The second objective of the project is to enable the organised dairies in these cities to reach their milk producers in order to continue supplying their commanding share of the market. Development of the basic transportation and storage network to facilitate regional and seasonal balancing of milk supply and demand has to be done. In order to provide raw milk with a more remunerative channel than the traditional one, the milk procurement systems in appropriate rural areas have to be developed. So the third objective is the formation of an all India milk-grid for economic balancing of supply and demand with balancing storage and transportation facilities.

Many developing countries in other parts of the world are wondering how to handle what they call “surpluses” of milk products. The so-called surpluses, for example of skim milk powder (SMP) and Butter oil (BO) can greatly accelerate development to the needy countries. Seen against the grim background of the present protein situation, all the talk of over-production and surpluses of milk is paradoxical. The advanced countries through bilateral and multilateral programmes can make full use both of the present so-called surpluses and also of the actual production potentials, to reduce the protein gap.

Presumably in a city, the milk scheme buys milk at 90 paise per litre from the producer and sells at 125 paise per litre, while the milk traders buy or produce milk at 150 paise per litre and sell at 175 paise per litre. The organised dairy has to introduce a good quantity of the recombined SMP and BO into the city’s market along with the available indigenous milk. As the price of the milk from the dairy is much lower, it can capture a fairly good share of the market from the traditional traders. By additional introduction of more and more of the recombined milk into the market, the dairy will be able to capture a commanding share of the market. When the traditional milk traders lose the command over the market, the rate of flow of animals into the cities comes
down. Ultimately, they will find city cattle keeping no longer profitable. The flow of animals into the city stops. The animals remain in the rural milk-shed areas, where they can be better taken care of. Thus, the best animals, which otherwise would have gone into the city, go back to the rural areas causing literally a flood of milk in the traditional breeding tracts in different parts of India.

The current world glut of milk products offers an opportunity to this. Apart from enabling the milk scheme to obtain the commanding share of the market, the funds realised from recombination and sale of donated products can be used to resettle the city-kept animals, to multiply their progeny and to increase organised milk production, procurement and processing—thus stabilising the major liquid milk scheme's position in the market.

Due to the accumulation of animals, which previously used to go to the cities, milk production is enhanced in rural areas. The modern dairy has to streamline and link up their procurement systems with the breeding tracts of the country. These breeding tracts and milk sheds areas spread over Punjab, Haryana, Bihar, U.P., Gujarat, Rajasthan, Andhra Pradesh as well as in parts of Maharashtra, West Bengal and Tamil Nadu. A chain of feeder and/or balancing dairies have been proposed to be built in these areas to mop up the surplus milk and to supply to urban markets. Once the procurement is increased, the dairy can bring down the use of recombined SMP and BO by the use of the indigenous supply of milk from the rural areas. This enhanced procurement will raise agricultural output and incomes in the rural areas and will at the same time provide urban population with supply of wholesome milk at a reasonable price. Completion of the resettlement of city-kept animals will put an end to the current waste of high-yielding animals and their genetic drainage.

In order to arrive at this end, the following line of actions is envisaged. Each of the four major cities' liquid milk schemes has to be brought up to full capacity. The bulk of the urban market for the traditional supplies of raw milk has to be transferred to the modern dairy. Resettlement of cattle in rural areas from the cities has to be done. The basic transportation and storage net work to facilitate regional and seasonal balancing of milk supply and demand has to be developed. In order to provide raw milk with a remunerative channel than the traditional one, the milk procurement system in appropriate rural areas have to be established. Finally efforts have to be made for the improvement of standards in dairy farming by programmes of animal breeding, veterinary services, etc. thereby increasing milk-yield per animal.
Project capital expenditure (millions, Rupees) to accelerate actions in the field of milk marketing and dairy development according to the action item-wise and yearwise break down is as follows:

<table>
<thead>
<tr>
<th>Action item</th>
<th>Year of operation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1. Expansion of the four cities' existing capacity to obtain a rapid increase in their distribution of liquid milk</td>
<td>16.6</td>
<td>2.5</td>
</tr>
<tr>
<td>2. Expansion of handling capacity by additions to existing handling facilities; erection of new urban liquid milk plants</td>
<td>17.5</td>
<td>52.5</td>
</tr>
<tr>
<td>3. Storage and long distance milk transport facilities</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4. Milk collection and chilling centres</td>
<td>3.4</td>
<td>10.9</td>
</tr>
<tr>
<td>5. Feeder/balancing dairies</td>
<td>8.3</td>
<td>22.2</td>
</tr>
<tr>
<td>6. Resettlement of city-kept cattle</td>
<td>14.0</td>
<td>35.0</td>
</tr>
<tr>
<td>7. Increasing milk production by provision of technical inputs</td>
<td>10.5</td>
<td>64.3</td>
</tr>
<tr>
<td>8. Development of improved milk animals</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>9. Organisation of rural procuremen</td>
<td>1.6</td>
<td>3.9</td>
</tr>
<tr>
<td>10. Project planning implementation and manpower development</td>
<td>1.7</td>
<td>6.2</td>
</tr>
<tr>
<td>11. Miscellaneous (unloading, storing &amp; transporting of WEP food in recipient country)</td>
<td>4.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Total</td>
<td>78.1</td>
<td>207.0</td>
</tr>
</tbody>
</table>
While increases in the capacity and throughput of existing dairy processing facilities are brought about, new city milk plants, feeder balancing dairies at the rural milk-shed areas and chilling centres are to be installed. By the end of the third year recombination of SMP and BO will reach the peak at 11 lakh litres a day. Meanwhile, the new and additional liquid milk schemes start operating. By the end of the 4th year new feeder balancing plants also will come into function. These plants along with the city liquid milk plants increase their procurements. In the 5th year—the last year of the project—feeder balancing plants will be completed. Rural procurement organisation would get momentum. This will enable the milk-grid to function better and help bringing down the recombination rate. By the end of the project recombination of SMP and BO would be completely replaced by the indigenous procurement system.

Thus over the project period indigenous procurement through the milk plants, is expected to rise by 1,75,000 litres daily. Of this, about 2,50,000 litres is expected from resettled city milk animals. The remaining is expected to come from the approximately 1,875,000 milk animals to be covered by milk procurement organizations in the milk-shed areas, which comprise of ten states of the country. Thus, the project will provide an organizational base by which owners of 18 to 20 lakh milk animals could be reached from systematic provision of technical inputs.

The long-term success of the project will depend on adequate supply of milk from milk-shed areas, a product/price mix which satisfies consumers and rewards producers and a planned manpower development programme. However, there can be no doubt that the good-will and means are at hand and the challenge can be met, if the means are used properly.
PROBLEM OF FOOD ADDITIVES AND CONTAMINANTS

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Nutrition to be effective has to be clothed in food technology, in terms of items of food with consumer appeal. It is in this regard that additives have a function in nutrition and technology, may be not a specific nutrient function but nevertheless an important function as a promoter in enhancing the appeal of food, its keepability, storage properties or maintenance of nutritional value. Some of the problems with regard to food additives and contaminants are discussed in the present paper. Direct additives to food such as anti-oxidants, emulsifiers, colours, flavouring agents, artificial sweeteners, etc., are generally controlled by Government and are accepted or rejected for use on the basis of "need", if they are "safe" for human consumption and if they confer some "benefit" to the consumer. Some of these additives are added intentionally to produce some desired technological, nutritional or presentational effects to the food whereas others get in there unintentionally through packaging, through processing steps, farming practices or environmental conditions. It has been estimated that the total number of food additives today exceeds 20,000. The National Academy of Sciences—National Research Council, U.S.A. in their publication enumerates about 3,100 food additives and it has been estimated that Americans on the average take about 4 lbs. of food additives per year in their diets. Contaminants, on the other hand, occur in foods often adventitiously due to environmental pollution and sometimes due to careless handling or faulty processing. The question of the ultimate effects of food additives and contaminants on man is unanswered. On the one hand, there are prophets of gloom who state that the effects of continued use of chemical additives in food will in the long run produce irreparable damage to humans and is disastrous. On the other hand, it is well known that the nutritive value and the quality of food obtainable today is very much better than those eaten by our forefathers, as a result of which people now live longer and are, in fact, healthier than they were even a few decades ago. On the one hand, perhaps altruistically industry clamours for flexibility in regulations that would offer them opportunities for innovation in foods in keeping with advances in food technology. On the other hand, the Government is rather wary of wholesale admission of food additives purely based on technological requirements and evaluated solely by animal experimentation. We all know that people of highest probity are sometimes deceived by self interest. Unlike the problem of drugs which are
used for specific effects over short periods of time under the guidance and responsibility of a physician in a patient, the problem of food additives and contaminants have highly emotional and psychological overtones because the consumer is not consciously aware of the potential hazards except perhaps to the extent of realising that the public health authorities safeguard his well being. It is natural, therefore, that Government agencies demand a vast amount of toxicological data before an additive is released for general use. Though one might argue that multiplicity of food additives is not necessary for the development of the food industry, one can also take the alternative view that it may be fortunate that fashions in food additives change so that any one person is unlikely to expose his body to one chemical for his entire life.

Many of our present food and drug laws were introduced in early this century when the main problem was to suppress the gross abuses of food adulteration. The problems now are totally different. They involve the control of direct additives (food colours, anti-oxidants, emulsifiers) which maintain the nutritional and organoleptic quality of the food during processing, distribution, storage and shipping; avoid spoilage, enhance keeping quality, stability and increased appeal of the food, or aid in food processing. Our own Prevention of Food Adulteration Act 1954 and Prevention of Food Adulteration Rules 1955 eminently fulfill the original purpose of the food and drugs act, viz. prevention of the gross adulteration of food but is however unsuited for the problems arising from rapid technical advance. In these days of continuous advances in biochemistry and food technology, therefore, it is necessary to have a more flexible and quicker moving system for dealing with permitted lists of food additives in the PFA together with more frequent informal or formal consultation and exchange of views on the problems of safety between the expert advisers of Government and industry. At the same time there should be a watch-dog committee which should keep under constant surveillance not only cases of malpractices in food industry and of substandard foods but also of harmful toxicants occurring in natural food.

In the course of man’s history most assumptions of safety have been based on empirical observations. In the modern scientific era safety has been determined from epidemiological considerations or from animal experimentation. It should be emphasised that ultimately “the evaluation of the safety of environmental chemicals is a matter of human judgement: it must balance the elements of risk associated with normal or intended use or even in some circumstances with improper or accidental use against potential advantages resulting from proper use. These proper and improper uses change in manner with time. Assessments of safety must take into account not only the intrinsic chemical, physical or mechanical attribute of the product in question but also the intelli-
gence, responsibility and susceptibility of the user or host. Therefore, it is
difficult to be absolutely certain about judgements of safety and the differences
between different countries regarding the permissible lists and permissible
concentrations in various foods. Scientific data no matter how extensive and
incisive it might be made to appear at a particular time is nevertheless often
incomplete. Hence the need for constant vigilance on the problem of food
additives and contaminants and the continual need for the exercise of public
control and regulation.

Food additives

There is nothing new in the idea of food additives. Thousands of years ago
the Chinese used ethylene and propene produced by the combustion of kerosene
kerosene to ripen bananas and peas. Pickling in salt, fermentation processes
resulting in a number of organic acids, such as lactic and acetic acid are methods
of food preservation that date from ancient times. Sugar and salt are traditional
preservatives from times immemorial. However, the society is becoming
increasingly conscious of the probable effects of the incorporation of a number
of non-nutritive substances in human foods. The recent controversy on the
use of cyclamate is an illustrative example. It is probable that there is no better
example of a case where many of the utterances have been more concerned
with prejudices and politics. It has been reported that both laboratory rats
and man are capable of converting a proportion of ingested cyclamates into
cyclohexylamine and cyclohexylamine is weakly carcinogenic for rats. The
immediate reason for the ban of cyclamates in the United States was the accep­
tance of the Delaney clause of the Food Additives Amendment with which
food manufacturers have to comply in the U.S.A. According to the Delaney
clause no substance that has been known to induce cancer in any animal species
may be incorporated in the food. In the United States therefore the fate of
cyclamates was determined when the pathologists agreed that some of the
rats exposed to them have developed carcinomas of the bladder. A second
example is monosodium glutamate which is generally used as flavour booster
for meaty flavour. In this case Olney and Sharpe demonstrated by sub­
cutaneous injection of a single dose of monosodium glutamate (50 mM per kg
of body weight to one new born premature rhesus monkey) that the lesion
in the periventricular region of the hypothalamus was specifically induced by
glutamate. The controversy surrounding monosodium glutamate in infant
food products has arised out of the fear on the part of mothers that their infants
would become mentally retarded as a result of their having been fed with
commonly available infant food products. However, there is no such risk
and no basis in fact that this could have occurred. The third case we will
consider is that of nitrites commonly used as preservatives for meat. Nitrates
as such in food or water have relatively low hazard potential. In fact nitrate can be injected intravenously at a dosage level of 41 mg per kg of body weight without ill effect; some 90 per cent of the nitrate administered is excreted in the urine but an entirely different situation arises if the nitrate is converted to nitrite. This can happen if the food is kept too long or is allowed to deteriorate or if the nitrite is subjected to the reducing action of microorganisms. Nitrites are found in many leafy vegetables. The acceptable daily intake of nitrates is 5 to 10 mg per kg body weight and nitrites 0.48 to 0.8 mg per kg body weight for people who are not a special risk. Since nitrites under certain conditions can form nitrosamines which are hepatotoxic, carcinogenic and mutagenic, any value of addition of nitrites in foods as preservatives has to be weighed against the possible risk to human life by ingestion of nitrites.

Sanders has discussed the spectacular growth of new foods and the usage of food additives in two articles in 1966. Starting with common salt the range of food additives today includes a number of organic acids, vitamins, amino acids, firming agents, stabilisers and thickeners, anti-caking agents, moisture retaining agents, preservatives, anti-oxidants, sequestrants, anti-staling agents, dough conditioners, colours, flavouring agents, solvents and leaching or contact additives. These additives have not been an unmixed blessing, for they have given rise to usage in diets of sometimes new chemicals and materials of which we have very little biological data. Because of controversy regarding the widespread use of additives there is a general tendency to avoid them as far as possible and use natural materials as against technologically developed materials. However, this has not much substance. Many naturally occurring chemicals found in foods are not devoid of harm, e.g. β-N-(r-L-glutamyl) aminopropionitrile in Lathyrus sativus, 3-N-oxalyl-L/3 diaminopropionic acid in Lathyrus sativus, 1,5-vinyl-2 thiooxazolidone in brassica, thiocyanate and other goitrogens in a number of foods like cauliflower, kale, etc., aflatoxin in groundnut meal, cycasin in the nut, Cycad circinalis, safrole, a constituent of essential oil of sassafras, oil of calamus, coumarin in tonka bean, anti-vitamins, haemagglutinins, cyanogens, saponins, allergens and other toxic factors in a variety of natural foods.

On the other hand, a large number of additives are being used in food technology and food industry without the slightest indication of risk. In bread making, for instance, traditional methods have to a large extent been replaced by mechanical dough development processes such as Chorley-Wood bread process. Already there is increasing interest in new areas as for example azodicarbonimide and some bakers would like to adopt entirely new processes of chemically assisted dough development such as that involving L-cysteine. This would avoid the need for expensive mechanical equipments and provide a very rapid method of
producing batches of bread to meet sudden demand. Another area where there have been marked changes in technology due to use of new additives is brewing. Traditionally, beer is produced locally for consumption within a few days. Now the brewing could be centralised and chemically sterilized with n-heptyl-p-hydroxy benzoate which could not be detected even by the most discerning palate. In this case, pasteurisation of large batches of beer which can lead to off-flavours is avoided.

One of the more important food additives which has invoked much comment and criticism recently is radiation preservation of foods. Radiation preservation of foods is certainly unique in the sense that never before in the history of food technology has such vast expenditure of scientific effort and money been made before its use could be permitted even on a limited basis. It has been stated that 'It's only the rock that sticks out above the waves that gets noticed.' This is certainly true with respect to irradiation of foods; drying and heat as methods of preservation did not have to stand the same degree of scrutiny. Radiation pasteurisation of fish, poultry and egg products, potatoes, onions and fruits offer a vast potential for preserving these products and many believe on the basis of careful scientific sifting of evidence that the advantages and effectiveness of 'radicidation' outweigh any possible risks using this process.\textsuperscript{23}

Food contaminants

Reference has already been made to many naturally occurring foods containing toxic constituents such as glycosides, proteins, saponins, alkaloids and other chemicals. Lathyrogens such as glutamyl amino propionitrile from Lathyrus odoratus produce osteo-lathyrism, oxalyl-di-amino propionic acid found in Lathyrus sativus produces neuro lathyrism. Gossypol contained in the pigment glands of the cotton seed produces depressed appetite, cardiac irregularity and loss of body weight in a number of animals and causes egg yolk discoulouration. Haemagglutinins are present in a number of seed meals, goitrogens are commonly found in a variety of vegetables. Cyanogenetic glycosides are found in almonds, cassava, sorghum and lima bean. A number of saponins particularly toxic to cold blooded animals are found in alfafa, soyabean and other foodstuffs. Aflatoxin has been found to be a contaminant of peanuts and is produced by a common mold Aspergillus flavus. Argemone oil in small amounts is often observed as an adventitious contaminant in mustard oil because of the close similarity between argemone and mustard seeds. This oil contains small amounts of isoquinoline alkaloids which are presumably responsible for the observed effects of argemone oil toxicity like capillaritis and epidemic dropsy. Many oils and fats when subjected to continuous heating, undergo
nutritional impairment because of the formation of hydroperoxides, epoxides, polymers and cyclic products. In some cases both carcinogenic and co-carcinogenic properties have been ascribed to thermally degraded fats. Migrant chemicals from various packaging material, paper laminates, lacquers, sealing compounds, optical bleaches and whitening agents for paper board, pesticide residues present in vegetables or meat are all contaminants of foodstuff in this sense and are potentially harmful. However, in the amounts that are present in foods it may be stated that though a good deal of caution has to be exercised to avoid indiscriminate treatment of food with these chemicals, a drive towards “zero risk” would be suicidal. Can we go out and look for a no risk environment? Even if complete elimination of artificial ingredients from food were possible, it is doubtful that life in a sterile world would be better than the one complicated by natural and man made chemicals. In fact all life has been, at all times, endangered by toxins, infections, infestations and poisons and the ability to withstand and overcome the inimical environmental pollutants is what has given life its quality of survival. There is even a theory propounded that the teleological and evolutionary development is mediated by virus. In these days of ecological enthusiasm for a balanced perspective on the subject, I would like to cite the article by Abel Wolman.

Biological testing of food additives

It is merciful that the use of food additives dates with a period when biological testing was neither required nor routine. It has been estimated that biological tests necessary to clear and notify new additive may well cost £ 90,000 in U.K. In the United States it has been estimated to cost $ 250,000. In spite of much careful experimentation and review of results and conclusions at present almost every developed country has an expertly drawn up list of permitted additives—all different—which create unnecessary and expensive barriers to international trade. Unfortunately, though we can measure the damage or risk caused by food additives to some extent, we have no mechanism or means of measuring the amount of satisfaction and advantage they bestow on the consumer.

Let us first of all look at the various steps required in the assessment of safety of food additives. The following are the investigations required:

1. Chemical specifications on identity and purity.
4. Biological effects, Acute studies, Intermediate studies and Life-span studies in animals chosen for Metabolic data.

5. Assessment of acceptable daily intake (ADI)—Check by human studies.

6. Plan use to conform to ADI.

7. Zoned distribution.

Before the biological tests even begin the product must completely be defined chemically. We also should know how additives react in the body. How do we assess safety? Toxicity is the capacity of a substance to produce injury, hazard is the probability that injury will result from such use, and safety is the practical certainty that injury will not result from the use of a substance of a proposed quantity in a proposed manner. A judgement of safety based on toxicity data and possible hazard is therefore subject to constant review and updating of information. It is also important to ensure that the toxicology tests are not done away from food, in circumstances and conditions very different from their normal use in diets. Though the subject of safety is an ever receding goal and as such elusive and our area of understanding in this field is bounded by such large areas of ignorance, we have to proceed in some pragmatic fashion. After the tests of chemical purity comes the acute toxicity tests in rats, mice and non-rodents by oral and parenteral routes of administration and general observations on condition, activity, appetite, reactions of toxic compounds, nature of functional disorders, changes if any and survival rates. Sometimes LD 50 (lethal dose for 50 per cent of the animals) is determined and the largest single dose tolerated (14 days observation) and action of the compound by chemical and metabolic results are also evaluated. Thirdly, short-term studies for example 90 days on rats or for a period of at least 10 per cent of the lifetime for other species and long term studies in at least two species are also conducted. In all these experiments, the clinical observations, behavioural tests, survival and autopsy data are examined. In addition, fertility, carcinogenicity and metabolic data are also obtained.

After having obtained all the toxicological data one has to be still extremely cautious to predict as to the complete safety of the additive in humans because the biological effects of materials depend on absorption, distribution, concentration at reactive sites not only of the substance observed but of many of the metabolites formed from it and these and the amount of metabolites vary between different animal species. In order for the results of animal studies to be of predictive value one must also have knowledge of the animal similarity from man regarding metabolic handling of the substance. These metabolic
studies are very difficult and time consuming to carry out and much more perceptive research in this area is urgently needed.

One gets into a mellow mood after an examination of the pros and cons on the question of food additives, between technologists who demand that most technologically useful additives should be allowed in foods without too stringent and time consuming biological testing and the 'naturalists' who want to pursue a natural quality of life unaided by anything we make or know. Even in natural foods who can claim to give full specifications of a wholesome food? Interpretation and application of biological findings to practical conditions of exposure of food to determine a 'no-adverse effect' dose is still very much in the domain of value judgement. Again it must be stressed that all toxicological tests are generally carried out on initially healthy animals receiving nutritionally adequate basal diets and in the extrapolation of these 'no-effect' levels to exposed populations including people of all ages, in various stages of ill-health, on poor diets and also exposed to various other chemicals and drugs as well—is certainly a grave and onerous responsibility. For reasons which have no truly rational basis, the arbitrary safety factor of 1/100 has become widely and sometimes uncritically adopted by regulatory and advisory agencies. This factor has achieved a somewhat sacrosanct status. Over has suggested the following dose relationships for the interpretation of toxicity tests.

<table>
<thead>
<tr>
<th>Dosage group</th>
<th>Result</th>
<th>Quantitative data required</th>
<th>Approximate acceptable dose relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lethal</td>
<td>Death</td>
<td>LD</td>
<td>10,000</td>
</tr>
<tr>
<td>Toxic</td>
<td>Demonstrable tissue damage</td>
<td>ED</td>
<td>1,000</td>
</tr>
<tr>
<td>Effective</td>
<td>Significant modification of structure or function</td>
<td>ED</td>
<td>100</td>
</tr>
<tr>
<td>Ineffective</td>
<td>No significant change in structure or function</td>
<td>No significant difference from controls</td>
<td>10</td>
</tr>
</tbody>
</table>

Acceptable dietary levels* (mg/kg.)

*This acceptable dietary level must in each case be related to the standard dietary dose, which may be expressed as parts per 1000 of the total diet for a 70 kg. man.
Recognising the inherent limitation of toxicological tests in animals and the fact that absolute assurance of safety cannot be guaranteed, the concept of "zero tolerance" or "poison per se" doctrine have no scientific relevance. Public outcry for 'zero' concentrations of chemicals is thus not only technologically non-enforceable but scientifically unsound though it may be often times legally easy and expedient. Science with the best of our efforts can only in fact minimize our errors. It is, therefore, of paramount importance that the regulatory authorities and the public are informed adequately and the whole subject of food additives and contaminants be put in proper perspective to them by nutritionists and scientists of allied disciplines without too much hand waving and without too many scurrilying into the band wagon.

REFERENCES

SYMPOSIUM ON
METABOLIC RESPONSE TO PROTEIN-CALORIE MALNUTRITION

Chairman: Poorwo Soedarmo, Indonesia
and
W. H. Sebrell, U.S.A.

Rapporteur: K. L. Mukherjee, India

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Phagocytic response of leucocytes in protein-calorie malnutrition — R. J. SELVARAJ .. 525
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Neurochemical changes associated with protein-calorie malnutrition — B. K. BACHHAWAT .. 543
The clinical condition called protein calorie malnutrition has been described as a syndrome extending from weight variability at one end, where the deficiency is primarily a lack of calories, with starvation, in a severely emaciated and dehydrated infant, as the outstanding consideration, to the other end, where the deficiency is primarily protein, occurring on a diet low in protein and high in carbohydrates, with resulting oedema, enlargement of the liver, pancreatic atrophy and numerous other changes.

The wide variability presented by this complex interrelationship between nutrients naturally produces a complex mixture of biochemical changes which are difficult to interpret.

Protein and Amino Acid Metabolism

The most characteristic biochemical observations are the low serum albumin and the distorted serum amino acid patterns. Hypoalbuminemia has been considered as one of the characteristic features of protein calorie malnutrition, both in the albumin concentration and in total circulating albumin. Gitlin et al concluded that hypoalbuminemia was due to a decreased rate of albumin synthesis. Ramos-Galvan et al also noted that the presence of oedema is not solely dependent on the serum concentration of albumin. Garrow and Waterlow found a very rapid incorporation into, and slow disappearance of S\textsuperscript{35} methionine from albumin indicating an altered tissue turnover rate. The abnormal phenylalanine-tyrosine ratio, together with the decreased arginine-ornithine ratio suggests a deficiency of the enzymes phenylalanine hydroxylase and arginase. Cohen and Hansen using \textsuperscript{131}I albumin and \textsuperscript{131}I globulin in cases of kwashiorkor concluded that the rate of albumin metabolism was low before treatment, and increased after recovery. The rate of albumin synthesis appears to be increased during the
early phase of adequate protein therapy, although the synthesis and turnover rate of gamma globulin was not affected except in the presence of infection. Chatterjee et al. observed that serum proteins were significantly lowered, although electrophoretic studies did not show any significant alteration in the globulins.

Nitrogen retention by nitrogen balance studies show that 11 to 60% of the nitrogen taken as cow’s milk is retained, indicating no impairment of protein synthesis by malnourished infants. African infants with protein calorie malnutrition treated with protein hydrolysates in milk at levels of 2.0 to 8.6 grams of protein per kilogram per day had nitrogen retentions of 25% to 50% of the intake.

Gomez also showed that nitrogen absorption and retention were proportional to intake in malnourished children. There was an abnormally large proportion of nitrogen retention on high protein diets during early recovery but increased retention gradually returned to normal as body protein was repleted. The relatively labile proteins of blood, muscle and liver may be depleted by as much as 30%, while proteins of other parts of the body may be little changed. The negative nitrogen balance of severe protein restriction occurs in large measure at the expense of the liver which may lose as much as 50% of its total nitrogen.

The synthesis of specific antibody proteins also may be limited in protein calorie malnutrition. Antibody response to diphtheria toxoid typhoid vaccine or typhoid paratyphoid A and B are reduced in children with severe malnutrition.

Aminoaciduria is one of the characteristic features of protein-calorie malnutrition. On the basis of their studies on plasma amino acids, Holt and Snyderman concluded that the first limiting factor in protein calorie malnutrition is nitrogen rather than an essential amino acid. Since protein deficits in kwashiorkor diets are not confined to non-essential nitrogen, the fact that nitrogen may be the first limiting factor does not mean that a second limiting factor may not be an essential amino acid. If one attempted to treat kwashiorkor by supplying nitrogen through non-essential amino acids, it possibly would be of some value, although how much is not known at this time.

Whitehead on the basis of the observation that the pattern of serum amino acids is disturbed in protein calorie malnutrition, has proposed an amino acid ratio as a diagnostic test in areas in which primary protein deficiency is the main nutritional problem. This test is based on the ratio between glycine, serine, glutamine and taurine—and leucine, isoleucine, valine and methionine. It
is of value only in areas in which primary protein deficiency is the main nutritional problem. Whitehead has proposed an index based on the ratio of the mM hydroxyproline per ml of urine to the mM of creatinine per ml per kg of body weight, because of the difficulty in collecting 24 hour urine samples for use in children between six months and five years of age. Between the ages of five and twelve years, the index formulation is not justified since the ratio of hydroxyproline to creatinine does not fall. Unfortunately when protein calorie malnutrition is complicated by hook worm or malaria infection, a high, rather than a low, excretion of hydroxyproline may be found.

Grimble and Whitehead have studied the changes in serum amino acid patterns in children fed different levels of protein after recovery from kwashiorkor. On the low protein diet, the changes fell into three phases as follows: On a reduced protein intake of 3.4 grams per kilogram per day, the concentration of amino acids was not significantly affected. Further reduction in the protein intake reduced the concentration of the branched chain amino acids and threonine but alanine and glycine were elevated. On 1.4 grams per kilogram, serine showed a transient fall. Methionine, tyrosine, phenylalanine, lysine, histidine and arginine were not affected. Dean and Whitehead described abnormalities in the metabolism of the aromatic amino acids in children with severe kwashiorkor.

Fat metabolism

In general, total body fat appears to be decreased in protein calorie malnutrition. In kwashiorkor it decreases with recovery. Seum lipids and total cholesterol are decreased and then increased with recovery. Plasma levels of free fatty acids are increased and contributed to the pathogenesis of the fatty liver. The fatty acids in the liver are the same as those in the fat depots. The absorption of fat appears to be variably affected. Gomez found it severely impaired and fecal fat increased. Fat absorption tests using vitamin A as a lipid marker show poor intestinal absorption in kwashiorkor but not in marasmus.

Plasma free fatty acids are oxidized more rapidly than normal in kwashiorkor and marasmus and the synthesis rate for fatty acids from C14 acetate is reduced in liver biopsy samples from cases of kwashiorkor. Truswell and Hansen favour the hypothesis that a major mechanism for the fatty liver in protein calorie malnutrition is the protein moiety of plasma lipoproteins.

Carbohydrate metabolism

Studies on carbohydrate metabolism in protein calorie malnutrition are
limited although hypoglycemia has been considered a major cause of death. Viteri et al report glucose absorption normal but glucose tolerance abnormal with prolonged hypoglycemia and terminal hypoglycemia. Marasmic infants have normal glucose tolerance tests. Glycogen concentration in the liver is decreased. Serum pyruvic and alpha-ketoglutaric acid levels are elevated. Hadden found that the blood glucose levels were lower than normal in kwashiorkor but plasma free fatty acids were elevated and correlated with impairment of glucose tolerance. He suggests that the metabolic findings indicate a block at the point of entry of short chain fatty-acyl-coenzyme-A into the citric acid cycle. Bowie was the first to call attention to the normal glucose tolerance in marasmus.

Wharton has found blood glucose homoeostasis to be impaired in kwashiorkor resulting in both high and low levels of blood glucose. Profound hypoglycemia was rare but was uniformly fatal whereas moderate hypoglycemia was common but of little clinical significance if blood glucose remained above 20 mg. per 100 ml. He feels that the distinction between these two hypoglycemic states in kwashiorkor accounts for some of the discrepancy in the literature on the significance of hypoglycemia in kwashiorkor.

**Electrolytes**

Balance measurements on cases of protein calorie malnutrition with oedema show that during the loss of oedema there is an overall sodium loss and potassium increase suggesting excessive body sodium and depleted potassium. There appears to be a depletion of the intracellular electrolytes. There is also a decrease in magnesium in muscle which is associated with an increased retention of magnesium during recovery. This magnesium deficiency may be associated with some of the neurological manifestations such as tremors and convulsions and with the electrocardiographic changes. Inorganic as well as organic phosphate in muscle is markedly reduced. Both forms of phosphate increase with recovery. Hansen and Lehmann have found that serum zinc and copper concentrations are significantly reduced in cases of severe protein calorie malnutrition and return toward normal values upon recovery.

Garrow has found that in addition to the reduction in total body potassium in kwashiorkor there is also more concentration of potassium in the head and on post mortem the brain has been found to have more concentration of potassium. He postulates that the mental changes in kwashiorkor may be associated with loss of brain potassium.
Enzyme alterations

Many studies have been made on alterations in enzyme activity in protein calorie malnutrition. Waterlow\(^1\) considers a decrease in choline esterase as an indication of the severity of the disease and McLean\(^2\) regards increased serum glutamic pyruvic transaminase and isocitric dehydrogenase as indicators of approaching death.\(^3\) Metcoff et al\(^4\) found an increase in intracellular water and sodium and a significant decrease in potassium phosphoenolpyruvate and oxaloacetate. They also measured enzyme activities of pyruvic kinase, lactic dehydrogenase, malic dehydrogenase, and isocitric dehydrogenase. The activities of all except lactic dehydrogenase were significantly lower in the muscles from the malnourished children. Montgomery\(^5\) found a low pseudocholinesterase correlated with oedema and decreased serum protein. Sandstead et al\(^6\) found a lowered alkaline phosphatase which increased on recovery from protein calorie malnutrition. Several investigators have found reduced serum amylase and lipase which are regarded as indicating pancreatic atrophy.\(^7\) Of the liver enzymes, xanthine oxidase and glutamic dehydrogenase are increased while catalase, malic dehydrogenase, transaminase and alkaline phosphatase are reduced.

A study of pyruvic kinase by Metcoff et al\(^7\) in muscle has shown this to be decreased. In the serum, in addition to the decreased amylase, lipase, alkaline phosphatase, choline esterase and pseudo choline esterase, increases have been reported in lactic dehydrogenase\(^8\), glutamic oxaloacetic transaminase and glutamic pyruvic transaminase, isocitric dehydrogenase and l-leucine amino peptidase.

McFarlane et al\(^9\) report that the serum transferrin levels correlated well with the nutritional state of children with protein calorie malnutrition and they feel that this is the most accurate guide to management. Serum transferrin levels of 0.45 mg. per 100 ml. are regarded as diagnostic of severe protein calorie malnutrition and values less than 0.30 mg. per 100 ml. indicate a poor prognosis. They feel that a rise in concentration of the serum transferrin was invariably a good prognostic sign.

More enzyme studies would be highly desirable, especially from the viewpoint of their interpretation.

Hormone changes

There is evidence of severe hormone changes in kwashiorkor. These involve thyroid hormone, growth hormone, the adrenal and sex hormones. The reports
are somewhat confusing because of the differences in the ages of the children, the degree of growth failure, and the differences between marasmus and kwashiorkor. Evidence of decreased thyroid function is indicated by reduced levels of protein bound iodine. Monckeberg and Beas found decreased basal oxygen consumption and decreased $I_{131}$ uptakes, which responded to thyroid stimulating hormone administration. Monckeberg has given human growth hormone to infants with severe protein calorie malnutrition and noted a significant weight gain and increased retention of nitrogen, phosphorus and potassium. Hadden and Ratshausen, however, failed to obtain an effect on growth or an increase in nitrogen retention by the use of human growth hormone. Their diets were more generous than those used by Monckeberg. Pimstone and Hadden also found elevated plasma growth hormone levels in kwashiorkor cases on admission with a gradual fall towards normal.

Monckeberg concluded that protein calorie malnutrition is characterized by a decrease in hormones produced by the adenohypophysis. Rate change was observed in the urinary excretion of 17-oxyosteroids and 17-hydroxy- corticosteroids on treatment of children with protein calorie malnutrition. Leonard and MacWilliams found a normal urinary output of cortisol in kwashiorkor. Rao et al found an elevated plasma cortisol and a normal response to ACTH in both marasmus and kwashiorkor. Alleyne and Young found elevated plasma 11-hydroxycorticosteroid in protein calorie malnutrition with a further response to ACTH.

It is clear from the above summary that the biochemical abnormalities in protein calorie malnutrition are so diverse that the total body metabolism of the child with protein calorie malnutrition has been so upset, that in one way or another, hundreds of different biochemical systems in the body have been affected. In addition to the biochemical changes due to the deficiency syndrome itself, protein calorie malnutrition is almost always complicated by infections of varying degrees of severity, nutritional and electrolyte loss through diarrhoea or vomiting, and parasitic infestation. All of these variables have naturally resulted in differences in findings by various investigators studying different systems under different conditions in many parts of the world. The wide variability in this complex metabolic syndrome makes it highly unlikely that any one specific biochemical test can be developed that will be diagnostic of protein calorie malnutrition.

From the biochemical viewpoint, I agree with the Committee on Assessment of Protein Nutritional Status that we should stop hoping for a simple master biochemical test and consider instead the possibility of a multiple test system to be integrated with a set of clinical criteria in order to reach a satisfactory diagnosis.
Present biochemical tests yield favourable information if their limitations are understood. If evaluated together with anthropometric measurements and clinical assessments, the three groups of observations provide the necessary objective background for assessing the nutritional status of communities, and evaluating the efficiency of various preventive and therapeutic regimes.

REFERENCES

Chairman's Remarks


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The proposition put forward by Gopalan that a failure of adaptation may condition the form and perhaps the development of clinical malnutrition, is an encouragement to me because it means that the work described in this paper may in the long run have some relevance to the urgent practical problems discussed by many others at this Congress.

The studies which I am going to summarize represent the work of many colleagues in the former MRC Tropical Metabolism Research Unit in Jamaica, now a department of the University of the West Indies. I wish to thank David Picou, George Alleyne, Joan Stephen, Ann Ashworth, Philip James and Joe Millward for allowing me to use their data.

If we try to define the word adaptation, the best I can do is: 'a reaction of the organism to environmental conditions which tends to maintain normal structure or function'. I am well aware that this is a circular definition, because it contains the word 'normal' and therefore begs the question. However, it serves to make the point that the concept of adaptation and the concept of normality are two aspects of the same thing. We could define the range of normal variation as the range within which adaptation is successful, and beyond which adaptation has broken down. In the last analysis, of course, this range can only be established by functional tests, but I think we can get much information by analysis of the mechanisms of adaptation. The outstanding example of this is the analysis by the physiologists of the mechanisms of acid base regulation. This whole problem of defining the normal has been discussed in more detail elsewhere.

Secondly, adaptation is relative and depends on one's point of view. There is a natural tendency to feel that I am normal but you are adapted. However, it is necessary to rid oneself of preconceived ideas. Von Muralt in a symposium on life at high altitude in South America pointed out that if a textbook of physiology were written by an Andean Indian it would treat many questions...
very different, and describe the remarkable mechanisms of adaptation of life at sea-level, the 'norm' being life at high altitude.

**Albumin metabolism**

Our first investigation of adaptive changes in protein metabolism in malnutrition was concerned with the regulation of albumin mass, partly because of the great nutritional importance of plasma albumin concentration, partly because albumin is accessible to labelling, and a great deal of work on its metabolism had been done by McFarlane and others. Ten years ago Picou and I in Jamaica and Cohen and Hansen in South Africa almost simultaneously published results which showed that in malnourished children the rate of albumin catabolism is decreased. The half-life in normal infants is about 13 days, whereas in malnourished infants it was twice as long. Obviously this looks like a protective or adaptive reaction to conserve albumin when amino acid supplies are reduced.

Although the two studies gave identical results, there were certain differences in the conditions. The Cape Town group fed their children a low protein diet for the duration of the test, whereas ours were given the normal diet used for treatment. However, our cases were more malnourished, judged by the weight deficit. The question therefore arose, whether the fall in catabolic rate was a response to the low protein intake per se, or to the extent of depletion of the body—two different variables. We set out to answer this question and at the same time to measure the synthesis rate of albumin as well as the catabolic rate. Since the plan was to give a single injection of labelled albumin and at intervals thereafter alter the level of dietary protein intake it could not be assumed that there was a steady state in which synthesis and catabolism are equal. We were greatly helped by having a whole body counter with which it was possible to measure the decay curve of total albumin in the body, without the necessity of making continuous urine collections. In order to calculate rates of synthesis and of transfer between the extravascular and intravascular pools arbitrary values for the rate constants were inserted in the equations for the models in the non-steady state and sets of curves generated with a computer which were then matched with the experimentally determined curves. The rate constants were taken as the values which gave the best fit. The method is described by James and Hay. Table 1 summarizes their findings. Four points are to be noted

(i) The malnourished child, if given protein, could synthesize albumin as efficiently as the recovered child.

(ii) In both states, reduction in protein intake caused a large fall in the rate of albumin synthesis.
Adaptation to Low Protein Intakes

(iii) In the recovered children on a high protein diet, the rates of catabolism and synthesis were equal—i.e. there was a steady state—whereas in the malnourished children catabolism was less than synthesis because they were regenerating their albumin.

(iv) When the protein intake was reduced, the rate of catabolism fell, although in the malnourished children this did not occur until the second week on the low protein diet.

TABLE 1

| Influence of the protein intake on rates of albumin synthesis and catabolism in infants* |
|-----------------------------------|---|---|---|---|
| mg albumin/kg/day on days :       | 0-10 | 10-17 | 17-24 | 17-24 |
| (high)                            | (low) | (low) | (high) |
| Recovered children :              |      |      |      |      |
| Synthesis                         | 222   | 148   | 138   | 236   |
| Catabolism                        | 219   | 178   | 140   | 156   |
| Malnourished children :          |      |      |      |      |
| Synthesis                         | 233   | 101   | 87    | 288   |
| Catabolism                        | 166   | 171   | 131   | 178   |

*Reference No. 6.
Protein intake shown in parentheses.

What the Table does not show is that in response to the reduced protein intake the synthesis rate fell rapidly but the catabolic rate lagged behind and changed more slowly. As a result, for a time there was a net loss of albumin, since catabolism exceeds synthesis. During this time there was a transfer of albumin from the extra-to the intravascular pool.

Since the results of James and Hay depend upon a number of assumptions, it was encouraging to find that identical conclusions were drawn by the South African workers from experiments in rats in which synthesis was measured independently by the \(^{34}\)C-carbonate method of McFarlane—a method which cannot be used in infants.

Here, then, is a beautiful example of a regulation or adaptation tending to maintain the circulating albumin mass by changes in three factors which vary independently and must be independently-controlled—the rates of synthesis and catabolism and the rate of net transfer between the intravascular and
extra-vascular pools. As far as I know, the nature of the controlling mechanisms has not yet been elucidated, but at least we can see the pattern of this adaptive response.

The work on albumin metabolism illustrates another point which is helpful in the understanding of adaptive changes. Claude Bernard over a century ago established the concept of the fixity of the internal medium of the cell. However, we have to recognize that while some properties or functions are relatively fixed, others are more variable, and it is at the expense of the variable functions that the fixity is maintained. In an analysis of the mechanisms, it is important to distinguish between the fixed and variable parameters. For example, some years ago Hoffenberg and his co-workers described the results of feeding low protein diets to healthy adults. Although they did not stress the point, their observations showed that a fall of 25 per cent in plasma albumin concentration was accompanied by a decrease of 75 per cent in the catabolic rate of albumin.

One might say, therefore, that from the point of view of diagnosing the extent of protein deficiency, the catabolic rate is 3 times as sensitive as the albumin concentration. Several years earlier I suggested this possibility, but could not prove it. Unfortunately, the test is not one that can be applied on a field scale. On the other hand, within wide limits a change in catabolic rate can hardly be regarded as pathological, whereas a significant change in the ‘fixed’ parameter—serum albumin concentration—is of much more importance.

Total protein turnover

From what has been said above, it looks as if albumin synthesis behaves just as one might expect from the characteristics of the polyosomes described by Munro in his paper to this Congress: when amino acid supplies run short, synthesis is immediately shut off. The next question we tried to answer is whether this is a general characteristic of protein turnover in the body as a whole. The method of measuring total protein turnover by constant infusion of $^{14}$N-glycine has been described by Picou and Taylor-Roberts. This method is based on a model containing two pools—a ‘metabolic’ pool and a protein pool. Undoubtedly this is a gross oversimplification, but independent evidence from other types of turnover study (see below) suggests that it works, in that it gives results which are consistent and reasonable. According to this model, amino acids entering the metabolic pool from food and those entering from the breakdown of body protein are mixed in a homogeneous pool. Some experimental evidence was in fact obtained to support this fundamental assumption. Secondly, an amino acid entering the pool can only have one of two fates: either it is synthesized to protein, or it is excreted as urea. Other pathways are considered to be quantitatively of such little importance that they
Adaptation to Low Protein Intakes

The purpose of the constant infusion is to produce an isotopic steady state in which there is a constant rate of excretion of $^{15}$N in the urine.

The results in Table 2 show that in infants a fourfold change in the protein intakes had no effect whatever on the overall rate of synthesis. There is a small change in the rate of catabolism, which may or may not be real. Similar experiments were done in rats with constant infusion of $^{15}$C-lysine. Here the steady state is shown by a constant specific activity of free lysine in the plasma. Table 3 shows that the total turnover was unaffected by low protein feeding for 3-10 days, or by starvation for 2 days. It seems, therefore, that the total protein turnover is a function that is rather closely fixed, and presumably therefore it is of biological importance. Total protein turnover is the sum of the turnover of all the proteins in the body, just as the basal metabolic rate is the sum of the oxygen turnover of all the cells of the body. It is interesting, therefore, that there seems to be a relationship between these two functions (Table 4). In the rat, as in man, the total turnover per kg body weight falls with increasing weight. It may be noted that these values for total turnover are some 4 times higher than those quoted by Munro, which were obtained many years ago by Rittenberg and his co-workers, with a single dose of labelled amino acid. Nevertheless, both those measurements and ours agree in showing that per unit body weight the turnover rate in the rat is some 4-5 times higher than in man.

**TABLE 2**
Rates of protein synthesis and catabolism in infants at different levels of protein intake, measured by intra-gastric infusion of $^{15}$N-glycine

<table>
<thead>
<tr>
<th></th>
<th>High protein</th>
<th>Low protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of infants</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Taken in (g protein/kg/day)</td>
<td>3.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Synthesized (g protein/kg/day)</td>
<td>6.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Catabolized (g protein/kg/day)</td>
<td>4.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Fraction of $^{15}$N excreted</td>
<td>24.3%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

*Reference No. 9.
TABLE 3
Total lysine flux in rats infused for 6 hours with 14C-L-lysine

<table>
<thead>
<tr>
<th>Condition</th>
<th>Flux (umole/100 g body-weight/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control males</td>
<td>75</td>
</tr>
<tr>
<td>Control females</td>
<td>81</td>
</tr>
<tr>
<td>Starved 2 days</td>
<td>76</td>
</tr>
<tr>
<td>Protein-free diet 3 days</td>
<td>69</td>
</tr>
<tr>
<td>Low protein diet 3 days</td>
<td>66</td>
</tr>
<tr>
<td>Low protein diet 10 days</td>
<td>68</td>
</tr>
<tr>
<td>Low protein diet 10 days + insulin</td>
<td>70</td>
</tr>
</tbody>
</table>

TABLE 4
Protein turnover and basal metabolic rate

<table>
<thead>
<tr>
<th>Body-weight (kg)</th>
<th>Protein turnover (g/kg/day)</th>
<th>Basal metabolic rate (C./kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rat</td>
<td>0.1</td>
<td>25</td>
</tr>
<tr>
<td>Infant</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Adult</td>
<td>70</td>
<td>2</td>
</tr>
</tbody>
</table>

Rates of synthesis and catabolism in liver and muscle

Although total protein turnover seems to be rather closely fixed, our experiments show that this constancy masks a change in the pattern of protein synthesis in different tissues when protein supplies are reduced. In the rat the constant infusion method allows measurements to be made of synthesis rates of tissue proteins. Unfortunately, this is not possible in children.

Results obtained in the rat are shown in Table 5. After short periods of starvation or low protein feeding, there is no change in the fractional synthesis rate of mixed liver proteins, or even a slight increase. The contradiction with the well-known fact that these treatments cause a substantial loss of liver proteins is probably explained by the fact that the measurements were made after two
or three days on the diet, by which time the liver is coming into equilibrium and not losing any more protein.

**TABLE 5**

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Synthesis-rate (% of control)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liver</td>
</tr>
<tr>
<td>Starved 2 days</td>
<td>105</td>
</tr>
<tr>
<td>Protein-free 3 days</td>
<td>113</td>
</tr>
<tr>
<td>Low protein 3 days</td>
<td>110</td>
</tr>
<tr>
<td>Low protein 10 days</td>
<td>120</td>
</tr>
<tr>
<td>Low protein 10 days + insulin</td>
<td>165</td>
</tr>
<tr>
<td>Low protein 5 weeks</td>
<td>80</td>
</tr>
</tbody>
</table>

The Table also shows that the fractional synthesis rates of mixed serum proteins was reduced. These measurements were made on the micro-scale, and albumin and globulins were not separated. It is probable that the fall in synthesis rate reflects mainly the behaviour of albumin, in agreement with the results obtained with iodine-labelling, described in the previous section.

In muscle, in contrast with liver, the fractional synthesis rate was greatly reduced by protein deprivation, even more than that of serum proteins. This would be regarded as an adaptive change, which makes more amino acids available for use by other tissues.

How can one explain the striking difference in the behaviour of these two tissues, liver and muscle? The liver occupies a special position, controlling the route of entry of supplies from the gut. After a meal containing protein, the amino acid concentrations in the portal blood increase substantially. In the face of these fluctuations in amino acid supply, the liver seems to be able to do three things.

(i) By taking up or giving out amino acids (except for the branched-chain amino acids) it maintains a rather constant amino acid concentration in the peripheral circulation. This has been shown by perfusion experiments. It seems, therefore, to exert a kind of homeostatic function.
(ii) Secondly, as we have seen, it can switch on or off the synthesis of albumin, and perhaps of other proteins which, like albumin, are secreted into the blood stream, such as pseudocholinesterase. However, this does not apply to the bulk of the cellular proteins of the liver. Perhaps the difference depends on a difference in the site of synthesis, since there is evidence that secreted proteins are synthesized by membrane-bound ribosomes and fixed cellular proteins by free polysomes. Nevertheless, it would be unwise to attempt too hard and fast a distinction, since the synthesis rate of some cellular proteins, e.g. tyrosine transaminase or serine dehydrase, seems to be very sensitive to changes in the amino acid supply.

(iii) Thirdly, the liver alters the extent of urea formation.

Table 2 shows that on a high protein intake, 24 per cent, and on a low intake only 3 per cent of the \( N \) infused was excreted as urea. If the tracer technique and the model are valid, this means that on the low protein intake only one-eighth as much of the amino-\( N \) entering the metabolic pool is converted to urea. In other words, there has been a diversion of metabolic pathways away from urea function and towards protein synthesis.

Schimke showed that in rats on a low protein diet, the activity of the urea-forming enzymes is decreased, and Spadoni and co-workers showed that low protein feeding leads to an increase in the activity of the amino acid activating enzymes or synthetases in the liver. These two changes would have precisely the effect mentioned above—of diverting amino \( N \) from urea formation towards protein synthesis. We have obtained evidence that similar adaptive enzyme changes occur in the liver in human infants. Of course, one cannot necessarily say that these enzyme changes cause the decrease in urea output. In Schimke's experiments the animals were kept on the low protein diet for 14 days before the enzyme measurements were made, whereas the urea output actually falls much more quickly. Das in our laboratory has shown that when the protein intake is reduced, the urea cycle enzymes fall and reach their final level in about 18 hours, which corresponds well with the time course of the fall in the urinary \( N \) excretion. Thus it does seem reasonable to postulate a cause-and-effect relationship, but the mechanism by which the adaptive enzyme changes are brought about is not known—whether it is hormonal or a direct effect of amino acid supply. The work of Potter and his group suggests that there may be very rapid, short-term fluctuations in liver enzyme activity in relation to food, which must be regarded as part of a normal rhythm. It is important to note, also, that the same dietary stimulus may alter the activity of different enzymes in different directions. Frequently, although not always, the enzyme activity
Adaptation to Low Protein Intakes

reflects a change in the amount, and therefore in the relative rates of synthesis and catabolism, of the enzyme proteins. The position of muscle is in strong contrast to that of liver. The level of amino acids in the peripheral bloodstream is much more constant than that in the portal blood, presumably because of the buffering action of the liver. What, then, is the stimulus or signal to muscle to reduce its rate of protein synthesis when low protein diets are fed? Changes in the level of circulating insulin are an obvious possibility. Garlick, in our laboratory, has recently shown that if rats are allowed access to food for 4 hours out of 24, a significant fall in the rate of muscle protein synthesis can be demonstrated about 20 hours after the end of the meal but not earlier. Changs in the level of circulating insulin are an obvious possibility. Garlick, in our laboratory, has recently shown that if rats are allowed access to food for 4 hours out of 24, a significant fall in the rate of muscle protein synthesis can be demonstrated about 20 hours after the end of the meal but not earlier. It remains to be established whether the time course of the fall in protein synthesis can be related to fluctuation in plasma levels of amino acids or insulin.

Millward has developed a method for measuring rates of protein synthesis and catabolism simultaneously by labeling with C-carbonate, and has determined these rates in the two main fractions of muscle protein—sarcoplasmic and myofibrillar—under various dietary conditions. On low protein diets the rates of synthesis of both proteins fell. The catabolic rate of sarcoplasmic protein also fell, but that of myofibrillar protein was increased. Starvation caused similar but more intense changes. Thus, as in the case of albumin, it looks as if rates of synthesis and catabolism are independently controlled, but virtually nothing is known about the mechanism by which the control of catabolic rates is exerted. What is surprising is the extent to which these large molecular-weight contractile proteins respond to the metabolic needs of the animal as a whole.

This short account of adaptive changes in protein metabolism raises more questions than it answers. I hope, however, that it does give some picture of the ways in which different tissues react and interact to maintain essential functions when external supplies of amino acids are reduced.

REFERENCES

PHAGOCYTIC RESPONSE OF LEUCOCYTES IN PROTEIN CALORIE MALNUTRITION

R. J. SELVARAJ

National Institute of Nutrition, Hyderabad, India

It is a widely accepted fact that resistance to infection is greatly reduced in cases of protein-calorie malnutrition. Normally, two major defence systems that protect the host against infections are recognized: one, antibody production and the second, phagocytic activity. Of these, the first one, that is, the formation of antibodies, has received considerable attention. Numerous reports have appeared in literature implicating protein-calorie malnutrition in decreased antibody formation.

However, the importance of the experimentally observed decrease in antibody production to an antigen challenge in contributing towards decreased resistance in malnutrition, is not very clear. Quite often, antibody production is tested with vaccines, dead bacteria, red blood cells, etc. However, if a test is also made simultaneously with a viable organism as antigen, malnutrition usually fails to lead to decreased antibody production.1 Under certain conditions, antibody production may decrease without any decrease in resistance to infection2 or antibody production may be normal but resistance to infection may decrease.3

It is known that the Y-globulin fractions invariably do not decrease in malnutrition. This would imply that in malnutrition, the general antibody forming mechanisms are not impaired seriously. With the availability of modern techniques, the major antibody fractions have also now been estimated. In kwashiorkor, the different immunoglobulin fractions are close to normal but for a small decrease in the IgG fraction.4 In marasmus, there is actually an increase in all the major fractions of immunoglobulins.4 Not only the circulating levels of immunoglobulins are normal, but also the malnourished subject apparently produces antibodies just as well as the normal child, when faced with infection.5

In severe protein-calorie malnutrition, the organism is in negative nitrogen balance and antibody production can logically be expected to decrease due to the lack of the building blocks, the amino acids. However, the organism apparently puts a high priority on antibody production. How
The other major defence mechanism that may be affected in malnutrition is the phagocytic activity. The major circulating phagocyte involved in this phenomenon is the polymorphonuclear neutrophil (PMN). As early as 1948, Asirvatham demonstrated that protein deficiency leads to a lack of mobilization of PMN to inflammatory areas. It is well known, that leucocytosis occurs during infection and that this anticipated leucocytosis does not occur in kwashiorkor with concurrent infection. Decreased particle uptake in protein-calorie malnutrition has been demonstrated, both in vivo and in vitro by several groups of investigators. However, the techniques employed for estimating phagocytic activity, so far, have been morphological; that is, counting the number of particles engulfed by the phagocyte under a microscope. This, at best, can be only semi-quantitative and liable to subjective errors. This technical limitation is probably the major cause for the lack of extensive studies on the phagocytic response in malnutrition.

Recently, a number of metabolic parameters have been shown to be associated with phagocytosis by PMN and they offer a rigid system by which one can check the phagocytic ability. There is a significant increase in glycolytic activity during phagocytosis. If glycolytic activity is inhibited, for instance with iodoacetate, phagocytosis does not occur, showing thereby that the energy for particle uptake is provided by glycolysis. Surprisingly, though, there is also a stimulation in respiration. This is mainly due to a stimulation in the hexosemonophosphate shunt activity as measured by an increase in glucose-1-14C oxidation. Besides these alterations in carbohydrate metabolism, Cohn's group first demonstrated that degranulation occurs during phagocytosis, which results in the release of a number of potent hydrolytic enzymes. They postulated that these lysosomal enzymes are the eventual bactericidal agents in these phagocytes. Iyer et al demonstrated a stimulation of formate oxidation and concluded that formate oxidation occurs with the help of hydrogen peroxide formed during the stimulated shunt activity. They suggested that the bactericidal activity of the leucocytes is due to the hydrogen peroxide formed during phagocytosis. Later, it was demonstrated that particle uptake and the release of the lysosomal enzymes occur efficiently under anaerobic conditions; however, bactericidal activity is greatly reduced in the absence of oxygen, showing thereby that oxidative metabolism with hydrogen peroxide production and not the lysosomal enzymes, is the main bactericidal agent in these cells.
Phagocytic Response in Protein Calorie Malnutrition

Using these metabolic parameters as guidelines, the possible involvement of the phagocytic system in increasing the susceptibility to infection in malnutrition was investigated at the National Institute of Nutrition, Hyderabad.

Leucocytes for these studies were isolated from venous blood of 19 malnourished and 14 normal children by the dextran flotation technique. The isolated cells were incubated in Krebs-Ringer phosphate medium, containing 20% heat-inactivated autologous serum. Phagocytosis was induced by offering heat-killed *E. coli* as particles. Glucose-1-^14^C was used at 5mM concentration as substrate.

Glycolytic and hexose monophosphate shunt activities of PMN are shown in Table 1. Lactate production in resting leucocytes—that is in the absence of phagocytic activity—does not differ between the two groups. However, in the presence of particles, the malnourished group has significantly lower glycolytic activity. More important is the fact that the stimulation of glycolytic activity, which is the phagocytic response observed in normal leucocytes, is absent in the malnourished. Out of the 19 patients studied only two showed a stimulation in glycolytic activity with particles. Since glycolytic stimulation is a sign of particle uptake, the leucocytes in malnutrition, probably are less efficient phagocytes.

The shunt activity is higher in resting, but lower in phagocytizing leucocytes obtained from malnourished patients. Further the phagocytic stimulation in the shunt activity is markedly reduced in malnutrition. This is due to a small increase in resting cell metabolism and a large decrease in phagocytic cell metabolism. The data presented in this Table imply a reduced bactericidal potency of PMN, since the stimulated shunt activity provides the necessary NADPH which is oxidized to hydrogen peroxide.

No correlation was observed in this study between the metabolic activities of PMN and the presence of vitamin deficiency signs or the presence of infection.

That the altered metabolic activities observed in these studies are really due to malnutrition was also established by longitudinal studies. Table 2 shows the effect of treatment with a high protein-high calorie diet on 12 of these patients. The results show a definite and significant improvement in the phagocytic stimulation of both the shunt and glycolytic activities. The patients were benefiting from the treatment as shown by the increased serum albumin levels.

The observed alterations in metabolic activities could be due to either altered leucocytic activity or due to altered serum factors. To resolve this,
<table>
<thead>
<tr>
<th>Subjects</th>
<th>Glucose-1-14C (m/umoles/10^6 PMN)</th>
<th>14CO₂ (m/umoles/10^6 PMN)</th>
<th>Lactate production (m/umoles/10^6 PMN)</th>
<th>Serum albumin (P.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>--</td>
<td>+</td>
<td>--</td>
</tr>
<tr>
<td>Normal</td>
<td>0.81*</td>
<td>5.79</td>
<td>734</td>
<td>69.5</td>
</tr>
<tr>
<td></td>
<td>± 0.175</td>
<td>± 1.018</td>
<td>± 178.9</td>
<td>± 15.86</td>
</tr>
<tr>
<td></td>
<td>(14)</td>
<td>(14)</td>
<td>(14)</td>
<td>(13)</td>
</tr>
<tr>
<td>Protein-calorie malnutrition (PCM)</td>
<td>1.30</td>
<td>4.58</td>
<td>337</td>
<td>57.1</td>
</tr>
<tr>
<td></td>
<td>± 0.526</td>
<td>± 1.864</td>
<td>± 146.3</td>
<td>± 22.95</td>
</tr>
</tbody>
</table>

P value for Normal and PCM: <0.01 <0.05 <0.001 =0.10 <0.01 <0.02 <0.001

*Mean ± S.D.

-- and + signs refer to the absence or presence of particles.
P.E. = Phagocytic Effect.

Figures in parentheses indicate number of experiments.
## TABLE 2

Leucocyte metabolic activities in children suffering from protein-calorie malnutrition, before and after treatment

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Number of observations</th>
<th>Glucose-1-14C → 14CO₂</th>
<th>Lactate production</th>
<th>Serum albumin (g %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(m/umoles)</td>
<td>P.E. (%)</td>
<td>P.E. (%)</td>
<td></td>
</tr>
<tr>
<td>Before treatment Mean ± S.E.</td>
<td>12</td>
<td>1.23** ± 0.593</td>
<td>4.28 ± 1.797</td>
<td>392 ± 173.5</td>
</tr>
<tr>
<td>Effect of treatment Mean ± S.E.</td>
<td>12</td>
<td>0.25 ± 0.749</td>
<td>1.98 ± 1.784</td>
<td>175 ± 222.4</td>
</tr>
<tr>
<td>P value for effect of treatment</td>
<td></td>
<td>&lt; 0.025</td>
<td>&lt; 0.05</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

* Differences from before treatment values.
** Mean ± S.D.
experiments were performed by exchanging cells and sera. Table 3 shows the results obtained. First, normal leucocytes were incubated either with autologous serum or with pooled serum from the patients. Both shunt and glycolytic activities were measured. The results showed no significant alterations in either of these metabolic parameters due to the presence of patients' sera. Similarly, when leucocytes obtained from malnourished

![Bactericidal Activities of Normal and PCM Leucocytes](image)

**VALUES ARE MEAN±S.E (PHAGOCYTE:BACTERIA RATIO 1:2)**
<table>
<thead>
<tr>
<th>Source of serum</th>
<th>Source of leucocyte</th>
<th>Glucose-1-$^{14}$C $\rightarrow$ $^{14}$CO$_2$</th>
<th>Lactate production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(m/umoles) P.E. %</td>
<td>(m/umoles) P.E. %</td>
</tr>
<tr>
<td></td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Autologous</td>
<td>Normal</td>
<td>0.76 ± 0.057</td>
<td>6.14 ± 0.054</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
</tr>
<tr>
<td>PCM (pooled)</td>
<td>Normal</td>
<td>0.76 ± 0.141</td>
<td>5.38 ± 0.141</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>(5)</td>
<td>(5)</td>
</tr>
</tbody>
</table>

P value for autologous Vs. PCM (pooled) serum

<table>
<thead>
<tr>
<th>Source of serum</th>
<th>Source of leucocyte</th>
<th>Glucose-1-$^{14}$C $\rightarrow$ $^{14}$CO$_2$</th>
<th>Lactate production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(m/umoles) P.E. %</td>
<td>(m/umoles) P.E. %</td>
</tr>
<tr>
<td></td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Autologous</td>
<td>PCM</td>
<td>1.22 ± 0.539</td>
<td>4.26 ± 0.539</td>
</tr>
<tr>
<td></td>
<td>(8)</td>
<td>(8)</td>
<td>(8)</td>
</tr>
<tr>
<td>Normal pooled</td>
<td>PCM</td>
<td>1.45 ± 0.234</td>
<td>4.24 ± 0.234</td>
</tr>
<tr>
<td></td>
<td>(7)</td>
<td>(8)</td>
<td>(8)</td>
</tr>
</tbody>
</table>

P value for autologous Vs. normal pooled serum

Values are Mean ± S.D.
Figures in parentheses indicate number of experiments.
patients were incubated with pooled normal sera, no improvement in metabolic activities were observed. Hence, the changes in the metabolic pattern observed in malnutrition are chiefly due to a defective phagocyte and not due to altered serum factors.

The changes observed in the metabolic activities of leucocytes from malnourished children lead one to conclude that the bactericidal potency of these cells will also be decreased. Direct experimental evidence was also obtained to justify the conclusions drawn from these metabolic studies, by measuring the bactericidal activity of PMN.

Bactericidal activity was measured by incubating leucocytes with an 18 hour culture of washed *E. coli* in the phagocyte: particle ratio of 1:2 for varying periods of time and measuring the number of viable bacteria present after incubation, by the standard colony counting techniques. Figure 1 shows the results obtained. It is evident that leucocytes from the patients show a marked decrease in bactericidal potency. Longitudinal studies were also conducted with 4 of these patients and the results are shown in Figure 2. An improvement in bactericidal activity is apparent as the
Phagocytic Response in Protein Calorie Malnutrition

patients had been under treatment for two to four weeks in all the 4 cases studied.

The normal antibody levels found in kwashiorkor and the remarkable efficiency with which these levels increase during infection, raise doubts regarding the involvement of the immunological response as a major factor in the increased susceptibility to infection observed in these patients. On the other hand, results obtained on the phagocytic response, indicate a definitely altered phagocytic metabolism and a decreased bactericidal potency of leucocytes. Hence, the phagocytic response in malnutrition deserves a much more intensive investigation than it has received so far.

REFERENCES

CUTANEOUS RESPONSE TO PROTEIN-CALORIE MALNUTRITION

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An important and striking clinical feature of kwashiorkor is the characteristic skin changes. Though 20-40% of cases of protein-calorie malnutrition have skin lesions, there has been so far no detailed studies on the biochemical composition of the skin in this condition.

Skin contributes an appreciable proportion of the total body weight, about 8-10% in the adult and probably more in the child. The crude protein content of the skin is nearly 20% and accounts for about one-eighth of the total body protein. Collagen constitutes 70% of the total nitrogen of the skin, and is mainly responsible for its mechanical strength and stability. It is obvious, therefore, that in any study of disorders of protein metabolism the skin must receive attention. An investigation was, therefore, undertaken to determine the effects of protein and calorie deficiency on the biochemical composition of the skin with particular reference to collagen metabolism.

Nineteen children suffering from kwashiorkor were investigated as inpatients of whom seven had characteristic skin lesions in the form of crazy-pavement dermatosis. Their ages ranged from 1-5 years. Skin biopsies were done at the time of admission, and in 10 children, repeat biopsy specimens were obtained after complete clinical cure. A piece of skin measuring 2.5 x 5 mm was taken from the anterior aspect of the thigh, and the repeat biopsy was performed on the opposite thigh. The biopsy material was also obtained in 10 normal children for purposes of comparison. The tissue was stored at -20°C till analysed. The epidermis was removed and the dermis thus obtained was dried, defatted and hydrolysed with 6N HCl for 24 hours. An aliquot of the hydrolysate was taken for dermal nitrogen estimation; analysis of the hydrolysate for amino acid pattern was done using an automatic amino acid analyser (Spinco Beckman). Total nitrogen content of the skin was estimated after hydrolysis of the whole skin.

The results of these analyses are presented in Table 1. The nitrogenous constituents of skin in kwashiorkor showed a gross reduction as compared to normal children and the reduction was much more in children with skin lesions. There was a reduction both in the total skin nitrogen content and
TABLE 1

Nitrogenous constituents of the skin in kwashiorkor

<table>
<thead>
<tr>
<th>Group</th>
<th>Total nitrogen</th>
<th>Epidermal nitrogen</th>
<th>Dermal nitrogen</th>
<th>Collagen nitrogen</th>
<th>Non-collagen nitrogen</th>
<th>Collagen/non-collagen nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normals (8)</td>
<td>18.74±1.05</td>
<td>2.71±0.52</td>
<td>16.03±1.48</td>
<td>10.66±0.75</td>
<td>5.24±1.53</td>
<td>2:1</td>
</tr>
<tr>
<td>Kwashiorkor without dermatitis (11)</td>
<td>14.31±2.23</td>
<td>2.56±0.83</td>
<td>12.95±1.37</td>
<td>7.78±2.13</td>
<td>5.17±0.83</td>
<td>1:5.1</td>
</tr>
<tr>
<td>Kwashiorkor with dermatitis (6)</td>
<td>10.90±1.34</td>
<td>1.71±0.57</td>
<td>9.20±3.32</td>
<td>5.86±1.72</td>
<td>3.13±1.60</td>
<td>1:9.1</td>
</tr>
<tr>
<td>Kwashiorkor after treatment</td>
<td>17.77±1.22</td>
<td>1.71±0.911</td>
<td>15.78±1.06</td>
<td>11.17±1.39</td>
<td>4.45±1.15</td>
<td>2.5:1</td>
</tr>
<tr>
<td>Normals versus kwashiorkor without</td>
<td>P&lt;0.001</td>
<td>NS</td>
<td>P&lt;0.05</td>
<td>P&lt;0.01</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>dermatitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normals versus kwashiorkor with</td>
<td>P&lt;0.001</td>
<td>P&lt;0.02</td>
<td>P&lt;0.001</td>
<td>P&lt;0.001</td>
<td>P&lt;0.02</td>
<td></td>
</tr>
<tr>
<td>dermatitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of treatment</td>
<td>P&lt;0.01</td>
<td>NS</td>
<td>P&lt;0.01</td>
<td>P&lt;0.01</td>
<td>P&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

Numbers in parentheses are numbers of subjects. NS = not significant.
Values are means±SEM. * Values for nitrogen are expressed as g/100 g dry defatted tissue.
L. Vasanthk

dermal nitrogen content. Both collagen nitrogen and non-collagen nitrogen content of dermis showed a reduction. After complete clinical cure, all values returned to normal. Estimation of amino acids of the dermis showed a quantitative reduction in all amino acids, which was reflected as a reduction in nitrogen content. But when amino acids were expressed as percentage of dermal nitrogen (Table 2), only hydroxyproline showed a significant reduction in children without skin lesions as compared to normals. In children with skin lesions, in addition to hydroxyproline, proline, glycine and tyrosine were also significantly reduced. The levels of arginine and ammonia were elevated in the skins of all cases of kwashiorkor.

TABLE 2

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Normal Without dermatitis</th>
<th>Kwashiorkor Without dermatitis</th>
<th>Kwashiorkor With dermatitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxyproline</td>
<td>5.6</td>
<td>4.1*</td>
<td>4.0*</td>
</tr>
<tr>
<td>Serine</td>
<td>2.6</td>
<td>2.7</td>
<td>2.9*</td>
</tr>
<tr>
<td>Proline</td>
<td>9.6</td>
<td>8.7</td>
<td>7.9*</td>
</tr>
<tr>
<td>Glycine</td>
<td>26.9</td>
<td>25.1</td>
<td>19.9*</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>0.8</td>
<td>0.8</td>
<td>0.6*</td>
</tr>
<tr>
<td>Arginine</td>
<td>6.3</td>
<td>11.8*</td>
<td>11.5*</td>
</tr>
<tr>
<td>Ammonia</td>
<td>5.5</td>
<td>10.0*</td>
<td>14.6*</td>
</tr>
</tbody>
</table>

Levels of aspartic acid, threonine, glutamic acid, valine, alanine, leucine, isoleucine, lysine and phenylalanine were not different from those in normal children.

* Significantly different from "normal".

The results of this study showed that there was a reduction in the protein content of the skin in kwashiorkor and that the collagen content was selectively reduced. This reduction in collagen may be due to either reduced synthesis or increased catabolism of collagen. The results of several investigations have shown that urinary excretion of hydroxyproline is lowered in kwashiorkor, invalidating the possibility of increased catabolism. It is likely, therefore, that the lowered collagen content is due to reduced synthesis. Another significant observation made in this study was the reduction in the tyrosine content of the dermis in children having skin lesions. This amino acid is known to be related to the maturation and structural integrity of collagen fibres. Tyrosine residues have been shown
to be involved in the proper alignment of tropocollagen and the work of Bowes et al has suggested an important role for tyrosine both in fibril aggregation and in maturation of collagen. The observation that there was a reduction in both the hydroxyproline and tyrosine content of skin, would permit the speculation that the skin lesions in kwashiorkor may be related not only to the lowered amounts of collagen but also to the relative structural immaturity of the collagen that is formed. Results of further studies both in animals subjected to protein-calorie deficiency and in children suffering from kwashiorkor have, in fact, supported this possibility (Tables 3 and 4).

One month old albino rats were divided into three groups. Animals in group I received 20% casein diet ad libitum, animals in group II received 5% casein diet ad libitum, while those in group III received 20% casein diet, in amounts so restricted that they maintained the same weight as animals in group II. The animals were sacrificed serially at intervals of 10 days, the final sacrifice being on the 40th day of the experiment. Total collagen, 0.14 M NaCl extractable collagen and hexosamine content of the skin were estimated. Hexosamine/collagen ratio was also determined in all the animals. The results of the study are shown in Tables 3 and 4. 0.14 M NaCl extractable collagen, insoluble and total collagen values showed a reduction while the value of hexosamine was elevated in animals of groups II and III as compared to group I. Similarly, the hexosamine/collagen ratio remained high in low protein (group II) and calorie deficient animals (group III) as compared to normal rats (group I). The reduction in 0.14 M NaCl extractable collagen may be considered as direct evidence that collagen synthesis was reduced in the skins of these animals, since this fraction of collagen represents the most recently synthesized collagen. Reduction in the total collagen content observed here is in line with earlier observations in the skin of kwashiorkor children. It has been shown that the ratio of hexosamine to collagen is an index of biological ageing of collagen fibres. The increased hexosamine levels and higher hexosamine/collagen ratio seen in undernourished animals would mean, that maturity of collagen is retarded.

To determine whether the maturation of collagen and the cross linking of fibres were impaired in the skins of children suffering from kwashiorkor, total collagen, 0.14 M NaCl extractable collagen and the heat labile collagen fraction which represents relatively immature collagen were estimated. The results of this investigation (Table 5) showed that there was a reduction in total collagen and a relative increase in the labile collagen content in the skins of children suffering from kwashiorkor, and that these changes were of a higher magnitude in children with skin lesions. The increase in heat-labile collagen in cases of kwashiorkor indicates a large pool of relatively immature
<table>
<thead>
<tr>
<th>Body protein</th>
<th>Control group</th>
<th>Days</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Soluble collagen, ug/g wet tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>737.00</td>
<td>465.90</td>
<td>132.93</td>
<td>112.26</td>
<td>733.66</td>
</tr>
<tr>
<td>F</td>
<td>443.56</td>
<td>193.75</td>
<td>110.20</td>
<td>92.30</td>
<td>437.66</td>
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<tr>
<td>Insoluble collagen, ug/mg dry defatted tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>40.82</td>
<td>49.26</td>
<td>60.70</td>
<td>72.76</td>
<td>46.41</td>
</tr>
<tr>
<td>F</td>
<td>40.55</td>
<td>43.03</td>
<td>70.66</td>
<td>77.56</td>
<td>39.23</td>
</tr>
<tr>
<td>Total collagen, ug/mg dry defatted tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>50.33</td>
<td>52.33</td>
<td>77.18</td>
<td>87.71</td>
<td>57.00</td>
</tr>
<tr>
<td>F</td>
<td>50.36</td>
<td>58.73</td>
<td>76.32</td>
<td>83.39</td>
<td>50.66</td>
</tr>
<tr>
<td>Hexosamine, ug/mg dry defatted tissue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>3.78</td>
<td>3.59</td>
<td>1.60</td>
<td>1.39</td>
<td>4.78</td>
</tr>
<tr>
<td>F</td>
<td>4.25</td>
<td>3.87</td>
<td>2.33</td>
<td>1.43</td>
<td>4.05</td>
</tr>
</tbody>
</table>

Statistical analysis is done between groups I and II and groups I and III. * P < 0.001, **P < 0.01, ***P < 0.02, ****P < 0.05.

* ug hydroxyproline/gram wet tissue. * ug hydroxyproline/mg dry defatted tissue.
Skin in Malnutrition

3

content of skin

<table>
<thead>
<tr>
<th>5% protein group</th>
<th>Weight-control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>Days</td>
</tr>
<tr>
<td>258.33*</td>
<td>75.03***</td>
</tr>
<tr>
<td>202.33****</td>
<td>51.30****</td>
</tr>
<tr>
<td>46.86</td>
<td>51.16****</td>
</tr>
<tr>
<td>51.93</td>
<td>50.16**</td>
</tr>
<tr>
<td>53.13</td>
<td>54.55**</td>
</tr>
<tr>
<td>56.70</td>
<td>64.56***</td>
</tr>
<tr>
<td>4.43</td>
<td>2.05***</td>
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<tr>
<td>4.05</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>59.60****</td>
</tr>
<tr>
<td></td>
<td>56.36****</td>
</tr>
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<td></td>
<td>57.90****</td>
</tr>
<tr>
<td></td>
<td>55.66**</td>
</tr>
<tr>
<td></td>
<td>64.09**</td>
</tr>
<tr>
<td></td>
<td>57.63**</td>
</tr>
<tr>
<td></td>
<td>2.44***</td>
</tr>
<tr>
<td></td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>5.07</td>
</tr>
<tr>
<td></td>
<td>2.21</td>
</tr>
<tr>
<td></td>
<td>57.36****</td>
</tr>
<tr>
<td></td>
<td>49.50****</td>
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<td></td>
<td>42.46***</td>
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<td>48.80**</td>
</tr>
<tr>
<td></td>
<td>49.41**</td>
</tr>
<tr>
<td></td>
<td>62.72**</td>
</tr>
<tr>
<td></td>
<td>2.21</td>
</tr>
<tr>
<td></td>
<td>1.23</td>
</tr>
</tbody>
</table>
collagen. Though there were no differences in the absolute amount of labile collagen in children with and without skin lesions, in children with skin lesions this component of collagen formed a much higher proportion of total collagen. This may be interpreted as indicative of a relatively higher proportion of immature collagen. The absolute amount of 0.14 M NaCl-extractable collagen was found to be reduced only in cases of kwashiorkor with skin lesions. This fraction of the soluble pool of collagen represents the most recently synthesized collagen and for the most part represents unpolymierised α-chains 15–7. A reduction in this component along with a reduction in total collagen indicates a reduction in collagen synthesis in kwashiorkor. In children suffering from kwashiorkor with skin lesions, there was a gross reduction in the total collagen content without a fall in the amounts of 0.14 M NaCl-extractable collagen. This may appear to be paradoxical, but can be explained as due to failure of the newly synthesized form to be converted to the heat-labile form. This observation is in line with our earlier suggestion that in children with kwashiorkor the maturation of skin collagen is inhibited.

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex</th>
<th>Duration of feeding in days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Control</td>
<td>M</td>
<td>0.0752</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.0855</td>
</tr>
<tr>
<td>5% protein</td>
<td>M</td>
<td>0.0791</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.0979</td>
</tr>
<tr>
<td>Weight control</td>
<td>M</td>
<td>0.0856</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.0946</td>
</tr>
</tbody>
</table>

Statistical analysis done between male groups I, II, III and female groups I, II, III.

* * P 0.01
*** P 0.02.

The results of all these studies show that in protein deficient states the metabolism of collagen in the skin is altered. There is not only a quantitative reduction of collagen but also a retardation in its biological maturity. These biochemical alterations may play a crucial role in the pathogenesis
<table>
<thead>
<tr>
<th>Group</th>
<th>Insoluble collagen(^a) (1)</th>
<th>0.14 M NaCl extractable collagen (2)</th>
<th>Heat labile collagen (3)</th>
<th>Total labile collagen ((2 + 3))</th>
<th>Labile collagen as % of total collagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Normals</td>
<td>2304 ± 105.10 (8)</td>
<td>82.0 ± 16.5 (5)</td>
<td>41.2 ± 8.1 (5)</td>
<td>117.2 ± 16.8 (8)</td>
<td>4.8 ± 0.82 (8)</td>
</tr>
<tr>
<td>II. Kwashiorkor without skin lesion</td>
<td>1201.8 ± 120.2 (****) (13)</td>
<td>33.2 ± 8.9* (5)</td>
<td>119.2 ± 17.5 (****) (5)</td>
<td>159.1 ± 28.3* (13)</td>
<td>12.3 ± 3.9 (****) (13)</td>
</tr>
<tr>
<td>III. Kwashiorkor with crazy pavement dermatosis</td>
<td>614.6 ± 95.8 (****) (5)</td>
<td>55.0 ± 7.4 (5)</td>
<td>96.8 ± 15.7 (**) (5)</td>
<td>151.8 ± 16.5 (5)</td>
<td>21.4 ± 12.4 (**) (5)</td>
</tr>
<tr>
<td>IV. Kwashiorkor after treatment</td>
<td>1770 ± 263.1() (8)</td>
<td>44.0 ± 8.1 (3)</td>
<td>41.0 ± 9.8() (3)</td>
<td>128.1 ± 27.9 (****) (8)</td>
<td>6.9 ± 4.4() (8)</td>
</tr>
</tbody>
</table>

\(^a\)Values are expressed as mg of hydroxyproline/100 mg of wet tissue.
\(^b\)Values are mean ± S.E.

Statistical analysis is done between Group I and II, I and III and II and IV.

\(*p < 0.05 \quad **p < 0.02 \quad ***p < 0.01 \quad ****p < 0.001\)

Figure in parentheses indicates number of subjects.
of skin lesions in kwashiorkor. As the structural stability of skin is altered due to these changes it may be expected that the skin becomes vulnerable to mechanical injury, particularly at pressure points and flexural areas.

The exact mechanism for the failure of maturation and cross linking of collagen molecules is not known. These processes are believed to be mediated through enzymatic reactions and it is likely that in severe protein caloric malnutrition, these reactions are altered in some way. Studies on the concerned enzyme activities may be expected to throw further light on this aspect.

REFERENCES

NEUROCHEMICAL CHANGES ASSOCIATED WITH PROTEIN CALORIE MALNUTRITION

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There are various metabolic changes associated with the development and maturation of brain. The developmental pattern of the central nervous system from early embryonic life through foetal, neonatal and young adult life is quite similar; however, the timing of birth in relation to brain growth is different in different species. For example some of the animals are born at an early stage of brain maturation, whereas in some other animals the brains are comparatively matured at birth. On this basis, Dobbing proposed for various species of animals the stage of 'maximum growth spurt' with respect to brain maturation. This growth spurt period coincides with the period of axonal and dendritic growth, glial multiplication and myelination. This period is also the vulnerable period in brain growth susceptible to nutritional deficiency which may cause permanent brain damage. In the rat, this period of brain growth is around 10 days after birth whereas in the human being the brain is partly immature before birth and continues to mature till the age of two years.

We have been interested for the past 10 years in the metabolism and physiological function of sulphated glycosaminoglycans (GAG) and sulphatides in brain. The GAG in brain are characterized as hyaluronic acid, chondroitin sulphate and heparan sulphate. Keratosulphate was found to be absent. The structure of some of the GAG are shown in Fig. 1. The polyionic nature of GAG, as protein polysaccharide complex which is essential for the structural rigidity of tissues and the low level of collagen in brain have given rise to interesting speculation regarding their physiological function in brain. Recently, Custod and Young have shown that in vivo administration of hyaluronidase to brain results in marked changes in neuronal activity with concomittant loss of GAG from the tissue. Moreover, it has also been shown that one of the important components associated in the axonal flow is sulphated GAG protein complex. The axonal flow is important for the supply of ions and other nutrients to synaptic areas. Biosynthesis of GAG has been established in various tissues and the pathway by which this takes place is shown in Fig. 2. It is clear from this
Fig. 1. Structure of glycosaminoglycans.

Fig. 2. Biosynthesis of glycosaminoglycans.
that the synthesis of protein is an integral part in the synthesis of GAG, since the GAG are covalently bound with protein. Moreover, the synthesis of protein precedes the synthesis of GAG. The sulphation of GAG takes place in close proximity or soon after the polymerization of uronic acid and hexosamine moieties. Earlier studies from our laboratory, on the incorporation of injected sulphate into total GAG, have shown that maximum sulphate incorporation takes place at birth which is decreased gradually with the maturation of brain and reaches a constant low level about 30 days after birth. The enzymatic transfer of sulphate from 3'-phosphoadenosine 5'-phosphosulphate (PAPS) to GAG was studied in this laboratory using young rat brain preparation and also the human brain of various ages. The activity of the enzyme was maximum with heparan sulphate as the sulphate acceptor; chondroitin-6-sulphate and hyaluronic acid were inactive as acceptors.

The sulphate containing lipids, sulphatides or cerebroside sulphate are components of the myelin sheath of the nervous system (Fig. 3). As building blocks of myelin they are of great importance and any abnormal changes

\[
\text{SULPHATIDE}
\]

Fig. 3. Biosynthesis of sulphatide.
in their concentration results in extensive damage to the myelin as seen in a disease such as metachromatic leucodystrophy. The incorporation of $\mathbb{S}$-sulphate into sulphatides of rat brain at various stages of development has been studied by Davison and Gregson. They found that the maximum incorporation was around 15-20 days after birth which coincides with the peak period of myelination in rat brain. The enzymatic transfer of sulphate from PAPS to endogenous protein bound galactocerebroside has been studied in our laboratory. A study of cerebroside sulphotransferase activity in the developing rat brain revealed that there was practically no sulphatide synthesizing activity up to 9 days after birth and there was a peak of activity around 18-22 days after birth, once again emphasizing the fact that the sulphatide synthesis is maximum at the myelination period.

Two facts emerge from these studies. The sulphation of GAG is at its maximum in the new born rat brain. Second, sulphatide formation is at its peak during myelination stage i.e. around 19 days after birth. Of special interest in this context is the age dependent variation in rat brain of the enzymic synthesis of PAPS, the sulphate donor for both the GAG and sulphatides. There was a major peak of PAPS synthesizing activity in the one day old rat brain and a second peak around 12 days after birth. It is very likely that the two peaks of PAPS synthesis in rat brain indicate its dual role as the sulphate donor for both the GAG as well as the sulphatides. The relationship between the synthesis of PAPS and the sulphation of GAG and sulphatides in the developing rat brain are shown in Fig. 4.

These studies imply that there is a close relationship between brain maturation and the synthesis of GAG and sulphatides. It is quite clear that a high rate of sulphatide synthesis coincides with the period of myelination. On the other hand, rapid synthesis of GAG may be a prerequisite step for myelination in brain. With this background of animal experiments, we have investigated certain biochemical changes occurring in the central nervous system of human kwashiorkor compared to normal children of same age group. We have been fortunate to obtain a certain number of human brain biopsy samples. These biopsies were obtained from children having progressive mental retardation, but histopathologically both neurons and myelin were found to be normal. Various enzymes and glycolipids were analysed from these human brain biopsies at various ages. The age dependent change of the enzyme which forms cerebroside sulphate by enzymic transfer of PAPS to endogenous protein bound cerebroside are shown in Fig. 5, and the arylsulphatase A, the enzyme which degrades cerebroside sulphate in Fig. 6. It is clear from this study that there is a marked
Fig. 4. Synthesis of PAPS, sulphated GAG and sulphatide in developing rat brain.
Fig 5. Cerbroside sulphotransferase activity in developing human brain.
Grey matter ○ ○ White matter • • •
difference in the distribution of this enzyme between grey and white matter and the maximum specific activity of the enzyme was observed in the frontal cortex biopsies at 5 years of age. Although the data so far available suggest that the growth of the human brain is rapid upto two years, nonetheless these observations suggest that certain regions of the brain are
continuing to mature till the age of five years or more. The involvement of protein is shown in the biosynthesis of sulphatide from cerebroside as well as in the biosynthesis of GAG, and since both of these compounds seem to be involved in the maturation and myelination process of brain, it was of interest to study some of the autopsy brains which had been clinically diagnosed as kwashiorkor. 11,12

We had with us five autopsy brains from children, 1, 3, 4 and 9 years old. The autopsy brain obtained from the nine year old child is of particular interest because this is an unusual one, since this has survived repeated episodes of kwashiorkor from early stages till nine years. Table 1 shows the analysis of cerebrosides, sulphatides and gangliosides in this brain. The glycolipids are not markedly changed in the one and three year old children. However, the decrease is marked at 4 and 9 years of age. The ratio of cerebroside to sulphatide is not markedly altered indicating that the nature of myelin is the same as in normal but there is a decrease in the synthesis of myelin. A similar observation of reduced glycolipids in kwashiorkor

<table>
<thead>
<tr>
<th>Sample</th>
<th>Age (Years)</th>
<th>Cerebroside + sulphatide (mg/gm of wet tissue)</th>
<th>Ratio Cerebroside : sulphatide</th>
<th>Ganglioside umole of NANA per gm of a cetone powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>2</td>
<td>12.5</td>
<td>3.0 : 1</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11.2(M)</td>
<td>3.7 : 1</td>
<td>4.01(M)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>12.8(M)</td>
<td>3.0 : 1</td>
<td>6.45</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>25.0</td>
<td>3.5 : 1</td>
<td>6.5</td>
</tr>
<tr>
<td>Kwashiorkor</td>
<td>1</td>
<td>3.6(M)</td>
<td>[4.6:1]</td>
<td>4.45(M)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>15(M)</td>
<td>3.3:1</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>14(M)</td>
<td>3.0 : 1</td>
<td>3.06</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5.3(M)</td>
<td>4.6:1</td>
<td>1.5 (M)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10.0</td>
<td>4.6:1</td>
<td>4.25</td>
</tr>
</tbody>
</table>

Analysis of cerebrosides, sulphatides and gangliosides were carried out according to the method of Kokrady et al. 11. M indicates mixed tissue of grey matter and white matter. Ganglioside analysis were carried out in grey matter and white matter separately except where indicated as M. Cerebrosides and sulphatides were analysed in white matter except where indicated.
Neurochemical Changes in Malnutrition

The total gangliosides are not affected in most of the cases except at 4 years and 9 years and there is marked decrease in gangliosides particularly in white matter. This has also been observed by Bass and his coworkers in the case of undernourished rats. They have also shown a decrease of proteolipids in undernourished rats.

Table 2 shows the cerebroside sulphotransferase and arylsulphatase activity in normal and malnourished brains. The activity of enzyme cerebroside sulphotransferase is markedly decreased in all the cases studied, specially at 9 years there is negligible activity of the enzyme. It may be mentioned here that in the assay system for the estimation of this enzyme activity we utilise the endogenous protein bound cerebroside, which is present in the brain, as an acceptor. It was thought that this low activity may be due to a lack of the acceptor. We are now able to partially purify this protein bound acceptor from sheep brain and this protein bound cerebroside was supplemented for measuring the sulphotransferase activity (Table 2). On the addition of partially purified protein bound cerebroside

**TABLE 2**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Age (Years)</th>
<th>Cerebroside sulfo-trans-ferase CPM/mg</th>
<th>Fold stimulation by protein bound acceptor</th>
<th>Arylsulphatase CPM/mg</th>
<th>nmoles of nitro-catechol formed/mg P/hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14.4(W)</td>
<td>13.1</td>
<td>1.1</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.2(G)</td>
<td>12.7</td>
<td>4.2</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>14.2(W)</td>
<td>--</td>
<td>--</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6.3(G)</td>
<td>--</td>
<td>--</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>18.0(W)</td>
<td>48.1</td>
<td>2.7</td>
<td>225</td>
</tr>
<tr>
<td></td>
<td>6.5(G)</td>
<td>68.8</td>
<td>10.1</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6.2(W)</td>
<td>--</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>0.8(G)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>57</td>
</tr>
<tr>
<td>Kwashiorkor</td>
<td>3</td>
<td>5.0(W)</td>
<td>38.6</td>
<td>7.5</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.1(G)</td>
<td>23.8</td>
<td>7.7</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.2(W)</td>
<td>79.4</td>
<td>36.1</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>1.2(G)</td>
<td>79.1</td>
<td>66.0</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.4(W)</td>
<td>59.2</td>
<td>148.0</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>0.1(G)</td>
<td>42.0</td>
<td>420.0</td>
<td>68</td>
<td></td>
</tr>
</tbody>
</table>

Protein bound acceptor was prepared from sheep brain as described earlier by Kokrady et al. Assay of cerebroside sulphotransferase and arylsulphatase A were carried out according to the method of Kokrady et al.
there is an increase in activity of the enzyme indicating that this protein bound cerebroside may be the limiting factor in the synthesis of sulphatide in malnourished brain. Chase and his coworkers have shown decreased
Neurochemical Changes in Malnutrition

synthesis of sulphatide using exogenous cerebroside in undernourished rats during the peak period of myelination. Our observation suggests that the endogenous acceptor which is a protein bound cerebroside is the one which is affected in this condition rather than the sulphotransferase. Figure 7 shows the radioautogram of sulphatide synthesis in white matter and grey matter of normal and kwashiorkor brains. It is rather interesting to note that in the normal white matter the most prominent radioactive spots are sulphatides, whereas in the case of kwashiorkor white matter there was a spot of a faster moving material presumably cholesterol sulphate and a prominent lower moving spot having a mobility of ceramide lactoside sulphate. However, this has not been further characterized. One of the speculations one can make is that because there is a considerable decrease in the degradation of ganglioside in this brain, the ceramide dihexoside may have been originated by the degradation of ganglioside.

A study was also undertaken to measure the total GAG in the kwashiorkor brain as well as to characterize individual GAG. The results suggest that there is a marked reduction even at the very early stage of malnutrition, i.e. at the age of one year there is a marked reduction in the total concentration of GAG compared to the corresponding control of same age (Tables 3 and 4). However, this decrease in the GAG concentration is much more marked as the malnutrition continues for a longer period of time, for e.g. in the case of the four year-old child it is one fourth of the normal value and in the case of the 9 year-old child who had repeated episodes of kwashiorkor the decrease in total GAG is more marked. Since we had autopsy tissue available we were able to characterize some of these GAG and the Table

<table>
<thead>
<tr>
<th>Kwashiorkor brain</th>
<th>ug Uronic acid/g lipid free dry tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I-A</td>
</tr>
<tr>
<td>One year old</td>
<td>502.3</td>
</tr>
<tr>
<td>Four year old</td>
<td>287.7</td>
</tr>
<tr>
<td>Nine year old</td>
<td>161.2</td>
</tr>
<tr>
<td>Normal child (New born)</td>
<td>1495</td>
</tr>
<tr>
<td>Normal child* (10 years old)</td>
<td>—</td>
</tr>
</tbody>
</table>

*In this case only total GAG was estimated.
TABLE 4
Concentration of various glycosaminoglycans in normal and kwashiorkor brain

<table>
<thead>
<tr>
<th>Glycosaminoglycans</th>
<th>Concentration of various GAGS in brain as the percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kwashiorkor 1 Year 4 Years 9 Years New Born 10 Years Normal</td>
</tr>
<tr>
<td></td>
<td>Hyaluronic acid 73.5 27.5 64.4 60 42</td>
</tr>
<tr>
<td></td>
<td>Heparan sulphate 8.8 10.2 12.4 4.4 10.6</td>
</tr>
<tr>
<td></td>
<td>Hyauronidase resistant, galactosamine-GAG 2.3 1.7 — — 4.4</td>
</tr>
<tr>
<td></td>
<td>Low sulphated chondroitin sulphate 5.0 31.2 8.4 10</td>
</tr>
<tr>
<td></td>
<td>Chondroitin sulphate 9.7 28.7 4.8 24.8 43</td>
</tr>
</tbody>
</table>

gives the variation of GAG in three different brain autopsy samples obtained from kwashiorkor. It can be seen from this that there is a considerable variation not only in the total amount of GAG, but also in the type of GAG. Nonetheless, in all the cases there was a marked decrease in the concentration of total GAG. The most interesting aspect is that at 9 years there is a marked decrease in the sulphated galactosamine containing GAG such as chondroitin sulphate, although the heparan sulphate concentration does not seem to change very markedly.

The observation of the lowering GAG concentration in the kwashiorkor brain is not very unusual because in our earlier finding on the urinary excretion of GAG, we have also observed marked decrease in the total concentration of GAG. The observation of the low tissue concentration of sulphated GAG, particularly chondroitin sulphate, in the three cases is of interest on the basis of the existing knowledge that the synthesis of protein core is necessary for the elongation of the GAG chain and impairment in the synthesis of chondroitin sulphate tends to occur in protein deficiency. Whether this impairment in chondroitin sulphate synthesis is of reversible or irreversible nature in a malnourished child is yet of speculative nature. It has also been shown by Wolf and his colleagues that sulphate activation which is an important initial step in sulphate metabolism is significantly decreased in livers of rats on a low protein intake. The lowering of the sulphated GAG in central nervous system may be a reflection of this.
Custod and Young noticed in their experimental cat with limited administration of testicular hyaluronidase, a withdrawn and unresponsive behaviour. The patients with kwashiorkor in the advanced state, exhibit a considerable mental apathy. This remarkable similarity between kwashiorkor patients and experimental animals justified at least to some extent the important role of GAG in brain function.

The present study has thus indicated changes in the level of chondroitin sulphate and low sulphated chondroitin sulphate in brain in protein-calorie malnutrition. Studies on sulphated GAG also clearly shows marked decrease, particularly if the malnutrition is continued for a longer period of time in the child. However, the observation that GAG is markedly lower even at the earlier stages where myelin lipids such as cerebroside and sulphatide are normal is consistent with our observation in animal experiments and suggests that GAG is an important component in brain maturation and protein calorie malnutrition may markedly affect this aspect of maturation in brain even earlier than the myelination process in brain. However, at present there is not enough information available to suggest the role of GAG in the process of myelination.

ACKNOWLEDGEMENTS:

The author acknowledges the help rendered by Miss Shalini Kokrady, Dr. E. V. Chandrasekaran and Mr. K. A. Balasubramanian in carrying out this investigation. He is also grateful to Prof. K. L. Mukherji, Institute of Child Health, Calcutta for his collaboration in this work, the Neurologists and Neurosurgeons of this institution who have provided with necessary tissues and also for their clinical assessment. This work was supported by Grant No. NIH-01-024-1 from the National Institute of Health, U. S. Public Health Service.

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SYMPOSIUM ON
ECOLOGY OF MALNUTRITION

Chairmen: P. Gyorgy, U.S.A.
and
Rajammal P. Devadas, India

Rapporteur: K. Halder, India

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The economics of malnutrition
— R. Muscat and Alan Berg ... 603
CHAIRMAN’S REMARKS FOR THE SYMPOSIUM ON
“ECOLOGY OF MALNUTRITION”

P. GYORGY

Philadelphia General Hospital,
Philadelphia, Pa, U.S.A.

In my opening remarks I feel it necessary to give some explanation for the title of today’s symposium, especially to the semantics of the word “ecology”.

In the past ten years it has become customary to identify the word ecology with the study of environment. One has forgotten that the Greek word “oekos”—the root of the word ecology—in exact translation means “home/family”. In its present scientific, biological use the mutual relations between the organisms and their environment has been retained (cf. The Oxford Universal Dictionary). For our special purpose, closer return to the original meaning of “ecos” appears to be very appropriate.

In a permissible-because-conscious exaggeration, past efforts to improve the deplorable nutritional conditions of the pre-school child in developing countries, or those in the disadvantaged population groups even in highly developed countries, have been largely unsuccessful. Neither food nor money alone can introduce lasting positive results. Of course this conclusion applies logically to the “Green Revolution” which is obviously essential. But as food, foodstamps, and money may not reach the “family/home”—or at least not in a fully desirable, permanent way—what is needed is a unified multidisciplinary effort, and not fragmentation.

Malnutrition is not only a medical problem. It has its overriding social foundation such as poverty, tradition, lack of motivation, and population pressure. Success depends on a synthetic effort to change attitude and behaviour. Modern psychology stresses—in analogy to Pavlovian teaching—the value of “conditioning”, or, in the lingo of the present trend in psychology, the “acquisition of secondary conditioned reflexes” (Van Eysenck).

Our limited, but well-controlled experience in the last 5-7 years in South-East Asia (Indonesia and Thailand) taught us to value the cooperation of national, young, dedicated, community workers. They need not be expert
Chairman’s Remarks

technicians, but more dedicated humanitarians, serving their own country. High school graduates, college students, etc. with the same racial and cultural background as their compatriots in the villages or urban districts should be the connecting link from the government to the people. As Sir Kenneth Clark, the renowned British expert of Art, Civilization and History recently pointed out: it is “kindness” which is missing in today’s world—especially for the children in the disadvantaged class, but also in affluent families.

Youth is recruited in many countries to serve in the army of their country, basically for “destructive” purposes, and although their important role and function in the security of their homeland should by no means be minimized, today there is a very urgent need to have a corps of youths to serve, for an extended period of time (about 2 years), in the communities for truly “constructive” purposes.

There is no time in these introductory remarks to go into more detail on the programme of such community workers. They need only short training to work as ambassadors of good will in their assigned communities. They should always fall back on senior consultants and health, agriculture, education, etc. services.

Young boys or girls are not the proper advocates of “family planning”. However, a young female community worker could easily select an older lady, acceptable to the women of the community, and, after proper orientation perhaps with the help of an experienced worker from the outside, utilize her as the local leader for the proper population policy.

I see no other way than such general mobilization of the people to bring about the desirable changes in the world. The ultimate goal, seen from the angle of our Congress on Nutrition, is prevention and not cure.
SOCIAL AND CULTURAL FACTORS IN MALNUTRITION
CONRADO R. PASCUAL
Food and Nutrition Research Center
National Institute of Science and Technology
National Science Development Board
Manila, Philippines

Man has started the conquest of space; he has landed on the moon and will probably be landing on other planets in the future. But ironic as it may seem, he has failed to solve the centuries-old problems of poverty, hunger and malnutrition confronting our world of today. Even in the affluent societies of the so-called developed nations, isolated pockets of hunger and malnutrition exist in the midst of abundance. Here, the problem lies not so much in the provision of sufficient food supply as in the adequate intake of the proper kinds of foods in the right proportion everyday.

A more glaring picture of malnutrition exists in Asia and the Far East where most of the world’s underdeveloped and developing nations are located. It is also the area of the world where the greater part of the world’s population is concentrated coupled with a rapid increase in population. Here too, the old traditional technology has persisted so that the utilization of modern technology has yet to be demonstrated and adopted. Furthermore, with less fertile lands, less grasslands, dry and humid climate and an unpredictable weather, poverty, ignorance, hunger, ill health and low productivity go on in an ever-vicious cycle, sapping the child’s ability to learn, sapping the country’s vital human resources and slackening the nation’s economic growth.

An increasing awareness of the crippling effects that hunger and malnutrition wrought on the nation’s economic and manpower development has prompted leaders and ministers of states to plan and carry out concrete programmes aimed at solving their country’s nutritional problems. However, despite a programme and efforts to prevent malnutrition, the nutritional picture particularly in this side of the world has not changed considerably. Malnutrition exists and will continue to exist for as long as the simple process of eating is made complex by a multitude of human factors. The problem of malnutrition cannot be considered in isolation. Deeper insights into the question of why people eat as they do is imperative. In the ultimate
analysis, the answer lies in the further study of a large variety of interrelated social and cultural factors in the achievement of proper nutrition.

The realization that social scientists have much to offer health and nutrition workers in helping to understand reactions to community programmes is reflected in a mass of literature underscoring the influence of social and cultural factors in malnutrition. The very close alliance between the behavioral science and efforts aimed at introducing dietary change requires the serious consideration of these factors by the nutrition scientists. Thus workers from various parts of the world have attempted to define non-dietary factors in the aetiology of malnutrition in their respective areas. Our present concern is to put forward in a general perspective the various social and cultural phenomena relevant to nutrition work and to be able to draw from its discussion, recommendations, for future research and at the same time promoting awareness on the part of community worker about these relevant sociocultural factors in developing practical approaches to nutrition work. It should be remembered that these phenomena in themselves may serve as barriers to good nutritional health.

Foster has briefly and concisely made the distinction that “culture is the behavior of people” and “society means people.” The causes of malnutrition could therefore be viewed as arising from the very way people think, feel and act about food as expressed in the group’s values and attitudes, traditions, habits, beliefs and customs. In short, people eat the way they do because they have been taught and learned in much the same way their parents have done before through the various activities and institutions their group has provided. Then too, the interactions between groups and individuals determine to a large extent the characteristics of the local diet. The interrelationships obtaining among residents of a community manifested in their kinship system may dictate what foods could be allowed a recently parturient young mother. The seat of authority in the home extending to the community may influence the acceptance or rejection of sound nutrition information. Schisms and conflict among individuals and groups may likewise spell the difference between success and failure of community nutrition programmes. Irrelevant as it may seem, the age at which young girls marry trigger malnutrition problems.

The individual’s nutritional status is therefore a product of the cultural environment and various social circumstances besides genetics, education and economics that surround him. Ramified into the larger network of society, we find that a group’s nutritional health has its roots in much the same factors. I shall now attempt to illustrate some of the cultural and social phenomena which contribute to malnutrition.
Values give direction to an individual's choice of action in the face of a situation. They influence the course of action a man would take such that when given a choice, he is most likely to select that which he feels and thinks is more important. A system of values serves as a regulator of the individual's actions by setting for him an order of priorities. Thus, uncovering the value system of a group would help enable a change agent to safely predict how well the information he is trying to impart will be received and acted upon. When health and nutrition do not occupy a high position in the people's scheme of priorities, the community nutrition worker is certain to meet difficulties in effecting dietary changes. Tracing poverty as a cause of malnutrition in India, Devadas\(^\text{2}\) stated that a major part of the meager annual per capita income is “spent on repayment of loans, interest on debts, ceremonies, fulfillment of social obligations and formalities, and food and other necessities.” If what she reported was made in the order of priorities, we can see that money available for food purchases is realized only after certain other commitments have been met. As is common in many other agricultural countries in Asia, the Filipino farmer experiences abundance during the harvest season. Cash accruing from the sale of crops or wages from farm labour are readily converted into material possessions and worldly goods, in addition to repayment of credits. Thus, in Philippine rural societies, we find that improvements in dwellings, purchase of household furnishings as well as holding of feasts coincide with the harvest season. During the rest of the year, the people try to stretch whatever cash is available for food in addition to the commonly limited use of local resources.

The differential value placed by people on certain foods may assign a highly nutritious variety in the lower rung of the food scale.

Attitudes, like values, are also highly internalized by the individual. These are predispositions to consider what is proper or improper. The emotional base of food which one learns from childhood through unconscious intent has its roots in attitudes overtly expressed by parents. Transmitted by an already existing tradition, attitudes embrace ideas which influence what the individual will do about food. The achievement for example, of either good or bad health is attributed to the will of God. “With God's mercy,” is an expression that often reveals the fatalistic attitude of Oriental farmers to rationalize his inability to assure a bountiful harvest. His seeming resistance to accept modern farming technology could also be viewed as an expression of the lack of confidence to conquer nature.
Social and Cultural Factors in Malnutrition

Pleasant or obnoxious associations with food classify these into edible or unthinkable for nourishing oneself. According to Jelliffe,23 “these subconscious classifications comprise some of the most deep-rooted aspects of all culture patterns”. He has classified foods into cultural super-foods, prestige, body-image, sympathetic, magic and physiological group foods. Doubtless, a knowledge of the way people classify foods is of great significance in community nutrition efforts.

Beliefs, Customs and Traditions:

What one believes in, one follows and adheres to with unquestioning faith. Beliefs, inherent and integral as they are in the cultural matrix, act as invisible forces in translating pre-set ideas into overt acts and customs. Handed down from generation to generation, beliefs lend authority to customs, leading one to accept traditional customs and practices in its face value. The interrelationship between beliefs and customs has been aptly put down by Niehoff14 who stated that a “culture does not have a custom without a corresponding belief that it is right and proper”. For instance, the belief that fish produce worms in children had led to the practice of withholding this from infants and toddlers at an age when they are in most need of protein foods. In the Philippine where rice and fish is the mainstay of the diet, such a belief eventually deprives the child of his easily available protein source. Similar situations exist where prevailing beliefs and customs lead to unnecessary food deprivation.

Food taboos may likewise prevent people from consuming nutritious foods even when these are easily available. In some rural communities of the Philippines, childbirth is believed to be a life crisis akin to a very serious illness. While it is accepted that special nourishment is necessary for the mother to regain strength, postpartum care centres on avoidance of specific foods thought to bring on disturbance both to the mother and child. Ironically, foods avoided are those which a woman would need most at this physiological stage. In the same light, the role of religion in shaping up local food patterns needs some attention. The Muslim’s avoidance of pork and the Hindus of beef are classic examples. Among Catholics, we often find that every Friday is a no-meat day. Then too, religious calendars schedule feasts and fasting periods. Although they may come once a year, feasting has a nutritional significance in that the diet of the average person is enriched particularly with protein foods. Culinary achievements are also displayed on these occasions. On the other hand, religious tenets prescribe foods that may be allowed during fasting as well as the length of time one has to undergo to become ritually clean.
It is sad to note that traditional dietary restrictions have been found to apply most often to precisely the nutritionally vulnerable groups: infants, toddlers and pregnant and lactating mothers. It therefore becomes clear to see how culture may affect a group’s nutritional status by setting the standard of action or behaviour towards food. The fact that such are taught and learned unquestioningly to the point that they become automatic reaction perpetuates traditional dietary habits. Culture dictates what one ought and should do in matters of food. However, the same barriers may be used to advantage in effecting dietary modifications.

Social factors:
Equally relevant in understanding and predicting success or failure of introduced changes in local food habits are the following factors.

Social Organization and Community Structure

The traditional lines along which groups are organized may affect efforts at changing dietary habits. In Philippine rural societies, the “family” extends to members outside the immediate circle embracing all those with whom fictive or pseudo-kin relations have been established. The strength of such a group is reflected in the serious fulfillment of mutual obligations and expectations. This is expressed in sharing one another’s grief as in death and also in feasting to celebrate happy events. Relatives, friends and neighbours find support in one another in times of need. Thus, an individual’s kitchen garden may be shared by so many people who may not have contributed at all in tending the patch. Evidently, this is inconsistent with campaigns motivating families to produce more food both for the market and for home consumption. A household may not be as keen in expanding its backyard garden knowing that the produce will only be shared by other people.

Friendship and neighbourhood patterns also influence acceptance or rejection of sound nutrition information. Such patterns establish a line of communication which discusses not only local affairs and gossips but matters of food, health and nutrition. The influence of group consensus should never be underestimated particularly in such a closely knit one. Certain conditions in the social structure also contribute to malnutrition. Devadas has stated that the caste system in India levies restrictions both in feeding and social intercourse. The system prescribes the kinds of food a man may eat or avoid, together with the complex of preparation, cooking and serving.
In the Philippine example, we find the seat of authority in the local villages as deterring progress in improving the community's nutritional status. Elected barrio village officials are the recognized administrative helmsmen looked up to by the people as leaders in various spheres of activities. Government workers seek their assistance in implementing national programmes at the local level. However, in real situations, various other individuals occupy the lead position in specific undertakings in the village. To seek out the real leaders in particular spheres and disregard the administrative importance of the elective village council is to invite disaster to any planned programme. In many cases, those who are elected to run the affairs of the community and thus entrusted with the promotion of the welfare of the village, may not be interested in community improvement programmes nor would they have the time to devote to this. It seems that qualities other than leadership guide the selection of village leaders. Only when the people would awaken to the true meaning of the word might they be able to choose the right men. In much the same way that group patterns may facilitate implementation of community nutrition programmes, conflicts and rivalries that arise among groups may serve to hinder progress in nutrition work. Factionalism seems to be a universal phenomenon that we find happening everywhere. Schism between individuals and groups may be accentuated by a community nutrition worker who may have accidentally associated herself with one of the rival parties.

*Age at which young girls marry:*

The tendency for most Asian girls to marry young puts them in a situation wherein actions taken even in married life are subject to the consent and approval of elders. Elders almost dictate what foods may be allowed and avoided by the young mother. It may be safely said that traditional habits persist in this way. Unless these are broken off at a point when the young mother is still receptive to change, weaknesses in the diet are perpetuated.

Closely related to the foregoing discussion is the locus of authority within the family. In most Asian countries, age symbolizes wisdom. Thus traditional respect for the elders is a feature of the social system. The old folks in the village are the ones most often consulted in various matters. Housewives seek the advice of the elderly women in matters of food and health. Problems on infant feeding and maternal nutrition are brought to their attention. The strength of their advice is backed up by years of experience and custom, but wanting in authority and knowledge.
Women make up a large percentage of the Asian population that is engaged in agriculture. The unavoidable circumstance of having to leave young children at home by the women who work in the fields is another contributory factor to the inferior diets of young children. The need to work outside the home implies that infants must be weaned at a much earlier age than desirable. This also means that the care and feeding of the toddlers are left to older siblings, relatives or neighbours who may not be as concerned as the mother. The situation is aggravated when older children forced to miss school are asked to look after the young ones.

The roles of urbanization and industrialization:

The possible role of urbanization in bringing about a poor or better diet may well be looked into with the emerging trend of rural people trekking into big towns and cities in search of better economic opportunities. The trek is usually precipitated by a desire to engage in non-farm occupations and enjoy the amenities provided by city life. In her study of the Bemba Tribe in Northern Rhodesia, Richards pointed out that a deterioration in the diet occurred upon contact with white civilization. We might also say that a similar change in the diet of rural people is taking place with the current shift from subsistence to a cash economy. Where before, for instance, the rural household was able to produce much of the food it needs, the move to the cities and towns for non-farm work does not permit a family to obtain a better diet from wages earned.

On the other hand, Chassey et al. in a study of 377 Mexican families document the finding that in the process of industrialization, food habits become increasingly complex and varied. Such change according to them is accompanied by similar changes in the social and economic milieu.

An interesting question that may be raised at this point is, are there more cases of poor dietary intake in the rural areas than in urban areas? To this, de Garine has said that “despite the afflux of food to towns, the lowest socio-economic classes of the urban areas probably have a nutritional status at least as deficient as the poorest rural people”. We would need more conclusive and specific studies to pinpoint the accompanying changes in diets with increasing industrialization and urbanization.

Poverty and malnutrition:

That income influences food intake is a point that needs no argument.
Social and Cultural Factors in Malnutrition

This is shown by the fact that in the Philippines for example, as the income level increases, there is a corresponding increase in the calorie and protein intakes. But to what extent available cash might determine the kind and amount of food that will reach the family table? The same example as reported by my colleague (Mrs. Quiogue) reveals that as the income level reached the P10,000.00 mark, a decrease in caloric intake was noted. While available cash determines the quality of the diet, still we may not be able to safely conclude that households with higher income enjoy better foods than those with lower incomes. However, it has to be admitted that those blessed with higher incomes are in a position to afford better foods and thus partake of better diets.

Freedman observed in his study of an Indonesian community that even those who can afford to eat better foods follow the same general pattern that is obtaining in the area. This is a factor which has to be dealt with in considering the relationship between income and malnutrition. In a similar study in a Philippine village it was found that housewives from three different income levels purchased foods which were surprisingly uniform. It is in this regard that we may underscore the importance of the other social and cultural factors discussed earlier. Children from families with different income levels may still suffer from protein malnutrition because the prevailing practice of withholding fish applies to all.

The direct relationship between poverty and malnutrition may be attributed to the fact that the former gives rise to conditions like poor environmental hygiene and sanitation wherein disease may flourish. Aggravated by a low resistance to infection brought about by inferior diets, the situation would definitely contribute to poor nutritional health. Improving the people's level of income is therefore significant in raising the standard of living for only when better homes, education and other social and physical amenities are provided might the people be motivated to spend more money on better foods. Perhaps it is only when income is viewed against family size, that the relationship could be highly appreciated.

The foregoing discussion briefly presents some of the social and cultural factors which must be considered in the aetiology of malnutrition. Eating is not only an instinctive act. One acquires the food habits of his group through the various institutions provided for this purpose. Improvements in health through better diets can therefore be achieved considering that nutrition is one of the most important environmental factors that influence health. More than lip service should therefore be paid to the need to consider social and cultural factors in programme planning. Workers must
be continually attuned to their significance in public health nutrition work and devise ways to utilize the social and cultural setting of a group in bringing about modifications in the diet.

A clear understanding of these factors must be brought to mind in introducing planned programmes in health and nutrition in each particular area. Innovations aimed at improving dietary habits must be fully integrated with a group’s social and cultural systems. People must be shown how new foods may be prepared using familiar cooking methods. High yielding varieties developed must meet the same taste requirements as the traditional breeds. Existing social structure must be utilized in the implementations of action programmes. Traditional channels of communication may be taken advantage of in disseminating health and nutrition information. Often, these are the aspects overlooked by most programmes.

While work has centred on uncovering what people eat and why, there is an apparent need to gain better understanding of human food behaviour. Depth studies to discover the various concomitant forces that provide the background for a group’s dietary habits are strongly indicated. We need to understand these phenomena in order to raise future children and adults who would select high-quality diets as part of the knowledge and activities handed down to them.

A group is always in a dynamic state. Its thirst for change is forever balanced by acceptors and rejectors seeking a state of equilibrium. Points in the group’s system which would permit change to occur as well as forces that serve as stumbling blocks must be unearthed. How does change occur? How can modifications be safely introduced without disrupting existing dietary practices? What changes in other aspects of the community’s life and/or repercussions may be expected as a result of the innovation? Answers to these would enable the nutrition worker to utilize to advantage those aspects that will eventually lead to dietary improvements.

Understanding the change agent or the innovating agency is just as important as defining a community’s social and cultural bases. We need to know the agent’s motivations and goals. A study of the organizational structure along with operational procedures must be considered in achieving programme objectives with a high degree of success. Plans and concrete programmes are many times token ones and therefore cannot be expected to achieve their goals. Too often, half-hearted sincerity and thus lack of full support on the part of the administration and the change agent himself has left many programmes on the brink of failure. If planned innovations
must make an impact on the people, these must have to be considered fully.

We have yet to plan realistic programmes based on findings from such studies. Another point which I want to bring out is the need for food and nutrition scientists to collaborate very closely with the social scientist. Doubtless, the tie-up between the two fields is so close to divorce one from the other. Also, there arises the question of providing community workers with a sort of practical training in the social field. Understanding the community and its people is basic to any planned change.

Nutrition cuts across the whole fabric of society in that it affects all individuals at all stages of their lives. Thus improvements and developments in this field would only be meaningful in so far as the people may apply scientific knowledge in everyday living situations in the home and community.

REFERENCES
ENVIRONMENTAL FACTORS IN THE INTERRELATIONSHIP OF NUTRITION AND INFECTION

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The occurrence of any disease in a population depends upon complex interactions among the host, the specific agent, and the physical, biological and social aspects of the environment. In infectious disease the agent is a pathogenic organism; in nutritional disease it is the deficiency or excess of a nutrient. In either case the agent is only one factor in a chain of multiple causation, and insufficient in itself to explain the occurrence of associated disease. Whether infectious disease follows exposure to an infectious agent depends on many factors, including the manner of infection and the resistance of the host. Similarly, whether or not nutritional disease will result from a given dietary intake depends upon the considerable number of environmental and host factors that determine the individual's requirement for the nutrient and its availability to him.

The great advantage of looking at malnutrition as a problem in human ecology is that it allows for a variety of approaches toward prevention and makes it possible to choose those that appear most feasible. From a practical viewpoint this generally means finding environmental factors that are both important in causation and amenable to change. These environmental factors, physical, biological, and social in nature, obviously influence the availability of nutrients by affecting the production, storage, processing, losses and marketing of food as well as the actual consumption of nutrients because the economic, political, and cultural determinants of food practices are environmental in origin. In addition, environmental factors markedly influence the requirement of individuals and populations for nutrients, and it is this aspect of the epidemiology of nutritional disease which is the focus of this paper.

Specifically, it presents some of the evidence indicating the most nutritional disease in developing countries, particularly among preschool children in whom it is most frequent, is not the result of diet alone but the interaction of poor dietary practices and heavy exposure to a wide variety of infectious agents. Moreover, to a considerable degree it is the occurrence of malnutri-
tion that exacerbates the frequency and severity of infectious disease. While the unsanitary environment and poor personal hygiene of most malnourished children are responsible for a more frequent and heavier contact with infectious agents, the frequency and severity of resulting disease depends heavily on the nutritional state of the host.

The situation is really one of synergistic interaction in which the consequences for the health or even survival of the preschool child cannot be understood from studying infection in the well nourished child or malnutrition in the absence of infection. For preschool children in the less privileged groups of developing countries, whether the apparent clinical result is nutritional or infectious disease, both malnutrition and infection are usually involved.

Effects of infections on nutritional status:

Various ways in which infections exert a profound influence on the protein nutritional status of individuals on diets marginal in protein are listed in Table 1.

**TABLE 1**

Effects of infections on nutritional status of man

<table>
<thead>
<tr>
<th>Acute: Decreased food intake due to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) reduced appetite</td>
</tr>
<tr>
<td>(b) withdrawal of solid food</td>
</tr>
<tr>
<td><strong>Increased metabolic losses—Decreased absorption:</strong></td>
</tr>
<tr>
<td>(a) if diarrhoea present</td>
</tr>
<tr>
<td>(b) if purgatives administered</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chronic: Decreased absorption due to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) parasites</td>
</tr>
<tr>
<td>(b) tropical enteropathies</td>
</tr>
</tbody>
</table>

Anyone who has attempted to keep dietary intake constant for metabolic studies during periods of even such mild infections as immunizations is well aware of the spontaneous decrease in food intake that accompanies infectious disease. In most cultures there is also a tendency to withdraw solid food, especially if fever or diarrhoea is present, resulting in a diet
lower in protein and other essential nutrients. This is a major factor in the loss of weight and frequency of clinical signs of nutritional deficiency following episodes of infectious disease in children whose nutritional status is borderline.

To these changes in food intake because of infection must be added metabolic losses of nitrogen, vitamin C, vitamin A, and a number of other

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**FIG. 1.** Nitrogen balance in acute tularemia. Average values for nine subjects with typical symptoms are shown related to their daily maximal rectal temperatures (top). Below, the daily deviations from the control period (days — 9 to — 1) average balance is plotted cumulatively. Reference 3, p. 1683.
nutrients. Over 25 studies demonstrating negative nitrogen balance with infections are summarized in the WHO Monograph, *Interactions of Nutrition and Infection,* and data on the metabolic effects of a wide variety of infections in children have since been obtained by the Institute of Nutrition of Central America and Panama, and in adults by the U.S. Army Medical Research Institute of Infectious Diseases.

Figure 1 illustrates the cumulative negative nitrogen balance in young men exposed to tularemia. Figure 2 illustrates the relative proportion of nitrogen loss due to decreased N intake and increased urinary N excretion, respectively. The losses are still considerable even when the infections do not produce apparent disease, as Beisel et al. have reported for individuals who remained asymptomatic when exposed to Q fever, tularemia, and sandfly fever. We have observed negative nitrogen balance resulting from immunization with the 17-D strain of yellow fever vaccine in children, although none developed fever or other symptoms. Table 2 shows the increase in urinary nitrogen excretion of four MIT students following

![Figure 1](image1.png)

**FIG. 1.** Difference in cumulative losses of nitrogen between subjects with typical tularemia and nonexposed men whose dietary intake was altered to reproduce exactly changes in food consumption observed during illness.

* Reference 3, p. 1685.
yellow fever immunization, observed even when they were consuming a constant formula diet furnishing only 0.1 gm protein per kg per day.

**TABLE 2**

Effects of yellow fever vaccination on urinary nitrogen excretion of young adult males fed low-protein diet (0.1 g egg protein per kg daily)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Before Infection</th>
<th>During Infection</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.P.</td>
<td>2.53±0.62</td>
<td>4.33±1.43</td>
<td>Max. temp. 100.2 F.</td>
</tr>
<tr>
<td>T.P.</td>
<td>2.83±0.14</td>
<td>3.85±0.55</td>
<td>Max. temp. 100 F.</td>
</tr>
<tr>
<td>N.D.</td>
<td>1.77±0.20</td>
<td>2.95±0.042</td>
<td>No temp. elevation</td>
</tr>
<tr>
<td>R.E.</td>
<td>1.91±0.88</td>
<td>3.21±0.18</td>
<td>No temp. elevation.</td>
</tr>
</tbody>
</table>

The mechanism of the increased urinary N loss during infection is presumed to be the mobilization of amino acid nitrogen from skeletal muscle as part of the stress response that makes them available to the liver for gluconeogenesis with subsequent excretion of the nitrogen of the amino acid as urinary urea. This has been confirmed in rats by direct muscle biopsy of post-infected animals. It is clear that nearly all systemic infections, no matter how mild, initiate this stress reaction, with resultant increased urinary N excretion and affect food intake as well.

To the extent that N is lost from peripheral tissues during an acute infectious episode, it must be restored once the episode is past, or the individual will remain protein-depleted. Experience indicates that this so-called anabolic period extends for much longer than the catabolic one. During this recovery period, protein requirements are markedly increased over those for healthy persons. If the diet does not provide the needed additional protein, the individual is progressively more depleted with each episode of infectious disease.

Many of the acute infections common in the preschool child cause diarrhoea, which results in a decrease in absorption of fat, protein, and other nutrients. Often absorption is further decreased by the administration of purgatives, an especially common practice when worms are seen in the faeces. To the effects of acute infections on intestinal absorption must be added the chronic effects of heavy intestinal parasitism and the flattening
of intestinal villi now recognized to be common in persons living in unsanitary tropical environments,\textsuperscript{16,17} probably as a result of frequent enteric infections and inadequate diets. Even non-enteric infections such as malaria seem capable of impairing intestinal protein absorption.\textsuperscript{18}

Considering the multiple ways in which infection can worsen nutritional status it is not surprising that nutritional disease as it is seen in populations is commonly associated with and precipitated by episodes of acute infectious disease. In the case of kwashiorkor, diarrhoeal disease and measles have been most commonly identified as responsible,\textsuperscript{13,19} although chicken pox,\textsuperscript{18} German measles\textsuperscript{19} and whooping cough\textsuperscript{19} have all been associated with individual cases. Even when other clinical signs of protein-calorie malnutrition do not develop, the effect of repeated infections on the growth of preschool children is of major significance.

It is the interaction of inadequate dietary intake and repeated infections that is responsible for the severe impairment of growth and development during the preschool years seen in the age group among the lower income populations of nearly all developing countries.\textsuperscript{1} Not only is this retardation in physical growth not made up in subsequent years, but development of the brain and central nervous system may suffer some permanent impairment when severe malnutrition occurs at a very early age for this reason.\textsuperscript{5,18}

As already noted, the effects of infection extend to vitamin and mineral deficiencies as well. In children, concentrations of vitamin A in the blood have been shown to be appreciably reduced in pneumonia, arthritis, acute tonsillitis and rheumatic fever\textsuperscript{20,21}, and to appear in the urine in chronic nephritis and pneumonia.\textsuperscript{22} Intestinal absorption of vitamin A may be impaired by \textit{Giardia lamblia,}\textsuperscript{23} and heavy infections of other intestinal parasites. It is not surprising, therefore, that xerophthalmia and keratomalacia are stated to be most commonly precipitated in children on borderline diets by episodes of diarrhoeal disease, measles, or other infectious diseases.\textsuperscript{24,23}

In 1917, Hess\textsuperscript{25} first called attention to the frequency with which children from low income families in New York City developed florid scurvy after contracting an acute febrile illness. There are now many studies demonstrating lower serum ascorbic acid values and/or increased urinary excretion of the vitamin as a result of malaria,\textsuperscript{24,26} typhoid fever,\textsuperscript{27} influenza,\textsuperscript{28} measles,\textsuperscript{29} tuberculosis,\textsuperscript{30} and even vaccination against small pox.

The data for the effects of infection on the status of other vitamins are
less extensive, but along similar lines. Of relevance to the frequency of megaloblastic anaemia in developing countries is the evidence that infections may precipitate folic acid deficiency in individuals whose intake of this vitamin would otherwise be sufficient.12 Other important effects of chronic infections in underprivileged populations, particularly the role of such infections as hookworm and malaria in the occurrence of iron deficiency anaemia, have been extensively reviewed elsewhere.1 Even the faecal blood loss with trichuris has been reported as contributing to iron deficiency anaemia in children.12

![Diagram](image)
Frequency of infections among preschool children of developing countries:

It is only recently that the extraordinarily high frequency of infection among the preschool children of lower income groups in developing countries has begun to be recognized. Mata et al. have followed children from birth to three years of age in a Guatemalan village, and consider the disease history of the child described in Figure 3 to be quite typical. Figure 4 shows a similar pattern in an Ethiopian village child considered representative by Eksmyr et al. Unpublished data on disease morbidity of preschool children in four villages in West Bengal and eleven villages in Punjab provide examples indistinguishable from these two.

Respiratory viruses have been shown by Kloene et al. to be exceedingly common among children in these West Bengal villages and the high frequency of diarrhoeal disease has been reported by workers in many different developing countries, including Guatemala, Costa Rica, Colombia, Jordan, South Africa, West Africa, and India. In fact, diarrhoeal disease is such a common feature of the early preschool years in developing countries that it has been identified as a distinct epidemiologic entity by Gordon. It is associated with lowered resistance to infection due to inadequate nutritional supplementation of breast milk and it can be caused by known pathogens such as enteropathic E. coli, shigellas, and salmonellas, but much more commonly seems due to organisms not ordinarily pathogenic in well nourished children.

The ordinary communicable diseases of childhood—measles, chicken pox, mumps, German measles, and whooping cough are commonly more severe in malnourished children and diarrhoea is a frequent accompaniment. The mortality rates for measles are 100 to 400 times higher in developing countries than in industrialized ones due in large part to the greater susceptibility of malnourished children. These large differences in mortality cannot be due primarily to medical care, because this is rarely required by well nourished children with the disease. Nor are they due to differences in the virulence of the measles virus, since well nourished children in developing countries have no more severe disease than those in industrialized countries.

There is extensive, although circumstantial, evidence that the severity of both diarrhoeal and respiratory diseases in preschool children increases with the degree of retardation in weight for age. Table 3 from a study in Haryana, India, and Table 4 from the village of Santa Maria 'Cauque, Guatemala' are examples. While it is difficult to separate cause and effect in this relationship in most instances, the magnitude of the weight difference.
and the relationship with height cannot be accounted for by a single acute episode of diarrhoea.

TABLE 3

Incidence of diarrhoea related to nutrition*

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Normal Nutrition**</th>
<th>Poor Nutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Freq. of episodes per 100 child weeks</td>
</tr>
<tr>
<td>0.2</td>
<td>246</td>
<td>2.8</td>
</tr>
<tr>
<td>3-5</td>
<td>152</td>
<td>3.8</td>
</tr>
<tr>
<td>6-8</td>
<td>89</td>
<td>3.7</td>
</tr>
<tr>
<td>9-11</td>
<td>63</td>
<td>4.5</td>
</tr>
<tr>
<td>12-17</td>
<td>64</td>
<td>2.9</td>
</tr>
<tr>
<td>18-23</td>
<td>38</td>
<td>2.6</td>
</tr>
<tr>
<td>Total</td>
<td>652</td>
<td>3.3</td>
</tr>
</tbody>
</table>

*Reference 55.

**Within 85+ of mean weight for age (Statistical Division, ICMR, 1968).

TABLE 4

Total cases and severe cases of acute diarrhoeal disease among children age 0-4 years, by nutritional state.
Santa Maria Cauque, Guatemala, February 1961 through June 1962*

<table>
<thead>
<tr>
<th>Person-years Nutritional state</th>
<th>Number of children</th>
<th>Person-Years</th>
<th>Number of cases</th>
<th>Number of cases/100 Person-years</th>
<th>Number of Severe cases</th>
<th>Number of Severe cases/100 Person-years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>25</td>
<td>35.4</td>
<td>35</td>
<td>98.8</td>
<td>8</td>
<td>22.2</td>
</tr>
<tr>
<td>First-degree malnutrition</td>
<td>74</td>
<td>104.8</td>
<td>172</td>
<td>164.1</td>
<td>65</td>
<td>61.9</td>
</tr>
<tr>
<td>Second-degree malnutrition</td>
<td>71</td>
<td>100.6</td>
<td>254</td>
<td>252.2</td>
<td>74</td>
<td>73.3</td>
</tr>
<tr>
<td>Third-degree malnutrition</td>
<td>9</td>
<td>12.8</td>
<td>35</td>
<td>274.5</td>
<td>14</td>
<td>107.7</td>
</tr>
</tbody>
</table>

*Reference 1, p. 251.

The most direct test of the extent to which nutritional deficiency in the child is responsible for part of the increased frequency and severity of infections among poor populations is direct nutritional supplementation.
The results of supplementary feeding programmes in Cali, Colombia, Santa Lucia in the West Indies, Venezuela and a group of villages in Punjab, India appear to support this conclusion. In Guatemala, where a supplementary feeding of preschool children was continued for 5 years, reduced morbidity and mortality from infectious disease were observed. Despite continued high case fatality rates for measles in surrounding villages and three measles epidemics, there were no measles deaths among children participating in the supplementary feeding programme.

**TABLE 5**

Ilnesses of children 0 to 59 months in Santa Catarina Barahona*

<table>
<thead>
<tr>
<th>Percent participation</th>
<th>No. of children</th>
<th>Annual days of illness per child</th>
<th>Average days duration</th>
<th>Illness per child per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>0—24</td>
<td>131</td>
<td>25.4</td>
<td>9.4</td>
<td>2.7</td>
</tr>
<tr>
<td>25—49</td>
<td>51</td>
<td>19.2</td>
<td>8.0 *</td>
<td>2.4</td>
</tr>
<tr>
<td>50—74</td>
<td>32</td>
<td>17.2</td>
<td>8.2</td>
<td>2.1</td>
</tr>
<tr>
<td>75+</td>
<td>83</td>
<td>16.7</td>
<td>7.6</td>
<td>2.2</td>
</tr>
</tbody>
</table>

@Reference 66.

**TABLE 6**

Respiratory disease in preschool children of feeding village by percent participation in food supplementation, May 1959—April 1964

<table>
<thead>
<tr>
<th>Percent Participation in Dietary Supplementation</th>
<th>Respiratory Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Cases</td>
</tr>
<tr>
<td>0—24</td>
<td>208</td>
</tr>
<tr>
<td>25—49</td>
<td>194</td>
</tr>
<tr>
<td>50—74</td>
<td>46</td>
</tr>
<tr>
<td>75+</td>
<td>143</td>
</tr>
</tbody>
</table>

*Reference 67.

Table 5 shows the decrease in overall total morbidity of children under 5 years of age with degree of participation in the feeding programme and Table 6 shows the same relationship for respiratory disease. Diarrhoeal disease among preschool children was much lower than in control villages in the first three years of the feeding programme but increased somewhat when the village was used for growth and behaviour studies involving a large field team.
REFERENCES


61. Lees, R. M. (1966). Protein-calorie Deficiency Disease in St. Lucia and the effects of Preventive Measures on the Mortality of Infants and Young Children. Thesis submitted to the Faculty of Medicine, University of Glasgow.
A great majority of young children who belong to the poor income groups in the developing countries are malnourished. They suffer from various grades of protein-calorie malnutrition ranging from mild degrees of growth retardation, which are recognised only by anthropometric measurements, to the very severe forms of the disease like kwashiorkor and marasmus.

Protein calorie malnutrition is now recognised to be the end result of a number of factors acting on the child. It is also recognised that these factors act directly or indirectly and that they act with different degrees of force in different children, under different situations. But, in all children who suffer from malnutrition, a basic and constant feature is inadequate dietary intake. The reasons for this situation are many and in a majority of cases, the most important single cause is economic—the family being too poor to afford the type of food the child needs. Two additional reasons which may be considered as being only slightly less important are:

1. that suitable foods in many instances are not always available; and

2. even when such foods are available these resources are not fully utilized.

There would appear to be three major reasons for families failing to utilize fully the available food resources. The first is, a lack of knowledge of the foods which children can and should eat associated with a lack of appreciation of the physiological fact that children need foods of a type that may not always be similar to that needed by adults. In addition it has been repeatedly observed in many instances that the pattern of distribution of food within a family, frequently contributes to nutritional deprivation in children.

The second reason is intimately connected with beliefs, traditions and
Malnutrition and Mental Function

Taboos which are linked with food habits. This can contribute significantly to inadequate intake of nutrients by children for reasons which are not economic. This is a factor that exists in most communities in many parts of the world; only the belief systems may vary. Many children are not permitted to eat meat, fish or eggs, or pulses even though the family can afford to buy small amounts of these foods, simply because of the belief that these foods are too rich and too heavy for infants and children. In many families certain types of foods are withheld during certain seasons of the year, because of the belief that these foods are either heat producing or cold producing—a belief that does not stand scientific scrutiny. Of even greater importance is the belief that most foods should be withheld from children during any illness however minor it may be, until the illness is over. All these practices contribute significantly to chronic malnutrition in infancy and early childhood in many poor communities. The practice of withdrawing food during illness is seen in many well-to-do and apparently educated families as well. In these groups, however, this practice may not have the same nutritional significance, since the diet of the child before and after the illness is quite satisfactory—a state of affairs quite unlike that of children belonging to the poor economic classes, who are in a borderline state of nutrition.

The third important reason for a child not being able to get adequate food, even when it may be available, is the mother-child relationship. In many poor communities mothers go out to work; the attention she is able to devote to her child, and her concern for ensuring a proper intake of food by her young children and their health when she is away from home may be expected to significantly influence the nutritional status of the child.

In addition to nutrient intake, environmental factors have important contributory roles, and among these, the role of infection would appear to be particularly significant. It is the experience of most investigators that in a great majority of children with advanced states of protein calorie malnutrition an episode of acute infection, either of the gastro-intestinal tract or of the respiratory system, seems to have a precipitating role.

The widespread prevalence of protein calorie malnutrition among children who belong to the poor income groups can, therefore, be easily explained on these considerations. But it cannot so easily be explained as to why among children of such communities, all of whom subsist on inadequate diets and all of whom are exposed to the same unfavourable environment, only some children develop signs and symptoms of advanced
states of protein-calorie malnutrition like kwashiorkor and marasmus, while the rest escape from these severe forms and show only varying degrees of growth retardation.

It is well known that there exist individual variations in nutrient requirements and it is possible that children with a high requirement for protein and calories, due perhaps to genetic factors, are those who will suffer most and develop clinical manifestations on dietary intakes which for other children would be only marginally deficient or even adequate. It is also known that not all children grow at the same rate and children with a high growth rate may be those who would develop kwashiorkor on marginally inadequate diets. It is also possible that children who have been exposed to recurrent attacks of episodes of infection are those that develop the more severe manifestations on marginally inadequate diets.

In addition to these possibilities, it may be expected that another important factor which can determine the degree of malnutrition and therefore the incidence of frank kwashiorkor in a poor community would be the maternal-child relationship. The economic status and the environmental factor being similar, the level of intelligence of the mother, the attention she bestows on her child, her motivations and resourcefulness and the degree of her concern for the child's well-being, may well be one of the key determining factors in deciding the degree of malnutrition, the child would suffer from. Children coming from homes of parents who are particularly deficient in these attributes may be specially vulnerable as a result of improper parental attention, particularly maternal care. Children born to and brought up by mothers who are the least intelligent, least resourceful, most ignorant and poorly motivated, may be those that suffer most.

Some evidence is presented here which suggests that this may indeed be so. This is not to imply that other factors are not important or that this is the only factor but it is possible that this may be a critical factor. Should this be so, it would be of more than mere academic importance.

A quantitative evaluation of these maternal attributes was done in two ways. First, through the administration of a questionnaire and second, by evaluating their performance in the Wechsler's adult performance tests.

An oral questionnaire was prepared and pretested. It was then administered to two groups of mothers— one group whose children were suffering from kwashiorkor and another group whose children were suffering
from non-nutritional disorders. These mothers were matched as far as possible for most variables like age, parity, family size, income, religion, caste and whether they came from rural or urban areas—all of which are factors which can modify their response. The questionnaire aimed at evaluating the mother’s knowledge in these specific areas:

(a) Her concepts regarding food values for children;
(b) Her concepts regarding weaning practices and timing of supplementary foods;
(c) Her attitudes on general health care; and
(d) Her concern for her child’s health.

Scores were assigned to the various possible answers and the performance of the mothers was expressed as a percent of a maximum of 100 marks. The results of their performance are shown in Table I.

**TABLE I**

Scores obtained by mothers of normal and kwashiorkor children

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Food concepts %</th>
<th>Weaning practices %</th>
<th>General health care %</th>
<th>Average total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normals</td>
<td>65.3±2.38 *</td>
<td>65.7±2.63</td>
<td>71.9±2.63</td>
<td>67.4±1.16</td>
</tr>
<tr>
<td></td>
<td>(40)</td>
<td>(40)</td>
<td>(40)</td>
<td>(40)</td>
</tr>
<tr>
<td>Kwashiorkor</td>
<td>51.1±1.95</td>
<td>47.6±1.87</td>
<td>59.6±1.87</td>
<td>52.1±1.18</td>
</tr>
<tr>
<td></td>
<td>(50)</td>
<td>(50)</td>
<td>(50)</td>
<td>(50)</td>
</tr>
</tbody>
</table>
| *Mean±Standard Error.  
The figures in parenthesis are the sample size.

There was some overlap in the performance of the mothers in the two groups, but in all the areas tested, the performance of mothers whose children had kwashiorkor was significantly poorer than that of mothers whose children had non-nutritional disorders.

It may, however, be argued that information obtained through such a questionnaire may not always be accurate, and that evaluation may not
lend itself to proper quantitation. To obtain additional information of a
more objective nature capable of quantitative estimation, a battery of
Wechsler’s adult intelligence performance tests was also administered to
these two groups of mothers. They included the following:

(a) Substitution tests;
(b) Picture completion tests;
(c) Picture arrangement tests;
(d) Block design tests; and
(e) Object assembly tests.

The performance of the two groups of mothers is shown in Table 2.
As in the case of the questionnaire there was some overlap, but there
were marked differences between the two groups in all the tests individually
as well as, taken together. The differences were particularly significant in
the block design and the object assembly tests which are believed to truly
measure a person’s basic capacity.

TABLE 2

<table>
<thead>
<tr>
<th></th>
<th>Substitution</th>
<th>Missing</th>
<th>Block</th>
<th>Picture</th>
<th>Object</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% features</td>
<td>% design</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Normals</td>
<td>31.7±4.68</td>
<td>44.0±3.40</td>
<td>16.4±2.00</td>
<td>28.6±3.95</td>
<td>36.4±3.91</td>
<td>27.6±2.53</td>
</tr>
<tr>
<td>Kwashiorkor</td>
<td>16.4±3.46</td>
<td>22.9±2.73</td>
<td>8.3±0.92</td>
<td>9.2±2.32</td>
<td>24.8±3.12</td>
<td>14.5±1.62</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.01</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.05</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

The figures in parentheses are the sample size.

On the basis of both the questionnaire and the more objective Wechsler’s
tests, it would appear that maternal intelligence and the mothers knowledge
in both specific and general areas, were generally poorer in mothers whose
children had kwashiorkor.
This observation may have practical relevance in at least two areas of protein calorie malnutrition. One of them is related to the association which is generally believed to exist and has been, in a limited way, demonstrated between malnutrition in early childhood, and mental function in later life. The other is related to the role of nutrition education in the control and prevention of childhood protein-calorie malnutrition.

There has been a growing body of evidence in recent years that malnutrition during late infancy and early childhood may seriously interfere with the capacity to understand and learn. Many experimental studies in laboratory animals have shown that malnutrition induced during the rapidly growing stage can induce behavioural changes. These studies have also shown that the chemical composition of brain in such animals is abnormal. For obvious reasons controlled long term studies in the human situation have been few and the results of the few such studies including one carried out at the National Institute of Nutrition in Hyderabad have suggested that children who have once suffered from kwashiorkor and have recovered perform poorly in intelligence tests as compared to children who have not gone through such an episode. In fact, in the studies conducted at the National Institute of Nutrition these differences were very marked and the performance were seen not only in intelligence tests but also in tests which measure inter-sensory integration. These observations may be considered as particularly significant, because the experimental and control children were matched for age, sex, religion, caste, socio-economic status, family size, birth order, general parental education and even the locality they came from and the school they attended.

These results then do suggest an important role for malnutrition in influencing mental ability. Before ascribing a major role for malnutrition in the poor mental development, it is necessary to look into the contribution which non-nutritional factors can make because it must be remembered that intellectual growth will be influenced not only by physiological factors which condition physical and chemical brain growth, but also by the social, cultural and psychological environment of the child. Just as optimal nutrition is necessary for the genetic potential for growth to be fully manifest, optimal intellectual environment may be necessary for the proper mental development and neuro-integrative competence. The social circumstances in which the child grows and develops, may become crucial in this connection.

The observations made here suggest that the poor mental performance of children with kwashiorkor may indeed be to a considerable extent due
to his poor intellectual environment. Kwashiorkor and poor mental functions, may in fact be largely due to the same unfavourable maternal attributes and not necessarily cause and effect.

The second aspect, on which these findings may have a bearing, is in the control and prevention of protein calorie malnutrition. The most desirable and long lasting solution to the problem must undoubtedly be aimed at an improvement in the economic status and physical environment. It is also necessary at the same time to improve the social status and inject the element of nutritional awareness, particularly of the mother. This would call for educating the mother not only on aspects of food and nutrition but also on the importance of the environment — particularly of the role of infections in precipitating and perpetuating malnutrition.

It has been suggested in recent years that one of the approaches towards this end is the establishment of what are termed as nutritional rehabilitation centres. One of the aims of such centres is to educate the mothers of children who are severely malnourished through their active participation. It is expected that the mother in turn will serve as an active agent in spreading nutrition education in the community. While this would appear to be sound philosophy, it is obvious that the mothers must be chosen with care.

It is now being suggested that mothers of children who suffer from the more severe and advanced states of malnutrition should be selected for this type of nutritional education. It is true that these are the mothers who are in most need of being educated since they appear to be the least informed, but our observations suggest that unfortunately, they may not be the best subjects. Their basic ability to understand and learn would appear to be limited and nutrition education beamed at this select group — which is not a particularly motivated one — may not produce the expected results. What is in doubt is not their desire to help their children, but what is in doubt is their ability to do so. It would appear, then, that while every effort should be made to improve the situation among these mothers, it is also essential to involve at least some mothers, with the necessary attributes in such a rehabilitation project, though their children may not really be in need of rehabilitation as badly as the severely undernourished children.

To sum up then, we may say that other factors being similar, maternal attributes may well decide the degree of malnutrition of children and that these attributes have relevance to some practical aspects of protein calorie malnutrition.
REFERENCES


Mammal man appears to be showing a decreasing ability or willingness to feed his young biologically—that is with human milk. This trend away from breast feeding has occurred in Western Europe and North America during the present century, although more recently an increasing interest has been shown by educated mothers in these areas.

In the last few decades, lactation failure has also become more common in Westernized well-to-do urban women in less developed areas of the world, as noted in Calcutta in 1956; and more recently, there is increasing evidence of a decline in breast feeding in the peri-urban poor in some tropical countries, such as in the Philippines and Singapore.

For some paediatric nutritionists, this is a matter of great concern; for others, it has little impact or is regarded as part of an “inevitable” process of change towards mechanized urban life in the technopolis of the future.

Before making a decision as to the place of human milk as an ecological force in the modern world, it is necessary to consider three questions concerning declining breast feeding—does it matter? What are its consequences? and what are the reasons for this change?

With regard to the first question—does it matter?—it will be best to consider from two points-of-view:

(a) Are there any specific properties of human milk as compared with animal milk or, rather, to be more precise, what are the differences between the processes of breast feeding and of bottle feeding with animal milk formula?

(b) What are the effects of lactation failure in different ecological circumstances?
Human Milk as an Ecological Force

(a) Specific characteristics of human milk and breast feeding:

This can best be consider under six headings: biochemical differences, anti-infective differences, psychological considerations, economic aspects, convenience, and maternal effects.

**Biochemical differences.** The gross composition of human milk has been known for years. However, completely under-appreciated is the fact that in the last decade there has been a great deal of further additional new modern scientific research. A study of the literature revealed that there have been some 300 papers on this particular subject over the last ten years, and only a few of these findings can be touched on today.

Human milk is a highly complex fluid, just as is the milk of any other species of mammal. However, the complex composition of milk varies very greatly from one type of mammal to another. The fact that scientific knowledge of the constituents of human milk is still enlarging and expanding, is indicated, for example, by the fact that as recently as 1966, six new polysaccharides were described as being present in human milk. Human milk contains over 100 constituents, many of which show specific differences from cow's milk.

Firstly, the pattern of fatty acids is different. There is a higher content of linoleic acid, and this has real advantages as far as the absorption of both calcium and of fat, the main source of calories.

**Human milk has a different content and pattern of nucleotides.** For instance, there is no orotic acid present and this different pattern may be related to the well-recognized ability of the breast-fed body to synthesize protein and grow rapidly.

Under-appreciated, also, is the fact that human milk contains active enzymes. In particular, lipase is present which commences the digestion of fat long before the intestinal fat digesting enzymes have been able to reach the ingested milk.

With regard to man-made environmental contamination, it may be noted that strontium-90 is present only in one-fifth of the concentration in human milk as in cow's milk. However, certain other ecological toxicants, such

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*A detailed symposium on "The Uniqueness of Human Milk" will be appearing in a forthcoming issue of the American Journal of Clinical Nutrition, and will contain an extensive bibliography.*
as DDT, may be present in human milk in greater proportions than in cow's milk.

Of importance nutritionally, the content of vitamin C and of folate is plainly very much greater in human milk than in boiled or processed cow's milk preparation, where these two thermo-labile constituents are destroyed.

In developing countries, there has been considerable work recently (although much more is needed) on the differences and changes—and more particularly the lack of changes—that occur in milk from lactating women who are less than adequately nourished. Work has been carried out by Gopalan, Belavady, Venkatachalam and others in India and elsewhere.

In this context, more investigation is needed into detailed relationships between maternal nutrition and lactation performance. However, at the same time, practical emphasis needs to be given to supplying the pregnant and lactating mother with an adequate diet of local foods to supply the nutrients needed to produce breast milk of good quality and volume, without depleting maternal resources and reserves.

Anti-infective differences: Human milk, including colostrum, is probably never sterile, containing the skin organisms and enteral bacteria ingested from the mother's nipple and breast. These, however, will usually be at a low level and, in any case, there will be no opportunity for multiplication to occur, as can obviously happen in cow's milk when it has to be transported from the cow to the human child. In addition and as important is the fact that human milk contains specific anti-infective constituents and components.

For example, Dr. Mata and colleagues in Guatemala have shown that human milk contains high concentrations of immunoglobulin A, which is protective against enteroviruses and *Esch. coli*. In fact, so effective is this and other constituents in this regard, that oral polio vaccination is extremely difficult to carry out in breast-fed infants.

In addition, lysozyme is present in 3,000 times the content in human milk as in cow's milk; likewise Gyorgy has identified two protective substances present in human milk and absent in cow's milk—the bifidus factor and also the antistaphylococcus factor.

Human milk is a live substance—not only because of its enzymes, but also because of its cellular content. In addition to colostrum corpuscles, motile macrophages are also present independently, and are part of the anti-infective protective mechanism of breast milk.
Breast milk, then can be said to have a positive protective effect, particularly an active anti-diarrhoeal effect. This realization has even been incorporated into some more recent cow’s milk formulations, and there is one preparation in France called "Galliazyme", which, in fact, adds lysozyme to a cow’s milk preparation.

Psychological considerations: Time does not permit going into this in detail, although there has been a great deal of work on this, both in animals and in the much more difficult studies in human beings. That differences would be expected is not surprising if one considers the usual process of artificial feeding as carried out in many maternity hospitals, which is totally the opposite of what one would imagine would be biologically desirable for the newborn infant.

The child is separated from the mother; the child is fed (or was until recently) at rigid intervals; the child cries and has no comfort. If there is a poor way to introduce an individual into the world, surely this sequence contains many of the ingredients. Recent studies carried out in various countries in human subjects have shown, as might be expected, that there is considerable difference in personality and emotional development between breastfed babies and bottle-fed babies. In particular, reference may be made to a recent monograph published in Czechoslovakia.

Economic aspects: (i) Family Economics. For any group anywhere, human milk is cheaper than cow’s milk. If one looks at the previous analyses of the cost of cow’s milk vs the cost of feeding the mother with the extra nutrients required for lactation, these frequently have been made with various misconceptions built into the analysis. They have been made with the assumption that large quantities of certain luxus foods, particularly animal protein, are required during pregnancy. This is not the case, and nutrient needs can be met by a mixed diet of locally available, economical foods of largely vegetable origin.

Calculations have also not taken into account the physiological fat stores laid down in pregnancy as calorie reserves for subsequent lactation. Lastly, it has been shown recently that maternal energy needs in lactation are very much less than previously believed.

In the less affluent areas of the world anywhere, including under-privileged segments of population in industrialized countries, it may be totally impossible to artificially feed adequately the child for economic reasons—so that the arguments concerning the relative costs of lactation vs purchased cow’s milk are theoretical and academic.
(ii) International economics. This aspect of the situation seems to have made no impact on nutritionists or planners. However, if lactation failure continues to spread, it is then certainly necessary to plan for the economical production and distribution of products suitable for feeding young babies. If this substitute for human milk cannot be produced within the particular country, it will then have to be imported, posing complex problems of international trade, of foreign exchange, hard currency and the like.

Convenience. Nowadays, urban life is based on convenience foods. Strangely, it is often forgotten that there are certain "natural convenience foods", for example, ripe banana and the avocado pear. These require no cooking, are sterile and can be fed to the child straight away. Likewise, in the present context, human milk is the original and natural convenience food for young infants, being readily available, of the right composition, requiring no preparation, at the right temperature, not infected and so forth. Also, it has been quite clearly shown that by minor modifications of dress, as introduced and popularized by the La Leche League International,* it is quite possible to breast feed babies conveniently and inconspicuously in the circumstances of modern Western urban life.

Maternal effects: An uninhibited let-down reflex and successful lactation have definite maternal benefits. These include the following: a lower incidence of breast abscess, a lesser incidence of nipple trauma, and earlier involution of the uterus. Also, the amenorrhea associated with lactation has a nutritional consequence in that it permits replenishment of iron stores. Carcinoma of the breast is less common in communities where repeated cycles of pregnancies and lactation are very much the order of the day.

The contraceptive function of lactation has been much debated but, in fact, recent work has shown that lactation inhibits ovulation.13 However, it is equally plain that, as a contraceptive, it is partially effective and cannot be relied on by itself. Another aspect of this matter is new MCH problems posed by possible interference with lactation by oral contraceptive drugs.

(b) Effects of lactation failure:

The effect of lactation failure has to be considered in relation to the biological phases of early life and to ecological circumstances.

*La Leche League International, 9616 Minneapolis Avenue, Franklin Park, Illinois 60131, U.S.A.
Biologically, there are three phases in early life—the foetus, the extra-uterine foetus and the transitional. Under natural circumstances, the extra-uterine foetus has many similarities with the intra-uterine foetus, with the breast taking the place of the placenta as the sole supply of food. During the transitional or “weaning” period, human milk has traditionally played an important role as a protein supplement to other exogenous foods, which should form the main diet of the child at this time.

The effect of lactation failure very much depends on the ecological circumstances. However, even in the “ecologically protected”—that is, the economically well-to-do, educated elite living in good hygienic circumstances—the concept that any cow’s milk formula is “just like mother’s milk” is totally incorrect. It is virtually impossible to obtain the same composition as human milk; certainly, this is very far away at the present moment. Witness to this is the fact that, over the past decade or two, various problems have arisen with different formulations of cow’s milk lacking in pyridoxine, in linoleic acid, in vitamin E, etc.

However, as will be appreciated, for the ecologically protected, cow’s milk feeding is possible, human milk feeding is best—for the many reasons outlined already, as well as for the prevention of infantile allergy and possibly various adult metabolic disorders as well.

Teleologically, one might consider this as unsurprising. Seal milk contains 30% fat because of the cub’s metabolic requirements in polar conditions, including the need to deposit subcutaneous fat. Possibly the high lactose content of human milk, the specific types of fatty acid present and other constituents, may be related to a major human characteristic of early infancy—that is rapid growth in the brain size and complexity.

For the ecologically unprotected—that is for the majority of the world—the situation is totally and absolutely different. Cow’s milk feeding is positively dangerous and human milk feeding is what one should aim for with all one’s resources. Under these circumstances, human milk must be considered not only from a nutritional point-of-view, but as an “anti-infective”, especially as a protection agent diarrhoea.

Despite great variations, certain general patterns of childhood malnutrition are to be considered in the world. Thus, in more traditional circumstances, the situation is still that human milk protects for the first six months or so of life, that the child grows, but not so well during the second semester, and the main impact of malnutrition comes in the second year of
life, the "secotrant". It is during this period that kwashiorkor often has its highest incidence, or, if the child is on the breast alone, unsupplemented ("breast starvation"), then "late marasmus" is likely to develop.

The situation is much different in "disurbanizing" circumstances—that is where the process of urbanization is occurring so fast that it is totally swamping the social services, health services, employment opportunities, and other facilities, resulting very often in the development of shanty towns. It is here that shorter periods of breast feeding are occurring, with a "move to the left" of the malnutrition picture towards infancy and a change from kwashiorkor to the "marasmus—diarrhoea syndrome". This has been noted, for example, by Dr McLaren in the Eastern Mediterranean and has been reported at the present Congress by Dr Sadre from Teheran. It also seems the case in the West Indies, as in three island investigations in recent years in the Caribbean, only marasmus as the severe form of malnutrition was detected in community surveys.

This pattern seems most likely to increase in the future, with special risks. Firstly, marasmus often takes longer to cure than kwashiorkor. It is an expensive disease. Secondly, the younger age group usually affected is probably more vulnerable to permanent brain damage.

Reasons for lactation failure: Many factors may be operative. Most importantly is the change in life style, a move from a rural subsistence way of life to an urban cash economy. The composite picture, the different constituents of this urban life style will vary. Women working outside the home in town occupations is frequently mentioned, but investigation shows this only applies to 15% in some West Indian countries in women who are not breast feeding their children. In other words, other factors are often more important, including the role of women in society, the breast as a sex symbol, the status of bottle feeding as the modern 20th century thing to do. These all affect the picture.

Also, the imitation by the lower socio-economic groups of the well-to-do statusful elite is obviously important. The main physiological reason for the failure of lactation is undoubtedly inhibition of the key psychosomatic let-down reflex, which is so easily affected by anxiety or confidence.

At the same time, there is an urgent need for an epidemiological study into the present situation of lactation in different parts of the world, a study which not only should be carried out by the nutritionist and the paediatrician, but by the sociologist as well. A study of this type is proposed at the
present moment by a Working Group of the PAG (Protein Advisory Group) of WHO/FAO/UNICEF, and could lead to a clear definition of the situation and, hence, guidance on an appropriate preventive programme.

**Approaches to lactation failure:** It is clearly established that human milk is superior to cow's milk for feeding young infants anywhere. However, the consequences of the trend away from breast feeding in ecologically unprotected, less developed areas are very serious. If it continues, there is certain to be an increase in incidence of diarrhoea-marasmus.

If this is the case, the question is if anything can be done, or is a fatalistic acceptance of the posture recommended?

As noted earlier, there is a need for further epidemiological knowledge—this is a neglected priority. Nevertheless, sufficient information is already available to approach the problem logically.

Firstly, much needs to be done through the health services. The training of personnel needs to incorporate modern knowledge of the biochemistry, immunology and psycho-physiology of lactation, as, for example, the let-down and prolactin reflexes. At the moment, this type of information is usually lacking from the training of health staff, including paediatricians and obstetricians. The major paediatric and obstetric texts on work in the USA and Western Europe usually contain very little, if anything, on these topics.

Likewise, there is a need to re-think the function of health units in this (and other) regards. For example, most Western maternity units have been designed almost as though intended to make breast feeding difficult. The child is taken away from the mother; at the slightest indication, the nurse will give a bottle feed of cow's milk or glucose water, or, after that, she will tell the mother that she has not got enough breast milk and will switch the child onto a bottle.

There is a need to re-think the functions of the maternity units and the paediatric wards. This, in India, is vastly better than in many parts of the world. Mothers do come in with their children. In some developing countries, you have the farce of a child who is breast fed, who develops an infection, comes into the ward, recovers from the infection and goes home to die of marasmus. The premature units should be particularly a case in point, and arrangements have to be made to have mothers living near, so that they can express their breast milk and quite earlier on can start breast feeding their young children directly.
The second approach is via food and nutrition policy. Usually people planning food and nutrition policy do not include human milk in their considerations at all. This is because it is not grown or bought in a can at the store. In fact, it is very ancient food and should be included. Perhaps if one introduced it with a full Madison Avenue promotional campaign as a new food, “Mamalac”, as a great technological breakthrough, it would then acquire headline potential. Because it has been around such a long time, food and nutrition planners just do not seem to appreciate its significance as part of the whole picture.

Another approach could be through the infant food industry, who have been responsible in recent decades for the introduction of a spate of highly priced, highly advertised, culturally and hygienically inappropriate infant foods into most parts of the Third World. Quite recently the commercial people have come to realise that it is neither desirable nor even ethical to introduce a costly, highly advertised processed cow’s milk preparation into a community where breast feeding is still the pattern and where there is no chance of parents being able to afford adequate quantities, and where the hygiene is such that the preparation of a clean feed is a total impossibility. This is unethical, and while part of the aetiology of marasmus is iatrogenic—that is due to the incorrect training of doctors and health staff, some also is commerciogenic.

Recently, there was a meeting in Bogota between paediatric nutritionists and the commercial food industry. It seems quite possible that it may be possible to channel the technological skill, the advertising expertise, and the money of the food industry towards products less harmful and more relevant to real needs. The goal of the pooled efforts of paediatric nutritionists and food industry in developing countries should surely be nutritional relevance and modest profit in mass markets.

There is also a need to consider legislation in relation to this pattern of lactation failure—for example, Day Care Centres and creches, the possibility of maternity lactation benefits, and also legislation concerning the food industry. Should there be an import restriction on certain foods? Should there be foods of only a certain protein content? Should there be a restriction on advertising of the culturally, socially, economically irrelevant foods in a particular country? It is very interesting to hear that there is now in India a Committee concerned with the “rational development of food industry”. It seems likely that infant foods, processed and traditional, will form part of their deliberations.

Health education is the last approach that can be mentioned now. By this, of course, much more is meant than the old-fashioned didactic: “I'm
telling you this is good for you" approach. It must be based on modern principles of motivation, especially on considerations of status. It is for this reason that the resurgence of breast feeding in educated women in the USA needs emphasis, and the La League International can play an important role in developing regions.

**Conclusion**

It is obvious that human milk has overwhelming advantages, especially in less developed regions. Cow's milk formulas have none, except for the mothers who are going out to work in towns.

Human milk is a live fluid. This is implied in the Koran, which equates it with the blood.

The situation is worsening as far as lactation failure is concerned in the world, and the question is what can be done about it.

One school says that this change is an inevitable part of modernization and urbanization, and little can be done or even attempted.

It is true that the same situation occurred in the Western World fifty years ago, and has now improved. But is it desirable for developing countries to go through the same difficulties that occurred at that time in the Western World? Is it certain that the same pattern of improvement in economics, education and food supplies will occur rapidly in all developing countries?

A more active approach is surely needed to prevent, or, at least, decelerate this trend towards lactation failure. Two calculations may add mathematical weight to this need. Firstly, in Asia, there are at this time 60 million infants in the first year of life, and, if all are breast fed, this means some 16,000 million litres of human milk per year. If there were a very rapid change from human milk to cow's milk for infant feeding, and assuming current milk yields in the area, this would need a herd of 114 million cattle, or a 40% increase of total milk production in Asia.

Secondly, on a domestic level, the basic wage in parts of India is 150 rupees a month. The cost of artificially feeding a three-month old child in Hyderabad appears to be between 30 and 40 rupees per month. There are many people who have markedly smaller incomes than this, and the financial impossibility is glaringly obvious.
Plainly, problems of malnutrition in young children in developing countries are extremely complex and preventive programmes need to cover the many factors responsible in the particular ecology. There is a need for inexpensive human milk substitutes for mothers working in towns, for the prevention and treatment of conditioning infections, for nutrition education towards the better use of locally available food mixtures for weaning and many other approaches, individualized to the situation in different countries.

However, in this whole complex, human milk and breast feeding have a particular and vital role, now proven scientifically, but recognized poetically thousands of years ago in India (Susruta, III, 10):

"May four oceans, full of milk, constantly abide in both your breasts, you blessed one for the increase in the strength of the child!"

"Drinking of the milk, whose sap is the sap of immortal life divine, may your boy gain long life, as do the gods by feeding on the beverage of immortality!"

REFERENCES

For the past five days we have heard testimony to the new vigour and quality of research which characterize the field of nutrition in Asia today. We have also heard and talked much about the increasing concern over the scale of malnutrition in the region and the need to attack the problem with a new sense of urgency.

Yet when one looks at the development plans of the countries in the region, or for that matter anywhere in the developing world, one seldom finds nutrition getting more than passing mention. Even where better nutrition is cited and discussed as an objective of a plan, its relative priority — measured by allocation of resources, or specific policy proposals — is low.

One is therefore tempted to ask, in this concluding paper of the conference: Is anyone outside the profession listening? or better: Have we demonstrated a convincing case that malnutrition should warrant more funds when weighed against other demands on scarce resources?

In a paper in 1969 we examined a series of policy issues relating to these questions and concluded then that from the planner’s view, an acceptable case for nutrition had not been made. It was also said that until a sufficiently strong case is presented, the impact of the scientific community will not reach beyond the periphery of the malnutrition problem. Since then, a rich dialogue has developed among many of those sharing the concerns. Issues have been more sharply defined, new rationale has been examined, and new conceptual approaches have been evolved. In short, we believe the case can now be advanced for nutrition’s role in the mainstream of development. This paper is an attempt to explore that case, looking at nutrition from the viewpoint of the development planner. Some nutrition proponents may take issue with this approach. It is commonly argued that the very fact of widespread malnutrition is itself grounds for
large programmes: that children should not have to justify their sustenance on socio-economic grounds. With clear appreciation of the human tragedy implied in malnutrition, we point to the evidence that over the years the case for nutrition as 'a moral imperative' has proved insufficient to claim more than a token portion of development resources.

At the outset we should state an important caveat to be borne in mind throughout this paper. We do not mean to imply either that malnutrition can be treated or overcome in isolation from other elements of the socio-economic framework, or that better nutrition alone is a panacea for under-development. On the contrary, nutrition is one of the many interrelated determinants of human performance requiring advancement. We do question whether the relative importance of nutrition, its role among the many factors, has been given the attention it deserves. We also suggest that under certain circumstances nutrition may be a precondition to the advancement of these factors.

Malnutrition is a disease. Expenditures to overcome or avoid diseases have commonly been regarded as a form of consumption, and consumption is often an unwelcome word in the halls of national planning agencies. This has not always been the case. Earlier developers of economic thought recognized that wealth flows from some kinds of expenditures on people, which were tantamount to investment in human capital, as well as from investment in non-human capital. Their view implies that expenditures to prepare a person to enter the labour force, or subsequently to increase or maintain his productivity eventually will produce a flow of income. However, this train of thought was eclipsed by the more mathematically precise economic growth models that came into vogue in the 1940s.

The planning models in general use do not take explicit account of the notion of investment in human beings. The models develop a view of the growth process which sees increases in tomorrow’s income as resulting primarily from today’s additions to material capital (or investment). The nature and productivity of the investment then determines the extent of the increase of future income.

Obviously, the more one consumes today, the less is available for investment—and thus, for generating future income tomorrow. Viewed in this light, consumption becomes an enemy of growth, not a handmaiden. Investment in steel plants, large dams, and other modern temples thus attained a new kind of sanctity. Consumption in the form of educational and health services, clothing, and eating—and even more flippant forms of consumption such as entertainment which can affect a person’s motivation—
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is recognized as having an instrumental impact on productivity. But since
the effects are so difficult to identify, all growth in income is imputed to
those measurable factors included in the model. The planner's personal
vision may transcend the confines of his model—or at least the inherent
bias against consumption, but his plans are constructed around the model
nonetheless.

Expenditures on health have suffered from this stigma. In the national
accounts they fall in the category of consumption. They contribute to the
current sense of well being and are consumed immediately, as is food or
a visit to the cinema.

In recent years, however, a new school of economic thought has begun
to advance beyond the confines of the models. A body of literature has
developed the theory of human capital, measuring returns to investment
in people. Guided by the techniques applied to measuring material capital
and the returns to investment, several writers have attempted to develop
similarly rigorous approaches to human capital. The impetus to extend
the concept of capital to human beings, developed from the observation
that the theory previously used could not explain all of the increases in
national output that had been achieved in several countries. As Professor
T. W. Schultz, a leading proponent of the development of human capital
theory, wrote in 1961:

Although it is obvious that people acquire useful skills and knowledge,
it is not obvious that these skills and knowledge are a form of capital,
that this capital is in substantial part a product of deliberate investment,
that it has grown in Western societies at a much faster rate than
conventional (non-human) capital, and that its growth may well be
most distinctive feature of the economic system. It has been widely
observed that increases in national output have been large compared
with the increases of land, man-hours, and physical reproducible capital.
Investment in human capital is probably the major explanation for
this difference.²

Elaborate work by Denison³ and others⁴ has shown that a significant part
of economic growth in the United States and Western Europe has been
attributable to education, but that even after taking education into account,
there remains an unexplained residual growth. Denison attributes this to
“knowledge”. To examine these efforts and their limitations further would
exceed the scope of this paper. For our purposes, it is enough to note
here that these authors reflect a breakthrough in economic thought—a
recognition that the quality of the labour force is an important factor in economic growth.

Inspired by this development in the theory of education, economists have attempted to develop a parallel approach to the economies of health. Several methods have been devised to measure the economic returns and they show substantial returns to health investment in the United States. The most common technique is to compare the costs of preventing a death with the worker’s future income, had he lived. The ratio of the income benefit to the costs of preventing its loss, is a ratio that is comparable to benefit-cost measurements of more standard project analysis. It is sometimes objected that the individual’s future consumption should be deducted from his income in calculating the net benefits. This is an error, since the objective of growth (and of economic activity generally) is future consumption, not merely the residual after personal consumption. The benefit consists both of a life saved and the consumption enjoyed by that person; if he also turns out to generate for future investment, so much the better. Another measurement is the investment in human capital that is lost through death any time prior to retirement. This second approach yields an estimate of the health “capital” that has been invested in a member of the labour force, along with food, clothing, housing, education and other expenditures necessary to enable a person to develop his particular skills. A variation in this approach measures the economic cost of debility, where death is not a factor. Whether an illness results in temporary loss of work days, or some temporary or permanent reduction in work capacity, the loss in output can be estimated in various ways and added to the cost of medical care. This can then be compared with proposed expenditure for preventing the occurrence of the illness in the first place.

Similar techniques are applicable in measuring returns to expenditures on better nutrition. From the earlier discussion of the impact of malnutrition on the individual, an improvement in nutrition (or an avoidance of undernutrition or malnutrition) can be economically equivalent to curing (or preventing) any other disease. Improved nutrition that returns an absent worker to the active labour force, or that overcomes a debility that is reducing a worker’s productive capacity, or that enables a child to return to school or to improve his understanding or retention of things taught, or that enables an adult to absorb more effectively in-service training or the advice of agriculture extension, clearly increases the flow of earnings above what it would have been in the absence of the improvement in well-being.
Once a person is restored to well-being, adequate nutrition (e.g., sufficient iron supply), is a maintenance expenditure. From then onward it contributes to present income only in the sense that in its absence, the person would lose some of the income-generating capacity he or she has when nutrition is adequate. It contributes to future income in the sense that its absence would interrupt current learning, or otherwise dilute activities that are necessary or contributory to future income generation. All distinction between consumption and investment would be destroyed if the expenditures on eating by all people who were adequately fed were labelled investment by extension of the idea that they were a necessary condition for maintaining a flow of income. Increments of nutrition lead to diminishing increments in potential productivity and then only up to a certain point. Beyond that point, in either quantity or quality, further increases in ingestion at any one time do not contribute to productivity, and in fact can reduce it.

In sum, an improvement in nutrition can have a continuing, current or maintenance effect on the productivity of an active member of the labour force, or it can take the form of an investment, enabling a person to earn a higher future income stream.

*Returns in a developing country*: Let us assume that our planner accepts the notion of human investment and the logic of the methods for calculating the benefits from avoiding death or restoring (or increasing) productivity through reducing or eliminating malnutrition. (The reader should be reminded of our initial caveat. Reduction of malnutrition and consequent realization of benefits may require joint attacks on other related problems, particularly synergistically-related diseases.) These analyses of the developmental importance of nutrition and well-being have been worked out for economies already highly developed. Before the conclusions can be aggregated and applied to the poorer countries, the planner faces another set of problems arising from important differences between developed and developing economies.

We might start with a benefit that is often central to discussions of health economics, the savings of medical costs where adequate nutrition would reduce the number of clinical admissions into the medical system. As long as there is an unsatisfied demand, i.e., as long as the potential case load exceed the treatment capacity of the medical system, the elimination of a kwashiorkor case frees up a bed (and other medical resources) for some other sick person who was otherwise unable to gain entry into the system. Since this is the typical situation, reduction of malnutrition
is not likely to bring about a reduction in current medical expenditures, or a slowing of the rate of growth in medical system investment, given the inadequacies of these systems. However, the adequate nutrition would enable the system to increase the welfare and restore the productivity of all those persons on the queue who would then be able to gain entry. The childhood morbidity data referred to earlier indicates the contributory role of malnutrition to some of the major prevailing childhood diseases. Examination of medical system statistics in any country would show the extent to which these diseases claim medical resources, and would give an indication of the numbers of people on the queue who might gain access as a result of reductions in malnutrition-related morbidities.

A benefit that has been cited but does not seem appropriate to transfer to a developing country is the saving in additional nutrients that a sick person otherwise consumes if his illness involves a loss in the efficiency of absorption. In such situations, the person must offset the malabsorption by eating more during the period of recovery. Where malnutrition is widespread, and food supply and income levels place severe limits on the consumption available to low-income families, the malnourished either do not have access to these medically-recommended high intakes (if they did, the malnourishment would not have arisen in the first place), or the extra needs of the clinically ill must be met by reducing the intake (and increasing the malnourishment) of those suffering less severe deprivation. In short, it cannot be said there would be a saving of cost when no cost is actually being incurred.

A category of benefits that appears to be potentially very large for a developing country (but much smaller for a developed country, especially where the prevailing social philosophy calls for relatively equal income distribution) is the reduction in productivity losses caused by the debility of a substantial portion of the labour force. Calculation of these losses, using the standard methods of health economics in the developed countries, would be extremely difficult. Medical data of the kind needed for such calculations are not available for most developing countries. The excess demand on the medical system also means that many of the sick never enter the statistics. The data that are available often reflect cursory diagnoses by paramedical personnel or by doctors whose need to work their way through long queues prevents careful examinations. Moreover, the synergistic character of much prevailing illness makes it difficult to pin down the exact contribution of malnutrition to illness or death. Beyond these problems is the overriding fact that most malnutrition does not show obvious signs and it rarely puts the sufferer into the queues. Thus, the
methods used to measure returns to health in the developed countries are, with some exceptions, usually not very helpful in the developing countries. This is especially true for the added step of determining the malnutrition component. In the developed countries, the fact that a very large fraction of the labour force is registered under institutional arrangements of some kind means that days lost due to illness, and even the nature of the illness can be derived from non-medical statistical sources outside the medical system itself, such as employment data, or medical insurance records. In the developing countries the coverage of medical insurance is normally small, and the large fraction of the labour force that works outside formal institutionalized employment, especially in agriculture, precludes generation of such data.

An alternative approach is to use aggregative data on food supply and the occupational distribution of the labour force. An interesting example is the work of Correa. He starts with an estimate of daily caloric need in different occupations which was worked out by Lehmann and others in Germany in 1949. The German study calculated the per cent shortfalls in work capacity resulting from different levels of shortfall in caloric intake. Correa works out the average caloric need for a country by dividing its labour force into occupational groups comparable to Lehmann’s and then calculating a weighted average caloric requirement for 100% physical capacity (with adjustments for temperature and other factors). By comparing this average with the average national caloric consumption derived from food balance calculations, Correa arrives at national working capacity shortfalls, which for developing countries are almost always very substantial, many being as high as 50% or more. As Correa recognizes, this method poses the same problems that limit the usefulness of the aggregative methods for estimating the incidence of malnutrition. Data limitations necessitate numerous heroic assumptions. The model equates productivity with human energy capacity, a weakness of all static “caloric gap” calculations that cannot take into account the impact of malnutrition on physical and mental capacity during the growth period of those now included in the labour force. A high level of aggregation (e.g., agricultural labour would include everything from chicken keepers to lumberjacks) and lack of regional or ecological differentiation (e.g., the differences in nutrients based on soil quality) can easily lead to large errors, and to the overlooking of the detailed features of the malnutrition problem that would enable one to understand its characteristics and raw relevant programmatic and policy conclusions. Still, the approach is imaginative and conceptually useful. It lays out for the first time, step by step, some of the links between impact on the individual worker and final aggregation into potential impact
on the national economy. For a single country, a more refined model could be developed using finer breakdowns of the labour force, adjustment of Lehmann's factors for local conditions, estimates of caloric requirements more carefully adjusted by occupation and local conditions (including seasonal factors) and estimated daily intake by income level. While this more elaborate approach would take one closer to an estimate of a potentially significant economic shortfall for occupations heavily reliant on human energy, it would stop short of taking account of important additional factors such as early childhood diet, intra-family food distribution, the impact of cooking habits on nutrient content, and the problems of efficiency of absorption.

The problem of surplus labour: In attempting to apply to a developing country any of these methods of calculating the cost of ill-being for present output (or for future output, in the case of a death prevented or a worker brought up to and kept at "par"), one must reckon with the implicit assumption behind all such studies, that the labour force—or more precisely, the occupational groups in which the relevant individual fall—is fully employed. Restoring a person to good health adds nothing to national production if he has no meaningful job. In our discussion with development economists, this is perhaps the most frequent and basic objection raised to all claims for economic benefits to better nutrition.

Developing countries are usually assumed to have a substantial labour surplus resulting from a combination of open unemployment and under-employment. This appears at first glance to weaken the case for seeking productivity benefits from better nutrition, especially for the masses of the unskilled. Although it would take us far afield in this paper to examine the employment problem in any detail, it will be useful to touch on a few aspects that have emerged from recent studies. These are changing our previously oversimplified picture and thereby are weakening the implication that health expenditures in developing countries are essentially welfare improvements with no productive economic payoff.

First, in rural areas it is often more common for labour to be in short supply than in surplus during harvest and other periods of intense activity. Do these workers try to feed themselves seasonally to higher capacity, like draft animals, then recede back to undernourishment and apathy during the slack periods?

Second, even where open employment exists, many functions impaired by a worker's malnourishment cannot be satisfactorily fulfilled by hiring
additional workers. In such cases the existence of a surplus does not argue against returns to better nutrition. Malnutrition also is reflected in accident rates and absenteeism. The literature contains numerous examples of factories where feeding programmes were introduced and lower accident and absenteeism rates were subsequently observed. While a reduction in accidents brings about both a welfare and an economic gain, the impact of reduced absenteeism is less clear in an employment market characterized by open unemployment and where employers make a practice of hiring apparently redundant labour, a common industrial practice in some countries. If two men are in effect sharing one place at a machine or work bench, the absenteeism of one is covered by the presence of the other, the employer (and the employees) sharing the wage for one work place between two men. If one of them were fed enough (and diet was sufficient alone) to eliminate his absenteeism, the result would be an increase in unemployment (unless union rules barred firing for mere—real—redundancy).

Third, it is worth recalling that many areas of the developing world have relatively low man-land ratios and do not appear to have a substantial underemployment problem.

Fourth, on closer examination, the pool of unemployment in many urban centres is not the commonly perceived homogeneous army of mere surplus human energy. Although considerable numbers of unskilled labourers are included in the pool, recent studies show there is also a large amount of unemployment among the educated. The rate of urban unemployment is greater among skilled and educated young people than among manual labourers. For instance in Malaya (1965), the urban unemployment rate among males 15 to 24 with secondary education was 30.9%, and among those with primary education 19.5% compared to 10.4% among male illiterates of the same age. In urban areas of Venezuela (1969) the rate among labourers with secondary education was 10.2%; with primary education 7%, and among illiterate labourers, 4.3%. The young remain unemployed for a while by choice preferring to wait for the job that will gain them entry into the professional field for which they are trained, and in which they will earn the largest future stream of income. This portion of the pool is conspicuous, often volatile, and therefore, a problem; but it reflects what economists call frictional unemployment.

In sum, to dismiss the value of nutrition as a factor in increasing productivity is to assume that underemployed labour is available or can be made available at a transfer cost lower than the incremental nutrition cost.
of providing equivalent work from the labour already in the vicinity, that it possesses required skills, and that the work is technically capable of being divided among more workers than are currently employed. However, provision of adequate nutrition to an adult now in the labour force does not necessarily lead to higher output and may not be most efficient route to higher output. Better health may be a necessary condition to a worker raising his productivity, but it is not a sufficient condition if health is only one of a number of obstructions, such as lack of cooperator factors, or limitations of technology, that have the effect of limiting the possibilities of additional returns to additional labour input. Whether an economically relevant labour surplus really exists at a given time and place, and what factors bar that surplus from productive employment, are empirical questions to which no general answers can be given apart from empirical examination. The key economic question, however, is not merely whether positive returns are possible, and under what circumstances, but rather how these returns compare with costs and with alternative resource uses. Before commenting on this, we should touch on two other aspects of the nutrition/productivity relationship.

Quality of human labour: Implicit in both the surplus labour model and in the attempts made thus far to measure the national production “cost” of malnutrition is the assumption that productivity is exclusively a function of human energy — of numbers of workers. Although energy loss no doubt is substantial, it is a limited basis for calculating the effect of malnutrition on national production. As development proceeds, human quality becomes more important than sheer physical capacity. Human energy gradually is replaced by machine energy (combined with more refined human skills) in many occupations traditionally reliant on human (and animal) strength. The proportion of the work force in agriculture declines, thus reducing demands on human physical energy output. Although this may sound like a long-run description of the development process, it is in fact already happening in many parts of Asia.

Timely initiative, physical dexterity and comprehension of increasingly sophisticated techniques all become critical to the successful exploitation of the new technologies. It has been commonly observed, for example, that large numbers of farmers fall short of maximizing net returns because they fall short, in varying degree, from full application of the recommended practices for cultivating the new high yielding varieties. To some extent this failure reflects constraints beyond the farmers’ control, (e.g., inaccessibility or high cost of credit). Other shortfalls like planting, depth error are not economic, but reflect factors such as education, mental performance level,
dexterity and attention. To our knowledge no effort has been made to sort out the factors in a systematic attempt to identify the limiting ones. Thus, at this stage, one can only point to the potential impact that malnutrition could now be exerting on adult farmers.

Probably the most important example of how poor quality cannot be compensated for by quantity is the small farmer. His decision-making on the use of his own resources is not divisible. If protein malnutrition during his childhood has impaired his mental development, and under-nourishment as an adult is compounding his disadvantages, his efficiency as a farm entrepreneur is not increased by the presence of unemployed labour in the neighbourhood.

Although many of these notions are new in the context of development planning, it is of interest to note that for some years they have been endorsed and commonly incorporated into the planning of military establishments. Special nutrition units have been established and special nutritious products developed. In some developing countries a sizeable portion of the total nutrition research budget is directed to the relationship of nutrition to the effectiveness of the fighting man.

Other economic benefits: There also will be additional economic benefits of a nutrition programme besides the direct productivity benefits as measured by the previously discussed techniques:

Activities of housewives which do not get measured in the national accounts because they do not enter the market economy, are economically important for many reasons, not least of which is the quality of care for the young.

The increased income of the well nourished worker (or well nourished child when he enters the labour force) will improve the living standards of his dependents, thereby raising both their current consumption and their future productivity.

The lower incidence of communicable diseases among the adequately nourished will, in turn, reduce the exposure to these diseases of others not participating in a nutritional programme.

Improved nutrition will raise the returns to other investments closely related to human well-being, such as education where the malnourished child often is unable to cope with the school expectations.
Comparison of benefits with costs: Finally, even where significant opportunities exist for returns to better nutrition, one needs to weigh the costs in relation to benefits. Will the increase in production achieved by the proposed expenditure be greater than the input or resource cost of achieving that increase and how will it compare with returns to alternative investments? The answer to this question will depend on whose malnourishment is to be corrected, what increments in productivity can be expected from these target people, how much programme of extra nutrition will cost, whether the productivity effect is immediate or delayed, and in the latter case, what discount rate is applied to obtain the present values of the benefits and costs that are to be compared.

Even in a labour-surplus market, there are several groups from whom a current or fairly short-run productivity pay-off from nutrition investment could be obtained: workers employed in machine-paced occupations in modern manufacturing sectors; students for whom malnutrition limits the potential joint returns from education and health expenditures; and small farmers facing the more exacting demands of new agricultural technologies. The most lasting and numerically widespread impact, however, probably would derive from providing adequate nutrition to mothers in the last trimester of pregnancy and to children from 6 months up through 3 years of age. Even if the children’s diets are fully adequate only during these critical months, but return to the average levels of their family income thereafter, they will have been brought much closer to their growth potential, particularly their intellectual potential. Even if their energy intake level remains inadequate by some desirable norm during adulthood, their productivity nevertheless will have been ratcheted up to a higher level that is more relevant to a modern economy than a level measured by sheer caloric output capacity.

We might illustrate the arithmetic of an investment in child nutrition with the following example:

Suppose a programme designed to meet all nutritional deficiencies costs $8.00 per child per year. (The $8.00 estimate is based on meeting deficiencies of a diet which currently satisfies three-fourths of a child’s protein need and two-thirds of his caloric need. The calculations were based on actual productive and distribution costs of Bal Ahar, an Indian-produced blended food currently provided in institutional child feeding programmes (It should be noted that the child feeding programme is being used here only for illustrative purposes, and is not being suggested as the lowest cost means of achieving a predetermined nutrition goal). The Bal Ahar commodity cost per child
per year is $5.00; administration cost is 65 pennies. The remaining $1.75 of the $8.00 estimate has been included for what are often non-measured costs such as fuel, cooking equipment and the time that teachers and health centre officials devote to the programme at the expense of their other duties and provides a nutritional supplement from 6 months through the third year to meet existing deficiencies. Let us also suppose that as a result of this programme, a disability in a child’s performance potential is avoided, and the child-turned-breadwinner produces $8.00 more income per year in his years 15 through 50, than he would have otherwise. If his income otherwise would have been $200 per year, productivity would be raised to a 4% higher level (or $208 per year), for the 45 year earning period, and our nutrition investment of about $20.0 would appear to be yielding an annual return of approximately 40%. Of course, returns beginning only 12 years after the investment is made, and stretching so far into the future, are remote compared with more immediate returns available from other investment opportunities. Thus, the notion of our annual 40% return is deceptive and needs to be corrected to take account of the long waiting period for this type of investment.

The standard method of comparing different future streams of costs and benefits is to reduce these streams to a single amount representing their present values. The standard set of compound interest tables used for this purpose show that even if we discount our 35 year $8.00 stream to its present value at a discount rate of 10%, our $20.0 investment still “breaks even.” (A discount rate of 10% is often used in project analysis in the developing countries, based more on a hunch consensus than an accepted body of theory and empirical underpinning). Put another way, if we discount the future returns at 10%, the amount of annual productivity increase needed to break even is about the same as the annual cost of the feeding.

Our illustrative increase in future productivity of 4% looks modest as a minimum result from higher levels of intelligence. What in fact, the actual rate of return will be depends on a large number of factors. The higher the initial income, the smaller proportionately need be the break-even increase in productivity. The larger the potential mental shortfall due to malnutrition, the greater might be the increase in potential performance from better nutrition. Whether the range of mental shortfall is relevant to future productivity depends on what occupational difference the performance improvement can lead to. In addition, the idea of increased productivity used in the example should be broadened to include the values of the side benefits and enhanced returns to other investments, mentioned above.
There are many links in the chains between diet, performance potential and economic returns which are better understood now than just a few years ago, but which require further research before our understanding is satisfactory. However, a broad increase in the intelligence of a substantial fraction of the future labour force is certain to have significant implications for economic growth and modernization. While work proceeds to define these implications more clearly, economic judgment recommends that the search for effective low-cost nutrition delivery systems should be pressed, that development plans be shaped to take account of nutrition objectives, and that investment in child nutrition be significantly increased above present levels. The question, "How much does better nutrition cost?" is obviously just as important as the question of benefits. Space precludes an extended discussion of alternative programmes and their costs.

Suffice to note that revolutions in both agriculture and food technology are now underway which may now provide answers to old problems at lower costs than was previously possible. A broad multi-policy approach to a nutrition strategy and nutrition problems viewed as socio-economic problems—rather than strictly medical or dietary problems—might yield interesting new directions for attacking malnutrition.

Beyond standard economic benefits:

Leadership: The discussion thus far has concentrated on the costs to society from malnutrition among the working masses. Another consideration, even more difficult to quantify but no less real, is the loss to society of potentially outstanding individuals. Since the origin of so many superior people in the middle and upper class is a result of opportunity rather than genetic potential, it seems appropriate to ask how many superior minds have been and are being lost or repressed because of malnutrition? If nutritional risk is as high as studies now indicate—affecting perhaps half of some populations—a substantial number of superior people will never come forward. This refers not just to the priceless contributions of the Tagores and the Gandhis, but also to the one-in-a-thousand or one-in-ten-thousand who can organize large resources, who can innovate, who can move men. Considering how very thin is the leadership elite in most countries on whom rests the burden of the nation's success or failure, such loss would seem to inhibit the chances for economic development.

Equality: A related economic consideration has social and political overtones. For societies whose prevailing philosophy places a premium on egalitarianism, it can be said that the intellectual loss caused by malnu-
Economics of Malnutrition

Malnutrition is the strongest obstacle to attaining this social goal. This is not to state the case for nutrition as a panacea; educational barriers, for example, are immense. However, a malnourished child's chances for social mobility are greatly restricted no matter what else is offered in education or other avenues designed by policy makers to facilitate upward movement within a society. Adequate mental development, hence adequate nutrition, would seem to be a necessary precondition to validate other programmes for mobility that are being developed as a matter of social policy. In short, if a child lacks curiosity and mental energy—to say nothing of the possibility of mental capacity—the other opportunities are not significant.

Human well-being: Most planners today appear to view malnutrition as a welfare issue, and programmes designed to alleviate it are budgeted accordingly. To move beyond this stage of token resources, many of us have assumed the need to justify the relationship of nutrition to development in traditional economic terms. In such terms, the life of the agricultural labourer and his family usually would be categorized as “very poor” or “destitute”. Yet, for all their economic privation, they have the potential for enjoying a wide range of non-economic consumption. We speak, of course, of man's appreciation of nature, of love, of friends, of good talk at the tea stall, and of the joy of children. These enjoyments may be viewed as independent of one's economic status. They include some of the major sources of satisfaction in life, satisfactions which by their nature are not marketable services, neither quantifiable nor measurable in the national accounts when the economist totes up the per capita availability of goods and services for personal “consumption”. But the person who is apathetic and physically drained by nutritional anaemia or debilitated by the seemingly constant bouts with nutritionally related diarrhoeas, cannot really savour these satisfactions. It is well-being, not income, that primarily determines whether or not a man, rich or poor, has the capacity to enjoy these most fundamental sources of human satisfaction. Well-being is the primary requisite, the sine qua non that determines the utility men derive from all other forms of consumption, whether measurable or not. The developing economies are not likely in the near future, to provide a very much wider range of material goods at the lower income levels. But it may be within the power of public policy to improve the level of nutrition, which in turn can increase the capability for a substantial portion of the population to enjoy whatever sources of consumption are available.

Objectives of developments: The purpose of development—of foregoing consumption today in favour of more investment—is to generate a higher level of human well-being tomorrow for more people. To most people in
developing countries, that higher level of well-being substantially means a better diet. Food is a major, perhaps the major problem of their lives. It is central to both their consumption and their production activities. For a person living at the income level that characterizes the malnourished, typically 65 to 80% of income goes for food. As his income rises, the proportion devoted to buying more food declines; but throughout the income range of the problem, the proportion remains high. The inadequacy and uncertain availability of food from year to year represents the condition of underdevelopment at its most immediate and palpable and dangerous.

Thus nutrition cum food represents the thin margin between mere survival and adequate growth and well-being. To be concerned with food as a commodity but not with nutrition—which is food analyzed into its nutritional constituents—reflects a double vision. The economic distinction between food and nutrition—ranking food “high,” nutrition “low”; or food “essential,” nutrition “welfare”—is a false distinction. Food has obvious tangibility features that nutrition lacks. Food costs and supplies can be measured and subjected to economic analysis. Food is unmistakable to the consumer and commands a price that allows measurement for entry into the national accounts. Nutrition in contrast is invisible, dimly understood by most consumers, and seldom commands a price. In fact, despite the essentiality of nutrition for life, the individual’s effective demand for nutrients is in many ways inefficient for meeting his needs. Eating is a complex activity that satisfies several wants besides nutrition—alleviation of hunger, aesthetic preferences, religious prescriptions, social customs. Some of these demands may be mutually inconsistent (e.g., aesthetics vs. nutrition). As the consumer tries to maximize his satisfaction of these several wants, the nutritional demand may be the one most prone to distortion. The consumer is least capable of evaluating the nutritional component and of recognizing the degree to which meeting the other objectives, within his sharp income constraint, is depriving him of the health he assumes he is acquiring. Such considerations argue strongly for government intervention to compensate for consumer inefficiency.

Although one cannot make a valid economic distinction between food and nutrition, one can make a physiological distinction between food quantity and food quality. Both are important; both are inadequate. To propose in 1971 a broad attack on the quantitative or caloric side of malnutrition would coincide with agriculture objective to which most developing nations already are pledged. Certain countries have attained or soon will attain self-sufficiency in cereals. The qualitative side of the food problem is a different story. Many countries, including the United States, are demonstrat-
Economics of Malnutrition

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ing that caloric sufficiency of itself is no answer to malnutrition, but finding solutions to other debilitating nutritional deficiencies has not received the same policy attention. This is not to quarrel with the existing emphasis on quantity, especially when recalling the bleak projections of just a few years ago. Yet, one can now envision a time in the near future when caloric inadequacies shall have been much reduced while serious nutritional deficiencies remain. Knowing what is now known, planners would be derelict in their responsibilities if they awaited the day of cereal adequacy before awakening to the additional needs and the programme preparation time implied in meeting such needs. As indicated earlier, new nutrition-related technologies may now provide more direct shortcuts and enable people to achieve substantially better nutrition and well-being at a much lower income, and much earlier in time than previously was possible.

Nutrition and population:

No discussion of nutrition and development would be complete without mention of certain aspects of the population problem (For a more comprehensive discussion of the subject, see reference 14). Better nutrition would appear to have the initial effect of increasing population growth by reducing mortality, especially infant mortality. If this were all there were to say on the nutrition-population relationship, nutrition programmes would appear to be affecting per capita income in opposite directions at the same time. On the one hand, productivity increases would raise income per capita. On the other, reduced mortality would accelerate the growth in population, tending to lower income per person. What would be the upshot? At this stage of knowledge, we think the answer would take the following form:

In the short run the net effect would depend on whose nutrition is being improved. For example, factory feeding programmes for adults could have immediate impact on output with marginal impact on mortality; with infant and child feeding, the impact is the reverse; mortality reduction is immediate, while the income effect is delayed. Indeed, a Malthusian might argue that the increase in real income experienced by the poor who are (or whose children are) getting a nutrition supplement, would merely allow population to increase until the higher number had cancelled with mortality rising back to its former level.

We know, however, that in the modern era, declining mortality has been followed by a decline in fertility, with per capita incomes rising to high levels and population growth rates falling and even nearing total stability in some
countries. The fertility declines have resulted from a variety of profound rural and economic changes that separate the modern era from man's previous history. High fertility has usually been perceived as desirable and beneficial where children were an economic asset, where security in old age vitally depended on surviving sons in the face of high mortality rates, and where religious and social customs favoured large families. The value and satisfaction of each successive child begins to decline as incomes rise, as the costs of child education increase, as compulsory education postpones the time when a child begins to add to, rather than draw on, family income, as the convenience of contraception improves, and as opportunities increase for female education and higher paying female employment, to mention a few among many factors. One of the most powerful factors inducing smaller family size appear to be declining mortality. As parent's confidence in the survival chances of their earlier children rises, their need for additional children to ensure achievement of desired family size declines. Thus, better nutrition which lowers child mortality can favourably affect one of the most important of the variables determining fertility rates. In addition, nutrition programmes may add a significant incentive to family planning programmes by directly linking services for contraception with measures to raise the well-being of existing children, and thereby their chances of survival.

Population stability in the past was maintained by higher rates of both births and deaths. With mortality declining in the developing countries, clearly the only acceptable route to reestablishment of stability (or much slower growth) is a regime of low rates of both births and deaths. Although further lowering of child mortality is not sufficient by itself, fertility is unlikely to come down to acceptable levels without it.

Thus, paradoxically, an important contribution to lower population growth may be to keep children alive. Because of malnutrition's enormous role in today's high child mortality rates, a planner who accepts this hypothesis would look to nutrition programmes for an important contribution towards attaining family planning objectives.

ACKNOWLEDGEMENT

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Endemic goitre is highly prevalent in Northern Thailand. It is to be found in an area covering approximately 10 provinces with a population of 6 million. The percentage prevalence is 30.90.

Prae, a province in the North, was selected for intensive studies. The advantages in selecting this province were:

1. It was relatively small (population 200,000) so that control programmes can be managed better.

2. Mountain ranges bisect Prae and travelling between these two halves is by rail only: there were only two portals of entry of salt into the province, both by rail. Therefore, salt distribution could be controlled more easily.

3. It offered a rare opportunity of having a control and experimental area within a single province, which were reasonably isolated from each other.

Prevalence studies of endemic goitre were done during 1960-62 among school children in all villages. School goitre was used as an index of current iodine nutrition in this and following surveys because of the lower grades ("young goitre") which were generally found in the school-age group. The results were standardized against variations in number of subjects among different age intervals (from 7 up to 14) by using a standard population (the school population in one village in Prae where prevalence was 0). In subsequent surveys, owing to the convenience in comparing prevalence in Prae with other provinces, the rates were adjusted against a reference population in which there were equal number of subjects in all age intervals.

The prevalence of goitre in Prae ranged from 0-90 percent. Levels of endemicity were defined as follows:
The distribution characteristics of endemic goitre followed a rather definite pattern:

(1) Prevalence was lowest in the river valley but increased considerably toward higher ground and mountain ranges.

(2) There were indications that isolation and a poor economic status generally played a very important role in the occurrence of endemic goitre.

(3) In moderately endemic areas, the morbidity ratio of goitre in both sexes favoured toward the female at a ratio of approximately 1:2 but as prevalence increased, so would the morbidity among the males, until a proportion of 1:1 was reached in the very severe endemic areas.

The correlation coefficient between the prevalence of endemic goitre and the proportion of morbidity in the male and female population is 0.65.

**Aetiology:**

**Iodine deficiency:** Low environmental iodine and low iodine intake are principal causes of endemic goitre in Thailand. Analyses of iodine content in water and soil of one goitrous village in Prat where goitre incidence was high showed very low values of iodine, only 1/4 to 1/7.5 of those of Bangkok. (Table 1). Analyses of the vegetables from the goitre village showed an iodine content as low as 1/6 to 1/16 of those from Bangkok. It is obvious from these analyses that the villagers have been in an environment in which the iodine supply from water and diet are always deficient.

Further, the urinary iodine excretion of the goitrous subjects was only 16 percent that of the Bangkok population, confirming a definite inadequacy of iodine intake.
Goitre in Thailand

TABLE 1

Iodine content of water and soil in Bangkok and in endemic goitre village (Suwanik et al.)

<table>
<thead>
<tr>
<th>Material</th>
<th>Bangkok</th>
<th>Source</th>
<th>Micro-grams per litre</th>
<th>Bangkok</th>
<th>Source</th>
<th>Micro-grams per litre</th>
<th>vs.</th>
<th>Goitre village</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterworks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yom River, Prae</td>
<td></td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>Bangkok</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Well in town, Prae</td>
<td></td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Dhonburi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>Chao Phya River</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stream, Goitre village</td>
<td></td>
<td></td>
<td>3.18</td>
</tr>
<tr>
<td>Bangkok side</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dhonburi side</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Micrograms per Kilogram

<table>
<thead>
<tr>
<th>Material</th>
<th>Bangkok</th>
<th>Source</th>
<th>Micrograms per Kilogram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangkok</td>
<td>1,220.0</td>
<td>Goitre village, Prae</td>
<td>162.0</td>
</tr>
</tbody>
</table>

Interference of thyroid function with goitrogens was excluded. The 24-hour $^{131}$I-uptake by the thyroid was high in these persons. This initial high uptake precluded the presence of any goitrogens which would interfere with iodide trapping. Perchlorate discharge tests were performed by administering 500 mg. potassium perchlorate at the fifth hour after administration of $^{131}$iodine. The results suggested that goitrogens were not interfering with the organic synthesis of thyroid hormones.

The goitrous subjects had much lower serum P.B.I. values than the euthyroids. However, they showed no clinical symptoms or signs of hypothyroidism. Chromatographic analysis of the serum suggested a higher proportion of triiodothyronine in comparison with the normals.

A 2-4 percent incidence of deaf-mutism and mental backwardness was present in the villagers in 3 highly endemic areas of the Prae province. These subjects had, in addition, sizeable goitre. It was believed that isolation, inter-marriage and poor living conditions in such a highly deficient area, for generations, contributed to its development. Cytogenetic studies suggested that severe lack of iodine and eventual reduction in thyroid hormone levels cause somatic cell mutation during critical stages of foetal development.
SALT PRODUCTION, TRADE AND CONSUMPTION:

Salt production in Thailand is concentrated along the coast at the bottom of the Gulf of Thailand, mainly in three or four provinces. From this area, the majority of the nation's solar salt is distributed throughout the country. Some earth salt is manufactured in the north-east provinces in scattered locations, but only in relatively small quantities. Extensive deposits of 99% sodium chloride have been discovered recently in one of the provinces of the northeast, but exploitation and utilization of these resources will not be done in years to come. Statistics available at this time are limited but it is believed the production of solar salt approximates 300/350 thousand tons with exports of 200/250 thousand tons. The remainder is used for internal purposes.

Dietary surveys indicate that the salt consumption per year in endemic areas is between 2 and 5 kg. of common salt per year. If we assume an average of 3½ kg. per capita, the need of the country for alimentary salt in 1970 will be about 130,000 tons, based on the estimated population of 37.8 million by 1970.

The salt is bought from the field and moved by barges to Bangkok to be unloaded at a railway station where it can be shipped directly by rail to the destinations. Approximately 70 percent of salt is moved by rail to the northern goitre area (10,000 tons/year). The remainder is carried by truck or barge traffic. There is very limited control on the salt trade. Salt iodation as a goitre control measure rests on agreement and mutual understanding between the Government and salt traders that:

1. All salt to be shipped to the area will be iodated. Extra expense involved will be borne by the Government.
2. The Government takes the responsibility of promoting the use of iodated salt in the area.
3. Salt will not be sold at a price higher than that of uniodated salt.

The overall consumption of salt is estimated to be about 10 grams per head per day. This amount includes actual consumption of 5 - 6 grams according to surveys made by the Nutrition Division in 1957, 1962 and 1963 and the remainder is included in the preparation of salty food products such as salted fish or meats, fermented fish, shrimp, fish sauce, pastes and pickles.
GOITRE CONTROL MEASURES:

On April 1962, the Government launched a pilot salt iodation project for the control of goitre in Prah with technical assistance from WHO and UNICEF. An iodation plant with a capacity of 4,000 tons/year was set up near the railway station. After the installation and running test of the plant was completed, distribution of iodated salt in that province was started in August 1965. The following year saw the establishment of another small plant in which locally designed machines were used in Chiangmai to provide 200 tons of iodated salt per year for local use.

After 2 years of operation, the programme entered its second phase with an establishment of another iodation plant of 14,000 tons capacity at Menam railway station in Bangkok. This plant served to iodate all salt shipped by rail to the north and was expected to cover a population of 6,000,000 in the 10 provinces of the north where goitre was prevalent.

The level of iodation was set at 1 : 20,000 in terms of iodate, based upon daily requirement per head per day of about 150 micrograms of iodine, and the daily consumption of salt of about 5 grams per head per day. This is probably on the high side, but it is suggested that higher levels of iodine may be desirable, aiming also at its therapeutic goals. We are of the opinion that a high level is much better than a low level especially in those areas where goitre is highly endemic and the lack of iodine in the environment is extreme.

Solar salt commonly consumed in Thailand, especially by the rural population, is in the form of crude crystals of varying sizes. The iodation procedure must be consistent with the consumer’s taste and acceptability. At the start of the project, the dry-mixing method was tried but it gave inconsistent concentrations of iodate with a tendency to be on the low side. The concentrations ratio was as low as 1:9 of the expected level. The iodate content varied depending on the size of the salt grain, the smallest having the highest concentration. Moreover, the iodate settled down at the bottom of the sack. Gravitation and moisture with prolonged storage certainly influenced the concentration. It was decided, therefore, that the dry-mixing method is undesirable for iodation.

Later experiments on drip method showed that all specimens gave iodate concentrations well within the acceptable range. Irrespective of grain size, mixing by dripping gave relatively uniform concentration (ranging from 1:13,000 to 1:26,000). The drip method therefore appears to be
more satisfactory and has since been used at the pilot plant in Bangkok. Samples taken at intervals from the plant and the distributors have been showing satisfactory concentration of iodate.

Iodine loss from storage of iodated salt did not take place until nine months. Considering the turnover rate of salt distribution and consumption, which will be fairly rapid in the poor economic areas, the period of storage will be reasonably shorter than three to six months. Once iodated and distributed to the terminal point, the salt will presumably be consumed before there is any loss or when the iodine loss in the salt is very minimal.

Once the Bangkok Iodation Plant started its operation, which was in August 1968, the Præ and Chiangmai plants were closed down. Seven provinces of the north were from then on supplied by the Bangkok Plant, while the last 3 are being surveyed for future marketing. Simultaneously, an evaluation team was set up with its headquarters in Chiangmai. It took up as its first task the survey of the distribution system of salt. Another task was to see that iodated salt was evenly distributed in all areas. The distribution of iodated salt in different districts of the 7 provinces under the current programme shows a wide prevalence range of 0 to 87 per cent. The points of origin and the village destinations of iodated salt at district level remain to be determined to complete the picture of the salt distribution system.

No law exists in Thailand which specifies exclusive use of iodated salt in any one area. Therefore, conversion of the market to iodated salt is done under following principles:

(1) Health education: through mass media, group meetings and individual contacts.

(2) Focal conversion programme: where goitre prevalence is high, arrangement is made with the village salt traders to import only iodated salt from dealers.

(3) Request for co-operation from truck operators who supply salt to endemic goitre areas to buy iodated salt from franchised dealers only.

The focal conversion programme proved to be effective in most instances and is fast becoming a mainstay in the control of goitre by iodated salt in Thailand.
In 1969, a follow-up survey in school children in the same schools as the preceding surveys was made in some selected areas. Areas were categorized as follows:

1. with uninterrupted iodation for 4 years
   (Pai Tone district)

2. with uninterrupted iodation for 3 years
   (Chiangdao district)

3. with uninterrupted iodation for 1 year
   (Long and Chiengsan districts)

4. with iodation for 3 years interrupted for 1 year
   (Wang Poong village)

5. control area

The results showed a consistent and remarkable drop in goitre prevalence in all areas. The decrease in morbidity does not seem to correspond to the length of iodation, viz., Chiang San rate dropped from 42.0 per cent to 2.6 percent in 1 year while the rate of drop in Pai Tone is comparatively slower (from 54.3 percent to 8.7 percent after 4 years of iodation). This is presumed to be due to another important factor, i.e. the prevalence of iodated salt on the market at any one time.

Goitre rates in Long area are of special interest for while this area was kept free of iodated salt as a control to Pai Tone area, the rates remained consistently high throughout the 5 year period. But after 1 year of iodation, the rate dropped to more than half the original (from 56.4 to 23.7 per cent).

The Pan area, though being in the province covered by the goitre control programme, somehow had not been supplied with iodated salt by existing commercial channels. A resurvey on school children, though unfortunately done during holiday time (with a smaller number of children than the initial survey), still showed consistently high goitre rate (55.3 as against 61 per cent). While the Chiang San area of the same province, with iodated salt on the market, had a rate decrease down to 2.6 per cent in 1 year.
The Wang Poong area originally had a high rate of 84.4 per cent. After 3 years of iodation, the rate was 32.6 per cent. Then there was an interruption of supply due to inadequate distribution of salt through commercial channel. The rate at the end of 1 year after interruption of iodation still showed remarkably low level (0 per cent). It is suggested that the ability of the body to retain administered iodine for a long period of time may be responsible for this phenomenon.

It is expected that if the goitre rate continues to decrease at such a remarkable degree, all areas under coverage of the programme should exhibit goitre rates well below the level of public health significance (30 per cent) by 1971. The deciding factor, of course, will rest on the success in manipulating the salt market.
A syndrome occurring in the Shiraz region characterized by dwarfism, hypogonadism, hepatosplenomegaly and anaemia was described by Prasad et al. in 1961. Originally they reported 11 cases. The usual causes of dwarfism were excluded. All came from villages and their diets were mainly bread made of whole wheat flour and were deficient in animal protein. Detailed laboratory studies excluded liver impairment. Anaemia responded to oral iron treatment, which also brought about a decrease in liver and spleen size, a slight increase in growth and slight but detectable changes in the genitalia. It was suggested that all of the clinical manifestations were due to zinc and iron deficiency, although supporting data could not be obtained.

Two years later Prasad and associates described the same syndrome in 17 dwarfs in Egypt, thus showing that the problem is not limited to Iran. Subsequently, cases have been reported from Turkey and U.S.A. Although all the 17 dwarfs studied in Egypt had blood losses due to parasitic infestation this was not true of those in Shiraz. On the other hand, there was no history of geophagia among the Egyptians. Again the diets consisted almost entirely of bread and beans.

Extensive laboratory investigations showed low plasma zinc concentrations and increased uptake of zinc-65. Other pertinent laboratory findings in these patients were retarded bone age, low urinary gonadotropins and 17-ketosteroids.

In Iran, this syndrome has an incidence of about 3.5% among 18-20 year old males in the rural population.

During the past 2 years therapeutic trials with zinc have been made using dwarfs with this syndrome as voluntary subjects. Sixty-four cases were referred to us by the Army Draft Board and 16 volunteered for the study. Figure 1 shows 8 typical cases of dwarfism. By randomized selection these dwarfs were given either a well-balanced diet with a placebo
Fig. 1. 8 dwarfs, 19-23 years old. Dr. Reinhold (6 ft. tall) and Dr. Ronaghy (5 ft. 8 in.) are shown as controls. The marked degree of growth retardation in these dwarfs is obvious.

(group I) or the same diet plus 120 mg. of zinc sulphate (ZnSO₄·7H₂O) each day (group II). Chronic infection, blood loss, or liver diseases were ruled out. They were kept in a nearby villa under close observation and were brought to the hospital periodically for examinations. The study was carried out with 16 males and 2 females. Recently, Ronaghy and Halsted showed that females also were susceptible to the syndrome. All patients having a hemoglobin of less than 10.0 gm% were treated with iron to raise hemoglobin to this level or higher.

Table 1 shows plasma zinc concentrations in different groups studied. Plasma zinc concentration is not significantly different in American and

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>ug/100 ml *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls Iran</td>
<td>28</td>
<td>95±12</td>
</tr>
<tr>
<td>Controls U.S.</td>
<td>53</td>
<td>96±13</td>
</tr>
<tr>
<td>Dwarfs</td>
<td>20</td>
<td>50±17</td>
</tr>
<tr>
<td>Villagers (6-12)</td>
<td>73</td>
<td>72±12</td>
</tr>
<tr>
<td>Villagers (12-14)</td>
<td>27</td>
<td>68±12</td>
</tr>
</tbody>
</table>

*Mean ± S.D.
Iranian controls. Villagers in Iran have a lower plasma zinc concentration and dwarfs tend to have significantly lower values than those of other villagers.

All except one showed an increase in height during the period of study. However, the response was significantly greater in those receiving zinc with one exception mentioned (Figures 2-5). He had no teeth and in addition

Fig. 2. The effect of hospital diet alone on a 20 year old male. A small change in height is noted in this patient after 6 months.

Fig. 3. The effect of hospital diet plus zinc on another 20 year old dwarf after the same period of time. Significant changes in height and external genitalia are noted.
Fig. 4. A female with the syndrome after good diet for 8 months and then after adding zinc for 3 months.

Fig. 5. The effect of a good diet and zinc after 3 months in a 23 year old female with the syndrome.
showed intestinal malabsorption. For these reasons he was excluded from the statistical evaluation. Table 2 shows the growth increments of the dwarfs after 6 months of treatment. The increment is $4.2 \pm 1.9$ cm. for those who received hospital diet alone and $10.5 \pm 3.7$ cm. for the zinc treated group. This is a highly significant difference when evaluated by the 't' test.

**TABLE 2**

Growth increment in nutritional dwarfs after six months' treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No.</th>
<th>Increase in height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital diet alone</td>
<td>9</td>
<td>$4.2 \pm 1.9^*$</td>
</tr>
<tr>
<td>Hospital diet plus zinc**</td>
<td>8</td>
<td>$10.5 \pm 3.7$, $P &lt; 0.01$</td>
</tr>
</tbody>
</table>

*Mean ± S.D.
**120 mg zinc sulphate daily.

The zinc treated subjects also showed an increase in gonadal function and development of secondary sexual characteristics (Table 3). The interval between admission into hospital and first ejaculation or menstruation is shown. The mean is 224 days (range 179-345) for those on hospital diet alone and 59 days (35-149) for the zinc treated group.

**TABLE 3**

Interval between date of admission and first ejaculation or menstruation

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>(Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Hospital diet alone</td>
<td>9</td>
<td>224</td>
</tr>
<tr>
<td>Hospital diet plus Zn**</td>
<td>7</td>
<td>59</td>
</tr>
</tbody>
</table>
AETIOLOGY:

A remarkable fact disclosed by the survey of conscripts rejected by the Iranian army because of subnormal stature was that all were affected by the syndrome of hypogonadism and arrested growth level in villages. Other evidence previously obtained led us to conclude that the village environment in Iran affected zinc nutrition unfavourably. Thus, zinc concentrations in hair were significantly lower in villagers than in city people. Plasma zinc concentrations also were lower in children and in pregnant women living in villages than in their urban socio-economic counterparts.

Recently, we have studied zinc balances of adult villagers. Very high retentions of dietary zinc and calcium occur following consumption of a hospital diet containing an abundance of available zinc. This is further evidence that villagers are zinc-depleted.

What is it about life in the village that disturbs zinc nutrition? Although the city offers a greater choice of foods, some of which may contain more available zinc than that available to villagers, a food consumption study showed that diets of rural and urban school boys differ little. Presumably, this is because of traditional food preferences, but lack of means may also be a factor. Both the villager in Iran and the city dweller of the poorer classes derive at least 75% of their calorie and protein requirements from bread. However, the bread consumed in the village is made in the home from whole meal wheat flour without leaven and baked without delay. On the other hand, bread in the cities is made in commercial bakeries. Although the same whole meal high extraction flour may be used, the dough is leavened and 2 to 4 hours is allowed for fermentation.

One of the important chemical changes brought about by fermentation is the partial destruction of phytic acid. Phytic acid (inositol hexophosphate) is a cyclic phosphosugar with a high affinity for calcium, magnesium and other divalent metals. All cereal, grains and pulses contain large amounts of phytate which are present as stable calcium and magnesium phytates. Dicalcium phytate in turn forms highly stable combinations with zinc and decreases its availability for absorption from the gastrointestinal tract.

Because the villager regularly consumes large quantities of a bread that contains all of the phytate of the wheat, his intake of phytate must be very high. This is shown by the analyses of village breads (Tonok) summarized in Fig. 6. The mean phytate concentration is 620 mg/100 g. of air dried bread. This is about twice the amount found in sangak or bazari, the
two most widely used city breads. If it is assumed that bread consumption is the same in the city as in villages, then the phytate intake of the villager is twice that of the urban resident. We offer this as the explanation for the various signs of zinc deficiency encountered in many villagers.

Fig. 6. Analysis of village breads.

PREVENTION OF ZINC DEFICIENCY:

The total zinc intake of the villagers averages around 25 mg/day and this exceeds the estimated daily requirement for man of 12 to 15 mg. by an apparently safe margin. However, it is the unavailability of phytate-bound zinc that brings about deficiency despite the seemingly adequate intake. Among several remedies that might be used to overcome the deficit of available zinc, the best would be the provision of a more varied diet which would decrease the consumption of bread and provide available zinc in the form of milk, meat, or sea-foods. Ultimately, this will be accomplished as the income and quality of life of the villager improves. A more practical approach and one that can be put into effect immediately
will be the modification of village bread-making methods so that partial destruction of phytate will occur. Whole meal flours in Iran contain two agents capable of destroying phytate, namely, yeasts and phytates. Addition of water to the flour is followed by active yeast fermentation within one or two hours. Within two to four hours, significant destruction of phytate occurs, as Table 4 shows. Fermentation overnight lowers the phytate concentration. This action of yeast in destroying phytate is well-known and is responsible in part for the low concentration of phytate in Western types of bread. Much could be accomplished also by improvement in flour making and the use of lower extraction flours.

**TABLE 4**

Destruction of phytate in wholemeal flour by fermentation

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>12-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phytate, mg/100 g.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>18</td>
<td>789</td>
<td>594</td>
<td>572</td>
</tr>
<tr>
<td>67</td>
<td>22</td>
<td>644</td>
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<td>570</td>
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<td>627</td>
<td>616</td>
<td>567</td>
</tr>
<tr>
<td>64</td>
<td>27</td>
<td>625</td>
<td>593</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>671</td>
<td>593</td>
<td>493</td>
</tr>
</tbody>
</table>

It is hardly necessary to point out that partial destruction of phytate would simultaneously increase the availability of iron and calcium with beneficial effects upon the anaemias and disturbances of bone metabolism that are so widespread among whole grain consuming populations.

**LOW ZINC AVAILABILITY AND PROTEIN UTILIZATION**

Phytate is closely associated with the proteins of grains and pulses and persists even in partly purified preparations. Oberleas and Prasad in 1969 in a study that deserves the thoughtful attention of all who are working with proteins of grains and pulses have suggested that the relatively poor nutritional value assigned to such proteins results in part from failure of the assay diets to include enough zinc to overcome the chelating action of phytate. For example, when sufficient zinc was added to soyabean assay protein, growth of rats approached closely that of the standard animal assay.
Problem of Zinc Deficiency in the Middle East

protein. Therefore, increasing the amount of available zinc in the rural diet may bring about improved protein utilization.

IMPORTANCE OF ZINC FOR PUBERTAL DEVELOPMENT:

The failure of some boys and girls to undergo puberty when intakes of available zinc are low and their striking response to treatment with zinc clearly shows that zinc must participate in essential processes related to puberty, and that the zinc requirement is increased at this age. The specificity of this need is demonstrated by the ability of zinc treatment to evoke the prepubertal response in gonadal development and growth 5 to 10 years after puberty would normally have occurred. However, it is noteworthy that zinc together with vitamin, mineral, protein and fat supplementation failed to accelerate growth of 6 to 12 year old village school boys. Moreover, in 12-13 year old boys zinc therapy failed to stimulate growth although increase in size of gonads and growth of pubic hair was stimulated as compared with randomly selected boys receiving a placebo. Failure to stimulate growth in these two experiments may mean that zinc exerts its effects late in prepuberty. On the other hand, since these boys continued on the usual village diet, it is also possible that utilization of zinc was interfered with.

The public health implications of the high phytate intakes of rural populations of the developing countries should be a major concern to all of us. It is now 46 years since the rachitogenic action of phytate was recognized. Its effect on interfering with iron absorption was demonstrated in the following decade. The demonstration that high phytate intakes are responsible for zinc deficiency in man adds proof that phytate is indeed a deleterious food constituent. It should be possible to decrease phytate intakes of rural populations by modification of bread making methods. Until this is done, optimal utilization of the essential divalent metals will not be possible nor can the nutritional potentials of the cereals and pulses be fully realized.

REFERENCES

NEUROLATHYRISM

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A brief review of the studies on lathyrism will be presented at this session. It could be pointed out at the outset that two groups of workers have been engaged in investigating this problem in its various facets and have made significant contributions to the elucidation of this problem. The first group is from the National Institute of Nutrition, Hyderabad, and the other group from the Indian Institute of Science, Bangalore.

Two distinctively different syndromes have for long been associated with the ingestion of the seeds of the Lathyrus species. Osteolathyrism is known to be caused by Lathyrus odoratus. This syndrome characterised by skeletal lesions is experimentally inducible in rats and avian species by feeding L. odoratus or the toxic principle, β-aminopropionitrile. Neurolathyrism, on the other hand, is characterised by neurological lesions and is invariably associated with the consumption of Lathyrus sativus. The present discussion will relate to neurolathyrism, a public health problem in parts of Central India.

The problem of neurolathyrism in Central India owes its origin to the practice of cultivation of a hardy leguminous crop, Lathyrus sativus. The seeds have a characteristic triangular shape and grey colour. The consumption of these seeds as a staple food leads to a crippling paralysis. Though this problem was reported in medical literature, the exact aetiological factor(s) was not known. The Indian Council of Medical Research and the National Institute of Nutrition have, therefore, made an extensive study of this problem since 1958. The major approaches of this study have been: (1) epidemiological, (2) clinical, (3) experimental, and (4) prevention and control.

The epidemiological aspects examined revealed the major factors responsible for the cultivation of the crop and its becoming a staple. Lack of adequate irrigational facilities, the hardy nature of the crop, the high yields and the practice of doling out Lathyrus seeds as wages have mainly been responsible for its choice as staple food. There has also been close association of the incidence pattern of the disease with the pattern of consumption of the seeds. Extensive surveys in the endemic zone have
shown the overall incidence of the disease to be around 4%. The disease is prevalent mostly in the landless agricultural labourers. The most susceptible age group is between 11-35 years and males are markedly more susceptible. Females appear to be relatively free from being afflicted by the worst forms of the disease. According to a recent survey, the estimated number of cases of lathyrism was of the order of 25,000 in one district of Rewa with a population of about 6 lakhs.

A brief description of the symptomatology of the disease is appropriate here. The onset of the disease is usually sudden and starts with a severe pain in the lumbar region and myospasm in the calf muscles of the legs. Clinical examination of the established cases of lathyrism show exaggerated knee jerks, ankle clonus, positive Babinski sign, muscular rigidity in the lower part of the legs and a characteristic scissor-gait. Clinical evolution of the disease has shown some interesting features. After the first warning signs (myospasm), most of the cases on record go into various stages of progressive physical disability. An important finding was that apparently healthy subjects subsisting on lathyrus diets, when subjected to physical stress, do exhibit ungainly gait and neurological examination revealed characteristic signs. This has been classified as the “latent” stage. Complete withdrawal of lathyrus from the diet at this stage has resulted in complete remission of the disease and hence this stage is considered important from the preventive aspect. The progression of the paralysis is shown below:
Figure 1 shows typical cases of neurolathyrism. One of the important lacunae in our knowledge of this disease is that there is as yet no clear cut histopathological report from cases of lathyrism regarding the nature of the lesion in the spinal cord. However, on the basis of the clinical picture, it is perhaps justifiable to presume that the lesion is in the pyramidal tract causing damage particularly to the motor neurones of the antero-lateral region.

The experimental aspect of the disease had not registered much progress till 1962 since production of neurolathyrism in various species of experimental animals was not possible by the oral feeding technique. It was in 1963 that a major break-through was made at the National Institute of Nutrition, Hyderabad. It was first demonstrated that administration of a concentrated extract of the seeds by the intra-peritoneal route could result in acute neurological symptoms in chicks. This subsequently led to the isolation and the identification of the actual neurotoxic compound present in the seeds. The neurotoxin has now been identified as 3-(N)-oxalyl aminoaalanine and is present in the cotyledon of the seeds to the extent of about 1%. The
pronounced neurotoxic property of this toxin has been demonstrable in
chicks, ducklings and baby pigeons when administered intraperitoneally.
In all these species, the toxin causes neurological manifestations of an
acute nature (Figures 2, 3 and 4). The optimal dose for the production of

![Image](image1.jpg)

**Fig. 2. Neurotoxic symptoms in a day-old chick administered neurotoxin from *L. sativus*.**

symptoms is 40 mg/100 gm. body weight. Intraperitoneal administration
of the toxin at doses appropriate to the body weight in adult animals did
not result in toxicity. Later, however, it was demonstrated that intrathecal
administration of the toxin to adult monkeys (three doses of 5 mg, each
given on successive days) or intracisternal administration to mice and rats
resulted in permanent neurological damage manifesting mostly as flaccid
paralysis of the legs (Figure 5). Histopathological examination in afflicted
monkeys showed destruction of nerve cells of the grey matter and demyeliniza-
tion of the spinal cord in the dorsolumbar region. This observation has
led to the suggestion that there could be a blood-brain barrier to the toxin
in adult animals. The experimental evidence obtained thus far has indicated
that the neurotoxin present in the seeds could be a major factor responsible
for the causation of neurolathyrism in man.
Having identified the neurotoxic factor, various approaches for prevention of the disease have been suggested. As an extreme step, banning the crop has been suggested. It soon became obvious that this was not practically feasible for immediate implementation. The next step was that of nutrition education in the endemic zone to reduce the intake of lathyrs to the minimum. A level of 25% of total daily intake was recommended as safe. This step again proved to be a slow-moving process. The next suggestion was to remove the toxin from the seeds by processing. The fact that the neurotoxin was a free amino acid, soluble in water, made it possible for evolving methods for removal of the toxin from the seeds. These methods were tried on a laboratory scale and then on a pilot scale for bulk samples. Two methods have been formulated and both these processing methods effect a removal of the toxin to the extent of 80-90%. These methods are being popularised in the endemic areas.

The first one is the steeping method where a large volume of water...
(3-4 times the quantity of seeds) is first brought to boil, the fuel is removed and the seeds then soaked in hot water for one hour. The steep liquor is then rejected. The seeds are then dried in the sun. This method can be easily practised at house-hold level. The defect in this method was that it resulted in the loss of water-soluble nutrients such as minerals and B-complex vitamins. An improvement over this method is the parboiling method. This is applicable to bulk processing, using the existing designs for parboiling of rice. The seeds are first subjected to prior soaking in luke-warm water in masonry tanks and the wet seeds are then charged into large steaming kettles and steamed for 15 minutes. The steam condensate removes the toxin to the extent of 80-90%. The seeds are then sun-dried. The product thus processed is good enough for preparation of chapathis (unleavened bread) and is acceptable to the consumers. A pilot project is to be set up in one of the endemic districts to popularise this method in the rural areas.
Another approach for removal of the toxin is the genetic approach. It has been known that the incidence of the disease has shown wide variation in the lathyrus growing regions. The northern zone in Madhya Pradesh is known to be highly endemic. An analysis of 600 samples of seeds drawn from nine districts of Madhya Pradesh showed wide variations in the concentration of the toxin (0.1 - 2.5%), the seeds with a high concentration being mostly from the northern zone. This study has led to a genetic selection of low-toxin lines of *Lathyrus sativus*. Collaborative efforts by the National Institute of Nutrition and the Indian Agricultural Research Institute have shown that it is possible to selectively breed low toxin lines. It is perhaps possible in the near future to get a toxin-free variety also. These measures will eventually lead to the gradual eradication of the crippling paralysis in man.
URINARY LITHIASIS IN THAILAND
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The medical literature of Western Europe, Great Britain and the United States in the 19th century, contains many references to the problem of idiopathic vesical lithiasis particularly in young children. This disease is no longer a major problem in the modern, industrialized countries. Reports of calculus disease in children following infection, immobilization, bladder—neck obstruction, and as a secondary response to foreign bodies in the bladder, continue to appear but cases of unknown etiology are rarely seen.

Idiopathic vesical disease, however, continues to be a major medical problem in many of the developing countries, particularly in the Middle East, the Near East, and the Far East. Among the many recent reports are those of Anderson in India,1 Tan in Indonesia,2 Ramadan in Syria,3 Eckstein in Turkey,4 and Halstead and Valyasevi in Thailand.5 It thus appears that the disease has, with the passage of time, disappeared from the more industrialized and affluent societies but continues in some rural areas of the agricultural, developing countries. However, it is interesting to note that vesical lithiasis has not been reported to occur with great frequency in children of South America, Central or South Africa.

In those areas where the disease is endemic in children, some similarities can be seen as follows: (1) It occurs predominantly in children under 10 yrs. of age. (2) The rate of hospital admissions is higher for boys than for girls. (3) Renal stones are not usually associated with the disease. (4) The rate of recurrence following surgical removal is estimated to be low in comparison to renal lithiasis in adults. (5) The stones are usually composed of ammonium acid urate with calcium oxalate or calcium phosphate. (6) The disease generally occurs among children of low socio-economic class; however, it has not been associated with overt signs of vitamin deficiency or protein malnutrition.

EPIDEMIOLOGICAL, CLINICAL AND BIOCHEMICAL STUDIES IN THAILAND:

In Thailand, the disease is much more common in the North and Northeast regions. Hospitalization for bladder stone was reported to occur
as much as 10 to 100 times higher in these two areas, as compared to the Central and South regions.

At the Ubol Provincial Hospital in Northeast Thailand, 53 percent of the major operations (excluding obstetrics and gynaecology) during 1956 to 1962 were for stones of the urinary tract. Admissions for bladder stones peaked at 3 to 4 years of age, and 47.2 percent of all admissions were children under the age of 5. It is of particular interest that about 6 percent of patients with bladder and urethral stones were children under 1 year of age. Crystalllographic studies of 200 bladder stones obtained from Northeast Thailand showed that calcium oxalate and ammonium acid urate are the two main compositions of these stones.

Epidemiological, nutritional and biochemical studies carried out in Ubol Province, the largest province in the Northeast with a population of over 1 million and mostly Lao-Thai ethnic group, revealed a striking difference in the incidence between the urban and rural areas. In Ubol city, the largest urban centre of the province, hardly any cases of vesical lithiasis were found. On the other hand, in the rural areas only a few kilometers from the city, the incidence of calculus disease in children was high. Though they are the same ethnic group (Lao-Thai) and live under the same environment there were marked differences in the prevalence of the disease. The over-all prevalence rate was 1.2 percent. Since the population of Northeast Thailand was about 9 millions at the time of study, it is estimated that there are probably 100,000 persons suffering from this disease at any one period.

The epidemiological findings in Thailand uncovered a unique opportunity for study of this disease in populations living in the same general area, of the same ethnic background, and yet having widely different rates of occurrence. The most pertinent findings can be summarized as follows:

1. Infant feeding practices—about 60 percent of village mothers started their infants on supplemental glutinous rice feedings during the first week of life and about 80 percent during the first month of life. In the city, on the other hand, only 8 percent of the mothers stated that they fed infants supplemental foods during the first 4 weeks of life. The amount of glutinous rice fed to village infants could supply approximately 50 to 60 calories per kilogram of body weight per day.

2. The 24-hour urine volume of the village newborn is significantly less than the city group. The urinary osmolarity was also low as compared to their counterpart in the city.
3. The concentrations and the 24-hour excretion value of phosphate in urine was significantly lower in the infants from rural areas. On the contrary, the urinary concentration and 24-hour excretion values of calcium were higher in the village than in the city newborns. No differences could be demonstrated in the older age group.

4. The total inorganic sulphate and the free inorganic sulphate in the urine were lower in samples from village boys up to 1 year of age. This was true whether the data were expressed on the basis of concentration, 24-hour excretion or expressed in relation to creatinine excretion.

5. Oxalate crystalluria was observed in 12 of the 28 village infants under 45 days of age. On the other hand, none of the 30 city infants of the same age group had oxalate crystalluria. Uric acid crystalluria was found equally in both village and city samples.

DIETARY SUPPLEMENTATION:

As has been reported previously, experimental animals form uroliths when fed diets deficient in inorganic phosphate or when their diets contain marginal levels of protein or sulphur-containing amino acids. Some insight into the question of the factors operating in the aetiology of pediatric bladder stone disease was obtained by studies of the influence of oral orthophosphate and milk supplementation upon crystalluria and urinary composition.

Oral orthophosphate and milk (Organic phosphate):

It was found that oral orthophosphate supplementation, in the amount of 500 to 600 mg of phosphorus daily, completely eliminated oxalate crystalluria and reduced the occurrence of uric acid crystalluria. Withdrawal of the phosphate supplement resulted in the recurrence of crystalluria within a few days. Infants receiving milk (~P 600 mg) demonstrated fewer occurrences of oxalate and uric acid crystalluria than the same infants during the control period when no supplement was provided.

The total urinary excretion of phosphate was uniformly low during the control period, but markedly increased after supplementation with orthophosphate. At the same time, the urinary calcium excretion was markedly decreased. In all subjects, the ingestion of either orthophosphate or milk induced a two to ten-fold increase in urinary pyrophosphate excretion.
It is of special interest to observe that administration of either orthophosphate or milk also induced a significant decrease of urinary oxalate excretion.

**Oral 4-hydroxy-L-proline:**

Further studies were carried out to find the possible sources of oxalate acid and the possible role of phosphate on oxalate metabolism.

Figure 1 shows the metabolic pathways of glyoxalate and oxalate. There are four possible external sources of oxalate viz. glycine, serine, hydroxyproline and ascorbic acid.

Studies designed to evaluate the role of these precursors on oxalate production were carried out in village infants. Among these precursors, hydroxyproline appeared to have a significant influence on urinary oxalic acid excretion and oxalocrystalluria.

One gram of 4-hydroxy-L-proline per day was given orally for 10 days after a control period and for 7 days after a 7-day supplementation of

**Fig. 1.**

The metabolic pathways of glyoxalate and oxalate
orthophosphate. Orthophosphate, approximately 500 mg phosphate in 5 ml.
solution (containing 1.75 g NaHPO₄ and 0.27 g KH₂PO₄ to provide an
approximately neutral pH) was administered daily for a period of 7 days.
All mothers were instructed to follow their routine feedings, including
breast milk, premasticated glutinous rice and water.

The number of subjects, mean ages and sequences of the supplementation
are shown in Table 1. During the control period, out of 60 examinations,
20 occurrences and 4 clumpings were observed. When oral hydroxyproline
was given, 93 occurrences and 47 clumpings were demonstrated among the
150 examinations (Table 2). This increase is statistically significant.

**TABLE 1**

<table>
<thead>
<tr>
<th>Villages</th>
<th>Number of subjects</th>
<th>Mean Sequence of supplem. ages, months</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>Control-HP₁-PO₄-HP₂</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>Control-HP₁-PO₄-HP₂</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>Control-HP₁-PO₄</td>
</tr>
</tbody>
</table>

A = Nong Jara, B = Tung Kun Noi, C = Nong Kae.
Control = distilled water for 5 days HP₁ = first period of 4-hydroxy-L-proline (1 g/day) for
10 days PO₄ = phosphate buffer (400-500 mg P/day) for 7 days and HP₂ = second period
of 4-hydroxy-L-proline (1 g/day) for 7 days.

**TABLE 2**

Effect of oral hydroxyproline and phosphate supplementations on oxalate crystalluria

<table>
<thead>
<tr>
<th>Period</th>
<th>Supplementation</th>
<th>Oxalate crystalluria</th>
<th>Number of infants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number of exam.</td>
<td>Number of occur.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Control, 4 days</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Hydroxyproline, 10 days</td>
<td>150</td>
<td>93</td>
</tr>
<tr>
<td>3</td>
<td>PO₄ buffer, 7 days</td>
<td>150</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>Hydroxyproline, 7 days</td>
<td>70</td>
<td>46</td>
</tr>
</tbody>
</table>

Statistical analysis was performed to compare the number of occurrences and clumping
versus number of examinations between periods 1:2, 2:3 and 3:4. \( P > 0.01 \) (by \( \chi^2 \)).
The oxalate crystals formed during the control period were mostly in the octahedral form (Figure 2). When hydroxyproline was administered, clumping of crystals was demonstrated as shown in Figure 3, and 4. The crystals were bigger and mostly in either dumbbell or ring forms. When these infants received the phosphate supplementation, clumping disappeared within 3 days and the number of oxalate crystals were remarkably reduced. Few crystals, in either dumbbell or ring forms were still found, but these crystals were partially broken as shown in Figures 5 and 6. It appears that the oral administration of hydroxyproline increased oxalate crystalluria and also induced clumping of these crystals. These findings were previously reported elsewhere.

The urinary excretions of oxalic acid and hydroxyproline after the supplementations are shown in Figure 7. The values are means ± standard errors. Hydroxyproline and oxalic acid excretions were significantly increased during the hydroxyproline supplementation period. Phosphate supplementation reduced the excretion of these two compounds. Oxalate crystalluria and the clumping phenomena were also markedly increased during the hydroxyproline supplementation period. Practically no crystals were found during phosphate supplementation.

Fig. 2 Oxalate crystalluria during the control period. Calcium oxalate crystals, octahedral form. X 400
A. Valyasevi and S. Dhanamitta

Fig. 3. Oxalate crystalluria during hydroxy-L-proline supplementation period. Clumping of calcium oxalate crystals, octahedral form X 400.

Fig. 4. Oxalate crystalluria during hydroxy-L-proline supplementation period. Clumping of calcium oxalate crystals, dumbbell and ring forms X 400.
Fig. 5. Oxalate crystalluria during phosphate supplementation. Calcium oxalate crystal, partially broken. X 800.

Fig. 6. Oxalate crystalluria during phosphate supplementation. Calcium oxalate crystal, completely broken. X 800.
The findings suggested that oral hydroxyproline administration induced high urinary hydroxyproline and oxalic acid excretions; and at the same time, oxalate crystals were increased in number and were clumped together. During the phosphate supplementation period, urinary hydroxyproline and oxalic acid excretions were markedly reduced and there was neither oxalate crystals nor clumping.

The mean urinary hydroxyproline excretion and concentration were studied in village infants. The results are shown in Figure 8. It is demonstrated that village infants, especially during the neonatal period, excreted higher amount of urinary hydroxyproline than the city group. Furthermore, urine volume especially during the first 4 weeks of life was small; therefore, urinary hydroxyproline concentration was even higher in this group of infants.

Hydroxyproline is derived almost entirely from collagen. In rats, it is estimated that about one-third of the total urinary hydroxyproline is derived from soluble collagen and the other two-thirds from insoluble collagen. Increased urinary hydroxyproline during growth depends on an increase in soluble collagen in the tissue.
We do not know the reason for high urinary hydroxyproline excretion in these village infants.

When the crystals and clumpings were stained with alcian blue, (stain mucopolysaccharide), it was observed that these crystals were attached to uromucoproteins. Studies of urinary mucoprotein revealed that village newborns excreted significantly higher amounts of total nondialyzable solie (TNDS) than the city group whose excretion of TNDS was comparable to that of American newborns (Figure 9). Furthermore, village newborns and infants excreted significantly lower percentages of the low molecular weight fraction and higher percentages of the high molecular weight fraction. Mia and Cornelius have reported a significant increase in the high molecular weight fraction in the urine of sheep receiving a "calculi-producing" diet. The high concentration of TNDS in the urine of these infants may favour
the clumping of the crystals. However, the reason for the difference in the excretion of TNDS and various fractions of biocolloid between the two areas is not known.

**Fig. 9.**

**URINARY TOTAL NON-DIALYZABLE SOLIDS (TNDS)**

**IN INFANTS (Ubol Thailand)**

- Ubol Village
- Ubol City

**AGES**

**HYPOTHESIS OF AETIOLOGY:**

Figure 10 shows our working hypothesis which is as follows:

Low dietary phosphate intake leads to a low urinary phosphate excretion and a relatively high urinary calcium excretion. Low intakes of protein and minerals, particularly Ca and P may contribute to poor bone development. Possibly collagen synthesis occurs at a normal rate but the utilization of the collagen to form bone and the various connective tissue is limited.
Should this occur, the unutilized collagen might be converted mostly to hydroxyproline and partly to oxalate. The other possible sources of high urinary hydroxyproline excretion may be from diets such as vegetables, fermented fish and the glutinous rice itself.

Deficiency of substances which enhance solubility (citrate, sulfate, Na, K, Mg, etc.) or substances which inhibit crystallization (pyrophosphate) may also promote oxalate crystal formation.

High urinary hydroxyproline excretion and concentration induce oxalate crystal formation. Furthermore, the size of these crystals will become bigger and their shapes may also change from octahedral to concentric forms. High urinary mucoprotein excretion may further induce clumping. If low urinary phosphate and high urinary hydroxyproline excretions continue for a considerable period of time, crystal clumping will become bigger and bigger. This clump will turn into a nidus of the stone eventually.

Fortunately, the majority of infants and children in these endemic areas may not continuously excrete low phosphate and high hydroxyproline due
to variations in dietary and fluid intakes etc. Therefore, the new crystal will probably not develop and crystal clumping will not occur.

Other factors such as long urethra in the male and anomaly of urinary tract, may also be important in the pathogenesis of the bladder stone disease.

Further longitudinal studies will be required to support this hypothesis. At the same time, it is also hoped that investigators in other endemic areas would carry out further studies in this direction.

REFERENCES

PELLAGRA IN SORGHUM EATERS

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Hyderabad-7, India

The association of pellagra with a maize diet has been recognized for more than a century. This association has been attributed to the low tryptophan content of maize and to the poor availability of its nicotinic acid. In the poor communities of South India, where rice is the staple, pellagra is uncommon. However, the disease is commonly encountered among the poorer communities of the Deccan plateau of India. In and around Hyderabad, agricultural labourers frequently suffer from this disease and nearly 1% of admissions to the general hospitals particularly in winter months are cases of pellagra.

A careful examination of the dietaries of these patients revealed that in more than 65% of cases the staple was jowar (Sorghum vulgare) and in 25% of cases history of consumption of both maize and jowar was obtained. These diets provided about 2000 calories and 45 g. of protein derived mainly from vegetable sources.

The clinical features of the cases investigated here were not different from those cases of pellagra reported elsewhere. They had typical bilateral, symmetrical dermatitis affecting the exposed, extensor surfaces of the body with varying grades of oral lesions like angular stomatitis and glossitis. Mental changes of a mild nature were seen in majority of cases.

Comparison of the chemical composition of rice, jowar and maize (Table 1) shows that the nicotinic acid content of jowar is similar to rice. The tryptophan content varies widely, certain strains having as high a content as in rice and others having low values. The nature of nicotinic acid present in the millet, jowar has been investigated. Acid methanol extracts of jowar on chromatographic analysis did not reveal the presence of bound nicotinic acid in jowar. Growth of rats and pups fed on jowar or lime treated jowar diets showed that the rats and pups consuming jowar diet grew better than those consuming treated jowar (Fig. 1) showing thereby that the nicotinic acid in jowar was mostly in an available form. Therefore, pellagra among jowar eaters cannot be explained either on the basis of
low tryptophan content or poor availability of the nicotinic acid, the two factors which are said to operate in maize eaters. However, both jowar and maize have one common feature with regard to their amino acid content: a high content of leucine.

**TABLE 1**

Amino acid composition of maize, jowar and rice

<table>
<thead>
<tr>
<th></th>
<th>Tryptophan</th>
<th>Leucine</th>
<th>Isoleucine</th>
<th>Nicotinic Acid*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize**</td>
<td>0.8</td>
<td>14.8</td>
<td>6.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Jowar@</td>
<td>1.2</td>
<td>12.9</td>
<td>6.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Rice</td>
<td>1.7</td>
<td>8.0</td>
<td>6.0</td>
<td>1.2</td>
</tr>
</tbody>
</table>

**Maize** et al (1946).
@Balasubramanian et al (1952).
†gr. 100 gr. of protein.
*mg per 100 ml.

BELAVADY & GOPALAN: AVAILABILITY OF NICOTINIC ACID IN JOWAR

![Graph showing growth curve of pups](image)

Fig. 1. Growth curve of pups
(†) Indicates the beginning of nicotinic acid administration.
(1)+ (3) Pups on treated jowar diet.
(2)+ (4) Pups on jowar diet.
(5) Pups on control diet.
Elvehjem and Harper et al. showed that supplementation of leucine caused retardation of growth in rats subsisting on low protein diet. The average protein intake in the dietaries of pellagrins is about 9%, the quality of the protein being poor. Therefore, the role of amino acid imbalance resulting from excess intake of leucine from jowar in the pathogenesis of pellagra was investigated in this laboratory.

RESULTS OF EXPERIMENTS CONDUCTED IN HUMANS:

The effects of oral administration of leucine on the metabolism of tryptophan and nicotinic acid were investigated in normal subjects and pellagrins. These subjects were fed a standard diet supplying approximately 50 g. protein (derived mainly from vegetable sources) and 2,500 calories. After stabilisation, each subject received 10 g. of leucine daily for a period of 7-8 days and later leucine was withdrawn. These studies showed that both in normal subjects and pellagrins, leucine supplements brought about a significant increase in the excretion of quinolinic acid and a significant decrease in the excretion of 6-pyridone of N-methyl nicotinamide (Table 2). The effects of the leucine administration were exaggerated in the presence of tryptophan load. On the other hand lysine supplementation did not alter the urinary excretion of tryptophan metabolites.

Also leucine administration produced a deterioration in the mental condition. An investigation of electroencephalographic patterns revealed abnormal patterns which were aggravated after leucine administration. The aggravation of the EEG abnormalities was associated with deterioration of the mental condition.

A possible effect of amino acid imbalance may be an interference with the utilisation of nicotinic acid for formation of nucleotides. To investigate this point, nicotinamide nucleotide synthesis in vitro in erythrocytes was investigated both in normals and pellagrins before and after leucine supplementation. The results showed that though the total concentration of nucleotides in pellagrins was not different from that of normal subjects, the ability of erythrocytes to synthesize these nucleotides in vitro was significantly low in pellagrins (Table 3). Oral administration of leucine depressed the synthesizing ability of erythrocytes; quinolinic acid also brought about a significant inhibition of synthesis in vitro. All these changes, however, did not actually alter the total nucleotide concentration in the erythrocytes. These apparently paradoxical results could be explained if the pattern of nucleotides was different in these subjects. Fractionation of the nucleotides was, therefore, carried out and marked differences were observed between
TABLE 2
Effect of leucine and lysine on the urinary excretion of tryptophan and some of its metabolites in normal subjects and in pellagrins
(Excretion in mg/24 hrs)

<table>
<thead>
<tr>
<th>Metabolite</th>
<th>Normal subjects</th>
<th>Pellagrins</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>of leucine</td>
<td>of leucine</td>
<td>of leucine</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>181.0 ± 12.79</td>
<td>146.7 ± 13.88</td>
<td>113.5 ± 9.96</td>
</tr>
<tr>
<td>Quinolinic acid</td>
<td>9.4 ± 2.35</td>
<td>32.2 ± 4.58</td>
<td>5.3 ± 0.80</td>
</tr>
<tr>
<td>Nicotinic acid</td>
<td>6.0 ± 0.78</td>
<td>6.7 ± 0.87</td>
<td>4.9 ± 0.83</td>
</tr>
<tr>
<td>N-Methyl nicotinamide</td>
<td>6.1 ± 0.22</td>
<td>6.9 ± 0.40</td>
<td>3.7 ± 0.3</td>
</tr>
<tr>
<td>6-Pyridone of N-Methyl nicotinamide</td>
<td>4.6 ± 0.3</td>
<td>1.7 ± 0.28</td>
<td>3.2 ± 0.52</td>
</tr>
<tr>
<td>5 Hydroxy indole acetic acid</td>
<td>28.6 ± 3.52</td>
<td>18 ± 2.19*</td>
<td>12.2 ± 1.23</td>
</tr>
<tr>
<td>Indoxyl</td>
<td>18.3 ± 1.68</td>
<td>13.5 ± 1.12*</td>
<td>27.5 ± 2.86</td>
</tr>
<tr>
<td>Total</td>
<td>26.6 ± 3.49</td>
<td>24.9 ± 2.58</td>
<td>13.9 ± 2.01</td>
</tr>
<tr>
<td>Free</td>
<td>12.9 ± 1.52</td>
<td>9.3 ± 0.85*</td>
<td>7.7 ± 1.15</td>
</tr>
</tbody>
</table>

*Significant difference; P<0.05.
**Significant difference; P<0.001

Experimental details are given in the text. The results are given as the means ± S.E. of six subjects from each group with leucine and from 3 subjects with lysine.
### TABLE 3

Effect of leucine on erythrocyte nicotinamide nucleotides in normal subjects and pellagrins

Nicotinamide nucleotides (mg/100 ml of erythrocytes)

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>5 days after leucine</th>
<th>5 days after leucine withdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual concentration</td>
<td>Synthetic activity</td>
<td>Actual concentration</td>
</tr>
<tr>
<td>Normal subjects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.7±0.42 (8)</td>
<td>11.8±0.90 (5)</td>
<td>4.3±0.29 (8)</td>
</tr>
<tr>
<td>Pellagrins</td>
<td>4.9±0.38 (8)</td>
<td>7.6±1.30 (5)</td>
<td>4.3±0.56 (8)</td>
</tr>
</tbody>
</table>

Values are given as means ± S.E.M. with the number of subjects in parentheses.
<table>
<thead>
<tr>
<th>Number of subjects</th>
<th>Erythrocytes mg/100 ml</th>
<th>Total nicotinamide nucleotides</th>
<th>NMN</th>
<th>NAD</th>
<th>NADP</th>
<th>% NMN</th>
<th>% NAD</th>
<th>% NADP</th>
<th>NAD/NADP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normals</td>
<td>12</td>
<td>5.02±0.44</td>
<td>2.48±0.27</td>
<td>1.41±0.21</td>
<td>54.42±2.13</td>
<td>34.58±2.13</td>
<td>1.99±0.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pellagrins</td>
<td>20</td>
<td>4.97±0.66</td>
<td>0.73±0.09</td>
<td>2.13±0.19</td>
<td>1.00±0.17</td>
<td>18.96±2.11</td>
<td>53.40±2.53</td>
<td>27.63±2.45</td>
<td>2.15±0.22</td>
</tr>
<tr>
<td>Pellagrins after treatment</td>
<td>10</td>
<td>4.97±0.66</td>
<td>0.18±0.04</td>
<td>3.01±0.45</td>
<td>1.38±0.14</td>
<td>6.50±2.04</td>
<td>62.80±2.79</td>
<td>30.70±2.45</td>
<td>2.18±0.21</td>
</tr>
</tbody>
</table>

Values are means ± S.E.

a. Not detectable except in 3 subjects.
normals and pellagrins. In cases of pellagra, erythrocytes contained significantly higher amounts of NMN and lower amounts of NAD and NADP as compared with erythrocytes from control subjects (Table 4). In controls NMN was present in very small amounts and averaged only 2.5% of total nucleotides while in pellagrins this accounted for nearly 20% of the total. Therapy with nicotinic acid brought about a reduction in NMN concentration and an increase in NAD and NADP levels.

RESULTS OF EXPERIMENTAL STUDIES WITH ANIMALS:

Experiments with leucine feeding in rats gave results which were similar to those observed in human beings. In both young and adult animals, leucine feeding brought about a significant increase in the urinary excretion of quinolinic acid and N-methyl nicotinamide.

Direct evidence that jowar was pellagragenic was obtained from experiments conducted in dogs. Dogs fed diets containing 65% jowar developed signs of 'black tongue'. The animals showed loss of appetite, salivation, characteristic ulceration of buccal mucosa and bloody diarrhoea. Animals which were treated with nicotinic acid improved. Black tongue could also be produced when diet containing 18% casein and enough of nicotinic acid was supplemented with leucine. Nicotinic acid deficiency was also induced in adult monkeys by feeding diets containing jowar.

Plant geneticists have developed a strain of maize called 'Opaque-2' strain which is nutritionally superior to the common varieties of maize. The leucine content of this variety is low and this enabled us to study the role of leucine in production of 'black tongue' in dog. The conventional 'Deccan Hybrid' variety of maize unlike 'Opaque-2' is very high in leucine. All pups fed on Opaque-2 maize diet showed good growth and remained healthy while pups fed Deccan Hybrid variety developed black tongue (Fig. 2). On the other hand animals fed Opaque-2 maize diet but which were also given leucine supplements developed the disease.

Mode of action of leucine

Studies were carried out in rats to elucidate the mechanism of action of leucine. One of the effects of excessive intakes of leucine is an increased excretion of urinary quinolinic acid. Effects of feeding leucine on the activities of some of the enzymes concerned with the metabolism of tryptophan via nicotinic acid pathway were investigated. Feeding leucine increased the levels of tryptophan pyrrolase and decreased QPRT (quinolinate phospho
ribosyl transferase). These effects could provide partial explanation for the increased formation of quinolinic acid and decreased formation of pyridine nucleotides. This observation coupled with the observation of inhibition of nucleotide synthesis from niacin in erythrocytes of pellagrins and leucine fed subjects may offer a biochemical explanation for the occurrence of pellagra in sorghum eaters.

Fig. 2. Litter-mate pups.
The pup on the right had developed black tongue on a diet based on Deccan Hybrid maize.
The pup on the left had received opaque-2 maize diet during the same period.

Leucine and mental changes
The precise manner in which leucine is involved in bringing about mental changes is still not clear. Levels of platelet serotonin in pellagrins with mental depression are significantly low as compared to normals. In line with this observation, rats fed 10% casein diet to which leucine was supplemented showed significantly low levels of brain serotonin as compared with control animals. The mental changes seen in pellagrins could be related to decreased levels of brain serotonin brought about by excessive intake of leucine from the diet but obviously further work is necessary on this aspect.
Pellagra in Sorghum Eaters

CONCLUSION

Studies reviewed above strongly suggest that excess of leucine may be aetiologically related to pellagra. This observation is interesting as this is the first demonstration of a human nutritional disorder brought about by amino acid imbalance. The observation is also of practical importance as it indicates that the identification of low leucine strains of jowar and maize and the selective propagation of such strains will be a practical approach to the problem in some parts of the world.

REFERENCES

REPORT ON THE INTERNATIONAL SYMPOSIUM ON CRITERIA AND METHODOLOGY FOR ASSESSMENT OF NUTRITIONAL STATUS (INTERPRETATION OF NUTRITION SURVEY DATA) HELD IN TOKYO IN NOVEMBER, 1970

NORIO SHIMAZONO

Department of Biochemistry,
Tokyo Medical College, Shinjuku-ku, Tokyo, Japan

It is my pleasure to have this opportunity to present a report on the International Symposium on Criteria and Methodology for Assessment of Nutrition Status, which was held in Tokyo on November 6th and 7th, 1970 under the auspices of the Malnutrition Panels of the U.S.-Japan Cooperative Medical Science Program. About a hundred participants came together, sixteen from South-East Asia, fourteen from the United States, and seventy from Japan. Asian countries from where the participants came were Indonesia, Korea, Malaysia, Philippines, Republic of China and Thailand. Indian nutritionists were also invited, but they cancelled the participation because of inevitable circumstances which occurred directly before the meeting. We are much obliged to all the participants for the success of the Symposium.

The programme was divided into four sessions, each of which had three subjects, and after several papers were presented on each subject, one hour discussion was given for each session. Forty-one papers were presented in total, and the abstracts were printed beforehand. We have the plan to publish the proceedings of the Symposium including the papers presented and discussions. Today I shall try to summarize the Symposium by a brief comment on each subject.

In the opening session the use of clinical data was discussed. It was clear that clinical examination was of value for the identification of characteristic nutritional syndromes, but it was relatively of little value in surveys because the appearance of the clinical signs is too late and too non-specific to be useful in the detection of mild forms of malnutrition. A useful way of using clinical data is obtained by correlation analysis with biochemical and dietary data.

The next topic was the use of anthropometric data, which are widely
used as sensitive indicators of nutritional status. Not only height and weight, but bone density, skinfold thickness and sometimes body proportion can also be useful to reveal the nutritional changes.

In considering dietary data it was clear that there are very large errors inherent in the collection of dietary data. Most data are collected as family data, and there is usually no information on the distribution of food among individual members of the family. The discussion pointed out the need for improvement of methodology. A question was raised as to how the recommended dietary allowances should be indicated in order to be useful for dietary survey: whether it should indicate the quantity of oral intake or the quantity of nutrient absorbed from the alimentary tract.

Biochemical data in nutritional surveys are thought to be specific and quantitative. Although the levels of vitamins and other nutrients in blood and urine have been measured as indicators of nutritional status, it is more important to know the functional measures rather than such static ones. Measures of enzymatic activity, for example, give a good indication of nutritional status, if the normal values have been established in a large number of normal people. In nutritional surveys of a large population, however, there are difficulties in performing biochemical tests and also difficulties in obtaining samples of blood, faeces and urine. It was also clear from the discussion that the interpretation of the biochemical data is still a problem.

In the discussion on the use of haematological data the multifunctional nature of nutritional anaemias was emphasized and that it was felt that it is not sufficient in a survey to identify the mere presence of anaemia but surveys need to go further and try to identify the specific factors which are responsible.

Endocrinological data will be very useful additional functional measures to the above-mentioned survey data. Fasting and malnutrition have a specific influence on the secretion of growth hormone, insulin, and selected adrenocorticosteroid hormones. The urinary secretion of 17-ketosteroids and 17-hydroxycorticosteroids seem to be sensitive to protein deficiency, but they are also affected by various other factors and experimental complications. It is necessary at present to seek adequate methods for the measurements of endocrinological functions.

On the second day we had the following sessions:

The discussion indicated that there are not only considerable problems of measurement in getting psychomotor cognitive data but also there are
problems of separating the effects of nutritional, psychological and social factors on the cognitive data.

In the discussion on behavioural data, the correlation of hunger and malnutrition was considered. The discussion revealed that in malnutrition socio-cultural factors, psychological factors and biological factors have important roles to play.

In the next topic electrophysiological techniques in the assessment of the effects of malnutrition were summarized, and, of these, electroencephalography proved to be one of the most promising. It will provide a measure of the effect of malnutrition on the functioning of the central nervous system, although the general application will be limited because of the need of equipment.

The discussion of physical performance clarified that the measure of maximum work capacity or maximum oxygen uptake would be sometimes useful for the nutrition survey. Examples were given and the influences of extreme heat, body hypohydration, food deprivation, protein and water intakes upon physical work were presented.

The next subject was vital statistics. It was emphasized that though infant morbidity or mortality data included all children under five years of age frequently, it would be better if age specific mortality focusing on the one month to one year and the second year death rates were used separately. The correlation between nutritional factors and the occurrence of various diseases in the population was also discussed.

Finally the response to infection was discussed. Disease specific mortality for common communicable diseases of childhood, particularly measles, and the incidence of diarrhoea, respiratory infections and total infectious episodes among pre-school children were found to indicate the prevalence of nutritional deficiency and to reflect a favourable response to effective nutrition intervention programmes.

These are the rough outlines of the presentations and discussions of the Symposium. This year the Malnutrition Panels of the U.S.-Japan Cooperative Medical Science Program have a plan to hold the Symposium on Role of Nutrition Intervention in Programs of National Development in Cambridge, Massachusetts, U.S.A. from October 18 – 23, under the organization of Dr. Scrimshaw.
Forty people from Nigeria, U.K., U.S.A., New Zealand, Hungary, Sweden, India, Ceylon and FAO., with experience in agronomy, biochemistry, food technology, animal nutrition, home science and large scale production, attended a three day "Technical Group" meeting on leaf protein organised by the International Biological Program in Sri Avinashilingam Home Science College, Coimbatore-11, from November 25-27, 1970 under the Chairmanship of Professor N. W. Pirie.

So far, the protein that has been made in quantities adequate for feeding trials has come from conventional crop plants. Many of these plants were not selected for abundant vegetative growth, but as sources of seed. We agreed that this work should continue, because the farming methods are known and that it should be extended to studies on crop strains that have been rejected for use in the usual manner; these may yield abundant vegetative growth. A very large group of fast-growing plants of species that are not now used in agriculture should also be examined. With support from the IBP, extraction equipment has been made that is suitable for laboratory scale work. This gives accurate and reproducible results and it should be used wherever possible in further work on screening plant species for the extractability of the protein in them. Plants, which are not used in agriculture now, when grown and harvested on a field scale are obviously the main potential source of protein. Some attention was also given at the meeting to the use of water weeds because much effort is already being expended on attempts to control or eradicate them. Because of the difficulty of collecting them, tree leaves are a possible but less probable source. We know already that many crops yield 3 or 4 times as much extractable leaf protein, per hectare and year, as can be produced by any other system of agriculture.
Work coordinated by the IBP so far, is restricted to this survey of the yields attainable from different species subjected to different forms of husbandry. Looking further ahead, the Technical Group considered the quality of the protein. Amino acid analyses show that protein made from different species, or harvested at different stages of growth, has a uniform composition and that the distribution of amino acids in it, is similar to that in FAO “reference protein”.

Feeding experiments on various animal species were discussed at the meeting. The possible explanations for some disagreement between amino acid analyses and the results of animal feeding were also considered. Part of the lysine is probably made unavailable to the animal, because of complex formation with polyphenols and similar substances that are present in the leaf. Further research was planned on means for minimising this complex formation by quick processing, by extracting in the presence of substances that would protect the protein from complex formation, and by selecting plant species that are relatively free from the substances that cause these harmful reactions. There is a satisfactory tentative explanation for the lysine discrepancy. A similar discrepancy between methionine analyses and the results of feeding animals on diets containing leaf protein with and without added methionine are as yet unexplained. This will be the subject of further research.

Work that has already been published showing that leaf protein improves nitrogen retention in infants and growth in children was discussed. It is more difficult to reach firm conclusions about acceptance by adults with established food habits. The experience of several participants at the meeting led to the conclusion that, with skill and patience acceptance can be won. Experience shows that any novel food is at first approached warily but that acceptance increases with experience. Different social groups react differently. An interesting survey in Nigeria showed that farmers and university staff were more ready than clerks to accept a novelty. The importance of example and of choosing the best conventional food as a vehicle for leaf protein was stressed.

The leaf protein used in these acceptance trials contains lipid and chlorophyll. Some participants felt that acceptance would be easier if solvent-extracted material, which is pale brown rather than green, were used. The experience of others shows that dislike for the green colour is soon overcome and is not a permanent obstacle. Furthermore, solvent extraction would greatly increase the cost of the product. Much of the carotene of the leaf accompanies the protein and it would be removed
by solvent extraction. The values vary from 0.5 to 2 mg. per g. of dry protein according to the species from which the protein was made. Because of the importance of leaf protein as a carotene source, the group agreed that the lipid should, if possible, be retained.

The basic argument for leaf protein production is that the yield is enhanced by using crops while in the vegetative stage of growth rather than waiting until they have reached maturity and produced seeds or some such conventional product. Vegetative growth is the basis of animal husbandry but conversion in animals is inefficient. By extraction we get half to two thirds of the protein in the form of human food. The remainder is in the fibrous residue and is still available for ruminant animals. When cattle are being intensively reared on pelleted feed, the process of drying a lush forage such as lucerne is expensive. The fibrous residue after leaf protein extraction contains 30 to 35% of dry matter compared to 8 to 12% in the raw crop. Drying costs are correspondingly smaller. This factor alone makes leaf protein production an attractive proposition in the USA and it is already being undertaken primarily as a means of cheapening the production of dry cattle feed with the extracted protein as a by-product that is used (mainly on account of its xanthophyll content) as chicken feed. It is sold for 25 US cents per kg. More thorough pressing and washing would increase the cost slightly and bring the cost into line with the UK estimate of 3 to 4 shillings per kg.

Those who have advocated leaf protein production have, from the very beginning, conceived it as an integrated process of fractionation in which raw material suited to only one use is converted into three products, each suited to a different use. The Technical Group fully endorsed this approach and realised that economic success depended on the optimal use of each product. Between 10 and 30%, of the dry matter of the leaf is soluble in water and appears in the whey that separates when protein is coagulated. This also must be used for economy and to avoid local pollution. Unlike the leaf or the protein-containing extract made from it, the whey can be economically concentrated in a vacuum multiple effect evaporator. In Hungary, it is added back to the protein for use in feed for non-ruminants. In Sweeden, New Zealand and Pakistan it is used as a medium on which to grow yeasts and other microorganisms. The merits of these different approaches will be examined more fully in future.

Bearing all these factors in mind, the Technical Group agreed that the research on leaf protein and the general problem of leaf fractionation should be encouraged. At the concluding session, presided over by Dr. K. K. P. N.
Rao, Regional Nutrition Officer, FAO, New Delhi, they agreed on a set of recommendations given below:

AGRONOMY:

1. (a) The amenability for protein extraction of existing crop plants should be studied.

   (b) It is likely that some of the plants hitherto unexplored may show better N extraction, be amenable to successive cuttings and be photosynthetically very efficient and non-toxic. Therefore, this work should be continued and extended.

   (c) Species found promising should be grown on replicated small plots with adequate fertilizer, and their regrowth ability explored using standard equipment for assessment of yields.

2. Agronomic trials should be carried out to investigate:

   (a) Spacing.

   (b) Fertilizer treatments.

   (c) Spraying micronutrients and chemicals, etc.

   (d) Effects of different frequencies of cuttings.

   (e) Seasonal variations — crops should be sown at different seasons because it is possible that growth at an unusual time of year will enhance vegetable growth.

3. Conventional crops which produce by-product leaves must be fully utilised.

PROCESSING AND ECONOMICS:

1. It is a generally accepted fact that a rapidly growing demand for different forms of protein is to be expected in the immediate future.

2. The past major emphasis of leaf protein research has been directed to the development and improvement of equipment and methodology adapted for small scale production for human consumption. Inter-
national Agencies should encourage and extend work with this equipment.

3. (a) Future endeavours should be directed also towards industrial scale ventures to produce both fodder and nutritionally adequate LPC for human consumption, and towards this end large scale feasibility studies should be made in various regions.

(b) Initial generous support for the capital costs of the first plants will be needed.

(c) Adequate number of research and technical personnel should be trained.

4. Basic research should be supported on factors affecting the yield and quality of leaf protein.

**EVALUATION:**

1. The adoption of a standard biological test for LPC, is recommended. The most suitable appears to be the AOAC method for PER estimation with rats. Both PER and weight should be reported.

*Nutrient standard*

In the absence of reliable data from a standard test, we recommend the following tentative levels. These would, however, be modified in the light of the collaborative work prepared.

\[
\begin{align*}
\text{PER} & : 1.5 \\
\text{Wt. gain} & : 25 \text{ g. in 4 weeks} \\
\text{Ash} & : \leq 5\% \text{ and total soluble solids} & : \leq 1\% 
\end{align*}
\]

2. We recommend that standard samples of LPC should be distributed (from a common source) for collaborative work.

*Topics for research:*

(a) Methods for available lysine estimation suitable for LPC.
(b) Studies on carotene content and stability.
(c) Shelf-life studies.
(d) Factors affecting quality using the standard PER technique.
ACCEPTANCE:

1. A tentative specification of a food grade leaf protein will be laid down in consultation with different workers at the national and international level.

2. Any plant producing leaf protein should meet the requirements laid down by the health authorities.

3. The products so produced will be tested in the nutrition laboratories. Home science colleges and other institutions.
   
   (a) For this purpose they must locate those food preparations, which are commonly and frequently consumed in the region and which will lend themselves to the incorporation of leaf protein.
   
   (b) For the commonly eaten preparations, recipes incorporating leaf protein should be developed and standardised. The objective is to ensure the consumption of at least 10 g. of leaf protein (i.e. 6 g. of 100% protein) per person per day. Efforts should be directed towards including this amount in one serving.
   
   (c) The recipes developed should be tested for acceptability by small and large groups.

4. Pilot nutritional feeding programmes should be organised to demonstrate the feasibility, the long term acceptability, and the nutritional benefits of leaf proteins.

5. Home Science Associations and allied organisations should constitute national working groups to implement these suggestions with the necessary financial assistance from governments and other agencies.

Acknowledgement:

The assistance rendered by Professor N. W. Pirie, The International Biological Program, and Dr. B. R. Seshachar, Chairman of the Indian Branch of the IBP is gratefully acknowledged.
The First South East Asian Regional Seminar on Nutrition was conducted under the auspices of the Central Coordinating Board of Tropical Medicine and Public Health – SEAMEC (South East Asian Ministers of Education Council) and the Faculty of Medicine, University of Indonesia, and held in Djakarta during October 27 to 31, 1969.

The idea of conducting a South East Asian Regional Seminar on Nutrition was based on the fact that in the South East Asian countries there is a similarity of conditions, needs and nutrition problems.

Population problems, food supply, marketing, education, public health problems and even the menu patterns are almost the same. Thus, exchanging knowledge, ideas and experience should be of benefit to us in our attempt to find a solution for our problem.

Realising the lack and utmost importance of a sound food policy and availability of experts in the field of nutrition the main objectives of the Seminar were formulated as follows:

1. To provide the medical profession with a good appreciation of a sound food policy, to be achieved through the exchange of information between participants from the SEAMEC member countries, invited guests and other attendants, and to formulate joint recommendations for mutual benefit.

2. To discuss the necessary requirements for a workable programme and basic curriculum of a post graduate course in Nutrition in the SEAMEC countries taking into consideration the present situation in South East Asia and the experiences in this field in other countries.
The total number of participants was 119 including those from the SEAMEC member countries, experts from other countries, M.N. and other agencies.

Five main groups of topics were discussed:

I. Population problem and family planning in relation to food supply and consumption.

II. Public health and clinical nutrition problems in South East Asia.
   Dietetics in the SEAMEC countries
   Parameters of health and nutrition

III. Menu patterns in the SEAMEC member countries and its relation to the existing deficiency diseases.
   Food composition tables.
   Nutrient and food allowances.

IV. Evaluation of food supply and consumption and of protein and carbohydrate sources.
   Processing and marketing of food.

V. a. Institutional development in nutrition.
    b. Post graduate course in nutrition.
    c. Teaching of nutrition in medical schools.

The general opinion of the participants of the Seminar was as follows:

1. The importance of family planning in relation to food supply at present was recognized as the increase of food production cannot keep pace with the high population increase in the SEAMEC member countries.

Family planning has been started in the SEAMEC member countries. Its implementation should be adopted taking into consideration the socio cultural conditions in each member country. Both husband and wife should be the focus in family planning.
2. The preschool age group was considered the most vulnerable group of the population in relation to malnutrition. It was felt that more efforts should be made to reach them at home and to stimulate the participation of the community.

3. Methods for the assessment of the nutritional state of the individual and community should be as practical as possible while all parameters for evaluation (Somatometric, biochemical, clinical) should be viewed as an entity.

4. The vitamin A deficiency problem, one of the important causes of blindness got much attention. A practical and effective way of prevention (administration of high doses of vitamin A 200,000–300,000 I.U. twice or once yearly, depending on local conditions) was considered.

5. The relatively low protein intake in the SEAMEC member countries was considered to be due to socio-cultural and economic factors.

6. Potential indigenous protein sources should be explored and exploited.

7. Food tables are considered an important tool in menu planning. Thus exchange of information and standardization of food analysis would be of much benefit.

8. A sound food policy is important for the planning of food supply adequate to meet the requirements of a healthy population. The first condition to achieve it is a close coordination and cooperation between the various disciplines like health, agriculture, economics, education, sociology and administration.

9. A need was felt for a well controlled Food and Drug legislation, adjusted to the socio-economic conditions in each member country.

10. The physician and nutritionist should take an active role in the establishment of the nutrient and food requirement standards of their country.

11. A strong need for teaching of nutrition in medical schools in the South East Asian countries was expressed; its implementation should take into consideration the local conditions. A coordinated
and integrated nutrition teaching was recommended with or without a separate Nutrition Department in the medical school.

12. A curriculum of an applied nutrition course to serve the First Regional Post Graduate Nutrition Course to be held in Jakarta, conducted by the Faculty of Medicine, University of Indonesia at the Indonesian National Centre for Tropical Medicine (Nutrition and Isotopes) of the CCBTM & PH — SEAMEO, was considered favourable.
This FAO Congress, which was held in the Hague from 16 to 30 June, 1970, was attended by about 1800 participants of whom over 600 were from developing countries and about 300 were under the age of 30. All participants had been invited to attend by the Director-General of FAO on a personal basis. People from widely different backgrounds attended the Congress. Some had been suggested by their Governments, others by non-governmental organizations or Freedom-from-Hunger Committees or by the United Nations or other specialized agencies. The final selection of those to be invited rested with the Director-General of FAO.

The main work of this Congress was done in eight commissions on the following subjects: Ensuring basic food supplies; Higher living standards and improved diets; People in rural development; Trade patterns and policies; Public sector support; Private sector support; Direct participation programmes; Mobilization of public opinion. The first four of these were held simultaneously during the first week and the last four during the second week. Background papers for each commission were pre-circulated.

In addition, there were panel discussions on the FAO Indicative World Plan for Agricultural Development; The role of youth in development; Perspectives of international development; Population growth in relation to economic development; and the conservation of man's environment. At the opening session addresses were given by H.M. Queen Juliana, H.E. U Thant, the Right Hon. Lester B. Pearson, the Burgomaster of The Hague and the Dutch Minister for Development Cooperation. All the addresses were relevant and some were bold. The Director-General of FAO, Dr. A. H. Boerma, gave an excellent keynote address at the beginning of the second day.

I attended the Congress from 16 to 25 June, heard the opening addresses and all the panel discussions. I joined the work of Commission II on higher living standards and improved diets, which was mainly about
increasing the protein content of the diets of nutritionally vulnerable groups and the need to develop national food and nutrition policies. Nothing scientifically new was said in this Commission. I thought it a mistake that the work of Commissions I and II were not combined. Commission I on ensuring basic food supplies was concerned with ensuring energy supplies and it appeared to me to be unsound scientifically to separate this discussion from that of Commission II on the protein problem. I also attended the first few sessions of Commission VIII on the mobilisation of public opinion, but left the Congress before the end of its work and so did not see its final report. The discussion I heard was mainly on local community action.

The Congress was of considerable political, economic and social interest and its theme might be said to have lain in President Kennedy's words during his opening address to the First World Food Congress: "We have the face of the earth in our own lifetime. We need only the will". These words were often quoted and the large youth contingent made it very plain that they felt passionately that not much will had been demonstrated in the seven years since that Congress and that what is now required is action and no more words. To underline this many of them went on hunger strike one day and they drew up a pledge form asking participants to promise 1% of their salaries for development.

At the end of the first part of the Congress, i.e., after the reports of the first four Commissions had been presented, the Chairman of the Congress (the Dutch Minister of Agriculture) summed up as follows:

I. There have been three main themes:

1. There is strong recognition of the fact that the speed of development depends on social, economic and political factors. Advances in science and technology alone may worsen the situation of the poor.

2. To achieve proper application of science and technology may require changes in the structure (economic, social and perhaps political) of countries.

3. New attempts must be made to bring all sections of populations into planning their own development.

II. Three important points have come up throughout the discussions:

1. Population must be controlled and family planning policies are
necessary throughout the world (there was an almost violent dis-
cussion on this — pro and con — during the panel on this subject.
All panel members were for population control. Much of the
audience, particularly the Africans, was not).

2. There is need for land reform, and the modernisation of rural
life (The Commission III report on people in rural development
was rejected by the plenary session on the ground that its recom-
mendations were thought to be too weak. It was to be redrafted).

3. Increased production will not, of itself, mean improved life or the
possibility of closing the protein gap unless it is accompanied by
redistribution of income.

III. It is relatively easy to say what should be done. It is difficult to
decide how to do it.

I found the Congress interesting and also disturbing, and am glad I had
the opportunity of attending. To give some indication of why I found
the Congress disturbing I quote the speech delivered by a representative
of the youth village at the closing ceremony of the Congress — most of
the younger participants lived at the so-called "New Earth Village", where
a pre-congress conference had been held, and it was from this community
that the constant enthusiasm and critical vigour of the younger participants
came. They held frequent meetings among themselves and invited senior
members of the Congress to the village for nightly discussions. The following
is the text of this closing speech.

"This is the last day before we end.

"But let us ask the question — have we really begun?

"We have talked in generalities and technicalities about food and
agriculture but the problem of development is not merely filling a man's
belly nor increasing the gross national product without at the same time
taking into consideration economic, social and moral implications.

"Hunger is a human problem — the dignity of man is at stake.

"And we have failed to get to the root of this problem.

"We have no illusions about this.
"All attempts to solve this problem within the existing system are bound to fail.

"Our experience of the past two weeks has only confirmed us of this.

"Strong and substantial proposals in this Food Congress are either ignored or watered down to tame and diplomatic proportions.

"Economic and political expediency has prevailed over human and moral considerations.

"There is an immediate need for radical transformation of the international economic order.

"There has been some confusion as to what is negative and what is positive.

"Too often criticism of existing structures and policies is rejected as being negative.

"This is not true.

"Positive criticism of existing orders must take place before concrete proposals can have their full impact.

"Nobody can rebuild a new order without critical evaluation of existing structures.

"There is much to be done and we are determined to do the following:

commit our support to the movements to liberate people of the Third World from hunger and malnutrition through concrete proposals of social justice and agrarian reforms;

fight the exploitation by our respective governments and elite classes both in the exploiting and exploited countries;

exert all efforts to bring to the attention of the whole world the plight of millions of peoples in exploited countries;

commit ourselves to the struggle for individual freedom and human dignity as a basic guiding principle in nation building;
eliminate all aid programmes which perpetuate a relationship among nations, a relationship of donor and beggar;

expose all international agencies and business establishments which undermine the economics of the Third World in the guise of aid and technological assistance...

fight all rich elite throughout whose main preoccupation is the accumulation of wealth which causes great exploitation of helpless masses.

"Further, we commit ourselves:

to support the struggles of people for social, political and economic independence through education and concrete organization of the peasants, labourers and other exploited and discriminated groups in society;

to morally and financially support just strikes of agricultural and industrial workers;

to help in the educational and organizational activities designed to awaken people to their rights and free them from the bondage of social inequality, social injustice and exploitation;

to pressure governments to reduce the outrageous expenditure on armaments and to channel this budget to liberating people, not destroying them;

to create pressure groups within countries for the implementation of the UNCTAD II resolutions and the major recommendations of this Congress;

to struggle for the opening of world markets without discrimination and with the basic right for equitable and remunerative prices;

and further commit ourselves to the implementation of these action programmes before the end of the Second Development Decade.

"Furthermore, we extend our appreciation for the opportunity for dialogue in the Congress. But this dialogue must be continued at all times and at all places, always involving youth and all other discriminated groups in society (for example women).

"We leave now, determined to act, and express our solidarity with all peoples' struggles for liberation from exploitation."
In his closing speech, the Director-General of FAO said:

"So now we come to the end of the Second World Food Congress.

"Let me say straight out that this has been one of the most exhilarating of my whole career.

"Firstly, on the personal plane, I have learned a lot and, when you get to my stage of life, it is encouraging to know that you still have new things to learn.

"Much more important of course is that we have all learned a lot from each other. It has often been the fashion to be rather cynical about international conferences, sometimes in the conferences themselves. Now, whatever else may be said about this Congress, it cannot be charged with cynicism."

Dr. Boerma went on to discuss the views expressed at the Congress and the action required of FAO. He explained something of the powers and responsibilities of FAO and then went on to say:

"But it will not just be for FAO to act. It will be for us all. For you, as well as for FAO, this Congress is not an end but a beginning. I hope that you all — whether as members of organizations or as individuals — will, like us, study the recommendations of this Congress which you helped to frame, and work out ways in which you can also help to see that they are carried out. Everything depends on this, on your continued participation in the objectives of this Congress once you have left these halls."

A report of the Second World Food Congress has been published in two volumes by FAO. This contains the text of the major speeches, reports of Commissions with their detailed recommendations and the full text of the Final Declaration of the Second World Food Congress.
REPORT ON THE IUNS CONFERENCE IN TUNIS, TUNISIA,
JANUARY 21-26, 1971

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Colombia University,
New York, N.Y. 10032, U.S.A.

The conference was primarily a workshop meeting of the committees,
 commissions, and council of the International union of nutritional sciences.
 In addition there were three half-day symposia on topics of special current
 interest.

Thirty-three countries were represented in the total attendance of over
100 participants. All officers, four additional members of the Council,
all commissions' chairmen except one, and representatives of all but three
committees were present. Five committees in commission V did not plan
for special meetings, but reports from others will be available.

Representatives were present from WHO, FAO, UNICEF and UNESCO.
The date for the conference was selected so that travel could be facilitated
for subsequent UN nutrition meetings in Rome, and particularly the First
Asian Congress of Nutrition in Hyderabad, India, January 26–February 2,
1971.

The contract with the Government of Tunisia and USAID for financial
support was managed very efficiently and with excellent co-operation.
However, the total of travel cost and per diem allowances limited the
number of cost-supported invitations to not more than 90 persons; hence
it was not possible to provide for all committee members. Selections had
to be made largely on a basis of reaching as many representatives of member
societies as possible, starting with an initial list of 90 and making replace­
ments as rapidly as communications permitted.

Proceedings from the conference, perhaps in mimeograph form will be
distributed to all members of committees, commissions and the council
and there is a possibility that they will be published in an established
journal.
Arrangements were approved whereby Nutrition Abstracts and Reviews will publish appropriate material furnished by the IUNS for their consideration, including in regular issues a special section for such items as (a) minutes of Council meetings and meetings of the general assembly, (b) advance announcements of officially sponsored conferences and congresses, (c) references to official committee reports, including summaries when of sufficient importance, (d) news items of special importance to nutrition scientists, and (e) when feasible, occasional reports in full, on a cost basis for reprints. Such items will be free from copyright restrictions.

The council expressed an active interest in the feasibility of establishing a permanent secretariat for the IUNS, jointly with other unions in the International Council of Scientific Unions (ICSU), e.g. in Biology, Biochemistry, Biophysics and Physiology.

Plans for the Ninth International Congress on Nutrition in Mexico City, September 3-9, 1972 were discussed at length with the Secretary-General, Dr. Chavez. All were agreed that it would be helpful to each host society in future years, for the IUNS to be officially responsible for organizing the technical parts of all International Congress, as is now the practice among all the other members of ICSU. Dr. Shimazono announced that Japan was prepared to issue a formal invitation to serve as host for the Tenth International Congress on Nutrition in 1975. The Council welcomed this assurance.

The Council agreed that communications with the International Union of Food Science and Technology (ICFUST) should be kept active and cordial to maintain an effective provision for expressions of mutual interest.

Dr. O. L. Klive was authorized to continue his activities in the direction of establishing a monitoring system for research in nutrition, on an international basis, particularly in association with the IBP and a successor organization as contemplated by UNESCO and ICSU. He had been active in exploring such a possibility while serving as Chairman of Committees I-II of the IUNS.

Commission III, Dr. Gyorgy et al, is arranging for a conference in Belgrade, Yugoslavia in 1971, to be sponsored jointly with other agencies.

Committee 7-I, Dr. Scrimshaw et al, is arranging a special conference on protein foods at MIT, October 25-27, 1971.
Dr. Guitzt reported at the conference that they had identified a new type of chemical material in the river water in Columbia, S.A. which is an active factor in causing endemic goitre, even when the iodine intake is sufficient to normally prevent goitre.

The Council noted with pleasure that Dr. Blaxter has succeeded in reorganizing the committee structure in Commission VI, and suggested that a note could be prepared to record this listing of personnel for insertions in the new IUNS directory.

The Council voted a resolution of appreciation to Dr. Kallal and those associated with him, for the excellent and generous hospitality extended in preparation for and during the conference; and a second resolution in appreciation of the work of Dr. King and those associated with him in preparation for the participation of members in the conference.
VITAMIN A NUTRITIONAL STATUS OF CHILDREN IN EAST JERUSALEM

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Heller Institute of Medical Research, Tel-Aviv University
School of Medicine, Tel-Aviv, Israel.

A. Rishni
Nutrition Unit, Ministry of Health, Jerusalem, Israel.

This is a preliminary report to a study on vitamin A status of children in East Jerusalem which started in the latter part of 1970 and which still continues.

Vitamin A deficiency has proved a major public health problem in the Middle East. Patwardhan found that 8.1% of the children below 6 years of age in East Jerusalem and Amman had clinical manifestations of vitamin A deficiency. Most of them had serum retinol levels which have been considered "low" by existing standards. He found that the ages most affected were between 3 and 5. Pharaon and co-workers found 5% of the children of Jordan below 5 years of age with "deficient" levels of serum retinol.

These alarming findings prompted us to evaluate the nutritional status of vitamin A in East Jerusalem as it exists today, so that a plan could be prepared to combat the deficiency if it indeed existed. In the future we would like to expand the study so as to include the population of the West bank as well as low income segments of the Israeli population.

THE STUDY CONSISTED OF THREE PARTS:

1. A clinical examination for vitamin A and other gross deficiency symptoms on 50 children, 5 years of age from low income families.

2. A chemical determination of blood haemoglobin and serum retinol and carotene levels.

3. An interview with the mothers of children for the collection of recall data on food purchases and consumption.

The 50 children who participated in our study were pointed out by the headmasters of their schools as coming from lowest income families. The
schools attended by the children provide free education which is compulsory from the age of 5 to 14. Children from private schools were not included since they represented higher income groups and better fed classes.

The clinical examination followed the criteria outlined by Darby and Pharaon in their ICNND Report, which included examination of the conjunctiva and cornea for xerosis, Bitot's spots, angular lesions, cheilosis, and other deficiency symptoms.

Haemoglobin was determined by the cyanomethaemoglobin method. Vitamin A was determined by the Carr-Price reaction, and carotene was determined by its absorbance at 450 mμ. A correction was made to the absorbance of 3 carotene at 620 mμ in the Carr-Price determination of Vitamin A.

The interview questionnaire with the mothers contained three sections: The first included questions on the family's socio-economic background, such as profession, number and ages of family members, number of rooms in the house etc. Here we also included a question on the occurrence of night blindness in the family. The second section included questions on intakes of vitamin A rich foods from plant origin. Here we succeeded in getting qualitative information only. The errors involved in obtaining quantitative data in this regard were too enormous. The third part included questions on the family's periodic food purchases, such as sacks of flour per year, loaves of bread per day, etc.

The results of our clinical examinations showed no deficiency symptoms of vitamin A or any other essential factor. When considering the fact that the sample studied was of a vulnerable age and represented the lowest income families there seems to be an improvement in the vitamin A nutritional status of the East Jerusalemites. Our findings on blood haemoglobin and serum vitamin A and carotene levels are shown in Table 1.

<table>
<thead>
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<th>TABLE 1</th>
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</table>

Vitamin A, carotene and haemoglobin levels of five year old children from low income families in East Jerusalem

<table>
<thead>
<tr>
<th>Vitamin A /μg/100 ml serum</th>
<th>Carotene /μg/100 ml serum</th>
<th>Haemoglobin grams/100 ml blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. ± S.D.</td>
<td>Ave. ± S.D.</td>
<td>Ave. ± S.D.</td>
</tr>
<tr>
<td>16.9±4.8</td>
<td>37.0±15.6</td>
<td>12.5±0.9</td>
</tr>
<tr>
<td>Range: 9.4 — 33.6</td>
<td>Range: 12 — 71</td>
<td>Range: 10.7 — 14.6</td>
</tr>
</tbody>
</table>
Eighty-five per cent of the children had "low" serum levels of vitamin A, and 57% had "low" carotene levels according to the ICNND standards. The haemoglobin levels were within normal range.

Our recall data on food purchasing has not yet been completed. However, examination of 20 out of 50 questionnaires showed that intakes of calories and proteins were adequate according to the recommended daily allowances.

The adequate intakes of protein and calories may provide an explanation for the absence of clinical manifestations of vitamin A deficiency in our population and that possibly transport of the vitamin is permitted or its metabolism is "unblocked."

I would like to conclude by saying that while we are encouraged by the absence of clinical signs of vitamin A deficiency, low serum levels of vitamin A call for a plan to raise the vitamin A serum content to safer levels.

We intend to start an education programme in schools and clinics where we shall, in addition to explaining the value of better vitamin A nutriture will also distribute a list of low cost carotene-rich food items which are within the preference choice of the population of East Jerusalem.

REFERENCE

PREVENTION OF VITAMIN A DEFICIENCY BY ADMINISTRATION OF MASSIVE DOSES OF VITAMIN A

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Malnutrition is widely prevalent among the preschool population in the developing nations and invariably these children show evidences of multiple deficiencies. Of these hypovitaminosis A assumes importance because, severe forms of this deficiency if not prevented, lead to irreversible blindness. The economic implications of this preventable blindness in preschool children on the developmental potential of these nations can very well be understood.

In a recent review of the global prevalence of hypovitaminosis Oomen et al. had estimated that the prevalence of vitamin A deficiency though variable goes up to the extent of 40%. Though there is no reliable information on blindness it is estimated that depending on the area, blindness attributable to vitamin A deficiency varies from 10 to 40%. Recent studies carried out in India10 had shown that the mean prevalence rate of vitamin A deficiency among preschool children was about 10% and mostly confined to the southern and eastern parts of the country.

The causative factors for the occurrence of vitamin A deficiency are well known and these are lack of availability and poor intake of vitamin A rich foods, associated with poverty, ignorance and faulty feeding habits among the population in general and specifically among young children.

The most obvious effective measure for the prevention of vitamin A deficiency would be to ensure regular and adequate intake of vitamin A. This can be achieved through nutrition education, encouraging the people to utilize local food resources which are cheap and rich in vitamin A content, e.g., green leaves. Regular intake of green leaves can improve the serum vitamin A levels.15 It had been reported17 that an intake of 40 gms. of green leaves daily even for a short period of 15 days could improve the serum vitamin A levels of preschool children.

However, nutrition education of the community with all its advantages is a difficult and long drawn-out process and thus can serve only as a long-term measure. Supplements of vitamin A as capsules and more
Prevention of Vitamin A Deficiency

recently through skim milk fortified with vitamin A have been distributed for several years through the health centres. Regular intake of these supplements has not been possible because of difficulties in reaching the preschool children and lack of adequate supplies and these programmes have not had the desired effect of reducing the morbidity due to vitamin A deficiency. Therefore, it is necessary to have additional measures which are capable of being implemented within the available resources and that too as a short-term measure or on an emergency scale. Since vitamin A can be stored in the body for long periods, one possible approach would be to administer a massive dose of vitamin so as to form a depot which can be used as and when needed, for prolonged periods. But before this method is adopted on a mass scale the following aspects need to be studied:

1. the target group;
2. the type of preparation;
3. the route of administration;
4. the dosage; and
5. frequency of administration.

Ocular manifestations of vitamin A deficiency occur mostly in young children. A majority of the children in the developing countries are born with low stores of vitamin A. Even so, as long as they are on adequate amounts of breast milk they do not manifest signs of deficiency of this vitamin. Invariably, it is only after the age of one year that clinical evidences of vitamin A deficiency occur and this is observed to increase with age. However, the severe forms of this deficiency like keratomalacia usually occur between the ages of 1 and 5 years. This is also the period when they are likely to suffer from other deficiencies like protein-calorie malnutrition etc., and the association between protein-calorie malnutrition and keratomalacia is well known. So, in the matter of prevention of vitamin A deficiency preschool children should get the priority.

In order to provide answers to the questions raised earlier a series of investigations on pre-school children as well as on experimental animals had been undertaken. Following the administration, orally and parenterally, of a large single dose of two preparations of vitamin A, viz., oil soluble and water miscible ones to pre-school children, the serum levels of vitamin A were estimated. Though there was a significant increase after oral administration of the oil solute preparation the levels remained unchanged with the parenteral route. On the other hand the water miscible preparation produced considerably higher levels by both the oral as well as the parenteral route. In the studies on albino rats the maximal hepatic
storage was observed with the oil soluble preparation administered orally. The administration of a sample massive dose of 300,000 I.U. to pre-school children could maintain high levels of serum vitamin A for a period of 6 months and satisfactory levels beyond 6 months. These studies had shown that the oral route was convenient and preferable. Since the objective of the prophylactic programme is to develop an adequate depot of the vitamin in the body as well as to maintain satisfactory levels in the tissues, the oil soluble preparation at a dosage level of 300,000 I.U. should obviously be the choice. Moreover, in a preliminary trial in the field with the water miscible preparation at a dosage level of 300,000 I.U. a considerable proportion (25%) of the children developed the classical signs and symptoms of acute hypervitaminosis A characterized by signs of increased intracranial tension such as mushrooming of fontanelles, restlessness, fever, diarrhoea, and projectile vomiting. Though these signs were transient and reversible with no residual effects they produced an alarming picture resulting in non-cooperation from the public. This practical experience ultimately decided the choice of the preparation in favour of the oil soluble one.

A pilot study was undertaken in rural areas around the city of Hyderabad. Twenty-three villages with an estimated total population of 18000 were selected. A preliminary rapid clinical nutritional survey of the available pre-school children revealed that the common nutritional deficiencies were protein-calorie malnutrition, ocular manifestations of vitamin A and oral mucocutaneous lesions of deficiency of B-vitamins. The prevalence of vitamin A deficiency showed an increase with age (Table 1). There were no cases of acute keratomalacia but 7 children showed evidence of healed corneal lesions with consequent loss of vision. Diet survey undertaken on a sub-sample showed that the intake of vitamin A was only about 60 mcg as against a requirement of 250-300 mcg/day.

**Table 1**

<table>
<thead>
<tr>
<th>Age(years)</th>
<th>Number</th>
<th>Xerosis</th>
<th>Bitot Spots</th>
<th>Vitamin A deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—2</td>
<td>399</td>
<td>0.60</td>
<td>0.00</td>
<td>0.60</td>
</tr>
<tr>
<td>2—3</td>
<td>482</td>
<td>3.24</td>
<td>4.86</td>
<td>8.10</td>
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<tr>
<td>3—4</td>
<td>466</td>
<td>4.78</td>
<td>6.48</td>
<td>11.26</td>
</tr>
<tr>
<td>4—5</td>
<td>466</td>
<td>12.32</td>
<td>6.69</td>
<td>19.00</td>
</tr>
<tr>
<td>5—6</td>
<td>329</td>
<td>14.90</td>
<td>9.10</td>
<td>24.00</td>
</tr>
</tbody>
</table>
Prevention of Vitamin A Deficiency

A dose of 300,000 I.U. of an oil preparation was administered orally to 1785 children between the ages 1 and 5 years and the dose was repeated once a year. Since the study was confined to pre-school children the administration of vitamin A was stopped as soon as they attained the age of 5 years. Thus the number of doses received varied with the ages of the children at the start of the study. The prevalence of vitamin A deficiency signs among the children who have received the doses regularly as they reach the age group 5 to 6 years are compared with the controls, i.e., those children who were in the age group 5 to 6 years at the beginning of the study and did not receive the supplement of vitamin A. Table 2 shows the reduction in the prevalence of signs of vitamin A deficiency among the children supplemented with vitamin A and this effect was most pronounced in the children between the ages of 1 and 2 years who had received the full complement of four annual doses. The expected increase in the prevalence rate of vitamin A deficiency with age was considerably reduced.

Serum vitamin A levels estimated on a sample of children at different intervals after a single dose of 100,000/ug of vitamin A showed that satisfactory levels were maintained for a period of one year and beyond (Table 3).

**Table 2**

<table>
<thead>
<tr>
<th>Initial age (years)</th>
<th>Number</th>
<th>Number of doses received and years followed-up</th>
<th>Age at the final assessment</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>168</td>
<td>4</td>
<td>5-6</td>
<td>3.57</td>
</tr>
<tr>
<td>2-3</td>
<td>247</td>
<td>3</td>
<td>5-6</td>
<td>2.02</td>
</tr>
<tr>
<td>3-4</td>
<td>293</td>
<td>2</td>
<td>5-6</td>
<td>6.14</td>
</tr>
<tr>
<td>4-5</td>
<td>303</td>
<td>1</td>
<td>5-6</td>
<td>8.25</td>
</tr>
<tr>
<td>5-6</td>
<td>329</td>
<td>0</td>
<td>5-6</td>
<td>14.90</td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>Serum vitamin A levels at different intervals after a single massive oral dose of 100,000 ug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls (No vitamin given)</td>
</tr>
<tr>
<td>ug/100 ml</td>
</tr>
<tr>
<td>4 months after</td>
</tr>
<tr>
<td>1 year after</td>
</tr>
<tr>
<td>2 years after</td>
</tr>
<tr>
<td>(No vitamin given)</td>
</tr>
<tr>
<td>ug/100 ml</td>
</tr>
<tr>
<td>20.4±0.89</td>
</tr>
<tr>
<td>(34)</td>
</tr>
<tr>
<td>37.4±3.78</td>
</tr>
<tr>
<td>(13)</td>
</tr>
<tr>
<td>27.4±3.37</td>
</tr>
<tr>
<td>(57)</td>
</tr>
<tr>
<td>24.0±1.27</td>
</tr>
<tr>
<td>(24)</td>
</tr>
<tr>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Initial age (years)</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1—2</td>
</tr>
<tr>
<td>2—3</td>
</tr>
<tr>
<td>3—4</td>
</tr>
<tr>
<td>4—5</td>
</tr>
</tbody>
</table>

TABLE 4
Prophylactic effect of massive dose of vitamin A in pre-school children
Since the emphasis of the study was on prevention, the proportion of children to be protected from the dangers of vitamin A deficiency during the period of supplementation should receive more attention.

The children in each age group were classified into 3 groups depending on the presence or absence of lesions of vitamin A deficiency both at the beginning and at the final assessment. The protection offered by the supplement ranged from 80-90% (Table 4). It may be of significance to state that during the entire period of follow-up no case of keratomalacia was encountered in the group of children investigated. Though the protection has been quite considerable especially in the younger age groups, in order to achieve better results it would be necessary to increase the dose of vitamin A. But in view of the dangers of inducing toxicity it may not be advisable to increase the dose further. But the same can be achieved by feeding the children a dose of 200,000 I.U. once in 6 months.

It was concluded from the study that prophylaxis against vitamin A deficiency can be achieved by the administration of a single massive dose of vitamin A to children early in life preferably around the age of one year and this programme should be capable of being implemented within the existing pattern of public health set up in this country.

Based on our experiences the Government of India, under the Fourth Five Year Plan, have implemented a large scale prophylactic programme against vitamin A deficiency among pre-school children. About 1.6 million children between the ages of 1 and 3 years covering the 7 States—Andhra Pradesh, Tamil Nadu, Mysore, Kerala, Orissa, Bihar and West Bengal are being supplemented with an oral dose of 200,000 I.U. of vitamin A in Arachis oil once every six months. This programme has been implemented by the Family Planning Department. The results of this programme are awaited with keen interest by all nutrition workers.

REFERENCES

CURRENT NUTRITION PROGRAMMES IN CEYLON
C. C. MAHENDRA
Nutrition Department, Medical Research Institute
Colombo 8, Ceylon

I shall try to tell you, in broad outline, what our major nutritional problems are and to give you a brief account of how we deal with them at present.

Calorie deficiency and protein deficiency continue to be our main problem, though the relative role of protein deficiency seems to have been somewhat over-emphasised in the past. The inadequacy of calories further aggravates any marginal protein deficiency. Bridging the calorie gap by the increased intake of the diet as presently constituted, should take care of the proteins as well, in most instances. However, population increase at 2.4% per year tends to outstrip any increases in the available supplies of food.

A diet survey undertaken in a rural area which had been surveyed 15 years previously, showed that calorie intakes had actually fallen since the last survey (Table 1).

A similar exercise undertaken in a semi-urban area (Table 2) was, however, not as depressing. There had been an improvement in calorie intake, though it was still short of the recommended allowances. All nutrient intakes, however, continued to be inadequate compared to those recommended by the Indian Council of Medical Research.

These and other surveys have also repeatedly shown that intakes of vitamin A are generally well below the recommended levels, especially in the poorer socio-economic groups. Clinical signs of vitamin A deficiency, especially grosser manifestations such as keratomalacia are, however, infrequent. Though the seas around the Island abound in a variety of fish, including shark, a project to meet the Island’s entire requirements of shark liver oil in an encapsulated form, has still to be implemented.

Anaemias of nutritional origin are widespread and a pilot project was undertaken in 1970—in collaboration with the World Health Organization—
<table>
<thead>
<tr>
<th>Year</th>
<th>Calories (Per consumption unit)</th>
<th>Protein (g)*</th>
<th>Vitamin A (I.U.)*</th>
<th>Iron (mg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>1935</td>
<td>6.0</td>
<td>1434</td>
<td>61</td>
</tr>
<tr>
<td>1970</td>
<td>1766</td>
<td>6.9</td>
<td>2880</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Recommended allowances for sedentary adult male</td>
<td>2400</td>
<td>55</td>
<td>9000 or 2250</td>
</tr>
</tbody>
</table>

*Intake per caput per day.
TABLE 2
Diet survey findings—Hiripitiya (Semi-urban)

<table>
<thead>
<tr>
<th>Year</th>
<th>Calories (Per consumption unit)</th>
<th>Proteins (g)*</th>
<th>Vitamin A (I.U.)*</th>
<th>Iron (mg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Animal</td>
<td>Vegetable</td>
<td>Carotene</td>
</tr>
<tr>
<td>1952</td>
<td>2059</td>
<td>10.7</td>
<td>33.8</td>
<td>2006</td>
</tr>
<tr>
<td>1970</td>
<td>2233</td>
<td>11.9</td>
<td>38.0</td>
<td>4156</td>
</tr>
<tr>
<td>Recommended allowances for sedentary adult male</td>
<td>2400</td>
<td>55</td>
<td>9000</td>
<td>or 2250</td>
</tr>
</tbody>
</table>

*Intake per capita per day.
to define the problem, before any concrete prophylactic or remedial measures were initiated. Of 188 mothers examined in 5 rural and semi-urban areas, 52.7% had haemoglobin levels of less than 11 g%—the level below which anaemia is considered to exist. The serum iron level was below normal in 40% of the women, whilst 5.7% had a low serum vitamin B₁₂ level and 19% a low serum folate level.

Goitre, another of our problems, is endemic in the districts with the heaviest rainfall i.e., the South West region of Ceylon. Since 70% of the Island’s population also reside in this area, a large proportion of the population is “at risk” and urgent prophylactic measures are required. This is due to a simple iodine deficiency in the diet and the UNICEF assisted project to iodate all the salt produced in the Island is awaiting implementation.

The increased needs of pregnant mothers for calories, proteins, vitamins and minerals are partly met by the distribution of skimmed milk, multi-vitamin tablets and iron tablets at these clinics. Though the W.H.O. recommends that iron tablets be given to all expectant mothers during the second half of pregnancy, inadequate supplies and irregular attendance makes this difficult to achieve in practice. Great emphasis is placed on health education, and nutrition education in particular, so that better use could be made of available food supplies.

At the postnatal clinics, which are usually combined with infant welfare clinics, the issue of skimmed milk and iron tablets to the mother is continued, and family planning advice given—now that this has been accepted as official government policy.

Widdowson and McCance have shown that the closer to the weaning period that undernutrition occurs the more permanent are the stigmata. Much attention has also been recently focussed on the effects of malnutrition in early life on subsequent mental development. The development and formulation of a cheap and acceptable weaning food is hence an urgent national priority and work in this direction is currently in progress at the Medical Research Institute in collaboration with the Ceylon Institute of Scientific and Industrial Research. Though the ultimate objective is to use locally available raw materials, the present formula includes wheat flour, green gram and 5% skimmed milk powder, and further research is continuing into the formulation of a product with locally available items, or items that could be produced locally if a demand existed.

As an immediate measure, the CARE Organization has offered a pro-
cessed product—Wheat-Soy-Blend (WSB) with an NPU of 65 and complete as regards vitamins and minerals. This has already been tried out as a weaning food on a limited scale, and has been found to be acceptable. It is now proposed to try it in 15 selected areas covering the 15 health areas into which the Island is divided before it is put to more general use.

It is during the 1 to 5 year period that the child is assailed by a variety of stresses and is also least equipped to deal with them. Most dietary survey findings are based on family unit surveys and do not give a true picture of the intakes of the pre-school child. It is likely that the intake of protein and calories of pre-school children are generally much less than family unit surveys indicate, and it is hoped to carry out a survey to assess their intakes separately.

Pre-school children are entitled to receive either fresh milk or skimmed milk at various centres conducted under a National Milk Scheme. They also receive 21 ozs of skimmed milk every fortnight at pre-school clinics. However, only 10.7% of the pre-school population attend the National Milk Scheme centres, and 9.2% the pre-school clinics, to obtain this milk. The problem is hence to motivate the mothers, or to offer them inducements, to bring the children to these clinics.

There has been a proposal recently to distribute a supplementary food such as wheat-soy-blend to these children together with their weekly ration of rice which is issued free from several distribution points, and this rice is seldom unclaimed. Since the main problem of these mothers is to find the time to attend clinics, at least the successful distribution of the product could be thus ensured.

A scheme for the evaluation of the nutritional status of school children was introduced in 1956 and envisaged the examination of children in the first, fourth and seventh standards. The medical officers who undertook these surveys were specially trained to recognise the deficiency signs. From the returns submitted, the subnutrition rate and malnutrition rate were obtained. The subnutrition rate was generally higher in girls than in boys and the average for the 3 age groups worked out at 23 and 20 for every 100 girls and boys examined respectively. For the Colombo area alone, however, the figure was as low as 9.8%. The malnutrition rate generally remained constant at about 4% for both boys and girls but rose sharply to as much as 48% in certain rural areas. This project was suspended in 1965 till it was reviewed and more equipment made available for accurate anthropometry.
The schools' mid-day meal as presently constituted consists of 5 biscuits made with wheat flour and skimmed milk supplied by the CARE Organization. Prior to this the children were given a 2 1/2 oz. bun made with wheat flour and 10 oz of liquid skimmed milk made with 1 oz of the dry powder (Table 3).

**TABLE 3**

<table>
<thead>
<tr>
<th>Schools' Mid-Day Meal</th>
<th>Comparative value of Bun and Skimmed Milk Vs. Biscuits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Calories (g)</td>
</tr>
<tr>
<td>1 Bun</td>
<td>267</td>
</tr>
<tr>
<td>1 oz. Dry Skimmed milk</td>
<td>101</td>
</tr>
<tr>
<td>Bun and Skimmed Milk</td>
<td>346</td>
</tr>
<tr>
<td>5 Biscuits</td>
<td>121</td>
</tr>
<tr>
<td>Recommended Allowances 10—12 Yr. old</td>
<td>2100</td>
</tr>
</tbody>
</table>

It was estimated that only 81% consumed the bun and 35% the skimmed milk. It was for this reason, and also because of distribution problems and difficulty in keeping a check on the quality of the meal that a decision was made—perhaps a debatable one—to replace the bun and the glass of milk with the biscuits. Though the child receives only about a third of the original nourishment from the bun and the milk, at least most of them now consume the biscuits, whereas formerly they did not.

A proposal to fortify the flour used in the preparation of the bun or the biscuits with lysine was not recommended since the improvement in the protein value was minimal and did not justify the exercise. This was more so since the meal was limited by calories as well.

Supplementing the wheat flour with wheat-soy-blend at 20%, 40%, and 60% levels not only produced a very poor quality bun or biscuits, but NPU assays actually showed a fall in values after the supplementation. This was probably due to some form of heat damage at the high baking temperatures.

No doubt the mid-day meal as presently constituted falls far short of the ideal of meeting a third of the child's requirements for the day, and improve-
ments are necessary. Present proposals are to incorporate the wheat flour and the skimmed milk in the form of a "milk bun" of a larger size (2½ oz.) and this is to be undertaken at special bakeries set up for the purpose by the CARE Organization throughout the Island.

Coming to the Nutrition Division of the Medical Research Institute we undertake studies into the extent and prevalence of various deficiency states and advice the Government as regards the implementation of nutrition programmes. Regular diet and nutrition surveys, studies into the aetiology of endemic goitre and anaemias of nutritional origin, the establishment of fresh height-weight standards for school children and the formulation of suitable weaning foods are some of the recent activities of the department.

Various voluntary organisations help in the implementation of nutrition programmes such as the National Milk Scheme where fresh milk and skimmed milk are distributed to preschool children and pregnant mothers. They also run institutions where neglected and orphaned children are cared for either with or without State assistance.

Lack of enthusiasm for various nutrition programmes, especially in those supervising them, could invariably be traced to an insufficient understanding of priorities and to poor training in basic principles. This has been corrected to some extent in Ceylon by an increased accent on nutrition in the curriculum of medical students and those taking post-graduate diplomas in Public Health and Child Health. All training schemes such as those offered by the National Institute of Nutrition in Hyderabad are also fully availed of through the generosity of the World Health Organization. It is these officers who will, in future, undertake the training of the para-medical staff in basic nutritional principles.

To make the best use of limited resources, nutrition education has a vital role to play in all developing countries. However, nutrition education becomes a futile and unrewarding experience when what is advocated is out of reach of a large proportion of the population. It would be like trying to complete a jigsaw puzzle with several of the pieces missing. This is not to belittle the role of nutrition education, but for its success, certainly basic ingredients such as a minimum purchasing power and a minimum level of literacy are also essential. It should also be integrated into a complete nutrition programme and not be an isolated academic exercise, as it so often tends to be.

A great deal of wasted time and effort would be spared if all projects are
not only planned and executed efficiently, but also evaluated at every stage. This becomes all the more relevant with limited resources. Have we succeeded or failed? Why, and at what cost? It is vital to have the answers before we reach for our next objective.

REFERENCES

PLANNING FOR AGRICULTURAL DEVELOPMENT IN INDIA

K. Kanungo, K. V. Natarajan and K. N. Syndranikan Nair
Indian Agricultural Research Institute
New Delhi-12, India

The Grow More Food (GMF) Campaign could be described as the first attempt at planning of agriculture in India. The Food Grains Policy Committee of 1947 voiced out the policy goal of attaining self-sufficiency in food with time-bound targets. Despite some creditable achievements, the GMF Campaign did not attain its main objective. However some of the strategies followed in later days owe their origin to the GMF campaign. The GMF Enquiry Committee which examined the programme in 1952, took note of the inherent weaknesses of the programmes. Agricultural improvement was to be conceived as an integral part of the much wider problem of raising the level of rural life and the Committee viewed agricultural development as inextricably linked up with the whole set of social problem.

To create among the villagers, a desire to change their outlook and a will to live better, the Community Development Programme was launched in 1952. It provides an organisation at the field level through which all programmes related to rural development are to be carried out, with direction and support from the higher echelons of administration. Experience, however, showed that this programme was failing to mobilise substantial enthusiasm, co-operation and participation of the rural people in the various activities. The working of the movement was, therefore, subjected to a close review by the Committee on Plan Projects in 1957. This Committee recommended "Democratic Decentralisation" which brought into existence, a system known as Panchayati Raj (rule by self-governing bodies).

Allocation of resources was done uniformly in all the Community Development blocks and did not relate to the needs and potentialities of each area. The result was that while the programme could, bring about a certain level of development all over the country, it failed to exploit fully the capabilities of different areas for achieving maximum production through concentration of resources and efforts. It was only in the beginning of the Third Five Year Plan that the principle of selectivity and concentration,

*The paper does not purport to represent the views of the organisations in which the authors are working.*
which formed the basis of the Intensive Agricultural District Programme (IADP) was accepted as part of the strategy of development in agriculture.

The steep fall in crop production in the drought year 1957-58 focussed attention on the seriousness of the food situation. A team of agricultural experts invited by the Government of India and sponsored by the Ford Foundation, recommended that instead of spreading the developmental efforts on a uniform basis, intensive efforts for production should be undertaken in selected areas which had optimum conditions for stepping up production, without affecting the normal production efforts in other areas.

The IADP, launched in 1960-61, marked an important step in the continuum of measures taken since the First Five Year Plan to accelerate agricultural growth. A programme known as the Intensive Agricultural Areas Programme (IAAP) was launched in 1964-65 which was a modified form of the IADP. After eight years of operation of the IADP, an Expert Committee suggested that the focus should be shifted from the 15 IADP districts to an intensive agricultural modernisation programme geared to the potentials of the farmers in all districts. This concept of intensive agriculture became an important landmark in the development of the new agricultural strategy. Such a strategy aims at a rapid breakthrough in agricultural production by increasing the productivity of crops through a combination of high yielding varieties and better technology on the one hand and multiple cropping on the other.

STRATEGY OF AGRICULTURAL DEVELOPMENT THROUGH THE TWO DECADES OF PLANNING:

The First Five Year Plan gave priority to the development of agriculture including irrigation and power. In the context of prevailing food shortages and high food prices, food production constituted the hard core of agricultural development programme.

The Second Five Year Plan was designed to bring about greater diversification in agricultural production. Besides foodgrains, more attention was paid to cash and subsidiary foods such as vegetables, fruits, meat, fish, eggs and milk. It was realised that the scope for increasing the area under cultivation was limited and that "the main source of increase in agricultural production must be increase in yields from more intensive, more efficient and more profitable agricultural production." Generally speaking, the techniques employed in the Second Plan for securing increase in production were largely the same as those adopted in the First Plan.

It was in the Third Plan that a real beginning was made in the direction of intensive agriculture. The IADP was taken up in selected districts endowed with irrigation and assured rainfall. Though there was an upward
trend in the production of most of the crops it did not keep pace with the targets set out in the Plan. This was due mainly to non-availability of adequate inputs specially fertilisers to the farmer. Against this background, the high yielding varieties programme was initiated and implemented.

Though resource commitment did not increase significantly in relative terms from one plan to the other substantial increases have been made in absolute terms. The details are given in Table 1. A real effort was made:

**TABLE 1**

Public Sector Investment on Programme for Agricultural Production

<table>
<thead>
<tr>
<th>(Rupees in crores)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S. No.</strong></td>
</tr>
<tr>
<td><strong>Plan</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1. Agriculture production including Research and Education</td>
</tr>
<tr>
<td>2. Development of Small Farmers and Agriculture Labour</td>
</tr>
<tr>
<td>3. Minor Irrigation</td>
</tr>
<tr>
<td>4. Soil Conservation</td>
</tr>
<tr>
<td>5. Area Development</td>
</tr>
<tr>
<td>6. Animal Husbandry</td>
</tr>
<tr>
<td>7. Dairying and Milk Supply</td>
</tr>
<tr>
<td>8. Fisheries</td>
</tr>
<tr>
<td>9. Forests</td>
</tr>
<tr>
<td>10. Warehousing, Marketing &amp; Storage</td>
</tr>
<tr>
<td>11. Food Processing and Subsidiary Food</td>
</tr>
<tr>
<td>12. Central Support to Financial Institutions (Agril. Sector)</td>
</tr>
<tr>
<td>13. Buffer Stocks</td>
</tr>
<tr>
<td>14. Cooperation</td>
</tr>
<tr>
<td>15. Community Development</td>
</tr>
<tr>
<td>16. Panchayats</td>
</tr>
<tr>
<td>B. Irrigation, Flood Control etc. :</td>
</tr>
<tr>
<td>17. Irrigation (Major &amp; Medium)</td>
</tr>
<tr>
<td>18. Flood Control etc.</td>
</tr>
<tr>
<td>Total A &amp; B</td>
</tr>
<tr>
<td>Total Public Sector Investment</td>
</tr>
<tr>
<td>Percentage of Investment in Agriculture</td>
</tr>
</tbody>
</table>

[@Including Community Development. **Anticipated Expenditure.**](source: Compiled from Third Five Year Plan p. 33 and Fourth Five Year Plan 1969-74 pp. 65-66.)
in the late sixties in resolving the perennial dilemma of balancing the interests of the producers and those of consumers through a policy of guaranteed crop prices and partly through the buying and selling operations of the Food Corporation of India.

AGRICULTURE IN THE FOURTH FIVE YEAR PLAN:

The present plan was formulated at a time when there was sufficient evidence on the contribution of research to increased production and the response of farmers to it under favourable price conditions. Significant results had already been achieved in the production of high yielding varieties of wheat and rice and hybrids of maize, jowar and bajra. Agricultural development in the Fourth Plan, therefore, relates to the evolution of appropriate seeds, fertilisers and cultural practices through intensive research and to the matching supply of necessary inputs.

The strategy for maximising production in the Fourth plan places small reliance on bringing additional land under cultivation. The strategy of production thus will revolve around certain principal measures which have been listed as follows:

1. coordinated research in respect of all important crops;
2. continued expansion of irrigation facilities and reallocation of irrigation practices so as to ensure optimum and integrated use of ground and surface water;
3. improvement in the utilisation of existing irrigation potential through special programmes;
4. expansion in the supply of fertilizers, plant protection material, farm machinery and credit;
5. full exploitation of the possibilities of raising yields provided by the new seed varieties in the case of cereals;
6. intensive efforts in selected suitable areas for raising the yield levels of major commercial crops;
7. measures to increase intensity of cropping; and
8. improvement in the agricultural marketing systems in the interests...
of the producer along with assurance of minimum prices for minor agricultural commodities.

A serious weakness identified is the lack of institutional credit for agriculture. The recent assessment by the All India Rural Credit Review Committee (1969) is fully reflected in the Fourth Plan document. The increasing credit needs of agricultural development programmes is proposed to be met through the process of institutionalisation of agricultural credit with a multi-agency approach.

If the green revolution in cereals, in particular the significant achievement in wheat production, has signalled a major break-through in foodgrain production, it has also released an array of new problems. For one thing continued heavy expenditure in research has been rendered necessary; as one seed variety is likely to last only for a few years and must be replaced by new varieties. Substantive steps have been taken to gear up research organisations to meet the new challenges. These include the reorganisation of the Indian Council of Agricultural Research, the launching of multi-disciplinary All India Co-ordinated projects on crop improvement, crop production and animal science, and the establishment of a number of Agricultural Universities.

Agricultural machinery and equipment are becoming gradually popular. The Agro-Industries Corporations set up in almost all States undertake hire purchase of agricultural machinery and equipment with provision for repair, servicing and training facilities and promotion of agro-industries. Central and State Warehousing Corporations have been constituted to develop warehousing facilities for agricultural commodities and inputs, in view of the emerging foodgrain surpluses.

Special programmes for the development of underprivileged classes and areas have been proposed in the Fourth Plan. Organised efforts will be made to provide to the small farmers access to inputs, credit, services and supplies. There are many composite projects which broadly fall into two categories: (1) agencies for helping small farmers (SFDA) and separate agencies for looking after marginal farmers and agricultural labour (MFAL), and (2) agencies which will look after both small and marginal farmers. A programme of integrated dry farming development is also being undertaken in areas where dry farming is practised on a large scale.

The two fold objective in agriculture in the Fourth Plan viz., of maximising production and remedying imbalances is as much applicable to animal
husbandry as to crop husbandry. The Fourth Plan accords high importance to livestock development. In spite of an enormous livestock population in the country, the return in terms of milk, meat and eggs, is low in India. Among the programmes for improvement of productivity of cattle, improved breeding techniques, fodder development, intensive cattle development projects and progeny testing programmes deserve mention. The technique of artificial insemination is widespread in the country.

While the Second Plan laid stress on the establishment of colonies of milk cattle in metropolitan cities, the policy in the Third Plan was to develop dairy projects with emphasis on milk production in rural areas linked with plants for marketing surplus milk in urban centres. A phased programme is intended to be drawn up to eliminate dependence of dairy projects on imported milk powder.

With the growth of poultry as a commercial enterprise during last decade, poultry farming has become lucrative. Development of piggery is becoming increasingly important. Pig breeders are being supplied improved pigs and technical know-how in piggery development blocks.

There are certain bright features in the potential for development in the animal husbandry sector which are worth noting. The area of practical problems in poultry has shifted from breeding to feeding and the problem of providing good, cheap and nutritious feed is not expected to present any difficulty. Recent developments in practical genetics including the frozen semen technique and the gradual perfection of artificial insemination offer a big potential for improvement of breeds of milch cattle.

Development of marine fisheries is important from the point of view of production of protein at low cost. The Fourth Plan programmes for fisheries have been formulated with the objectives of production of nutritious food, creation of employment opportunities, socio-economic development of fishermen, utilisation of new natural resources and earning of foreign exchange through export.

**PLANNING PROCESS AND TECHNIQUES:**

The Planning Commission which is directly concerned with the formulation of the plants lays down certain general guidelines for a relatively long period, say, 10-15 years, after a careful study of the technical possibilities, needs of the economy and alternative patterns of development. The first step in agricultural planning is the determination of requirements or demand
for various agricultural products, at the end of the plan period, and the perspective period (15-20 years). The second step in the agricultural planning process is the estimation of supply or fixation of production goals. The increase in production is sought to be achieved through measures such as extension of cultivation to new areas or intensive cultivation of areas already under the crop. The latter include creation of additional irrigation facilities, measures for conservation of soil and development of land, increased use of fertilisers, measures and improved seeds, application of plant protection measures and other improved cultural practices.

In view of the inter-dependence between agriculture and the rest of the economy, the Agriculture Plan has to be fitted into the rest of the Plan. As agriculture contributes nearly 50 per cent to national income, the agricultural plan in a sense, conditions the overall plan and is conditioned by it.

Within the framework of the Five Year Plan, Annual Plans are drawn up taking into account the resources actually available from year to year. Annual Plans can be viewed as being that part of the Planning Process which lie closest to the stage of implementation and are concerned specially with the short-period problems of the country.

Effective organisation and co-ordination at each level is essential to the success of agriculture. Since the inception of the Third Five Year Plan certain steps have been taken towards improving administrative co-ordination in matters relating to agricultural development. Co-ordination Committees have been set up in the States where decisions having a bearing on the working of the Departments of Agriculture, Irrigation, Revenue, Animal Husbandry, Fisheries, Forestry, Cooperation, Community Development, etc., are taken. In a number of States, Agricultural Production Commissioners or Special Secretaries responsible for coordinating the activities of aforementioned departments have been created.

MANAGERIAL ASPECTS OF DEVELOPMENT:

Uptil now a descriptive review of agricultural development has been given which has lead to the emergence of a new strategy for agriculture whose performance constituted the back-drop for the present Fourth Five Year Plan. This presentation is primarily an attempt to collate the available material for the benefit of the distinguished scientists and participants gathered at the First Asian Congress and to share with them India’s experience of two decades of planning for agricultural development.
A self-sustaining process of technological change adequately supported by an appropriate infra-structure and commensurate managerial competence, will call for:

(a) availability of new technology that is highly productive and profitable;
(b) effective demonstration and extension of this new technology; and
(c) a process of continuous development of even newer technology at a pace matching the rate at which the economic benefits of the most recently adopted technology are exploited.

This puts the future of agricultural development on a tripod consisting of: (i) research and development support, (ii) agro-industries and agri-business for manufacture, supply and marketing of inputs and other associated requirements at the farm level, and (iii) administrative competence in the formulation, management and administration of relevant programmes and projects.

As we move away from a purely schematic pattern into a project approach in agricultural development, the following tasks assume importance:

(i) Increase of the efficiency of credit institutions and particularly cooperatives;
(ii) The need for ensuring effective and proper utilisation of credit with suitable supervisory and consultancy arrangements;
(iii) The strengthening of the technical competence of the commercial banks through appointment of trained professionals and orientation training of existing personnel to meet the special requirements of agricultural projects and the attendant reforms in organisation, personnel and loaning procedures.

With the introduction of high yielding varieties programme, significant increases have been registered in the production of foodgrains within a short period especially in the wheat growing regions. Consequently, the earlier trends of marketable surpluses in respect of foodgrains have undergone considerable change and strategic locations have to be identified for putting up storage facilities. Buffer stocking of foodgrains and other agricultural commodities also calls for immense storage potential. At the same time, the needs of scientific storage at the farm level cannot be neglected.
The leadership in Indian planning has fully recognised the dynamic and emerging contexts of technological advances and gaps and the attendant social changes and stagnation. As agricultural technology becomes increasingly sophisticated and exacting, it becomes necessary for the planning machinery to keep abreast of the progress with a view to take corrective measures.

Recently a detailed review was made by the Planning Commission of consumption trends of fertilisers and the factors affecting fertiliser use. An analytical review was also made of the progress of the high yielding varieties programme, which revealed that the area coverage of high yielding varieties of rice was progressing satisfactorily but with no tangible impact on yield. In regard to maize and jowar (Sorghum) the Commission had pointed out that the yield levels assumed for these crops were attainable but the principal problem lay in achieving the area target.

As agricultural development expands, appropriate and unorthodox programmes cutting across departmental and organisational boundaries have to be formulated. Therefore the planning machinery has to go in for innovative structures which act as a catalyst of the programme and ensure that it is translated into action without delay. One such programme concerns the coordination of nutrition programmes at the central level. A Nutrition Coordination Group was set up in the Planning Commission which coordinates, reviews and solves problems relating to nutrition programmes of the Union Departments. The Group has been able to make critical scrutiny of the progress of expenditure and achievement of physical targets under the various nutrition programmes. Several problems of coordination which are being solved progressively include research programmes undertaken at the National Institute of Nutrition on nutritive value of foods and especially high yielding strains of foodgrains; similar research carried out under the auspices of the Indian Council of Agricultural Research; problems of providing a suitable organisational base for the feeding programmes at the field level; issues related to the production of "Bal Ahar" and other protein supplements utilised in school feeding and pre-school feeding programmes. Fortification of common items of food are also taken up for inter-departmental co-ordination at these meetings.

REFERENCES

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2. Report of the Grow More Food Campaign, Ministry of Food and Agriculture, Government of India, June 1952. (The Committee was constituted on 8th February 1952 under the Chairmanship of Shri V. T. Krishnamachari).


5. Second Five Year Plan, Planning Commission, Govt. of India, 1956.

Cereals, millets and pulses (legumes) constitute the major portion of the diet of the people in India. Presently, production and requirement of these is around 100,000,000 tons. Production of different grains during the year 1970-71 is given below:

<table>
<thead>
<tr>
<th>Grain</th>
<th>Production (000,000 metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>20.09</td>
</tr>
<tr>
<td>Rice</td>
<td>40.43</td>
</tr>
<tr>
<td>Maize</td>
<td>05.67</td>
</tr>
<tr>
<td>Millets</td>
<td>21.61</td>
</tr>
<tr>
<td>Gram</td>
<td></td>
</tr>
<tr>
<td>Other pulses</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.49</strong></td>
</tr>
</tbody>
</table>

Holding large quantities of grains in storage constituted a sizeable business in the country prior to World War II. Quantities ranging between 50,000 to 10,000 tons were held by individual traders and agriculturists. Weather and pests were recognised as the main destructive agencies and protection from these was rendered possible by keeping grain in an underground facility. This facility very commonly adopted then, prevented pest survival on grain due to exhaustion of oxygen. A damage of 8-10% however seems to have been taking place on account of microbial activity in such storage. In the absence of better techniques, wastage upto 10% was considered inevitable and accepted as the storage risk.

Development in the country after World War II gradually rendered underground storage obsolete and at the same time focussed attention on wastage of food in storage. Holding of grain was mainly a commercial problem in the earlier years. As war on waste gained momentum in respect of foodgrain storage in India, it has become a techno-commercial problem.
Technology of grain storage has covered the following different aspects during the last two decades in India: —

(i) Storage structures;
(ii) Effect of pest damage;
(iii) Pesticide use and its consequences;
(iv) Quality standards; and
(v) Scientific utilization of grain.

STORAGE STRUCTURE:

Structure is the basic requirement for housing grain. Based on requirements three distinct groups became necessary. These are: —

(a) Storage of buffer reserves;
(b) Storage of commercial operation stocks; and
(c) Storage on the farm.

A structure to be really effective has to provide protection from weather, pests and pilferage, economy in storage, facilities for easy in and out movement and has to be capable of being set up with local resources. Prevalent structures satisfied only the economic and resources questions. Designs were, therefore, drawn up for different types of structures numbering eleven and these have been tested in various parts of the country for suitability to hold reserves and operational stocks. On the basis of results obtained from the tests, design of a structure for maintaining reserves and operational stocks has been standardised and all construction in the country is now planned, based on the standard. The standard structure is rodent, termite and damp-proof, is convenient for moving in and out of grain, is able to hold 1 ton per 6 sq. ft. of floor area and costs around Rs. 130/- per ton of storage capacity (exclusive of cost of land). Ventilation in these structures is controllable and therefore, fumigation of stored grain is rendered easily operative. Capacity of the standard type targeted for construction is about 8 million tons and of that already constructed during the decade is a little over 4 million tons.

Similarly, investigations were undertaken in respect of farm storage of capacities ranging between 1–10 tons. Corrugated steel bins which have facilities for internal aeration are found satisfactory. A programme of distributing upto 2000 bins to agriculturists every year is now on hand. Use of the bins on the farms have shown that the cost of bins is fully met in a period of 10 years out of what would have been lost in storage had tradi-
tional methods continued to be used. The life of the bins at the same time is about 30 years.

EFFECT OF PEST DAMAGE:

Insects, rodents and birds are recognised to be the main pests of stored grain. Severity of damage by each of this group has been stressed by various workers but very little information has been on record with regard to nature of the damage. During last two decades this information has been collected and made use of in preparing quality standards and for taking legal measures. Investigations on the damage caused by *Sitophilus oryzae* L., *Trogoderma granarium* Everts and *Chlosochroma Chinensis* L. have yielded following results:

(i) Protein is denatured;
(ii) Vitamins of the group ‘B’ suffer a relatively heavy loss;
(iii) Cooking and baking quality is severely affected;
(iv) Consumers are able to make out difference in taste at the level of 15% of apparent weeviling;
(v) Appetite of rats fed continuously on insect damaged food was adversely affected; and
(vi) A positive correlation between damage caused by insects and true uric acid accumulating in the grain and its products as a result of insect activity exists.

In case of rodents and birds the types and numbers affecting grain have been estimated. Steps to be taken to successfully eliminate these pests from storage have been extensively tried upon and standardised. For farm storage, a simple hazardless device for fumigating grain at a low cost has been developed. This comprises Ethylene dibromide in requisite quantities being placed in glass ampoules which are wrapped in filter paper and enclosed in cloth bags. The ampoule is broken before introduction in the grain and because of the filter paper and cloth, fumigant vaporises in required time and glass pieces remain within the cloth bag. The technique has proved effective and useful.

In the control of rodents anticoagulants opened up the possibility of making villages and towns rodent free. This technique is now being utilised in different regions of the country to free rural areas of rodents. The programme of rodent control is being operated as a coordinated programme of controlling rodent population with anticoagulant and preventing further
Grain Storage in India

growth by making all grain storage in the area rodent proof. The coordinated programme has been initiated in 5 States of the country so far.

PESTICIDE USE AND ITS CONSEQUENCES:

It is appreciated that for conservation of foodgrains in storage use of pesticides is unavoidable in the present situation. Irradiation and airtight storage, the alternatives to pesticidal use have been tested and to some extent airtight storage stands implemented in India. Annually 400,000 tons of grain is now being stored in airtight conditions. Operational and financial considerations, however, limit extending the technique to all grain handled. Measures to ensure only use of safer pesticides which do not leave a significant residue like Malathion and DDVP and fumigants have been, therefore, taken with a view to control possible misuse. Qualified personnel trained for the job are further required to handle the pesticides as far as storage of food materials is concerned.

Surface treatments and fumigations as carried out in India are not leaving residue in the grain in excess of limits specified by joint WHO/FAO Committee, on storage and treatment for a period of upto 3 years.

QUALITY STANDARDS:

Consumers assess quality mainly by visual observation. This traditional method of quality determination continues to be adopted for foodgrains like rice and wheat. For technological considerations of storage, transport and processing this technique, it is appreciated, is not satisfactory. Standards for quality taking into consideration various physical constituents of grains have, therefore, been finalised and being implemented in the purchases made by the Government and Cooperatives. Resistance to their implementation in the markets has now been overcome and agriculturists also have started appreciating the importance of technological grading of grain. A proposal for introducing chemical composition like 'protein content' in the case of wheat as a constituent of quality standard is very much desired by end users of wheat namely the flour millers and bakers. Scientists involved in grain breeding and handling programmes also want the introduction of this factor in quality standards. It is expected that with the improvements in the technique of analysis brought about, the standard could be made to cover this constituent shortly. Wheat would then be rendered capable of being priced on the basis of nutrients.

Rice categorization in the country in spite of wide varieties being produced...
and marketed is now brought on par with international standards. Millets and pulses continue to be assessed on the basis of physical constituents but improved standards are expected to cover these grains in the course of the next two years.

SCIENTIFIC UTILIZATION OF GRAIN:

Milling with a view to maximise the use of grain for human consumption has received special attention in the country during the last decade. Progress has been achieved by setting up mills for rice and wheat based on technological development programmes. Fabrication of required machinery in the country as well as training personnel in new techniques have been simultaneously taken up. Institutes have been set up for studies on problems of grain storage and rice milling. Processing, drying and aeration of grains as a result of these developments is now being undertaken on an increasing scale using technology to the extent possible.

Handling of large quantities of grain starting from the markets to the consumer by Government and Public Sector agencies have shown that losses in such grains are mainly due to loss of moisture and in the course of a year’s storage do not exceed 0.5 per cent. Heavy financial outlay is however unavoidable in such handling. Construction of modern storage facilities for a million tons of grains costs as much as rupees two hundred millions. Recurring costs of handling amount to another two hundred millions. Such handling, though tempting from the point of view of minimising losses and regulating distribution, are, therefore, required to be examined and limited to economic possibilities. In the alternative, storage on the farm means distribution of the operation over a large number of agriculturists wherein education in the techniques to be adopted and control to ensure correct adoption is difficult. In the developing countries, possibly a balance between the two types of storage seems to be the proper answer in the existing situation.
Calorie and protein supplies are largely drawn from cereals, pulses and oilseeds. The caryopsis of cereals and cotyledons of pulses and oilseeds suffer from damage caused by insects, fungi and rodents. Out of the total production in the Asian countries about 70 per cent of the produce are stored and consumed in the rural areas and another 30% which constitutes the marketable surplus reach the urban consumers through trade channels. These grains undergo qualitative and quantitative biodeteriorations due to the activities of the commensals. The aggregate damage caused by the commensalistic activities of moisture, seed enzymes, insects, fungi and rodents result in significant reduction of the potential sources of calories and protein. The total calories which ought to have been available to the nation are not consumed by the population because of the selective consumption by pests and pollution by their activities. The losses from the field to consumption are estimated variously by different countries (Table 1). In developed countries, the losses are estimated to be 25% (1970, Aug.) and losses in the tropical countries are at least 10% higher. These losses are largely responsible for gross-shortage of food and also the status of nutrition.

The traditional storage structures of the countries of the region predispose to the microecological factors leading to selective growth of actinomycetes, cephalosporium, aspergillus, penicillium, mucor, rhizopus, curringhamella, verticelium, fusarium and verticiliastrum. In addition to these, stored-product insects carry with them bacterial flora and also toxicogenic fungi. During their activities and movement they increase the microbial load and also bring about qualitative deteriorations (Table 2). Aflatoxins, islando-toxin, citrinin, ochratoxin, gibberilin, clavatin, fusarin and other complex molecules with toxophoric groups are elaborated in situ. Even in a dry-grain insect activity leads to such pollution. Moisture migration in bulk grain also is responsible for creating favourable microecological conditions for the growth and development of saprophytic and toxicogenic organisms (Table 3). If the nutrition of the populations of these developing countries will have to be improved, the wastage and deterioration in quality and quantity caused by these agencies should be minimised.
TABLE

Estimated pre-harvest and post-harvest losses in India

<table>
<thead>
<tr>
<th> </th>
<th>Pre-harvest</th>
<th>Post-harvest</th>
<th>Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td> </td>
<td>2001 (K. B. Lal)</td>
<td>15-250 (CFTRI)</td>
<td>30</td>
</tr>
<tr>
<td> </td>
<td>2008 (Plant Pro.)</td>
<td>15-200 (NRC)</td>
<td>40-60</td>
</tr>
<tr>
<td>Pest and disease</td>
<td> </td>
<td> </td>
<td> </td>
</tr>
<tr>
<td>Rodent</td>
<td> </td>
<td> </td>
<td> </td>
</tr>
<tr>
<td> </td>
<td>100 (Post harvest handling Comm. preventable)</td>
<td>3-50 (Threshing, handling)</td>
<td>40-50</td>
</tr>
<tr>
<td> </td>
<td>10-15 (Storage)</td>
<td>3.5-4.5 (Processing &amp; Transport)</td>
<td>40</td>
</tr>
<tr>
<td> </td>
<td>4.5-4.5 (Hotels and Household)</td>
<td> </td>
<td>27-34</td>
</tr>
</tbody>
</table>

foodgrain losses in some countries

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>Pakistan</th>
<th>Africa</th>
<th>California</th>
<th>U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10(^7) U.S. Sci. Panel</td>
<td>20(^6) (Ordish)</td>
<td>15-30(^9) U.S. Sci. Panel</td>
<td>20(^11) F.A.O.</td>
<td>16(^14)</td>
<td>20(^15) (Stakman)</td>
</tr>
<tr>
<td>17.3 US Sci. Panel</td>
<td>30(^8) (Shimitt)</td>
<td>18.7-10.4 (Weitz Hettelsatter)</td>
<td>30(^13) (Hall)</td>
<td>6.8(^18) (Metcalf)</td>
<td>10(^19) (Cotton)</td>
</tr>
</tbody>
</table>

\[ \begin{array}{cccccc}
27.3 & 50 & 33.7-60.4 & 50 & 22.8 & 30 \\
\end{array} \]
### TABLE 2

Correlation between parameters of deterioration in sorghum

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Relationship between</th>
<th>Correlation coefficient ( r )</th>
<th>Regression equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Moisture</td>
<td>Free Fatty acids</td>
<td>0.202** ( y = 23.91 + 2.6x )</td>
</tr>
<tr>
<td>2.</td>
<td>Moisture</td>
<td>Fungi</td>
<td>0.170* ( y = 14.43 - 91.12 )</td>
</tr>
<tr>
<td>3.</td>
<td>Moisture</td>
<td>Apparent uric acid</td>
<td>0.240** ( y = 1.121x - 7.843 )</td>
</tr>
<tr>
<td>4.</td>
<td>Fungi</td>
<td>Free fatty acids</td>
<td>0.234** ( y = 46.63 + 0.03x )</td>
</tr>
<tr>
<td>5.</td>
<td>Fungi</td>
<td>Apparent Uric acid</td>
<td>0.904*** ( y = 24.4 + 0.0017x )</td>
</tr>
<tr>
<td>6.</td>
<td>Insect count</td>
<td>Kernel damage</td>
<td>0.549*** ( y = 1.16 + 0.199x )</td>
</tr>
<tr>
<td>7.</td>
<td>Insect count</td>
<td>Total uric acid</td>
<td>0.127 ( y = 4.604 + 0.025x )</td>
</tr>
<tr>
<td>8.</td>
<td>Kernel damage</td>
<td>Total uric acid</td>
<td>0.489*** ( y = 2.02 + 0.35x )</td>
</tr>
<tr>
<td>9.</td>
<td>Total uric acid</td>
<td>Apparent uric acid</td>
<td>0.893*** ( y = 0.302 + 0.726x )</td>
</tr>
</tbody>
</table>

* 5 per cent significant.
** 1 per cent significant.
*** 0.1 per cent significant.

* Reference 24.
Progress in Protection of Foods

TABLE 3
Moisture content of rice and microflora

<table>
<thead>
<tr>
<th>Moisture Type</th>
<th>Microflora—Total count (No./gr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unsterilised</td>
</tr>
<tr>
<td>8 P, As, Act</td>
<td>2.5 × 10⁵</td>
</tr>
<tr>
<td>9 P, As</td>
<td>2.3 × 10⁵</td>
</tr>
<tr>
<td>10 P, As</td>
<td>3.8 × 10⁵</td>
</tr>
<tr>
<td>13 P, As, Rhi</td>
<td>7.8 × 10⁵</td>
</tr>
<tr>
<td>16 P, As, Rhi, Muc</td>
<td>8.6 × 10⁵</td>
</tr>
<tr>
<td>17 P, As, Rhi, Muc</td>
<td>1.0 × 10⁶</td>
</tr>
<tr>
<td>20 As, Rhi, Muc, Yeasts</td>
<td>3.0 × 10⁶</td>
</tr>
<tr>
<td>23 Rhi, Muc, Yeast, Bact.</td>
<td>7.2 × 10⁵</td>
</tr>
<tr>
<td>26 Muc, Yeast, Bact.</td>
<td>12.0 × 10⁵</td>
</tr>
</tbody>
</table>

P = Penicillium.  
As = Aspergillus  
Act = Actinomycetes  
Rhi = Rhizopus  
Muc = Mucor  
Bact = Bacteria

Another group of pests associated with grain handling and distribution are the commensal rats. Rodent hair, faecal matter, urine and body odour are directly introduced by the rodent activities in the precincts of grain handling. Zoonoses are also carried by them. Food borne diseases associated with their activities are on record. The organisms are varied and may lead to serious infections by salmonella, pseudomonos, spirochitis, plague bacteria. Moreover, vectors like fleas and mites are transmitted or dispersed from them to the food or directly to the human subject. Though the direct ingestion of food by rodents is quite significant, the indirect pollution of the foodgrains and related deterioration in quality are much more serious. The filth and excreta resulting from rodent infestation are the subjects of food regulations. Microbial pollution of foodgrains and their products caused by birds and lizards, is still an unexplored area of research.

Whereas on the one hand the pests are responsible for the reduction in the quality and quantity of the food produced in these countries, on the other hand the misuse of pesticides for their control pose problems of chronic and acute toxicities in humans and pollution of the environment. In the absence of safe and effective techniques and also due to ignorance on the
part of the users on the harmful effects of pesticides, they are applied erroneously. Mixing of seed and grains with pesticides and seed dressing substances are prevalent in some parts of this region. Moreover, overtreatment with high dosages and persistent pesticides are not uncommon in public health, household pest control and agriculture. These are responsible for increasing the quantum of the xenobiotics particularly the pesticide in our food, biosphere and environment. In many countries protein deficiency in diet, hepatic and renal deficiencies and climatic stress prone the populations vulnerable to chronic effects of the pesticidal substances. Experimental evidence has been obtained that protein deficiency in diet can result in the manifestation of chronic toxicities of the pesticides comparatively more than the pesticides present in adequate diets. Permissible limits of the pesticides in foods are being prescribed increasingly by the countries of this region. The major limitation has been the non-availability of well trained pesticide residue analysts and also the sophisticated equipment which are required for regulatory purposes. However, it is possible to check gross misuse by a surveillance of these xenobiotics in the food, water, air and adipose tissues which can be performed by using improvised micro-thin layer chromatography coupled with bioassays. Training programmes have to be launched for such a band of well trained pesticide residue analysts so that monitoring, in a routine manner of food, water and soil can be taken up immediately to prevent excessive residues by follow up actions on residue control.

INTEGRATED CONTROL MEASURES:

The problem of infestation of foodgrains in the post-harvest period will have to be adequately attacked as an integrated programme for preventing losses at various stages of storage, processing and distribution.

Preharvest prophylaxis: Infestation of sorghum, maize, pulses and paddy often originate due to oviposition by stored-product insects prior to harvest. The infestations remain latent within the kernel and only become evident when the products are stored for a few weeks in the farm storage or warehouses. The internal infestation is also a source of associated fungi and other microorganisms (Table 4) which are inoculated in the various tissues of the kernels (Fig. 1). Preharvest prophylaxis with malathion, captan, gardona, tricalcium phosphate and B. thuringiensis formulations will not only reduce the field infestation but also prevent infestation by stored product insects and associated fungal infection.

Insect-proofing: The preharvest prophylactic composition should be such that no harmful residues are obtained on the crop at the time of harvest.
TABLE 4
Effect of pre-harvest prophylactic spray on post-harvest storage of sorghum

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Malathion concentration at the time of storage</th>
<th>Frass per cent</th>
<th>Kernal damage</th>
<th>Uric acid/100 g</th>
<th>Microbial count $\times 10^{-3}$</th>
<th>Living adult count per lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control in unimpregnated bag</td>
<td>0.0</td>
<td>24.6</td>
<td>19.6</td>
<td>140</td>
<td>1,365</td>
<td></td>
</tr>
<tr>
<td>Control in insect-proofed bag</td>
<td>0.0</td>
<td>20</td>
<td>15.9</td>
<td>174</td>
<td>1,280</td>
<td></td>
</tr>
<tr>
<td>Malathion treated in control bag</td>
<td>4.5</td>
<td>2.6</td>
<td>18</td>
<td>101</td>
<td>951</td>
<td></td>
</tr>
<tr>
<td>Malathion treated in insect-proofed bag</td>
<td>8.2</td>
<td>0.0</td>
<td>1.0</td>
<td>4.2</td>
<td>7</td>
<td>37</td>
</tr>
<tr>
<td>Fumigated and treated bag</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>3.7</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

![Fig. 1: New techniques for rural storage problems.](image)

1. Preharvest oviposition by stored product insect. Fungal inoculum being carried by Sitophilus oryzae.
2. Preharvest prophylactic spray for controlling field infestation.
4. Improved warehouse.
5. Unitized bins.
6. Bulk storage of pulses by sealing intergranular space.
7. Dehydro-bin for controlling condensation of moisture.
Fig. 2: Improvement of a metal bin for controlling moisture damage to grain

*Left*
Dehydrobin showing channel at the rim and silicagel or oil seal tube for collection of condensed moisture.

*Right*
Control bin made of copper without any provision for removal of condensed moisture.
Therefore, the selective pesticides having low or no mammalian toxicities are selected. This treatment only eradicates field infestation (Table 5). Insect-proof packaging and insect-proofing of containers are further required for preventing cross infestations. Formulations based on malathion, pyrethrin and lindane could only be used for the packaging materials, as these formulations should not give rise to migration of the pesticide from the treated surface, to the products stored in these containers. The permissible limits of the pesticides should never be exceeded in the food grains stored in such containers. Processes have, therefore, been developed for the insect-proofing of gunny bags, laminated bags and also storage structures with non-volatile and high viscosity carriers and synergists.

**TABLE 5**

<table>
<thead>
<tr>
<th>Spray volume per 10,000 sq. ft. (100 x 100)</th>
<th>Malathion concentration in ppm</th>
<th>Malathion in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 litre</td>
<td>0.3</td>
<td>9.4</td>
</tr>
<tr>
<td>23 ..</td>
<td>0.6</td>
<td>20.1</td>
</tr>
<tr>
<td>21 ..</td>
<td>0.9</td>
<td>38.2</td>
</tr>
<tr>
<td>40 ..</td>
<td>0.25</td>
<td>7.3</td>
</tr>
<tr>
<td>40 ..</td>
<td>0.5</td>
<td>16.3</td>
</tr>
<tr>
<td>40 ..</td>
<td>1.0</td>
<td>40.2</td>
</tr>
<tr>
<td>40 ..</td>
<td>1.5</td>
<td>73.7</td>
</tr>
<tr>
<td>40 ..</td>
<td>2.0</td>
<td>138.4</td>
</tr>
<tr>
<td>40 ..</td>
<td>2.5</td>
<td>194.3</td>
</tr>
<tr>
<td>40 ..</td>
<td>3.0</td>
<td>247.7</td>
</tr>
<tr>
<td>60 ..</td>
<td>0.3</td>
<td>28.8</td>
</tr>
<tr>
<td>80 ..</td>
<td>0.3</td>
<td>27.1</td>
</tr>
</tbody>
</table>

Attempts have also been made to improve the traditional storage structures, by making them insect-proof, rodent-proof and moisture-proof. The diurnal temperature changes lead to moisture migration in above ground storage structures, particularly in metal structures. An improved metal bin containing a rim at the top and a dished cover, designated as "Dehydro Bin" has been developed. (Fig. 2). It has been designed to condense the excess moisture and facilitate removal of the same by the natural process. This structure has been evolved on the basis of fundamental studies on the phenomena such as, diurnal temperature changes, thermal conductivity of storage structures, thermal gradient within the storage structure, composi-
tion of intergranular air, moisture migration, condensation of moisture and related factors. Grains stored in the Dehydro Bin developed by Majumder and Narasimhan become progressively dry with the period of storage (Table 6). In a hermetic storage the moisture migration is a serious problem particularly where the diurnal temperature fluctuation is high. This new structure is of great advantage to the tropical countries. If there is internal infestation because of the lack of preharvest prophylactic treatment, liquid fumigants such as EDB, chloropicrin and ethyl formate are found to be safe for use in the rural and household conditions.

**TABLE 6**

Evaluating Dehydro Bin for Storage of Insect-free Sorghum under Temperature Fluctuations

<table>
<thead>
<tr>
<th></th>
<th>Moisture Conditions (%)</th>
<th>Insects</th>
<th>Microbial Viability (FFA mg. KOH/100 g.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehydrobin (copper)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>11.6 Good</td>
<td>Nil</td>
<td>1.2 29 66</td>
</tr>
<tr>
<td>M</td>
<td>12.2 Good</td>
<td></td>
<td>2.3 33 67</td>
</tr>
<tr>
<td>B</td>
<td>11.1 Good</td>
<td></td>
<td>6.5 40 67</td>
</tr>
<tr>
<td>Copper bin with channel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>15.4 Cakey</td>
<td></td>
<td>15.0 Nil 103</td>
</tr>
<tr>
<td>M</td>
<td>14.0 Cakey at periphery</td>
<td></td>
<td>8.5 6 .98</td>
</tr>
<tr>
<td>B</td>
<td>18.6 Cakey</td>
<td></td>
<td>22.5 2 130</td>
</tr>
<tr>
<td>Lab. control in glass bottle (isothermal)</td>
<td>12.0 Good</td>
<td>Nil</td>
<td>1.1 50 56</td>
</tr>
</tbody>
</table>

**Gaseous sterilization:** Often the grains are harvested in the rainy season. In some cases the relative humidity may be very high in the atmosphere during such periods. The grains immediately after harvest cannot be dried due to such inclement weather. Sporicidal fumigants such as methyl iodide, ethyl formate, chloropicrin, phosphine-ammonia mixture of 1.5:1 w/w have been found to be quite useful for gaseous sterilization of the wet grains. The treatment reduced the microbial load and also inhibited the development of microbial growth during the exposure period (Tables 7 and 8). When the weather is favourable and relative humidity of the atmosphere is low the wet grain is exposed for sun drying. Such gaseous sterilization process has been extremely effective against the toxigenic fungi. A process has been developed for bulk sterilization and aseptic storage, which is designated as Ballooning Technique (Fig. 3). Herein a combination of sporicidal fumigants containing EDB, MB and ethylene oxide are applied from outside the balloon. The gas permeates through the polyethylene and
TABLE 7
Screening of fumigants for their fungicidal action

<table>
<thead>
<tr>
<th>Fumigant</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56 mg/l</td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td></td>
</tr>
<tr>
<td>Methyl bromide</td>
<td></td>
</tr>
<tr>
<td>Ethylene dibromide + Methyl bromide + chloropicrin</td>
<td></td>
</tr>
<tr>
<td>Chloropicrin</td>
<td></td>
</tr>
<tr>
<td>Ethyl formate</td>
<td></td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td></td>
</tr>
<tr>
<td>Propylene glycol</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td></td>
</tr>
<tr>
<td>Ethylene dichloride</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td></td>
</tr>
<tr>
<td>Carbon disulphide</td>
<td></td>
</tr>
<tr>
<td>Betapropiolactone</td>
<td></td>
</tr>
<tr>
<td>Crotyl bromide</td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td></td>
</tr>
<tr>
<td>Sulphur dioxide</td>
<td></td>
</tr>
<tr>
<td>Phosphine (1:0.3) (PH₃ : NH₃)</td>
<td></td>
</tr>
<tr>
<td>Phosphine + Ammonia (1:1)</td>
<td></td>
</tr>
</tbody>
</table>

+ = Effective.
- = Ineffective.

TABLE 8
Effect of PH₃ : NH₃ (1:1) on the Microflora of rice
Treated = 100 mg/l of PH₃ : NH₃ (1:1)
Temp : 76-78°F.
Exposure : 96 hrs.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture %</th>
<th>Count/ gr.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mould x 10³</td>
<td>Bact. x 10⁸</td>
</tr>
<tr>
<td>Control</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Treated</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Control</td>
<td>25</td>
<td>3000</td>
</tr>
<tr>
<td>Treated</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
kills the infection in the hot spots. The balloon further protects from absorption of moisture from the atmosphere and also contamination from outside.

![Figure 3: New techniques of storage in urban areas](image)

9—Homescale fumigation.
10 & 11—Durofume Process for large scale storage in tropical climates.
12, 13 & 14—Rodent control techniques using rat repellents, optical attractant and emulsified burrow fumigant.
15—Ballooning technique for storage of moisture sensitive commodities.
16—Gaseous sterilization of moist grain to prevent mould growth.
17—Infrared heat disinestation of processed dehydrated foods.
18—Inpackage vacuum disinestation.

Non-toxic grain protectants: Pesticides which are in current use belonging to the groups of phosphatic, chlorinated, carbamates are not free from mammalian toxicities though they vary in comparative toxicities to insects, moulds and mammals. Therefore, attempts have been made to develop products which are of selective toxicity to insect pests (Fig. 4). The investigations were directed towards developing products which could utilise the vulnerable features of stored-product insects such as the weakness of exo-skeleton susceptibility to dehydration, metabolic differences in mineral requirements and virulence of some specific micro-organisms for pathogenicity (Table 9). Therefore, the comparative differences between these insects and man in the structure, physiology and immunology have been employed for the control of the pests.
TABLE 9
Comparative effects of the non-toxic food protectants on insects and rats

<table>
<thead>
<tr>
<th>Product</th>
<th>Symptoms in insect</th>
<th>Effect on rats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricalcium phosphate</td>
<td>Rapid utilization of energy reserve and autolysis, impaired metabolism, super-numerary moulting loss in weight, molting of skin, teratogenic changes in pupal case.</td>
<td>Improved growth beneficial effect.</td>
</tr>
<tr>
<td>Activated clay</td>
<td>Sorption of cuticular lipoid and rapid dehydration of exposed insects.</td>
<td>No effect on growth and enzymes. Slight indirect beneficial effect due to absorption of toxic metabolites in the intestine.</td>
</tr>
<tr>
<td>B. thailandensis</td>
<td>Only selectively pathogenic to lepidopterous insects, produces septicemia in susceptible larva, loss of appetite is the first symptom.</td>
<td>No adverse effect on growth, liver, kidney, spleen and vital organs—even at 1000 ppm in diet.</td>
</tr>
</tbody>
</table>

Fig. 4: Selected pesticides and non-toxic grain protectants

19—External toxic symptoms of Tricalcium phosphate on larvae and pupae.
20 & 21—Showing histological pictures of the midgut region in control and tricalcium phosphate treated respectively.
22—Activation process of kaolinic clays.
23 & 24—Showing electron micrograph and X-ray of the activated kaolin (meta H-halloysite).
25—B. thailandensis
26 & 27—Control and treated leaves.
28 & 29—Control and infected larvae.
30 & 31—T.S. through midgut control and treated larvae.
Sorptive mineral: Activation process on earths particularly kaolin has been found to induce insecticidal activity by producing sorptive micro-capillaries of specific pore diameters. A process has been developed for its production from ordinary China clay or even low grade clays deposited in almost all parts of India. The active ingredient in the insecticidal clay is identified as meta-H-halloysite. Electron microscopy, differential thermal analysis, X-ray diffraction, gas adsorption, oil bleaching property, bulk density and lipophilic activity have been determined for quality control in the production of this activated earths. Feeding trials on rats with grains treated with activated earths in grains have given indirect beneficial effects on the growth of rats. No acute or chronic toxicity could be observed. These insecticidal clays can be mixed with raw grains or seeds. It has been observed that in seeds it not only protects from insect attacks but also prevents the growth of saprophytic fungi as these insecticidal clays act as dehydrating agents.

Selective metabolic inhibitor: Another product which is also innocuous from the human and animal point of view but highly toxic to insects is tricalcium phosphate. This substance affects the growth of insects by acting as a metabolic poison. Since the insects do not possess any endoskeleton, calcium phosphate is not required in high quantities for insect growth and metamorphosis. Histopathological studies indicated that fat, glycogen and tissue reserves are utilised at a very fast rate in presence of calcium phosphate in the diet of insects. The exoskeleton of insect becomes very hard, friable, discolored and sometimes with nodular growth exhibiting pathological symptoms. Autolysis of tissues, supernumerary moulting and loss of weight are conspicuous symptoms of toxicity of tricalcium phosphate to insects. With a trace of glucose and vitamins particularly of the B-group, potentiation of toxicity of tricalcium phosphate is very conspicuous. Trehalose and vitamin D reverses the action of tricalcium phosphate on insects. A dosage of 0.2% on grains and their granular products has been found to be sufficient for protecting them from insect attack. This composition could enter into the protective and many processed foods (Table 10). Since the Indian diet in general, is deficient in calcium, enrichment of human dietary with this grain protectant formulation, based on calcium phosphate, glucose and vitamin, offers great promise for application in protecting stored grains and their processed products.

Bacterial Lepidoptericide: Yet another insecticidal product with selective effect on insect and found harmless to higher animals is the bacterial insecticide. This organism is a strain of Bacillus thuringiensis originally isolated from Heliothis obsoleta larva infected in the Institute’s field.
<table>
<thead>
<tr>
<th>Material</th>
<th>Rice</th>
<th>Wheat</th>
<th>Sorghum</th>
<th>Maize</th>
<th>Bengal gram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Kaolin</td>
<td>71</td>
<td>66</td>
<td>81</td>
<td>43</td>
<td>96</td>
</tr>
<tr>
<td>Activated kaolin**</td>
<td>46</td>
<td>19</td>
<td>33</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>Tricalcium phosphate</td>
<td>23</td>
<td>0</td>
<td>19</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Tricalcium phosphate + glucose</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(95% + 5%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat flour + Tricalcium phosphate + glucose</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(75% + 24%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>136</td>
<td>143</td>
<td>188</td>
<td>110</td>
<td>173</td>
</tr>
</tbody>
</table>

* Minimum effective dosage of calcium phosphate + glucose was 0.25% in rice.
** Minimum effective dosage of activated clay was 0.50% in pulses.
A submerged culture method for sporulation and production of toxin has been developed. In addition, a tray culture process has been standardised for mass production of highly potent and viable spores of the organism. Field trials through State entomologists have shown highly promising results for use on vegetable crops, oilseeds, pulses and even cereals. For controlling lepidopterous insects on paddy and other grains and grain products, the spore powder even at 1-10 ppm concentrations has been found to be effective. This product is effective against malathion resistant species of lepidopterous insects.

Fundamental and applied research on food protection has opened up new possibilities of controlling insect pests with non-toxic and selective protectants minimising the application of the wide spectrum residual pesticides. While controlling pests pollution of the environment can easily be avoided. Emphasis should therefore shift from “production” to “conservation” to maintain the balance between the population and the food as it could lead to more spectacular increase in quality food for the growing nations.

REFERENCES

THE IMPACT OF INDUSTRIALISATION AND URBANISATION ON FOOD CONSUMPTION PATTERNS IN DEVELOPING COUNTRIES REFERENCE — INDIA

M. Mathias
Hindustan Lever Research Centre.
Bombay, India

Many criteria have been applied to determine whether a country is developed, developing or under-developed, such as, the growth in the Gross National Product, the per capita income and its rate of increase, the number of cars or TV receivers per 1000 population, the daily average nutritional intake and so on. In the context of urbanisation, however, there is one more criterion of living standards and that is the distribution of population between urban and rural areas and the per capita income.

Table 1 clearly shows that a very close correlation exists between national average per capita income which is indicative of living standards and the percentage of population residing in the cities. For example, in the United States, which has the highest per capita income of 3,000 US Dollars, as much as 70% of the population is urban, whereas in India, which regrettably comes at the bottom of our list, only 18% of the population lives in the cities and the average national per capita income is as low as 77 US Dollars.

It hardly needs stating that urbanisation is the out-growth of industrialisation and it is quite understandable that as industry expands and becomes more productive, it takes the weight of the population off the over-burdened land necessitating the mechanisation of agriculture and thus increasing per capita agricultural productivity and prosperity. It is also significant that in the really affluent countries, industry and activities other than agriculture make the major contribution to the Gross Domestic Product, whereas in the developing countries, agriculture may account for as much as 50% of the national income. Even in a country like the USA, which for many years has been the granary of the world, only 3% of the gross domestic product comes from agriculture, whereas in India, it is 49% and in Russia as much as 24% (Table 2).

Until the Green Revolution of the last few years with its package inputs of high yielding varieties of seeds, fertilisers, pesticides and improved agricultural methods leading to a break-through in agriculture, the only means
Industrialisation and Food Patterns

TABLE 1

Income and population distribution

<table>
<thead>
<tr>
<th>Country</th>
<th>Per Capita National Income (1966) (US $)</th>
<th>% Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Urban</td>
</tr>
<tr>
<td>1. U.S.A.</td>
<td>3175</td>
<td>70</td>
</tr>
<tr>
<td>2. Sweden</td>
<td>2500</td>
<td>73</td>
</tr>
<tr>
<td>3. U.K.</td>
<td>1535</td>
<td>80</td>
</tr>
<tr>
<td>4. Italy</td>
<td>949</td>
<td>48</td>
</tr>
<tr>
<td>5. Philippines</td>
<td>226</td>
<td>30</td>
</tr>
<tr>
<td>6. Egypt</td>
<td>166</td>
<td>38</td>
</tr>
<tr>
<td>7. India</td>
<td>77</td>
<td>18</td>
</tr>
</tbody>
</table>

TABLE 2

Sectoral contribution to gross domestic products

<table>
<thead>
<tr>
<th>Country</th>
<th>G.D.P. (Billions)</th>
<th>Agri.</th>
<th>Industrial Total</th>
<th>Mfg.</th>
<th>Construct.</th>
<th>Trans-</th>
<th>Retail &amp; wholesale Trade</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.A.</td>
<td>799.3</td>
<td>3</td>
<td>32</td>
<td>28</td>
<td>5</td>
<td>6</td>
<td>16</td>
<td>38</td>
</tr>
<tr>
<td>U.K.</td>
<td>33.8</td>
<td>3</td>
<td>39</td>
<td>34</td>
<td>7</td>
<td>8</td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td>U.S.S.R.</td>
<td>207.4</td>
<td>24</td>
<td>30</td>
<td>39</td>
<td>9</td>
<td>6</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>INDIA</td>
<td>243.9</td>
<td>49</td>
<td>16</td>
<td>14</td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>15</td>
</tr>
</tbody>
</table>

To one who has lived all his life in the city, the urban environment holds no terrors, but its effect on the newly arrived rural immigrant can well be imagined. Coming from the wide open space of the country-side, the all pervasive nature of urban living with its sense of confinement, noise and movement must produce a depressing, even a traumatic impact. He cannot escape from it and it influences and conditions every aspect of his daily life. No longer is he his own master measuring time by the seasons and prosperity by the monsoon; he now has a bus to catch, a time clock to
punch and a fixed pay packet to receive. No longer can he pick and choose his friends by caste or community; on the factory floor his team-mates may be from distant places, so also his neighbours in his tenement or apartment house. He is introduced to new products, new ideas, new ways of life and exposed constantly to the multi-media of press, cinema, radio and outdoor advertising. Nor does his wife escape the intrusion of urban life—she has to get used to buying milk in a bottle, she gradually sees the advantages of the pressure cooker, the LPG stove, electric fan and the fluorescent light.

Fortunately, human nature is flexible and gradually the metamorphosis takes place, attitudes change and become more responsive to the need for change. He may change his style of dress at least in public and per force he may have to learn a new language, but it is universal experience that his food habits die hardest. He hangs on tenaciously not only to the dishes his mother made, but also her ideas on nutrition. It is strange that people who have adopted what one may call a uniform urban way of life with regard to all other aspects of living will revert to their own distinctive food styles even generations after they have left their place of origin. This is a most important factor when considering the food problems arising out of urban concentration. The second factor which marketing men have learnt from bitter experience is that people will initially reject food with which they are unfamiliar or which in their opinion does not taste right, no matter how nutritious it may be.

While existing food consumption patterns relate to cultural, religious and social groups and the availability of local foodstuffs, changes in consumption habits are determined by a number of factors, such as, income, environment, education particularly in nutrition, exposure to new ideas, the need for convenience and in India, and probably in other eastern countries the gradual break-down of joint family system. Such changes may manifest themselves quantitatively, qualitatively and in the variety of dishes consumed. For staple foods, such as cereals, it has been established that the quantity consumed in the lower income groups is directly related to income, until a point is reached when the need for such staples is fully met and more expensive foods, such as meats and vegetables can be afforded. The cereal content of the diet then becomes inversely proportional to income. There is an interesting quantitative change in the type of cereals consumed as income increases and as opportunities to buy what are considered better types of cereals are available. For example, people may shift from coarse grains, such as jowar (sorghum) and bajri (millets) to wheat and rice. A recent comprehensive survey in Maharashtra State covering both urban and rural areas has provided a great deal of information on consumption patterns
in the State. The percentage of families eating wheat increased from 21% in the rural areas to as much as 84% in the metros, which is almost in reverse proportion to the numbers eating jowar (sorghum) which declined to 3% in metros from as much as 64% in the rural areas (Table 3).

TABLE 3

<table>
<thead>
<tr>
<th>Eating Habit—Maharashtra</th>
<th>Percentage of Families Eating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metro</td>
</tr>
<tr>
<td>Wheat</td>
<td>84%</td>
</tr>
<tr>
<td>Jowar</td>
<td>3%</td>
</tr>
<tr>
<td>Egg</td>
<td>11%</td>
</tr>
<tr>
<td>Milk</td>
<td>39%</td>
</tr>
<tr>
<td>Tea</td>
<td>97%</td>
</tr>
<tr>
<td>Coffee</td>
<td>11%</td>
</tr>
<tr>
<td>Bread</td>
<td>40%</td>
</tr>
<tr>
<td>Biscuit</td>
<td>19%</td>
</tr>
</tbody>
</table>

When one looks at the per capita daily consumption in Maharashtra, it is interesting to note that in fact the total quantity of cereals consumed per day in the rural areas at 392 grams is higher than in the metros at 278 grams, but the type of the cereal is different with wheat predominating in metros and jowar in the rural areas (Table 4). As was said earlier, rising incomes and urbanisation results in a shift to better type of cereals and a gradual reduction in cereal intake being replaced by more expensive foods.

TABLE 4

Per capita consumption per day—Maharashtra  
(in grams)

<table>
<thead>
<tr>
<th></th>
<th>Metro</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>88%</td>
<td>76%</td>
<td>40%</td>
</tr>
<tr>
<td>Wheat</td>
<td>176%</td>
<td>151%</td>
<td>45%</td>
</tr>
<tr>
<td>Jowar</td>
<td>4%</td>
<td>48%</td>
<td>244%</td>
</tr>
<tr>
<td>Total cereals</td>
<td>4%</td>
<td>289%</td>
<td>392%</td>
</tr>
<tr>
<td>Total pulses</td>
<td>55%</td>
<td>45%</td>
<td>47%</td>
</tr>
<tr>
<td>Oil &amp; fat</td>
<td>32%</td>
<td>23%</td>
<td>7%</td>
</tr>
<tr>
<td>Sugar</td>
<td>24%</td>
<td>21%</td>
<td>11%</td>
</tr>
<tr>
<td>Milk</td>
<td>195%</td>
<td>143%</td>
<td>66%</td>
</tr>
<tr>
<td>Green vegetables</td>
<td>60%</td>
<td>39%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Higher incomes have a more profound effect on the qualitative nature of
the diet and lead to the introduction of so-called fringe foods like biscuits,
icelande, beverages, tea, coffee and soft drinks. Referring again to the
Maharashtra Survey, it is seen that in the urban areas, 19% of the population
consumed biscuits and eggs compared with less than 1% in the rural areas
(Table 3). In this context, it is worth referring to the manner in which fringe
foods like biscuits are found acceptable, even when basic food habits do
not change. The consumption of biscuits has increased from 16,000 tonnes
to 62,000 tonnes in the last eighteen years, per capita consumption increasing
nationally 2½ times from 44 gm to 116 gms. It is expected that per capita
consumption will again double in the next ten years. It must be appreciated,
however, that these are national figures and do not at all reflect the pattern
of consumption between urban and rural areas, nor the distribution of
consumption between income groups within each of these sectors of the
population. It would be safe to assert, however, that the bulk of the increase
in consumption of biscuits has come from the urban areas.

A recent phenomenon has been the rapid growth in the increase of con-
sumption of bread in the urban areas, particularly in those towns where the
Government chain of Modern Bakeries has installed its units. In Mah-
rashta, bread is consumed by as many as 40% of the families in metro,
whereas only 1% in rural areas consume bread (Table 3). It may be said
that this is as much a function of availability and advertising, as it is of
basic changes in food habits. It is, however, an example of the manner in
which a nutritious and if necessary fortified food may be gradually introduced
into the diet in a hygienic and economical manner.

It is well known that statistics based on averages are highly misleading,
particularly in the context of wide variations in per capita consumption
relating to income. For instance, Table 5 shows the growth in consumption
of vanaspati (hydrogenated vegetable fat) between rural and urban areas
over a period of 1961-70 indicating that in the rural areas, per capita
consumption is as low as 0.65 kg whereas in the urban it goes up to 2.08 kg.
2.09 kg is again an average of consumption in different income groups.

Table 6 shows the extent to which income affects the consumption in
different income groups. It is seen that in the upper income group the
per capita consumption of oil, ghee (clarified butter) and vanaspati per
annum is more than what it is in the lower income group. Increase in
incomes combined with the exposure to new products and ideas in basic
consumption regions affect changes upwards in the social scale with people
moving, for instance, from unrefined to refined oils then to vanaspati and
then to ghee. Similarly, from jaggery to refined crystal sugar and in the
highest income groups, perhaps, to saccharine.
TABLE 5

Rural & Urban consumption of Vanaspati

<table>
<thead>
<tr>
<th></th>
<th>Population (Million)</th>
<th>Per capita consumption (kg)</th>
<th>Total (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>Urban</td>
<td>80</td>
<td>1.592</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>363</td>
<td>0.582</td>
</tr>
<tr>
<td></td>
<td>All-India</td>
<td>443</td>
<td>0.764</td>
</tr>
<tr>
<td>1970</td>
<td>Urban</td>
<td>110</td>
<td>2.080</td>
</tr>
<tr>
<td></td>
<td>Rural</td>
<td>450</td>
<td>0.650</td>
</tr>
<tr>
<td></td>
<td>All-India</td>
<td>560</td>
<td>0.930</td>
</tr>
</tbody>
</table>

TABLE 6

Market structure for oils, ghee and vanaspati—1971
Bombay—Per capita/per annum

<table>
<thead>
<tr>
<th>Income group</th>
<th>Oils kg.</th>
<th>Ghee kg.</th>
<th>Vanaspati kg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>1.9</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Middle</td>
<td>2.4</td>
<td>0.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Upper</td>
<td>2.1</td>
<td>0.7</td>
<td>1.1</td>
</tr>
</tbody>
</table>

To the extent that industrialisation and urbanisation stimulate higher and more regular incomes, they will change consumption patterns in quantity and quality, but not necessarily in the variety of dishes and promote the sale of low cost fringe foods, such as, soft drinks, ice-cream, biscuits, savoury and sweet snacks, etc. Regular urban incomes permit permanent inclusion of new items in the diet, whereas in the rural areas incomes being notoriously unpredictable, the individual is reluctant to indulge in expenditure in a good year, which he will have to curb when things go badly. The major question then is whether industrialisation and urbanisation do, in fact, promote higher incomes. In Table 7 we have tried to break-down the population of urban and rural areas and relate national income to these population groups. It will be seen that in the projection for 1971, the four metro towns, Bombay, Calcutta, Delhi and Madras, which have only 2.7% of the population produce as much as 8.6% of the national income.
TABLE 7

Distribution of incomes in 1971 at 1960/61 prices

<table>
<thead>
<tr>
<th></th>
<th>Per capita income (Rs.)</th>
<th>Population 1971 (million)</th>
<th>Total income (at 1960-61 prices) (Rs./million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Metros</td>
<td>1070</td>
<td>15</td>
<td>16,050</td>
</tr>
<tr>
<td>Rest of Urban</td>
<td>600</td>
<td>98</td>
<td>58,800</td>
</tr>
<tr>
<td>Rural</td>
<td>250</td>
<td>451</td>
<td>112,750</td>
</tr>
<tr>
<td>All-India</td>
<td>333</td>
<td>564</td>
<td>187,600</td>
</tr>
</tbody>
</table>

The entire rural area with 80% of the population contributes only 60% of national income. It is quite understandable, therefore, that the per capita income in the metros and in the rest of the urban India at Rs. 1070 and Rs. 600 respectively far exceeds the rural average of Rs. 250/-. Furthermore, the spread in the income distribution from the highest to the lowest incomes in the urban areas is much wider, offering scope for the sale of a larger variety of the products. Industrialisation and urbanisation in India, so far, have brought quantitative and qualitative changes, without fundamentally affecting the variety of foods consumed by different cultural groups, nor the manner in which these foods are basically purchased.

It is well known that knowledge is a state of mind, which precedes action by gradually changing attitudes. The time lag between knowledge and action may be very long, depending upon what one would call the credibility gap. Again, in the case of food and nutrition, particularly in older societies, there is a reluctance to accept new ideas, especially when they conflict with one's accepted beliefs. Increase in knowledge is a function of environment, education and advertising, to which the urban resident is far more exposed than his rural counterpart. In this connection, the Maharashtra Survey shows the extent to which the resident in the urban area is aware of nutrient concepts related to vitamins, minerals, calories and protein compared with his rural counterpart. For instance, only 11% housewives in the rural area know about vitamins, whereas in metro, this figure is as high as 64% (Table 8). Minerals and calories are less well-known, but surprisingly the concept of proteins, if not the word, is understood by 43% of the housewives in metro and probably by more of their men folk compared with only 6% in the rural area.

In more sophisticated societies, the most dramatic change in consumption habits has been the widespread acceptance of the so-called convenience
Industrialisation and Food Patterns

TABLE 8
Awareness of nutrient concepts—Maharashtra

<table>
<thead>
<tr>
<th>Percentage of housewives aware</th>
<th>Metro</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamins</td>
<td>64</td>
<td>44</td>
<td>11</td>
</tr>
<tr>
<td>Minerals</td>
<td>29</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td>Calories</td>
<td>22</td>
<td>32</td>
<td>6</td>
</tr>
<tr>
<td>Protein</td>
<td>43</td>
<td>29</td>
<td>6</td>
</tr>
</tbody>
</table>

foods, namely, foods which have been processed and then canned, dehydrated, frozen or in some other way preserved for subsequent use. At the one extreme, these foods may have to undergo the full process of re-constitution in cooking whereas, at the other, they may be ready for consumption.

Many factors have combined to promote the acceptance of convenience foods in the normal diet to the point where the majority of families would consider it old fashioned to go through the entire cooking procedure adopted by their mothers and grandmothers starting from fresh materials. Basic to these factors is the change in status of women, specially with regard to those who are now employed on a whole-time basis. Where time is of such importance and where no domestic help is available even at a price, the consumer will adduce a significant value to convenience and the saving of time. It would not apply in a country where time is of less importance and where domestic assistance is available even in the middle income groups and where the market is extremely price sensitive. This price sensitivity is the major obstacle in the developing countries to the widespread acceptance of convenience foods, as it results in a vicious circle of low production in the field and in the factory, no economies of scale and consequently the necessity to sell processed foods at a considerable premium over fresh foods, thus inflating the added value of convenience beyond the point which the consumer is prepared to accept.

In addition to the obvious problem of hygiene, sanitation, public health, public transport, water supply, education and so on, resulting from the rapid unplanned urbanisation, there is a major problem in logistics of food to be supplied when concentrated areas of consumption are far removed from the areas of production. Distribution and storage of food present no problems when most of the population live on the land and are self-sufficient but they become formidable when bulky commodities have to be moved considerable distances and undergo long storage. It is only food processing that can meet these problems by preserving food, reducing its
bulk, retaining its nutrition and rendering it more susceptible to transport, distribution, storage and delivery. On the face of it, this will appear to be a challenge to the food scientists and technologists, but in fact, if it is to be successful, it must involve the plant scientists, the agronomist, the commercial man, the skills and techniques of marketing people and, above all, the nutritionists. In brief, the task is to achieve economies of scale both in agriculture and in processing, and thus to make available to the urban population processed foods in the form they find acceptable at a price they will pay and of a high nutritional quality.

In meeting this challenge, the nutritionists and the scientists should work closely with marketing men in understanding consumer's needs and attitudes. It would be futile to try and market a product merely on the strength of its nutritional quality or even its cost, if it does not fit into the existing consumption patterns. On the other hand, changes can and will take place as a result of campaigns which will educate the consumer both with regard to the advantages of processed foods on the grounds of cost, convenience and nutrition. Experience has shown that this is a slow process and a breakthrough can only be expected if there is a rapid change in social and living conditions, promoting higher incomes and thus reducing price sensitivity and allowing a higher added value for the factor of convenience.
LACTASE DEFICIENCY IN INDIANS
VINODINI REDDY AND JITENDER PERSHAD
National Institute of Nutrition
Hyderabad-7, India

In recent years great interest has arisen in the phenomenon of lactose intolerance in apparently healthy subjects. This disorder has been reported to be common among Asians and Africans, in contrast to a low prevalence in Caucasians. Most of the subjects that have been studied are negroes and 'Oriental adults' residing in the United States and Australia. The lactose intolerance in these subjects has been attributed to an inherited lactase deficiency. In view of these observations, it has been suggested that the importance of milk in planning diets for undernourished populations in Asian countries should be re-evaluated.

The results of a recent study reported from India have also shown that lactose intolerance is frequently seen among adult subjects. There is, however, little information regarding its incidence in children. Since preschool children form the major beneficiaries of many nutrition programmes which utilise skim milk as a supplementary food, this question acquires considerable practical importance. Also, it has to be examined whether lactose intolerance necessarily implies milk intolerance.

An investigation was, therefore, undertaken to determine the incidence of lactose intolerance and the levels of intestinal lactase in a group of Indian adults and children.

STUDIES IN ADULTS:

In 12 apparently normal adults, jejunal biopsy was performed using a Crosby capsule. The biopsy sample was examined both for histology and the disaccharidase levels. Lactase, sucrase and maltase were determined by Dalqvist's method. In six of these subjects, 60 g. of dry skim milk containing 30 g. of lactose was given daily and the biopsy repeated after 4 weeks.

Oral lactose tolerance tests were done in 18 normal adults which included the 12 subjects in whom biopsy was also performed. A loading dose of 50 g. of lactose was employed. Blood sugar levels were determined by Park and Johnson's method at 0, 30, 60 and 120 minutes after the dose.
Jejunal biopsy was performed in 15 normal children using a paediatric Crosby capsule. The biopsy specimens were utilised for histological examination and disaccharidase assay.

Oral lactose tolerance tests were done in 54 apparently normal children including the 15 subjects in whom biopsy was also performed. Their ages ranged from 7 months to 7 years. A lactose load of 2 g/kg body weight was used. In 8 children who showed intolerance, the study was repeated with a lower dose of 1 g. of lactose per kg. All these children were given supplements of reconstituted dry skim milk in quantities which provided 2 g. of lactose per kg. for the next few days and they were observed for symptoms of lactose intolerance.

RESULTS AND DISCUSSION

Gross appearance: Under the dissecting microscope the mucosal surface showed either leaf-like villi or convoluted pattern. No case showed finger-like villi.

Histology: The mucosal pattern was essentially normal with long and slender finger-like villi in most cases and broad leaf-like villi in a few.

Disaccharidases: (Table 1)

Lactase activity in the intestinal mucosa was low in all the subjects studied while the activity of the other two enzymes—sucrase and maltase was normal. The values ranged from 0—0.9, 2.0—7.6 and 5.4—33.7 units/gm wet weight for lactase, sucrase and maltase, respectively. The values expressed per gram of protein also indicated isolated lactase deficiency.

In children, lactase activity ranged from 0.2—6.6 U/g wet weight. The enzyme concentration was more than 1 U/g in all the 9 children who were below the age of 3 years, while in the older children the levels ranged from 0.2—1.4 U/g.

The adult subjects and the children above 3 years were not accustomed to drinking milk whereas the infants were getting either breast milk or cow’s milk in their diets and their lactase activity was normal. Association of lactase deficiency with a history of low milk consumption has been pointed out earlier and it was suggested that there may be an adaptive decline in
TABLE 1
Levels of intestinal disaccharidases

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No.</th>
<th>Lactase</th>
<th>Sucrase</th>
<th>Maltase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unit/g wet weight</td>
<td>Unit/g protein</td>
<td>Unit/g wet weight</td>
</tr>
<tr>
<td>Adults</td>
<td>12</td>
<td>0.19 (0-0.9)</td>
<td>7.8 (2-24)</td>
<td>3.8 (2-7.6)</td>
</tr>
<tr>
<td>Children above 3 years</td>
<td>6</td>
<td>0.57 (0.26-1.48)</td>
<td>15.5 (6.8-35.5)</td>
<td>4.4 (2.1-7.8)</td>
</tr>
<tr>
<td>Children below 3 years</td>
<td>9</td>
<td>2.1 (1.0-6.6)</td>
<td>54 (21-169)</td>
<td>4.2 (3.2-7.4)</td>
</tr>
</tbody>
</table>

*Mean with range.
Unit of disaccharidase activity = u moles of disaccharide hydrolysed/minute.
the enzyme following withdrawal of milk from the diet after weaning. A post weaning decrease in lactase activity has been demonstrated in animals and it has also been shown that this decrease can be prevented if lactose is provided as the only source of carbohydrate. However, in man, milk drinking does not seem to affect lactase levels. Recently, 5 normal healthy adults who were in the habit of drinking substantial amounts of milk regularly were also investigated. Lactase activity was found to be less than 1 U/g wet weight in all of them in spite of regular milk intake. In the 6 subjects in whom biopsy was repeated 4 weeks after skim milk supplementation, there was no increase in lactase activity (Table 2). Similar attempts to raise the enzyme level with a prolonged lactose diet have failed. Conversely, lactose deprivation in normal subjects 10 does not lower lactase levels. These observations argue against adaptation to lack of substrate playing a role in low lactase levels.

### TABLE 2

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Initial Lactase unit/Int. protein (mg/g)</th>
<th>After 4 weeks of milk Lactase unit/Int. protein (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lactase unit/Int. protein (mg/g)</td>
<td>Lactase unit/Int. protein (mg/g)</td>
</tr>
<tr>
<td>1</td>
<td>0.15/30.3</td>
<td>1.10/62.5</td>
</tr>
<tr>
<td>2</td>
<td>0.16/42.0</td>
<td>0.13/61.5</td>
</tr>
<tr>
<td>3</td>
<td>0.26/20.7</td>
<td>0.16/53.2</td>
</tr>
<tr>
<td>4</td>
<td>0.10/55.0</td>
<td>0.10/51.0</td>
</tr>
<tr>
<td>5</td>
<td>0/39.8</td>
<td>0/44.0</td>
</tr>
<tr>
<td>6</td>
<td>0/32.5</td>
<td>0/42.1</td>
</tr>
<tr>
<td>Mean</td>
<td>0.11/36.7</td>
<td>0.08/52.4</td>
</tr>
</tbody>
</table>

All the subjects who received skim milk showed intolerance initially but the symptoms became milder or altogether disappeared after 3 to 4 weeks, though there was no increase in the enzyme activity. Other workers 8 have also observed that absorption can improve with prolonged intake of lactose. The exact mechanism of this adaptation is not clear.

### Lactose tolerance test: (Table 3)

Nine out of the 18 adults studied, developed symptoms of intolerance after the lactose load. They complained of abdominal pain, distension and passed loose stools within 24 hours. Eleven subjects showed flat tolerance curves as judged by a failure of blood sugar to rise above 25 mg % from
**TABLE 3**

<table>
<thead>
<tr>
<th>Lactose tolerance test</th>
<th>No. of subjects</th>
<th>Maximum rise in blood sugar—mg %</th>
<th>No. of subjects with flat curves</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adults</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tolerant</td>
<td>9</td>
<td>33 (22-49)</td>
<td>4</td>
</tr>
<tr>
<td>Intolerant</td>
<td>9</td>
<td>19 (8-36)</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>—</td>
<td>11</td>
</tr>
<tr>
<td><strong>Children</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tolerant</td>
<td>34</td>
<td>36 (10-70)</td>
<td>11</td>
</tr>
<tr>
<td>Intolerant</td>
<td>20</td>
<td>26 (3-43)</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>—</td>
<td>22</td>
</tr>
</tbody>
</table>

*Rise in blood sugar was less than 25 mg %.

The mean maximum rise in blood sugar was 33 mg % in the tolerant group and 19 mg % in the intolerant group. However, not all subjects with intolerance had flat curves. Two subjects had intolerance but showed a normal rise in blood sugar and four subjects had flat curves but no symptoms.

Twenty of the 54 children developed symptoms of intolerance following the lactose load of 2 g/kg, but none of the 8 in whom the test was done with a dose of 1 g/kg, had such symptoms. The rise in blood sugar was less than 25 mg % in 11 out of 34 tolerant and 11 out of 20 intolerant children. There was no correlation between the rise in blood sugar, symptoms of intolerance and the enzyme activity.

It was observed that all those who showed symptoms of intolerance had lactase deficiency but the converse was not true. Some children showed a satisfactory rise in blood sugar and had no symptoms following lactose load though their lactase activity was low. The possible explanation for this discrepancy could be that the enzyme levels determined in a single biopsy specimen may not indicate the total lactase available. Desai *et al.* have found that in patients with tropical sprue as well as in normal subjects, lactase activity in the ileal mucosa was higher than that observed in jejunal mucosa.
These observations raise an important question. Does lactase deficiency or intolerance to lactose load necessarily imply clinical milk intolerance? Several factors like total lactase available, the dose of the lactose and the amount of milk consumed at a time are important in determining symptomatic response.

In the present study symptoms of intolerance were observed in 20 children when 2 g/kg of lactose was given. In 8 of these intolerant children, when the test was repeated with a dose of 1 g/kg, there were no symptoms. All of them showed a satisfactory rise in blood sugar as well. These observations suggest that though the enzyme activity is low it may be adequate to handle the lactose well when presented in small amounts.

The most important observation made here was that out of 20 children who had intolerance to 2 g/kg lactose load, only 4 had symptoms when milk containing equivalent amounts of lactose was given. Even in these children, symptoms disappeared when the milk was given in divided doses. All the children could consume 200 ml of milk containing 15 g of lactose at a time without any untoward effects. These results clearly show that lactose intolerance does not necessarily imply milk intolerance.

Many developing countries are currently receiving dry skim milk from various international organizations and this is being used as a protein supplement particularly for pre-school children. In most nutrition programmes, the amount of milk given to a child rarely exceeds 150 to 200 ml at a time. Results of the present study indicate that the incidence of lactase deficiency and lactose intolerance is lower in children than in adults and even those children who have lactose intolerance are unlikely to develop symptoms with these amounts of milk supplements. High incidence of lactase deficiency should not, therefore, be used as an argument against the distribution of skim milk to undernourished populations in Asian countries.

REFERENCES

DIETARY STUDIES AND EPIDEMIOLOGY OF HEART DISEASE

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Coronary heart disease (CHD) of atherosclerotic origin, has a multifactorial aetiology. Among the several factors contributing to its aetiology diet has a definite role.

In 1958 we started a prospective epidemiological study on CHD in population groups that included cohorts of men, aged 40-59 in seven countries: Finland, Greece, Italy, Japan, Netherlands, U.S.A. and Yugoslavia. The examination procedure for the men in each of the fourteen cohorts included standardized questionnaires on family status and medical history, anthropometry, physical examination, ECG, blood samples, and qualitative urinanalysis.

The dietary studies involved seven-day weight records of all foods eaten by men in statistical sub-samples of all the cohorts except the cohort of U.S. railroad men. Repetitions of these seven-day surveys covered different seasons of the year. Nutrients consumed were measured by chemical analysis of food composites or equivalent composites as well as by calculations from tables of food composition. Special tables of food composition, based on locally analysed foodstuffs, were used for Finland, Italy and Netherlands. For Greece, Japan and Yugoslavia food composition tables for international use were modified for local food peculiarities. The diets of U.S. railroad men were estimated by calculation from dietary interview and recall records, supplemented by visits to the homes of a small sub-sample.

After initial examination the men were followed-up with checks by an internist on mortality and major morbidity several times a year, and then were re-examined, as at entry, after five years. Complete five-year re-examinations covered 94 per cent of all survivors. At the tenth year another re-examination was carried out for most of the cohorts, but because the data are not yet completed we will refer here only to the results of the first five years.

Table I summarizes some of the dietary data in terms of averages for the
several countries. In general the energy intake tended to be high because most of the rural Europeans in these studies are farmers and do rather heavy physical work. The percentage of total calories from proteins shows very little variation, but this is not the case for total calories from fats. Table 2 gives data for the five cohorts in Yugoslavia as an example of findings in individual cohorts.

### TABLE 1
Average composition of 7-day diets of men aged 40-59 in different cohorts

<table>
<thead>
<tr>
<th>Country</th>
<th>% total calories from proteins</th>
<th>% total calories from fats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zutphen, Netherlands (N)</td>
<td>12.0</td>
<td>42.6</td>
</tr>
<tr>
<td>East Finland (E)</td>
<td>12.6</td>
<td>39.2</td>
</tr>
<tr>
<td>West Finland (W)</td>
<td>12.2</td>
<td>35.4</td>
</tr>
<tr>
<td>U.S. Railroad (U)</td>
<td>15.0</td>
<td>39.0</td>
</tr>
<tr>
<td>Crete, Greece (K)</td>
<td>10.5</td>
<td>40.3</td>
</tr>
<tr>
<td>Corfu, Greece (G)</td>
<td>11.4</td>
<td>32.7</td>
</tr>
<tr>
<td>Crevacore, Italy (C)</td>
<td>12.9</td>
<td>27.2</td>
</tr>
<tr>
<td>Montegiorgio, Italy (M)</td>
<td>11.4</td>
<td>[24.9]</td>
</tr>
</tbody>
</table>

### TABLE 2
Average composition of 7-day diets of men aged 40-59 in different cohorts of Yugoslavia

<table>
<thead>
<tr>
<th>Cohort</th>
<th>% total calories from proteins</th>
<th>% total calories from fats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgrade Faculty (B)</td>
<td>14.0</td>
<td>35.0</td>
</tr>
<tr>
<td>Zrenjanin (Z)</td>
<td>13.5</td>
<td>37.0</td>
</tr>
<tr>
<td>Velika Krsna (V)</td>
<td>13.5</td>
<td>24.0</td>
</tr>
<tr>
<td>Slavonia (S)</td>
<td>14.1</td>
<td>32.8</td>
</tr>
<tr>
<td>Dalmatia (D)</td>
<td>13.6</td>
<td>30.6</td>
</tr>
</tbody>
</table>
Seasonal variation for the three energy-yielding classes of nutrients was in general very small; there was good agreement between the average percentage of calories derived from proteins and fats, even when the repetitions were made in different seasons and with different men in the dietary subsamples. Accordingly, it can be concluded that the cohorts are reasonably well characterized by the average nutrient values reported here.

However, the picture is quite different for individuals. As shown in Table 3, within-individual variation (SD_{wi}) for percentage of total calories from proteins and fats in the diet is similar in magnitude to, between-individual variation (SD_{bi}) in all the cohorts. This means that within the group the individual men cannot be reliably distinguished from one another in regard to the proportional representation of the energy yielding nutrients in their diets. This explains why we have been unable to find significant correlations within cohorts between individual serum cholesterol measurements and the estimated nutrient intake of those individuals.

### Table 3

<table>
<thead>
<tr>
<th>Cohort</th>
<th>No. men</th>
<th>% Total calorie from</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protins</td>
<td>SD_{wi}</td>
<td>SD_{bi}</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Finland</td>
<td>24</td>
<td></td>
<td>1.0</td>
<td>1.3</td>
<td>3.0</td>
</tr>
<tr>
<td>West Finland</td>
<td>31</td>
<td></td>
<td>1.1</td>
<td>1.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Crete</td>
<td>18</td>
<td></td>
<td>1.3</td>
<td>1.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Crevalcore</td>
<td>15</td>
<td></td>
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<td>7.3</td>
</tr>
<tr>
<td>Montegiorgio[11]</td>
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<td></td>
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<td>1.8</td>
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</tr>
<tr>
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<td>1.6</td>
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</tr>
<tr>
<td>Slavonia</td>
<td>17</td>
<td></td>
<td>1.0</td>
<td>1.3</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Before examining the relationship between the dietary data and the incidence of CHD, let us first see the correlation between one risk factor like serum cholesterol concentration and the incidence rate of CHD. In Figure 1 the serum cholesterol medians for all cohorts are plotted against the five-year CHD incidence rate (age standardized) of CHD deaths and “hard criteria” infarcts. The correlation coefficient is 0.76. For CHD incidence rate of all CHD cases the correlation with serum cholesterol is r = 0.84 (Figure 2).
Fig. 1. Five-year incidence rate (age standardized) of CHD deaths and "hard criteria" infarcts plotted against median serum cholesterol concentration of the cohorts. B=Belgrade Faculty, C=Crevalcore, D=Dalmatia, E=East Finland, G=Corfu, K=Crete, M=Montegiorgio, N=Zutphen, S=Slavonia, U=U.S. Railroad, V=Velika Krsna, W=West Finland, Z=Zrenjanin.

Fig. 2. Incidence rate of all CHD cases plotted against median serum cholesterol concentration of the cohorts. Cohort designations as in Fig. 1.
The average dietary calories per kg of body weight are plotted against the median serum cholesterol concentration in Figure 3 and against the age-standardized incidence rate of all CHD in Figure 4. The correlation

![Correlation Chart](image)

**Fig. 3.** Median serum cholesterol concentration plotted against dietary calories per kg of body weight. Cohort designations as in Fig. 1.

![Correlation Chart](image)

**Fig. 4.** Incidence rate of all CHD cases plotted against dietary calories per kg of body weight. Cohort designations as in Fig. 1.
coefficients are respectively \( r = 0.07 \) and \( r = 0.04 \). Clearly there is no tendency for the average dietary calorie intake per unit of body size to be related to either average serum cholesterol concentration or to incidence rate of CHD.

Also, there is no correlation between proteins expressed as percentage of total calories, and CHD incidence rate among the men CHD-free at the outset (Figure 5). The same is true in regard to serum cholesterol.

![Graph](image)

**Fig. 5.** Incidence rate of all CHD cases plotted against average percentage of total calories from proteins in the diet. Cohort designations as in Fig. 1.

Total fats in the diet, as percentage of total calories, plotted against the incidence rate of CHD deaths and infarctions or of all CHD cases are summarized in Figures 6 and 7. The correlation coefficients are rather low; \( r = 0.39 \) and \( r = 0.37 \) respectively. But let us now consider the individual classes of fatty acids. The values expressed as percentage of total calories in twelve cohorts are reported in Figure 8. The saturated fatty acids show major differences among the cohorts, rising from as low as only three per cent of calories in Japan to as high as 22 per cent in East Finland.
Epidemiology of Heart Disease

Fig. 6. Incidence rate of CHD deaths and infarcts plotted against average percentage of total calories from fats in the diet. Cohort designations as in Fig. 1.

Fig. 7. Incidence rate of all CHD cases plotted against average percentage of total calories from fats in the diet. Cohort designations as in Fig. 1.
### Average % Calories from Fats

**Men 40-59**

<table>
<thead>
<tr>
<th>Location</th>
<th>Saturated F.A.</th>
<th>Monounsaturated F.A.</th>
<th>Polyunsaturated F.A.</th>
<th>Average %</th>
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</thead>
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<tr>
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<td>3</td>
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<td></td>
</tr>
<tr>
<td>Velika Krsna</td>
<td>9</td>
<td>12</td>
<td>3</td>
<td>24%</td>
</tr>
<tr>
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<td>9</td>
<td>13</td>
<td>3</td>
<td>25%</td>
</tr>
<tr>
<td>Crevalcore</td>
<td>10</td>
<td>14</td>
<td>3</td>
<td>27%</td>
</tr>
<tr>
<td>Dalmatia</td>
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<td>16</td>
<td>7</td>
<td>32%</td>
</tr>
<tr>
<td>Slavonia</td>
<td>14</td>
<td>16</td>
<td>3</td>
<td>33%</td>
</tr>
<tr>
<td>Coreu</td>
<td>7</td>
<td>22</td>
<td>4</td>
<td>33%</td>
</tr>
<tr>
<td>Crete</td>
<td>8</td>
<td>29</td>
<td>3</td>
<td>40%</td>
</tr>
<tr>
<td>West Finland</td>
<td>19</td>
<td>13</td>
<td>3</td>
<td>35%</td>
</tr>
<tr>
<td>Zutphen</td>
<td>19</td>
<td>16</td>
<td>5</td>
<td>40%</td>
</tr>
<tr>
<td>U.S. Railroad</td>
<td>17-18</td>
<td>17-18</td>
<td>4-6</td>
<td>40%</td>
</tr>
<tr>
<td>East Finland</td>
<td>22</td>
<td>14</td>
<td>3</td>
<td>39%</td>
</tr>
</tbody>
</table>

Fig. 8. Average percentage of dietary calories provided by saturated, mono-ene, and polyunsaturated fatty acids.
Fig. 9. Median serum cholesterol concentration plotted against average percentage of total calories from saturated fatty acids in the diet. Cohort designations as in Fig. 1.

Fig. 10. Incidence rate of CHD deaths and infarcts plotted against average percentage of total calories from saturated fatty acids in the diet. Cohort designations as in Fig. 1.
The average concentration of cholesterol in the blood serum was highly correlated with the average percentage of calories provided by saturated fatty acids in the diet; \( r = 0.88 \) (Figure 9). Also as shown in Figures 10 and 11, incidence rates of CHD deaths and infarcts and of all CHD incidence proved to be highly correlated with the percentage of calories from saturated fatty acids in the diet, with \( r = 0.80 \) and \( r = 0.86 \) respectively.

![Graph showing correlation between % calories from saturated fatty acids and incidence rate of all CHD cases.

A rather low negative correlation was observed between mono-ene fatty acids, expressed as percentage of total calories and the incidence rate for all CHD \( (r = -0.40) \) (Figure 12). The polyunsaturated fatty acids as percentage of calories were very similar among the several cohorts and accordingly showed no correlation with either serum cholesterol averages or CHD incidence.

Total carbohydrates, expressed as percentage of total calories, were not significantly correlated with either incidence rate of CHD deaths and infarcts or with the incidence rate of all CHD cases the correlation coefficients being \( r = 0.05 \) and \( 0.23 \) respectively (Figures 13 and 14). But if we now consider some of the individual carbohydrates, we have different results.
Fig. 12. Incidence rate of all CHD cases plotted against average percentage of total calories from mono-ene fatty acids in the diet. Cohort designations as in Fig. 1.

Fig. 13. Incidence rate of CHD deaths and infarcts plotted against average percentage of total calories from carbohydrates in the diet. Cohort designations as in Fig. 1.
In Figure 15 the percentages of total calories from sucrose are plotted against the CHD incidence rate of CHD deaths and infarcts for some of the cohorts. The correlation coefficient is 0.71. A similar correlation was observed for sucrose versus incidence of all CHD cases \(r = 0.77\), Figure 16 and the average serum cholesterol level \(r = 0.83\), Figure 17. One important point has to be stressed first. The correlation between CHD incidence and sucrose intake is lower than with the percentage of total calories from saturated fatty acids in the diet. And, most significantly, the percentage of total calories from sucrose is highly correlated with percentage of total calories from saturated fatty acids (Figure 18), the correlation coefficient being \(r = 0.88\). This can be considered a common nutritional phenomenon that when the diet is high in saturated fatty acids, there tends to be a correspondingly high consumption of sucrose.

This is not the place to consider whether this is due to economic factors or psychological ones or to both. It is more interesting instead to identify the primary factor responsible for CHD. Besides the higher correlation shown with the percentage of total calories from saturated fatty acids, let us also consider briefly the situation as observed in countries characterized by a low fat and very high sucrose consumption, as for instance some of the Latin American countries. In Colombia, according to the recent survey of the Interdepartmental Committee on Nutrition for National Defence, sucrose...
Fig. 15. Incidence rate of CHD deaths and infarcts plotted against percentage of total calories from sucrose in the diet. Cohort designations as in Fig. 1.

Fig. 16. Incidence rate of all CHD cases plotted against average percentage of total calories from sucrose in the diet. Cohort designations as in Fig. 1.
Fig. 17. Median serum cholesterol concentration plotted against average percentage of total calories from sucrose in the diet. Cohort designations as in Fig. 1.

Fig. 18. Average percentage of total calories from sucrose in the diet plotted against average percentage of total calories from saturated fatty acids in the diet. Cohort designations as in Fig. 1.
consumption of the military personnel reaches 19 per cent of total calories and total fats, 16 per cent. For the civilian, sucrose constitutes 14 per cent and total fat, 19 per cent. Serum cholesterol values are 140 and 165 mg/100 ml respectively. A similar situation has been observed in Equador. In populations or groups where consumption of sucrose is very high, much higher than that observed in some of our cohorts (12.5 per cent of total calories for U.S. railroad, 10.5 per cent for Zutphen, 10 per cent for Finland), serum cholesterol values are very low, and even lower than in our cohorts with very low sucrose intake and medium fat consumption.

Before closing let us consider briefly the problem of starch cereals. Groen has observed certain Middle Eastern population groups with a low serum cholesterol level, consuming a diet rich in bread, and low in cholesterol, total and saturated fat and sucrose. Unfortunately, we do not have at hand the data for all the cohorts examined. However, in Figure 19 the percentages of total calories from cereals are plotted against the incidence rate of all CHD cases for those cohorts from which data are available \( r = -0.36 \). Similar results have been observed in regard to serum cholesterol \( r = -0.55 \), Figure 20. The data are too few for evaluation. However, starchy cereals seem to exert a favourable influence.

![Graph showing incidence rate of all CHD cases plotted against average percentage of total calories from cereals in the diet.](image-url)
In conclusion it can be said that the diet of free-living populations shows a wide variability between individuals and also there are so many counteracting factors that cannot be considered separately. However the amount and the type of fats in the diet seem to be among the primary factors in the aetiology of CHD and it is concluded that this effect is mediated principally by the serum cholesterol levels.

REFERENCES

Nutrition education is considered as one of the essential activities for the improvement of nutritional status. Through nutrition education we are expected to bring our technical knowledge to people in an appropriate way so as to motivate them to accept and follow the message for the sake of their own and their children's better health.

This view was accepted as early as when nutrition education activities became part of the public health work and there was hardly a meeting, conference or symposium dealing with nutrition that would not include in its report or recommendations a paragraph on nutrition education. But in spite of due emphasis being given to nutrition education as an instrument for dealing with nutritional problems, the hitherto available experience indicates that the results achieved were not up to the expectations. It is difficult to escape the feeling that the gap between the accumulated technical knowledge and its practical application is still widening.

There may be several reasons, some already recognized, which may limit the effectiveness of nutrition education activities, among which the inadequate training of potential educators is also one. It is a well known fact that among medical personnel the medical doctor is often inadequately prepared during his undergraduate training to cope with nutritional problems of the community. Taking for granted that a physician in the community health services is overloaded with clinical work and seldom carries out the routine public health activities himself, still his leading position in devising and guiding the activities of other health personnel remains crucial. It is felt therefore that a practising physician should be in a position: (a) to define the specific nutrition problems of the community, (b) to analyze the importance of ecological factors, (c) to give advice on balanced diets preferably composed of locally available foodstuffs, (d) integrate such experience in the activities of basic health services like well-baby clinics, prenatal and postnatal care, school health, etc., and (e) to acquire sufficient experience for the treatment of malnutrition.
Unfortunately many medical schools even in the countries with high prevalence of malnutrition do not give proper emphasis on nutrition in spite of the efforts, already formulated in numerous reports saying that nutrition should be made part of the syllabi in biochemistry, physiology, internal medicine, obstetrics and of course, public health. In our own experience the upgrading of nutritional teaching depends on the one hand on the availability and status of nutritionists within a medical school or an affiliated institution, and on the other on the interest and receptiveness of the heads of departments. That means that the teachers themselves should be first introduced to the subject of nutrition and only then could it be expected that students will follow, as the interest and motivation of students is largely determined by that of the teacher. This could be achieved by (a) organizing courses in nutrition for teachers of physiology, biochemistry, internal medicine, and particularly public health at the appropriate nutrition or public health institutes, and (b) providing them with more financial support for nutritional research. It has been realized however that, by and large, medical personnel realize the importance of public health activities including nutrition only after joining the health service when they start facing practical problems. It seems therefore that much more emphasis should be given to postgraduate training wherever there is an opportunity. Public health and MCH postgraduate training courses are particularly suitable for integrating nutrition, although, under certain conditions, a postgraduate training in nutrition could also be contemplated. Yet for practical reasons, only a limited number of health personnel particularly those working at the community level would be in a position to attend a full-time postgraduate course. Such training should be in the first place reserved for those who are or will be in leading positions and will take responsibility of practical operations. For the majority of health personnel it would be more realistic however to plan the shorter in-service refresher courses. Such courses even though of short duration (ranging from 1-3 months) are long enough to introduce the basic concept of modern nutrition and with skillfully planned field practices may be quite adequate to provide the trainees with sufficient technical experience to enable them to use clinical and anthropometric methods for the assessment of nutritional status and to get them acquainted with the principles of collection and interpretation of dietary information. If such an in-service training in nutrition is integrated with other health activities like MCH, obstetrics, school and environmental health etc., the combined clinical and field practices would be a good demonstration of to what extent nutrition is responsible for the ill-health of a community. I think it is important for the trainees and for many professional nutritionists too to realize that the dimension to be given to nutritional activities should be decided on the basis of specific health situations in a community. Since all health activities in a community are
more or less channelled through the same personnel, an undue overemphasis of one aspect may cause dissatisfaction among the other services whose cooperation for an integrated approach is essential.

Although I was asked to say a few words on the training of medical personnel in nutrition, it is quite obvious that such a scheme should be complemented by a similar one to provide nutritional training to other health workers. This is particularly true of health personnel employed by community health services as it is they who are really carrying out the day-to-day routine work at the village and family levels. I would like to take this opportunity to emphasize the important role a nurse, a health visitor, and under the present conditions especially, a midwife may play in dealing with nutritional problems of the community.

However the "nutritionally oriented" health personnel is only one of the prerequisites for starting a nutrition education programme in the community. Another critical step is to decide what or how much of the acquired technical knowledge can be applied under the existent conditions in the community. There are many examples to show that some trainees when posted in the community were only too anxious to see all their experience put into practice with the danger of such approach becoming too rigid and consequently unrealistic. Therefore before starting a more systematic approach or programme, more specific information is needed about the relative importance of various ecological factors inherent in the development of malnutrition and also about the "receptive capacity" of the community which depends by and large on economical and cultural factors as well as on the social structure of the community. Such analysis can hardly be made by community health services alone. It would rather have to rely on the assistance by nutrition services within a country's health service preferably organized as a nutrition unit within the ministry or directorate of health services. Such a unit should be able to offer assistance in the collection of base-line data for the assessment of nutrition conditions of the community and to provide professional guidance and training for carrying out practical work.

But if all the ideas mentioned here are accepted as correct we may still fail in developing a successful practical nutritional work in the community. In our own experience our failures can only partly be attributed to the inadequate technical knowledge of the health personnel. The major factor however was the absence of a realistic and systematic public health orientation of the basic health services. After all the medical doctors and other health and paramedical personnel who are undergoing nutrition training will not become nutritionists and nutrition is not to be their main responsibility either.
Rather, they are expected to integrate nutrition with other aspects of public health activity into their daily routine. Should such activities come to be recognized as the responsibility of the community health service, there is a fair chance that after a nutrition-orientation course, nutrition will become part of such activity. But it is not seldom that we witness health personnel in the basic health services limiting their activity to aiding those who seek their assistance. Systematic public health work is insufficient and often carried out in the form of "campaigns" as a result of the pressure exerted by the higher administrative centres. At this point I think quite a relevant question should be asked as to what extent the basic health services are really capable to carry out practical nutrition and similar activities we expect them to do. The time has come for launching a few "operational research" schemes to find out how much of nutrition education and to what effect, the basic health services in a community can successfully carry out under the existing staffing and organizational pattern. I think this is the core of the problem. If this is not made clear I fear our professional nutrition educators may be left facing their task all alone.

We should therefore attempt to utilize all the avenues available to make medical personnel aware of nutritional problems of their communities and to provide them with the technical knowledge necessary to cope with them. But at the same time we have to point out that without a clear nutritional policy within the nation's health services, the application of the experience acquired through the training will not yield the expected results.
A SYSTEMS APPROACH TO THE PROBLEM OF MARASMUS

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A popular catchphrase at the present time is "systems analysis". I am unaware of the term's origin or even its precise meaning, but I gather it implies the employment of many disciplines and a multiplicity of approaches to a problem. We have endeavoured to adopt the systems approach in our research into the problem of marasmus in the Middle East over the last 8 years in Beirut.

Our department in the Medical School of the American University of Beirut in its research activities is made up of three related units: (1) laboratories, (2) metabolic unit, and (3) field project. In collaboration with scientists in other departments we form a group of clinicians, biochemists, statisticians, sociologists, psychologists, food scientists, and others who have in recent years focused our attention on the problem of marasmus as we see it in Lebanon. This paper outlines some of our findings and documents where more detailed accounts of the work are to be found for those who are interested.

DEFINITIONS AND CONCEPTS:

We have been concerned for some time about the imprecise way in which the various types and degrees of malnutrition in young children are described. There is little uniformity of reporting and consequently incidence and prevalence figures from different places are virtually meaningless.

Based on serum albumin and four clinical signs we have published a simple scoring system for the severe forms of P.C.M., viz., marasmus, marasmic-kwashiorkor and kwashiorkor (Table 1). Application of this system for 12 months in a hospital in Amman, Jordan resulted in 42.4% of all admissions under the age of 4 years being classified as P.C.M. (marasmus 27.4%, marasmic-kwashiorkor 12.5%, kwashiorkor 2.5%). Only 13.2% of these patients had actually been diagnosed as malnourished by the physician.
**Scoring system for protein-calorie malnutrition**

<table>
<thead>
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<th>Condition</th>
<th>Points</th>
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<tbody>
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<td>Oedema</td>
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<tr>
<td>Dermatosis</td>
<td>2</td>
</tr>
<tr>
<td>Oedema plus dermatosis</td>
<td>6</td>
</tr>
<tr>
<td>Hair change</td>
<td>1</td>
</tr>
<tr>
<td>Hepatomegaly</td>
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<tr>
<td>Serum-albumin (or serum-total-protein) (g. per 100 ml)</td>
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</tr>
<tr>
<td>1.00</td>
<td>(3.25)</td>
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<td>1.00-1.49</td>
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<td>(7.00-7.74)</td>
</tr>
<tr>
<td>4.00</td>
<td>(7.75)</td>
</tr>
</tbody>
</table>

Score = sum of points. Marasmus 0-3 (25% wt. deficit), Marasmic kwashiorkor 4-8, Kwashiorkor 9-15.

Mild and moderate forms of P.C.M. are as it were the submerged part of the iceberg and consequently even more difficult to define. In our experience biochemical tests have not proved to be sensitive enough, or practical in the field to be of value. We have made special studies of the amino acid ratio of Whitehead and the hydroxyproline index. The recent separation in our laboratory of serum albumin into bound and unbound fractions by isoelectric focussing and the demonstration of the disappearance of the unbound fraction in malnutrition may provide the basis for a more sensitive index.

On the other hand we have been very impressed with the value of simple somatic measurements in defining what we prefer to term "failure to Thrive." In studies carried out in rural, suburban and urban areas of Lebanon we have developed an Index of Thriving, employing weight, height, head circumference and mid-arm circumference for age in relation to international standards (Table 2). When age is not known and in circumstances where accurate weighing may not be possible we have shown that the ratio, head circumference/mid-arm circumference is constant in the preschool child period and correlates closely with the weight for age and also the Index of Thriving. Values of >0.310 indicate nutritionally healthy; 0.310—0.280 mild P.C.M.; 0.279—0.250 moderate P.C.M. and <0.250 severe P.C.M.
Problem of Marasmus

TABLE 2

Index* of Thriving

Values are compared with standards as percentages

<table>
<thead>
<tr>
<th>Measurement</th>
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</tr>
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</tr>
<tr>
<td>Height</td>
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<td>1</td>
</tr>
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<td></td>
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<td>Head circumference</td>
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<td></td>
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</tr>
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</tr>
<tr>
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<tr>
<td></td>
<td>60 and less</td>
<td>5</td>
</tr>
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</table>

*Index is the sum of 4 scores.

By applying this simple test we find among the preschool children of low socio-economic groups in Lebanon the following incidence of P.C.M.: 33.1% mild 8.1% moderate and 0.9% severe P.C.M.

PATHOGENESIS:

The socio-economic background to the marasmic form of protein-calorie malnutrition (P.C.M.) is quite different from that of the kwashiorkor form. Case histories of marasmic infants in our unit respectively illustrate the important role of early weaning, dilute and dirty formulae, repeated infections especially gastro-intestinal and starvation "treatment". These factors are operating most strongly in communities undergoing rapid social change.
Consequently childhood malnutrition mainly takes the form of marasmus throughout the Third World.

A 12-month hospital study in Jordan showed that factors related primarily to economics, education and hygiene played a greater part than dietary factors in determining whether a child became malnourished.7

Preliminary results of a field study in three areas in Lebanon provide further information along the same lines.8 In the same community families with a child who is “failing to thrive” contrast strikingly in a number of ways with those in which the corresponding child is “thriving.” The “failure to thrive” family is larger, suffers from more infections, has less educated parents, poorer living conditions and lower income; as little as $30 per family per month seems to make all the difference.

CLINICAL ASPECTS:

More than 120 grossly marasmic infants have been fully studied during their transformation from “living skeletons” to happy, bouncing babies in our 10-bed metabolic unit in Beirut over the last 5 years. Our studies begin after control of infections and restoration of fluid and electrolyte balance has been achieved in the general pediatric wards.

Almost always the clinical picture is of an infant 3-9 months of age with pure marasmus with 50% or more of body weight deficit. Occasionally oedema or low serum albumin is indicative of marasmic kwashiorkor and only rarely do we see kwashiorkor or other deficiencies.

The recovery of a marasmic infant presents a real challenge to the paediatrician and imposes a considerable burden on the hospital service. Certain conditions must be met if it is to take place. The alternative is, in our experience,8 a high mortality and relapse rate in those discharged prematurely after being admitted for a few days only for control of electrolytes, dehydration and infections.

In each large centre of population where protein-calorie malnutrition is rife, at least one Malnutrition Unit should be established along the following lines:

1. Attached to, but not part of, Paediatric Service.
2. Prolonged stay (2-4 months).
3. Control cross-infections.
4. Nursing aids.
5. Stimulation.
6. Diet (a) lactose intolerance.
   (b) high calories (200 kcal/kg/day).
7. Immunisations.

Cases that are 3rd degree Gomez should be admitted with acute illness. Such centres will treat children more malnourished than those for whom the Nutrition Rehabilitation Centres of Bengoa and of King are intended. They should be attached to, but not an integral part of, a paediatric service preferably of a medical school. The Director of the Unit should ideally be a Paediatric Nutritionist on the staff of the paediatric department to which the Centre is attached. He must be administratively free from the pressures usual in paediatric wards to discharge cases rapidly. As we have found, much of the nursing can be done by nursing aides as the patients are usually not acutely ill and formula preparation and feeding takes up much of the time of the nursing staff.

Proximity to the paediatric wards is desirable but direct contact should be cut to the minimum to reduce infections as much as possible. Visitors from the outside, including mothers should be admitted on a limited basis for the same reason and precautions observed. Despite every precaution we have found these weak infants to be very susceptible to prevailing infections. Until we initiated a vaccination programme during their stay in the Unit several years ago we found in our follow up studies that the few deaths that occurred after discharge were from acute infections, especially measles and poliomyelitis. We now start inoculations as early as 2 weeks after admission to the Unit with triple vaccine, poliomyelitis and measles.

We found that retardation of growth as measured by low hydroxyproline is frequently related to cross infections but sometimes it may coincide with the upset caused by the eruption of several retarded teeth at once. Two other practical points are of considerable importance in relation to obtaining good recovery. Body composition studies showed that although there is little if any weight gain in the first month there is high retention of nitrogen and this is accompanied by a considerable loss of body water even in marasmus which has no clinical oedema, as high values return to normal (Table 3). Thus, the progress at this time is more real than apparent, and evident to the biochemist but not to the unaided clinician.
TABLE 3

Changes in total body water (TBW) and extra-cellular water (ECW)

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>Mean TBW actual</th>
<th>No. of cases</th>
<th>Mean ECW actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>× 100 expected</td>
<td></td>
<td>× 100 expected</td>
</tr>
<tr>
<td>On admission</td>
<td>12</td>
<td>106</td>
<td>16</td>
<td>127</td>
</tr>
<tr>
<td>After 1 month</td>
<td>15</td>
<td>105</td>
<td>17</td>
<td>118</td>
</tr>
<tr>
<td>After 2 months</td>
<td>14</td>
<td>100</td>
<td>16</td>
<td>111</td>
</tr>
<tr>
<td>After 3 months</td>
<td>15</td>
<td>92</td>
<td>15</td>
<td>102</td>
</tr>
</tbody>
</table>

The nature of the diet is important from several points of view. Like others we have found that the malnourished infant recovering from gastro-enteritis is often intolerant of cow or humanized milk formula. We have been unable to demonstrate by lactose tolerance tests that this is due to lactase deficiency. Nevertheless withdrawal of milk and substitution of a vegetable protein food mixture (laubina) results in rapid return to normal bowel movements. This intolerance to milk is only temporary and after 1½ - 2 months of rehabilitation milk can be safely reintroduced.

Although the usual form of malnutrition in childhood is a multi-faceted undernutrition with all nutrients affected, the major defect concerns protein and calories, as reflected in the new generally adapted term, protein-calorie malnutrition. In the past there has been a tendency to overemphasize the role of protein. This has partly arisen from the greater attention paid to kwashiorkor and the neglect of marasmus. In both types of P.C.M. but most especially in marasmus a high calorie intake is essential if rapid catch up growth is to take place. Our own data (Table 4) show that the calorie/protein ratio (/kg/day) is highly correlated with the % utilisation of protein for tissue.

MENTAL RETARDATION:

From all over the world evidence is accumulating to show that malnutrition in early life retards behavioural development. Whether full recovery is possible after optimal treatment and maintenance have been instituted is not yet clear. Our limited studies in this difficult field have been designed to study over one or two specific points.
Problem of Marasmus

### TABLE 4

<table>
<thead>
<tr>
<th>Number of diet periods of 1 month each</th>
<th>Intake calories/kg/day</th>
<th>% utilisation protein/kg/day for tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10-19</td>
<td>5</td>
</tr>
<tr>
<td>67</td>
<td>20-29</td>
<td>17</td>
</tr>
<tr>
<td>28</td>
<td>30-39</td>
<td>21</td>
</tr>
<tr>
<td>84</td>
<td>40-49</td>
<td>31</td>
</tr>
<tr>
<td>2</td>
<td>50-59</td>
<td>60</td>
</tr>
<tr>
<td>1</td>
<td>60-69</td>
<td>42</td>
</tr>
</tbody>
</table>

We first tested marasmic infants, using the developmental scale of Griffiths, every two weeks throughout 16 weeks of treatment in our Unit. Throughout, one group received extra stimulation in addition to dietary and nursing care provided to all. This first group showed a significantly greater increase in D.Q. A control group of healthy, low socio-economic, children matched for sex and age was tested in the same way. They performed as well as the British standard group. (Table 5)

### TABLE 5

<table>
<thead>
<tr>
<th>Control (N=20)</th>
<th>1 2 3 4 5 6 7 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotor</td>
<td>109 114 114 115 118 119 120 119</td>
</tr>
<tr>
<td>Personal-Social</td>
<td>112 114 114 112 115 115 114 113</td>
</tr>
<tr>
<td>Hearing and Speech</td>
<td>103 110 109 106 106 107 107 106</td>
</tr>
<tr>
<td>Eye and Hand</td>
<td>107 109 108 110 106 107 110 106</td>
</tr>
<tr>
<td>Performance</td>
<td>104 104 106 104 109 111 114 111</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Malnourished (N=20)</th>
<th>Admission</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Unst. St. Unst.</td>
<td>49 47 48 78 71</td>
<td></td>
</tr>
<tr>
<td>Locomotor</td>
<td>47 47 83 70 70</td>
<td></td>
</tr>
<tr>
<td>Personal-Social</td>
<td>55 47 76 66 66</td>
<td></td>
</tr>
<tr>
<td>Hearing and Speech</td>
<td>61 54 78 69 69</td>
<td></td>
</tr>
<tr>
<td>Eye and Hand</td>
<td>60 55 82 73 73</td>
<td></td>
</tr>
</tbody>
</table>
Malnourished infants admitted before the age of 6 months made a better recovery in D.O. on discharge than those older. The latter had presumably been malnourished longer.

Results of a follow-up study are continuing and show that the stimulated group continues to perform better at home than those that did not receive extra stimulation during rehabilitation. Even so it is evident that they do not reach the level achieved by the control group.

The studies:

By the use of orally administered $^{15}$N-labelled ammonium citrate and estimation of the total nitrogen and $^{15}$N excretion in the urine we have shown that the child receiving an adequate diet for treatment of marasmus or kwashiorkor is able to conserve nitrogen to a remarkable degree and build it into protein. 19

Of course, the dietary nitrogen is normally absorbed in the form of amino acids and we were next concerned to study the pattern of nitrogen conservation from different amino acids, unessential and essential. To date we have completed studies with $^{15}$N glycine and $^{15}$N lysine. The results in Table 6 are mean values for 3 infants in each instance.

| TABLE 6 |
|------------------|------------------|------------------|------------------|
|                 | Absorbed $^{15}$N N excreted % | Total N as urea % | Absorbed $^{15}$N N excreted % | Total N as urea % |
| Glycine         |                   |                   |                   |                   |
| Marasmus        | 41                | 73                | 36                | 78                |
| Recovered       | 80                | 88                | 55                | 85                |
| Lysine          |                   |                   |                   |                   |
| Marasmus        | 56                | 75                | 11                | 29                |
| Recovered       | 74                | 92                | 41                | 72                |

The results show that:

1. $^{15}$N excreted is lower in marasmus than in recovery for both amino acids. This is accounted for mainly by the smaller amount of $^{15}$N urea excreted in marasmus.
2. Lysine $^{15}$N was retained to a greater degree than glycine $^{15}$N in both marasmus and recovery. This difference was more marked in marasmus.

3. $^{15}$N in urea excreted in marasmus after feeding $^{15}$N lysine was less than 5% of the total administered isotope.

4. Glycine turnover appears to be typical of total protein turnover. On the other hand the very high retention of $^{15}$N lysine in marasmus suggests that this amino acid is in very high demand. Amino acid requirements of the acutely malnourished child are probably different from those of the normal.

REFERENCES

MID-ARM/HEAD CIRCUMFERENCE RATIO: A NEW TECHNIQUE TO ASSESS MARGINAL PROTEIN-CALORIE MALNUTRITION IN A COMMUNITY.

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The need has long been recognized for a simple, objective means which can be used by general public health workers with limited knowledge of nutrition to assess the physical development of population groups, especially pre-school children, in relation to their nutritional status. Somatic measurements have been used extensively for this purpose because (1) they are easy to carry out, (2) they arouse no antagonism in the parents, (3) they require simple apparatus, (4) alterations in some of these measurements precede in many cases the appearance of any clinical sign of malnutrition, and (5) they correlate well with the severity of malnutrition measured by other methods. On the other hand, the disadvantages encountered are: (1) availability of good local or international standards which should reflect the optimum growth of normal children under standard conditions of health and nature, (2) the need for well trained personnel working under standardized conditions and following a standardized procedure, (3) the need for accurate birth-date and age, which in many instances is unobtainable in many developing countries, (4) the use of a weighing machine which is a delicate instrument requiring intelligent use, and a length measuring board which is heavy to carry and sometimes gives unreliable results.

To avoid the problem of prediction of age biochemical tests (e.g. amino acid ratio in plasma, serum transferrin, hydroxyproline excretion in urine, urinary creatinine/height ratio, urinary urea/creatinine ratio), anthropometric tests (e.g. weight/height, chest/head circumference, weight/head circumference) or miscellaneous tests (e.g. buccal mucosal changes, auricular cartilage elasticity, or hair root morphology) have been advocated. Some of the above indices have been discussed elsewhere. Recently the weight/height$^2 \times 100$ index has been claimed to be independent of age and suitable for this purpose. Using the data of the Children's Medical Center, Boston, it can be seen that the weight/height$^2 \times 100$ index proposed by Rao et al. varies considerably with age during the pre-school period. The index for the Lebanese children is seen to be actually higher than the 50th percentile.
of Boston children in the second year of life, when for the same period of age their weight for age percentage ranges between 85-90% of standard or mild P.C.M. The 0.150 figure suggested by Rao et al as a mean index for the Indian normal studied group is in fact much lower than that of the 3rd percentile curve index of Boston.

We have proposed the use of the mid-arm/head circumference ratio which shows no sex difference and between 3 months and 4 years is practically constant (Fig.1). The curve of the mean values of a group of 1231 children in a field study in Lebanon is slightly lower than that of the standard values and is also unaffected by age or sex (Fig. 1). In addition further comparison has been made to check the feasibility of the use of mid-arm/head circumference ratio to assess marginal protein-calorie malnutrition. Such comparison was made with weight for age percentage in five grades, as suggested by Jelliffe. The differences between means of the ratios for all five grades were highly significant (P < 0.001) (Fig. 2). For field use, the following broad nutrition classification may be recommended: ratio > 0.31 nutritionally

![Graph showing mid-arm/head circumference ratio in relation to age and sex. The standard curves are from the data of Wolanski and the Lebanese are mean values for 1231 children in a field study.]

**Fig. 1.** Mid-arm circumference/head circumference ratio in relation to age and sex. The standard curves are from the data of Wolanski and the Lebanese are mean values for 1231 children in a field study.
A. A. Konawati and D. S. McLaren

healthy: .309 - .280 mild P.C.M.; .279 - .250 moderate P.C.M.;  .250 severe P.C.M.

Mid-arm/head circumference ratio can be considered a valuable index for assessing early malnutrition in pre-school children. The two measurements can be simply taken by a stout tape measure. No allowance need to be made for sex and age, no reference standard is required and com-

Fig. 2. Relationship between the mid-arm circumference/head circumference ratio and the percentage weight/age. Bars indicate group mean± S.E.; $r_{spear} = 0.68$ ($P \leq 0.001$) $y = 0.199905 + 0.001351 x$. 

*Mid-arm/head circumference ratio can be considered as a valuable index for assessing early malnutrition in pre-school children. The two measurements can be simply taken by a stout tape measure. No allowance need to be made for sex and age, no reference standard is required and com-*
Anthropometric Methods

Complicated mathematical procedures are completely avoided. It is ideal for use by unskilled personnel who have to work without close supervision.

REFERENCES

ABSTRACTS OF
RESEARCH COMMUNICATIONS
Nutrition and Agricultural Development

1. SCOPE OF GENETIC AND AGRONOMIC ENRICHMENT OF CEREAL PROTEINS

A. Austin, H. D. Singh and V. K. Hanslan

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Indian Agricultural Research Institute,
New Delhi, India.

In view of the importance of upgrading the quantity and quality of protein in the basic staple foods as the quickest and easiest way of combating undernutrition and malnutrition problems which are widespread particularly among children in many areas of the world, concerted attempts have been made at the Indian Agricultural Research Institute for a systematic examination of breeding materials of cereals and millets for high protein and high lysine. In 3785 strains of wheat from advance generation, the protein content varied from 9 to 23 per cent. The variability for protein was very marked. About 72 per cent of the new strains showed protein content ranging from 13 to 17 per cent. Two hundred and thirty four promising strains which came out superior for protein and other agronomic characters were further screened for total lysine. About 46 per cent of these strains showed more than 13 per cent protein combined with more than 2.7 per cent lysine. The results in general offer possibilities of developing high protein cum high lysine varieties.

Similar possibilities have been observed in grain Sorghum (jowar) and pearl millet (Pennisetum typhoides).

In rice and maize the variability for protein was much less than that obtained in the other crops. In rice for example the protein content varied from 6 to 13%. About 64 per cent of the materials showed 6 to 9 per cent protein only.

Marked varietal differences for the content of protein and lysine in endosperm, embryo and pericarp of the maize grain were observed.

Scope of improving cereal proteins by agronomic practices has been further investigated.
Out of the recently introduced high-yielding varieties of wheat the essential amino acid contents of 3 were determined and compared with the 2 local varieties which are considered good from the point of view of physical characteristics and protein contents. Physical characteristics like doughing has not been so good as the local varieties. However, from the nutritional point of view the proteins obviously are of utmost significance as wheat is the staple food of the bulk of the people in West Pakistan and contributes 80 per cent of the daily dietary intake.

Total protein content of the new varieties was slightly higher than the indigenous ones and varying from 11.7 to 12.4 per cent as compared to 11.3 to 11.4 per cent in the native varieties. The amino acid contents are given in the Table below.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Phe</th>
<th>Met</th>
<th>Leu</th>
<th>Lys</th>
<th>Val</th>
<th>Ileu</th>
<th>Thr</th>
<th>Try</th>
</tr>
</thead>
<tbody>
<tr>
<td>C273</td>
<td>656</td>
<td>271</td>
<td>814</td>
<td>215</td>
<td>508</td>
<td>520</td>
<td>328</td>
<td>136</td>
</tr>
<tr>
<td>C591</td>
<td>581</td>
<td>217</td>
<td>673</td>
<td>194</td>
<td>490</td>
<td>479</td>
<td>285</td>
<td>114</td>
</tr>
<tr>
<td>Mexi-Pak</td>
<td>620</td>
<td>211</td>
<td>714</td>
<td>164</td>
<td>456</td>
<td>433</td>
<td>246</td>
<td>105</td>
</tr>
<tr>
<td>Mangla</td>
<td>569</td>
<td>206</td>
<td>762</td>
<td>145</td>
<td>496</td>
<td>472</td>
<td>242</td>
<td>121</td>
</tr>
<tr>
<td>Norteno</td>
<td>570</td>
<td>198</td>
<td>657</td>
<td>136</td>
<td>422</td>
<td>423</td>
<td>260</td>
<td>99</td>
</tr>
</tbody>
</table>

In the above Table C273 and C591 are local varieties of wheat while Mexi-Pak, Mangla and Norteno are the newly introduced varieties.

It will be seen from the data on the whole the essential amino acid spectrum in the newly introduced varieties is not very much different from the native varieties although in some cases the quantity was slightly lower in the new varieties particularly as compared to C273 local variety.

In view of the exceptionally high yields of the new varieties it is suggested that their cultivation be further enhanced as far as possible, which, however, depends on the provision of more irrigation facilities and more fertilizers.
3. PRESENT RESEARCH EFFORTS TO INCREASE RICE YIELDS

S. V. S. SASTRY

All-India Coordinated Rice Improvement Project,
Hyderabad, India

Tall, weak strawed, lodging and low N-responsive varieties cannot be relied upon for consistent high rice yields. Consequent to the development of plant type concept, breeding programme in tropical Asia are reoriented towards developing dwarf rices. Plant type is simply inherited and hence can be incorporated in diverse genetic backgrounds to suit varied needs. Dwarf rices like Jaya, IR 8, etc. possess not only a very high yield potential but also exhibit a high degree of stability. While total dry matter produced (grain+straw) is comparable in dwarfs and tall, grain/straw ratio is more favourable in dwarfs due to better photosynthetic efficiency, resulting from superior plant type.

In addition to yield, consumer preferences for grain type, cooking characteristics, resistance to pests and diseases are extremely important in rice breeding. The adaptability of the varieties thus far recommended by AICRIP matches with different agro-climatic regions of the country. Realisation of high yields rests in proper management of the rice crop, the most critical of which are nitrogen and water management. Optimum timing of nitrogenous fertilizer increases the efficiency of added nitrogen by approximately 30%. In some locations, insect and disease protection is extremely critical for attaining high yields.

Host plant resistance for pests and diseases is being pursued on high priority. Excellent donors have been identified for resistance to blast (Te-tep and Tadukan), tungro viru (Latisail), gall midge (W 1263) and leaf and plant hoppers. The donors for resistance to bacterial leaf blight (BJ-1) and stem borer (TKM 6) are relatively poor in levels of resistance. Reasonable success has been obtained in transferring resistances to stem borer, gall midge, tungro virus and leaf hoppers into productive dwarf plant types.
Milk and milk products are among the most perishable of all the foods. They need to be preserved, otherwise spoilage occurs due to action of micro-organisms or due to the enzyme or chemical reaction.

The present methods of preservation of milk and milk products involve one or more of the general principles of prevention of the entrance of micro-organisms, inhibition of growth and activity of micro-organisms and destruction of micro-organisms. On the basis of these general principles, various methods such as asepsis, use of low temperatures, use of high temperatures, fermentation and drying have been employed in preservation of milk and milk products.

All over the world, market milk is preserved by the process of pasteurization and sterilization by application of heat. A recent development in processing of milk is sterilization by Ultra High Temperature process with aseptic packaging. Such a milk needs no refrigeration and is called a "long life milk."

Milk products are manufactured from milk or cream for the purpose of preservation. Fermented milk such as Dahi, Yoghurt, Kefir and Acidophilus milk and most kinds of cheese are preserved by encouraging growth of lactic acid bacteria.

For the first time in India, modern methods of preservation and processing as applied to buffalo milk have been used in last two decades. In the present day civilization there is greater need for application of modern technology for preservation and processing of milk and milk products so that such a nutritive food could be shipped on a large scale from areas of abundance to countries where low nutritional standards prevail. In addition to other food constituents milk contains protein whose amino acids pattern is nearly as complete as those of egg and meat. Thus milk has become a very important tool in hands of nutritionists to use in supplementation of protein where it is necessary to improve the over all nutritive value of milk.
The need for inclusion of liberal quantities of fish in Indian diet to improve the per capita animal protein intake in an effective and economical manner has been emphasized. Besides quality protein, Indian fishes are found to be good sources of fat, various vitamins and minerals like calcium, phosphorus, iron and copper. The muscles of fish and shell fish also abound in essential free amino acids. The body fat of fishes like Sardina longiceps has been determined to contain pharmacologically important poly-unsaturated fatty acids C_{20:5} and C_{22:6}. Qualitative and quantitative losses of nutritive factors in fish during preservation by icing and irradiation and processing into frozen, canned, dehydrated and smoked products have been evaluated and measures to minimise such losses briefly indicated. Large quantities of miscellaneous trash fish in our fish landings have been shown to lend themselves to profitable utilization into fish protein concentrate, fish paste and fermented products for human consumption.

Preliminary studies made on the existing and induced variation for protein quality and quantity in various cereals and pulses have indicated a great scope for the genetic improvement in their nutritional quality. Emphasis has been laid on the improvement in the limiting amino acids lysine and methionine in cereals and pulses, respectively. In addition, gluten quality was determined. Fast, inexpensive and reliable analytical tests have been developed to suit the testing of plant breeder’s material obtained from early generation.
7. HYBRIDIZATION AND PROTEIN QUALITY IN SORGHUM GRAIN

Y. G. DEOSTHALE AND K. C. PANT

National Institute of Nutrition, Hyderabad, India

Grain samples of cross (F₁ and F₂) and backcrosses (BC₁) among eight varieties of sorghum grown in replicate at two locations, Delhi and Coimbatore, were analyzed for protein and lysine content. Protein content in the material obtained from Delhi was significantly more than that from Coimbatore indicating locational variation (P < 0.01). No such locational differences were seen in lysine content.

In both F₁ and F₂ population the protein content was significantly lower than that in parental population and also in the backcrosses. No hybrid vigour for protein was observed in the F₁ crosses. Backcrossing on to any one of the parents resulted in an increase in protein content as compared to protein in F₁ hybrids. In this process the protein value seemed to be restored to the level in parents.

Lysine content (g/16g N) in parents, F₁ population and BC₁ population was statistically not significant. However, in F₁ population lysine was found to be significantly lower than that in parents alone. In 15 out of 40 F₁ hybrids lysine content was more than the best parent. The extent of heterosis observed was of the order of 0.5 to 21.0%. Hybrid vigour for lysine was observed in most of the F₁ crosses of IS 968 and IS 10202.

8. EFFECT OF AMINO ACID SUPPLEMENTATION ON BIOLOGICAL VALUE AND NET PROTEIN UTILISATION OF SOME VARIETIES OF MAIZE AND GROUNDNUT

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And

C. S. I. R. O., Ryde, N. S. W., Australia

The comparative quality of proteins in local maize (Ludhiana), Hybrid maize variety Illinois 1656, groundnut varieties Punjab Groundnut No. 1, &
145/12-P was determined in terms of biological value (B.V.) & net protein utilisation (N.P.U.).

On test diets with 7% protein from local and hybrid maize, the biological values were found to be 65 & 55 respectively, and the NPU Values were 54 & 46. In the same experiment, the B.V. & N.P.U. values of a Casein control at 7% level were 74 & 62 respectively.

Supplementation of maize proteins with 0.8 per cent L-lysine lead to increase of B.V. from 65 to 72 in local and 56 to 68 in hybrid maize, when fed at 7 per cent level of protein. The N.P.U. Values increased from 53 to 60 in local maize and 45 to 58 in hybrid maize.

The B.V. of groundnut protein was found to be 60 for Punjab G.N. No. 1 and 58 for variety 145/12-P with 10.0 per cent level of protein in the diet. These values increased to 66 and 65 on supplementation with 0.1 per cent DL-methionine. The corresponding N.P.U. Values of these varieties were 52 and 49 respectively and they increased to 55 and 56 on supplementation.

9. A STUDY ON THE NUTRITIONAL VALUE OF SOME NEW RICE VARIETIES INTRODUCED IN INDONESIA

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Nutrition Institute
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Five new rice varieties — IRRI 5, IRRI 8, Syntha, Dewi Ratih and C4-63 were studied for their nutritive value. The last three varieties were introduced by the Central Research Institute for Agriculture, Indonesia, and although their yield potential is slightly lower than the IRRI varieties, the rice itself is reported to be more acceptable to the taste of the Indonesian consumer.

The protein content of IRRI 5 is 7% and of IRRI 8 is 6.4% whereas that of for the Indonesian varieties is: 6% for Syntha, 7.3% for Dewi Ratih and 9% for C4-63, as compared to red or brown rice with 6.6%.

The PER values of the 4 rice samples were all above 2, compared to the average PER value of 2.9 for skim milk powder. The value for IRRI 5 is 2.3; IRRI 8, 2.5; Syntha, 2.2; and red rice, 2.1.
The new rice varieties did not show significant differences in their protein content and in the NPU-op values, except C4-63 whose protein content was 9%.

The amino acid pattern (determined by the Central Institute for Nutrition and Food Research TNO, Zeist, Netherlands) did not show any significant difference from the general pattern of rice. Lysine and threonine remained the first and second limiting amino acids. Our rat experiments with amino acid fortified diets also confirmed these findings.

The new rice variety C4-63 with its higher protein content, suggests a change towards a better direction. Its significance in the diet of the population at large and also its possible impact on the nutritional status of the consumers in Indonesia, especially of the toddlers where PCM is prevalent, awaits further observation, and in the meantime does not warrant any optimistic speculation.

10. INFLUENCE OF GENETIC FACTOR ON THE QUANTITY AND QUALITY OF PROTEINS IN CEREALS AND PULSES

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In the past, maize of improved protein quality, has been developed genetically. The present work was, therefore, intended to study the genetic variability in the quantity and quality of proteins existing in different varieties of food grains so that such information could be an aid to a breeder for future improvement work.

The assessment of the quality of protein in cereals and pulses was based on the study of their limiting amino acids. The data obtained on different cereals (wheat, maize and sorghum) and pulses (ure, mung, arhar, French bean, sesame, peas and soyabeans) reveal the existence of wide varietal differences in the amount of protein as well as in the limiting amino acids, such as lysine in cereals, and methionine in pulses, suggesting thereby that the genetic constitution of the seed has a pronounced effect on the quantity and quality of protein. There is thus a great scope for improving the quantity and quality of proteins through genetic manipulation.
Many high yielding varieties of rice have now been selected for large scale cultivation. The choice of these varieties has been governed not only by their high yield, but also by their nutritional quality. The emphasis on nutritional quality has, however, so far been on the protein content and the amino acid make up. Since rice constitutes the staple for a vast majority of the population, the nature of carbohydrates in rice and their digestibility also merit investigation. The amylase content and the starch-iodine blue value were determined in relation to the cooking quality of six rice varieties, i.e., IR-8, 'Jaya', 'Padma', 'Hamsa', TN-1 and B. C. 5. The results of such a study are presented here. Also, the rates of in vitro digestibility using $\alpha$-amylase were measured. The significance of in vitro experiments were further tested in vivo in human subjects with two of the varieties which greatly differed in their in vitro rate of $\alpha$-amylolysis.

The amylase content ranged from 15 to 22 per cent of the starch. The variety 'Hamsa' had the highest value while IR-8 had the lowest value. The rate of $\alpha$-amylolysis of 'Hamsa' variety was the highest and that of IR-8 rice the lowest. Feeding trials using 'Hamsa' and IR-8 on human subjects indicated, that though a larger number of subjects showed higher blood glucose values with 'Hamsa' as compared to IR-8, these differences were not statistically significant.
1. DEVELOPMENT OF WEANING FOODS IN CEYLON

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Data collected during the course of a 10 year study of the levels and rates of growth of nearly 20,000 children from birth to six years of age, in eight rural and two urban areas in Ceylon, reveal the urgent and widespread need for an adequate diet at the time of weaning. The absence of any traditional methods of weaning and the fact that a large section of the rural and urban population belongs to the low income group makes it necessary that the weaning food should be cheap and easy to use.

The problems of manufacture of a “National weaning food” and its formulation with specific reference to protein levels, protein quality, calorie density and the levels of fat, minerals and vitamins will be reviewed. The form of manufactured products and cost of production will also be discussed.

2. AFLATOXIN CONTAMINATION OF FOODS AND ITS SIGNIFICANCE IN THE AETIOLOGY OF INDIAN CHILDHOOD CIRRHOSIS

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A limited survey of several common items of food has indicated the presence of significant quantities of aflatoxin. By virtue of its heat stability at normal cooking temperatures, the ingestion of aflatoxin along with the food becomes almost inescapable under the existing conditions. It is, therefore, clear that children (particularly after the weaning stage) also consume such foods and get exposed to aflatoxin. During the course of a study extending over a period of five years, and covering nearly 250 cases of healthy, cirrhotic and kwashiorkor children, adequate evidence has been collected to suggest that aflatoxin is involved in the aetiology of Indian childhood cirrhosis.
3. RECENT DEVELOPMENTS IN THE DEGOSSYPOLISATION OF COTTONSEED PROTEIN

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Cottonseed contains protein along with oil and gossypol in glands. While the deoiling is rather easy, the gossypol separation from cottonseed protein is rather difficult. Since the toxic component can bind with lysine thus reducing the protein quality, any method of degossypolisation can leave behind different levels of free and bound gossypol. The earliest method consisted of partly binding gossypol with protein and obtain a protein product, nutritionally satisfactory.

However, recent developments in the gossypol removal follow different approaches. The three new developments in these approaches are, (i) press solvent extraction using conventional hexane solvent (ii) direct extraction using aqueous solvents, & (iii) direct extraction using hexane for deoiling, followed by gossypol gland fractionation for recovery of proteins.

4. TRADITIONAL METHODS OF FOOD PROCESSING FOR INFANTS IN PAPUA-NEW GUINEA

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Papua-New Guinea is one of the most rugged countries in the world due to high mountain ranges that extend from one end to the other end of the island. Therefore, there are many tribes which are isolated from each other and each has its own traditional methods of food processing for infants.

Breast feeding is the only method, that is given to every infant 2 days after delivery till they passed the infancy stage. This will apply to every tribe whether it is in the villages, hamlets and hills.
Breast feeding is followed by a diet of sago-jelly, sweet potatoes, papaya, pumpkin, fish and meat, and these are started as early as 2 weeks in some districts of the country.

Methods of food processing consist of "Mu-Mu" boiling and cooking on fire and the prepared food is given either pre-masticated by one of the parents or as a small portion, when the infant has teeth.

5. NUTRITIONAL STUDIES ON VEGETABLE TONED MILK—MILTONE

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A process using protein isolated from groundnut in toning of milk has been standardised. The vegetable toned milk obtained from this process (Miltone) has all the desirable characteristics of milk. Miltone is being produced in Bangalore to the extent of 1,000 litres per day.

The nutritive value of Miltone is altered to a great extent by the conditions of processing. Control of aflatoxin levels in Miltone is of paramount importance since the edible groundnut flour used has usually some aflatoxin content. It is possible either to reduce this to the limits prescribed by Protein Advisory Group (PAG) by removal of the fungus-affected seeds or to destroy the aflatoxin in the protein liquor by treating it with hydrogen peroxide. Both the methods have been employed in the process. The Protein Efficiency Ratio (PER) of optimally processed Miltone was 2.4. But when treated with hydrogen peroxide for the removal of aflatoxin the PER was reduced to 1.9 indicating the deleterious effect of treatment with an oxidizing agent. Other processing steps also have considerable effect on the nutritive value. When Miltone was made into lactic curds, the PER was increased to 2.7. Sterilisation of Miltone brought about a slight lowering of the PER (2.2). The NPU (Net protein utilization) value of Miltone and Miltone curd were 60.7 and 62.3 respectively. Miltone has also been used for feeding children in the age group 6-8 months.
6. DEVELOPMENT OF A WEANING FOOD BASED ON “SHATI” (CURCUMA ZEDORIA ROSC)
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A composite food was prepared by blending shati “palo” with precooked dehydrated black gram pulse (Phaseolus mungo), carrot (Daucus carota) and amla (Phyllanthus emblica) in proper proportions to make it adequately balanced with regard to calorie, protein, vitamins and minerals.

Three groups of rats were fed 3 diets at 10% protein level; A-having the composite food, B-composite food supplemented with milk powder and C-standard casein diet. The PER values for the 3 diets were 2.37, 2.49 and 2.93 respectively. Overall digestibilities were 84.13%, 85.4% and 93.4% and protein digestibilities, 79.6%, 76.4% and 87.6% respectively. The liver lipid contents of the 3 groups of animals were 3.33%, 4.25% and 4.43% respectively. The group of rats fed composite diet had good growth and healthy appearance, but developed distended abdomens. No abnormal pathological changes were observed in the livers of the 3 groups of rats.

7. BROWNING OF CHAPATTIES
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One of the attributes which makes the recently introduced dwarf wheats less acceptable to the consumer is that Chapatties made from them are brownish in colour. Experiments to elucidate the biochemical causative factors reveal that besides the grain coat colour, (in the case of reddish grain coat varieties) which cause immediate browning of dough and Chapatties, high tyrosinase (phenol oxidase) activity in dwarf wheats is responsible for dough darkening and subsequent browning of Chapatties.
Research Communications

The reaction involves oxidation of phenols and some amino acids to quinones which polymerize and interact with protein to form complex products. The rate of dough darkening is determined by the release of free phenols from phenolic glycosides by the activity of the enzyme, β-glycosidase, and their subsequent oxidation in the presence of tyrosinase.

8. THE EFFECT OF PROCESSING OPERATIONS AND COOKING ON THE THIAMINE, RIBOFLAVIN AND NICOTINIC ACID CONTENT OF SOME EGYPTIAN NATIONAL FOODS

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The vitamins were determined following each of the processing operations and cooking to which 5 food items are subjected.

Flour, bread, beans, rice and sesame products were chosen on their merits as the chief sources for calories, protein, and the B-complex vitamins particularly for low income Egyptians.

Flour & Bread: Extractions (100, 91.87, 5. and 72%) of Egyptian wheat flour (Variety Hindy), dough fermentation, baking and toasting of Egyptian bread.

Broad Beans: Green pods, raw or stewed; dry pods after water soaking are slowly baked with water under pressure (baked beans), sprouted and cooked in water (Nabet) or decorticated and the ground meal is mixed with greens and spices to soft paste which is subjected to short cooking (Bisara), or oil-fried as small cakes (Taemia).

Rice: Brown partially polished containing germ, polished and parboiled polished rice. Washing is followed by heating with water until soft.

Sesame products: Sesame butter (Tahina) is produced by water soaking of sesame seeds, cracking of seeds coatings, removal of coatings by suspending in brine, roasting of decoated seeds, grinding of seeds (Tahina) Sesame sweets (Halwa Tahinya) is made by mixing equal weights of Tahina and cooked sugar.
9. THE USES OF KADELE AS PROTEIN-RICH FOOD IN INDONESIA

R. JESSU

Kadele or glycin max or Soya bean, is a kind of bean from the family of Leguminaceae which is planted and grown in tropical areas. It is known to improve the fertility of the soil and therefore Kadele is planted between the two rice-planting seasons.

Kadele is rich in protein (about 35% to 40%). It has great value as a protein rich food in Indonesia where there is lack of animal protein. In Indonesia, Kadele, is used for making a variety of food preparations. (Kadele powder, Ketjap and Kadele Milk etc.).

The composition and nutritional aspects of some of these food products will be discussed.

10. ISOLATION AND CHARACTERIZATION OF ANTITHIAMINE FACTOR PRESENT IN RICE-BRAN

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Several workers demonstrated the existence of an antithiamine factor in rice-bran. Attempts were made to purify this principle from rice-bran in this laboratory as a result of which the anti-thiamine factor was obtained in a pure state.

The major steps in the process of purification were:

1. Extraction with chloroform water.
2. Repeated extraction with solvent.
3. Column chromatography.

The substance was found chromatographically to be a single substance.
having one Rf on silica gel G thin layer plate as demonstrated by sulphuric acid charring test. This anti-thiamine factor is a viscous substance, soluble in water, ethanol, and methanol and has no affinity toward non-polar solvents. On treatment with dilute hydrochloric acid it breaks down giving rise to a reddish brown oily layer. The original compound and the reddish brown layer both gave positive test for Emmerie and Engel’s reaction indicating the presence of tocopherol-like compounds in it. The aqueous layer obtained after acid hydrolysis gave positive test for the existence of sugars. It shows absorption maximum at 270 m/μ in UV region (ε= 41.5).

11. NUTRITIVE PROPERTIES OF DEHYDRATED GROUNDNUT PLANT MEAL IN CHICK RATIONS
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To overcome the general scarcity of grains used for human consumption, dehydrated groundnut plant meal is a newer agricultural byproduct which was tested in our laboratories for its nutritional value in poultry feeding. The green groundnut plants immediately after harvest of the nuts, were shade-dried and made into a meal. Chemical composition of this meal was as follows: 14% crude protein, 1.6% calcium and an appreciable carotene content (100 mgs/kg. of meal).

Two feeding trials of 6 weeks duration indicated that a 12% level of dehydrated groundnut plant meal in chick rations stimulated growth rate and also feed utilization. In the third experiment, in which both dehydrated groundnut plant meal and alfalfa meal were tried at different levels, it was observed that diets containing 5% groundnut plant meal resulted in a significant increase in growth rate compared to basal ration and this increase was almost equal to that containing same levels of alfalfa meal. When the levels of both meals were raised to 10% in chick rations, there was a slight and nonsignificant depression in growth rate. Liver storage of Vitamin-A was highest in chicks fed 10% groundnut leaf meal diets. This suggests
that dehydrated groundnut plant meal is efficiently utilized by chicks when included at least upto 5% level in chicks rations. In all the experiments, there was a considerable economy in the cost of rations per unit weight gain compared to the basal ration containing no dehydrated leaf meal.

12. NUTRITIONAL STUDIES ON SINGLE CELL PROTEIN OBTAINED FROM PETROLEUM HYDROCARBONS

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Single cell protein (SCP) obtained by culturing yeast on gas oil has been studied for nutritional quality. Besides the type of yeast used, it has been found that the processing conditions have important effects on the nutritional quality of protein. Analysis of the product shows that it contains 50-60 per cent crude protein (Nx 6.25) and 5-7 per cent nucleic acid. Substitution of the control diet at 10 per cent level of protein by SCP maintained the growth of rats comparable to those of control animals. Toxic and Pathological effects of feeding SCP to rats have also been studied.

13. NUTRITIVE VALUE OF FISH FLOUR FROM SHARK MEAT

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Among the high protein foods of marine origin, Shark Meat deserves greater emphasis from Nutritionists as it is not commonly utilised as a popular human food except in Australia. Presence of urea upto 2% in elasmobranch muscle affects both the flavour and the keeping quality of the processed products using traditional methods. The present authors have investigated the possibility of its conversion into fish flour, advocated in recent years as a solution to problems of malnutrition in Asia. It is of interest to note that tropical waters abound in these ill-utilised fish, known for their high protein content. Without taking recourse to urease treatment, the
authors have developed an integrated process for obtaining urea free shark flour based on cooking, soaking in dilute acetic acid and alcohol extraction. The final product pale yellow in colour and bland in taste showed a protein content of 99% and was found to be acceptable at 15% level in cereal preparations.

In view of the conflicting reports in existing literature essential amino acid composition has been studied in greater detail employing chemical and microbiological methods. Lysine content is 12.88% (microbiological assay), available lysine being 9.77%. Protein efficiency ratio (P. E. R.) of shark protein was observed to be $2.96 \pm 0.24$ as compared to skim milk protein (3.00).

It is estimated that the cost of the final product may not exceed Rs. 3.50 per kg. not taking into consideration the scope for by-product utilisation for which shark is ideally suited. Annual landings of sharks and rays in India is of the order of 40,000 tons.

14. NUTRITIONAL STUDIES ON DEHULLED SESAME PROTEIN CONCENTRATE

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Presence of hull in Sesame (*Sesamum indicum* LO) contributes to colour, bitterness, high oxalate and fibre content of the meal and thereby limits its use as a protein supplement. This drawback was overcome by wet dehulling of the seed using lye treatment. The edible flour obtained from the dehulled seed has over 50 per cent protein content and its nutritive quality is superior to that of the undeulled sesame cake. Supplementation of the flour with lysine, the only limiting amino acid in sesame protein, significantly improves the nutritive value of the protein concentrate comparable to that of skim milk powder.

The high level of sulphur amino acids, particularly methionine present in sesame suggests its use as a supplement to diets deficient in these amino acids. Wheat and rice based typical Indian diets are reported to be most limiting in sulphur amino acids, when compared with the amino acid pattern of egg. A study on the effect of supplementation of wheat diet with optimal level of methionine or sesame flour with and without addition of
lysine, minerals and vitamins was carried out in weanling rats. While addition of methionine or sesame flour did not improve weight gains and feed efficiency of rats, lysine supplemented sesame flour gave a better growth response. In all cases fortification with minerals and vitamins resulted in significant improvement in the overall nutritive value of the diets.

Since sesame flour is one of the few rich sources of methionine among plant proteins and shows marked improvement in its protein quality on lysine supplementation, it can be used with advantage in the preparation of processed protein supplements for human consumption. Incorporation of dehulled sesame flour in composite protein foods based on legumes has been found to improve their protein quality.

15. NUTRITIONAL EVALUATION OF LEAF PROTEINS USING THE ACTIVITY OF XANTHINE OXIDASE AS AN INDEX

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The nutritional evaluation of leaf proteins prepared from raw materials and processed differently has been carried out with respect to their capacity to promote growth and replenish the cellular components of the protein depleted liver as reflected in the activity of xanthine oxidase.

The study was carried out in three experiments:

a) to study the effect of complete starvation and refeeding casein and berseem leaf protein concentration (LPC).

b) to study the effect of leaf proteins under different drying conditions.

c) to study the effect of different leaf proteins in regeneration of protein depleted rats.

Rats when starved for 3 and 6 days, suffered a great loss in body and liver weights and in liver total nitrogen and xanthine oxidase activity. When the 6 days starved animals were refed casein and berseem LPC the response in the above parameters was significantly lower in case of berseem LPC than casein, thus indicating that berseem LPC is inferior to casein. In a second experiment the diets prepared from casein and cowpeas LPC as wet
cake and those dried at 60°C and 80°C were fed to weanling rats for 4 weeks. Casein was found to be better than Cowpeas LPC diets and the cowpeas LPC as wet cake were superior to that dried at 60°C and 80°C with respect to liver weight, liver total nitrogen and xanthine oxidase activity. The body weight gains with casein diets were considerably higher than those with cowpeas LPC diets. In another experiment, the rats were protein starved for 3 days. They lost in body weight, liver weight, liver total nitrogen and xanthine oxidase activity. Regeneration with casein displayed maximum values in terms of body and liver weight, liver total nitrogen and xanthine oxidase activity than with LPC from berseem, cowpeas and cauliflower. However, cauliflower LPC was found to be better than the other LPC preparations.

16. INCLUSION OF WILD LEGUMINOUS SEED PROTEINS IN ANIMAL NUTRITION
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High protein content of several wild leguminous seeds suggested their possible inclusion in animal nutrition. However, their unpalatability, bad odour and toxicity in some cases, despite their nutritional adequacy, disallowed feeding of the entire seeds. Therefore their soluble proteins were extracted, fractionated and isolated in more or less pure form at appropriate pH. Amino acid analysis of the protein isolates revealed them to possess fairly balanced amino acid pattern although in good many cases, methionine and tryptophan appeared to be the limiting factors as substantiated by analysis as well as animal experiments. Supplementation of the protein isolates with the limiting factors (methionine and tryptophan) wherever necessary, restored normal growth in experimental animals and also proved to maintain a positive nitrogen balance in them.

When adequately balanced with the essential amino acids, the wild seed protein isolates do not appear to induce any deleterious physiological after-effects on the experimental animals as evinced by liver protein and several enzyme assays. Thus the results obtained tempt one much to recommend their suitability for inclusion in animal nutrition and perhaps in human nutrition as well. However, long-time decisive feeding trials are necessary before any final conclusions are drawn.
17. A SPECIFIC ENZYMATIC PROCEDURE FOR THE DETERMINATION OF $\beta$-OXALYL-$L-\alpha,\beta$ DIAMINO PROPIONIC ACID PRESENT IN *LATHYRUS SATIVUS*

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$\beta$-oxalyl-$L-\alpha,\beta$ diaminopropionic acid (ODAPRO) is one of the main neurotoxic components present in the seeds of *Lathyrus sativus* (Khesari dal). Khesari dal is used as an adulterant of *Cicer arietinum* (Bengal gram), *Cajanus cajan* (Red gram) and other pulses in view of its comparatively low cost. A paper electrophoretic and chromatographic procedure for determination and an anthocyanin test for detection of adulteration with khesari dal have been reported. These methods lack the specificity and sensitivity of an enzymatic procedure.

The present method involves extraction of ODAPRO from the test sample, separation from neutral, basic and mildly acidic amino acids on a cation exchange column and acid hydrolysis. Hydrolysis of ODAPRO to oxalate and $L-\alpha,\beta$ diaminopropionic acid (DAPRO) is nearly quantitative. The DAPRO formed is converted to pyruvate by a specific ammonia lyase purified from extracts of a pseudomonad. Pyruvate is determined as its 2:4 dinitrophenyl hydrazone by standard procedures or with the NAD dependent lactate dehydrogenase.

Data on the ODAPRO content of several samples of khesari dal as determined by chromatographic and enzymatic procedures will be presented.

18. DRIED BEET PULP AS A GRAIN REPLACEMENT FOR DAIRY COWS AND SHEEP

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Six experiments were conducted to study and improve the nutritional value of dried beet pulp for its efficient and optimum utilization in the rations of ruminants. In the first experiment, three metabolism trials were conducted...
with wether lambs to study the nutrient digestibility and energy utilization of rations containing four different levels (0–60%) of beet pulp as a replacement for corn in the control ration. No significant differences were observed in the digestibilities of dry matter, energy and crude protein of rations containing even 60% beet pulp or comparable level of corn. Crude fiber digestibility increased at each increase in the level of pulp. The metabolizable energy of the rations did not change and averaged at about 71% of gross energy. A lactation trial involving eight cows in the second experiment showed no significant difference in fat corrected milk production when a control ration containing 57% barley was compared with a 55% beet pulp ration. The result of the third experiment indicated that when four percent fat was added to a fat deficient ration containing 50% beet pulp, milk yield increased significantly by 7.5%. In three successive experiments the effects of feeding high concentrate rations containing four levels of corn or beet pulp on yield and composition of milk, body weight gain, energy utilization and rumen fermentation characteristics of cattle and sheep were studied. No significant differences in yield and composition of milk, and body weight gain was observed even when 73% of the corn in the control concentrate ration was replaced by beet pulp. The metabolizable energy of the rations averaged 2790 kcal/kg and did not differ significantly. An increased production of rumen VFA and a less frothy rumen ingesta were observed when beet pulp replaced corn in the high concentrate dairy ration.

19. THE ABSORPTION OF IRON FROM RICE AND WHEAT

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Iron deficiency anaemia is widely prevalent in India in spite of seemingly adequate amounts of dietary iron. Most of the iron, however, is derived from cereals—rice or wheat, which is the staple. Chemical balance studies have shown that the availability of iron from these foods is relatively low. The validity of chemical balance data has, however, in recent times, been questioned. Absorption of iron from rice and wheat was, therefore, determined in 23 normal healthy human volunteers by the standard meal technique, using either labelled ferrous sulphate or a standard meal spiked with 55Fe. A dose of 5 mg. of iron was given on an empty stomach. The radio-activity excreted in faeces over the next 6—8 days was measured in a NaI scintillation probe of a medical spectrometer with a fixed geometry. The average iron
ab orption was 33% from ferrous sulphate, 8.6% from rice and 12.6% from wheat meals. These results are similar to those found earlier using chemical balance studies. It is proposed to further confirm these data using the double isotope technique.

20. THE AVAILABILITY OF IRON FROM GREEN LEAFY VEGETABLES AS COMPARED TO IRON SALTS FOR SCHOOL CHILDREN
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Anaemia is one of the major public health problems in India. Surveys conducted by the Nutrition Research Laboratories (1968) have revealed that approximately 50 per cent of the children in India have haemoglobin levels less than 10 g. per cent.

Green leafy vegetables furnish liberal quantities of iron in the vegetarian diets. They have the additional advantage of being rich in carotene, folic acid and vitamin-C. Nirmala et al. (1968) found a significant increase in the haemoglobin and PCV value of a group of adolescent girls fed amaranth when compared to that of a group fed iron tonic. Similar findings were reported by Devadas and Prema (1969) on elementary school children.

The present study compares the availability of iron from a green leafy vegetable, namely, *Amaranthus flavus* and iron supplements in the form of a salt ‘Fersolate’ and a tonic ‘Colliron’ given as supplements in a school lunch, over a period of eight months.

21. BIOLOGICAL EVALUATION OF THE PROTEINS OF RAMDANA (*AMARANTHUS CAUDATUS*)
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Studies were carried out in male weanling albino rats to evaluate the nutritive value of a protein isolate from Ramdana, the seed of *Amaranthus caudatus*. On the basis of a protein efficiency ratio of 2.5 for casein, the
protein efficiency ratio of the Ramdana protein isolate was 1.8. The animals receiving the control casein diet showed superior weight gains and protein efficiency ratios. However, the vegetable protein isolate was found capable of maintaining normal hemoglobin levels, liver protein content and xanthine oxidase activity in rats.

The biological value as determined by nitrogen balance trials in rats was found to be 70% for casein and 65% for the Ramdana protein isolate.

Amino acid supplementation studies indicated that lysine was the limiting amino acid in Ramdana protein. Significant improvement in protein quality was obtained when the protein isolate was supplemented with lysine. Further study is needed to delineate the optimum level of lysine supplementation.

The protein isolate incorporated at 18% level in the diet supplied adequate quantities of methionine for the growing rat. Furthermore, in vitro digestibility studies showed that it did not contain any trypsin inhibitor. It was readily accepted by the experimental animals and was free of adverse physiological effects.

The presence of neurotoxic compounds in the seeds of *Lathyrus sativus* has been reported earlier from these Laboratories. Many legumes are known to contain trypsin inhibitors and it was considered possible that *Lathyrus sativus* may also have an anti-tryptic factor which may not only affect its nutritional value, but also have an association with the neurotoxic properties of the legume.

Pulverised *Lathyrus sativus* seeds were extracted with phosphate buffer (pH 7.5) and with distilled water. Both extracts had anti-proteolytic activity when tested against trypsin as the enzyme. The trypsin inhibitor was isolated and purified from *Lathyrus sativus* seeds, and found to be a single protein compound with 12.1% protein, on dry weight basis. The purified inhibitor was thermolabile and four times more susceptible to heat treatment than the crude preparations.
23. FURTHER STUDIES ON FISH PROTEIN CONCENTRATES TO OVERCOME PROTEIN MALNUTRITION

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With the enormous increase in population every year we will be unable to protect the human race from severe protein depletion. We will be forced to resort to the inexhaustable and nearly unutilized reserves of the oceans. The seasonal catches of certain cheap and abundant varieties of fish could be conserved for better utilization in the form of fish protein concentrates (FPC).

A number of FPC samples utilizing these surplus fish such as silver bellies, have been analysed for their proximate composition and for their methionine and available lysine content. FPC is a rich source of protein containing more than 80% protein and methionine and available lysine content is in the range of 2.8–3.5 and 9–10 g/100 g protein respectively. Many of the common diets being deficient in protein and methionine, and available lysine could be nutritionally improved by supplementing them with FPC.

To process huge quantities of available fish it is necessary to preserve them till they are taken out for FPC manufacture. In this connection studies have been concluded using oil sardines of low, medium and high fat content. The fish with high fat content could be left with ethanol for 3–4 days whereas fish with low fat content could be taken out of ethanol after a storage period of about a week. These studies are based on FFA content of fish and the changes in colour in storage of fish under ethanol.

FPC has been successfully incorporated at a high level of about 25% in the form of wafers. This will not present any difficulty in popularising FPC as the product is attractive in appearance and other aspects.

There is also a great possibility of preparing FPC type C by modifying the characteristic flavour of fish by use of pure cultures such as Aspergillus oryzae, A. flavus along with suitable nutrients.

24. POULTRY LITTER AS A SOURCE OF PROTEIN AND ENERGY FOR RUMINANTS

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Poultry litter, a waste product of the poultry industry comprising mainly chicken excreta and the bedding material used in the poultry house is pre-
ently used primarily as fertilizer. The annual production of litter in Lebanon has been estimated to be between 100 and 135 thousand metric tons.

Three experiments were conducted to study the protein and energy value of poultry litter for ruminants. The local wood shaving poultry litter analyzed 28% crude protein and 15% crude fiber, dry matter basis. Three digestion trials were conducted in the first experiment with eight wether lambs fed rations containing 0, 25, 50 and 75% unprocessed litter. No significant differences were observed in the digestibilities of different litter nutrients as the level of litter increased in the rations with the exception of crude fiber which was higher at the 25% litter level. The DP and TDN values of the litter when used even at the 75% level in the ration were 21.4% and 53.2% respectively. In the second experiment, equicaloric rations containing 0, 25 and 50% poultry litter were fed ad libitum to three groups of Holstein bull calves during a 90-day fattening trial. Even though daily feed intake and average daily gain decreased at each increase in the proportion of poultry litter in the rations, the daily gain of 1.5 lb. in the group fed 50% litter ration was higher than the gain of stock raised locally. The result of carcass grading and taste-test indicated a significant preference of 25% litter group over control. An effort was made to increase the feed intake of the litter ration in the next experiment, by incorporating 30% screened poultry litter in a practical fattening ration containing ten per cent molasses. No significant differences were observed in the average daily gain and feed intake between the control and litter fed groups.

25. STUDIES ON THE DISTRIBUTION OF ANTI-THIAMINE FACTOR IN DIFFERENT FOODSTUFFS

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Several workers observed that some foodstuffs like rice (rice bran), fern, blue berries, mustard seed (Brassica juncea) etc. contained certain principles which inactivated thiamine. The present paper deals with the studies on the distribution of this anti-thiamine activity in different foodstuffs. These studies confirm the observations of the previous workers in some of the foodstuffs. Besides other foodstuffs commonly used by the Indian people and not tested before for the antithiamine activity has been analysed for the
existence of antithiamine activity. Further preliminary studies towards the purification of the anti-thiamine factor present in the mustard seed (Brassica juncea) has also been undertaken by using different techniques; as a result, final material thus obtained is several times more purified in comparison with the starting material.

26. STUDIES ON THE EFFECT OF PROCESSING ON THIAMINE, RIBOFLAVIN AND Niacin CONTENTS OF PRECOOKED DEHYDRATED PULSES

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Studies are reported on the effects of processing on thiamine, riboflavin and niacin contents of various pulses e.g., red gram (Cajanus indicus), black gram (Phaseolus mungo), Bengal gram (Cicer arietinum) and green gram (Phaseolus radiatus), which are generally supplied in a precooked dehydrated form. These dals reconstitute easily under all operational conditions including high altitude.

Expressed on dry weight basis, percentage loss of thiamine during processing including cooking at 15 lbs. for 10-30 mts. and subsequent dehydration was of the order of (11.1) for red gram, (13.8) for Bengal gram, (34.3) for black gram and (24.3) for green gram. The percentage loss of the same vitamin on reconstitution in boiling water worked out to be (11.8) for red gram, (16.0) for Bengal gram, (17.4) for black gram, but no appreciable loss was noticed for green gram dal. Similarly, processing loss of riboflavin was of the order of (20.8) for red gram, (12.0) for Bengal gram, (22.7) for black gram and (21.0) for green gram. Further losses of riboflavin on reconstitution of the precooked dehydrated pulses worked out to be (1.7) for red gram, (3.6) for Bengal gram, (2.3) for black gram and (9.9) for green gram. The percentage losses of niacin in precooking and dehydration worked out to be (12.3) for red gram, (20.1) for Bengal gram, (11.1) for black gram and (13.9) for green gram. The observed loss on reconstitution worked out to be (2.4) for red gram, (3.7) for Bengal gram, (7.9) for black gram and (4.7) for green gram. The data suggest that in the processing of pulses involving cooking at 15 lbs. for 10-30 mts. as also dehydration of cooked dals in a crossflow air drier at about 70°C for periods varying from 2-2½ hrs. for green gram to 4½-5 hrs. for black gram there is appreciable loss of thiamine, riboflavin and niacin. When reconstituted and used, these pulses,
would give approximately about 70% of the vitamin originally present except for thiamine in black gram, which will be available to the extent of 50% only.

27. EFFECT OF BAKING AND DEEP FAT FRYING WITH SUGAR AND JAGGERY ON THE AVAILABLE LYSINE OF WHEAT

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Total and available lysine content was estimated in raw wheat flour and three kinds of biscuits and pooris (Plain, with sugar, with jaggery). Young weanling rats were fed with the above seven diets at 10% protein level. Weight gain and feed consumed were recorded. After six weeks feeding the diets were supplemented with lysine to bring the available lysine content to that of raw wheat flour and continued the experiment for two weeks.

Total and available lysine content decreased both in baking and deep fat frying processes even without additions of sugar or Jaggery. Addition of sugar did not cause any additional destruction of available lysine but the addition of jaggery resulted in the maximum loss of available lysine. Attempts were made to correlate the available lysine content of the diet with the protein quality by biological experiments. Protein efficiency ratios of all the poori diets were found to be lower than the biscuit diets. Addition of jaggery both in biscuits and pooris decreased the protein quality to a greater extent than the addition of sugar. From the observation that even after bringing the available lysine content of all the diets to the same level by supplementing with lysine, the rats on poori diets gained less weight than those on biscuit diets it is suggested that in deep fat frying some other essential amino acid in addition to lysine might have been destroyed.
INTRODUCTION:

Children malnourished during active period of growth & physical development will not grow into healthy adults. Malnutrition affects not only their health but also their capacity to learn. The midday meal is of vital importance to majority of school children in Ceylon and the Govt. has recognised the principle of supplementary feeding of the school children.

Up to 1968 the free mid-day meal consisted of a bun (2½ ozs) and ½ pint of milk from 1 oz. of skimmed milk. Animal protein and specific nutrients like Calcium and Riboflavin were thus supplied. Thereafter biscuits replaced the bun.

DEFECTS:

Fat and Vitamin A not supplied.
For an underweight child calories are insufficient.
All the children do not take milk.

PROPOSALS FOR IMPROVING NUTRITION:

a. Grading of schools nutritionally.
b. Selection of appropriate meal.
c. Health Education in Nutrition.
d. School gardens.

2. EVALUATION OF PROTEIN BISCUITS AS NUTRITIONAL SUPPLEMENT TO SCHOOL CHILDREN—A PILOT STUDY

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The importance and need for good nutrition during early childhood are
universally accepted. In a developing country such as India where malnutrition is rampant, some form of dietary supplementation is essential.

Because of the high nutritional value and economic importance, soyabean would be a promising food for supplementation. Soyabean has disadvantages such as poor taste and presence of antinutritional factors such as trypsin inhibitor. These were overcome, and soya-based and groundnut-based biscuits were manufactured by a local food factory in Poona.

The efficiency of these biscuits was evaluated in a pilot study in 116 school children, from poor families in Poona. Each child was given a supplement of 4 biscuits, each giving 1.25 gm. protein and 35 calories. Children receiving biscuits for more than 41 days showed in 3 months a significantly higher weight (average 0.35 kg) and height (average 1.85 cm.) gains than the control group. The results did not reveal significant differences between the groups fed soya or groundnut biscuits. Trypsin inhibitor in soya-biscuits was destroyed in the manufacturing process.

The use of high calorie biscuit, is strongly recommended in the school feeding programme.

3. FAILURE OF A MASSIVE ORAL DOSE TO PROTECT PRE-SCHOOL CHILDREN FROM VITAMIN-A DEFICIENCY.

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Large oral doses of vitamin-A palmitate (100,000 mcg and 50,000 mcg) were given to normal pre-school children resident in an orphanage. Their serum levels and those of the controls were estimated frequently. The children were maintained on recommended intakes of protein and calories. The vitamin-A content of the diet, as carotene, with similar to that of pre-school children in Tamil Nadu.

Following 100,000 mcg vitamin-A, serum levels of the children were higher than those of the controls for 13 weeks. On repeating the experiment serum levels dropped between 15-19 weeks.

Following 50,000 mcg of vitamin-A, levels indicative of deficiency were
observed from 14–16 weeks after the dose. By 18 weeks, statistically significant differences between the two groups were not encountered. Two children who were given the dose showed xerosis and Bitot's spots after the 10th week.

Oral doses of vitamin-A, of the magnitude stated above, were ineffective in preventing deficiency in pre-school children for more than 13–18 weeks.

4. PROTEIN INTOLERANCE IN NEWBORNS AND INFANCY
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   This is a study of 20 newborns and infants who were on high protein diet. The clinical picture consisted of increased appetite, excessive crying, abdominal distension and failure to gain weight in spite of high intake of calories, often up to 250-300 calories per kg/ per day. They also had tachypnoea, tachycardia, marked abdominal distension, and polyuria. It was found on analysis of the diet, that the babies consumed a large amount of protein in the milk. The symptomatology of the present condition and of carbohydrate malnutrition described by us and the milk injuries (Melharsaden) described by German authors are similar. However, these children did not have carbohydrate malnutrition as they were taking adequate amount of carbohydrates in the diet. Treatment consisted of reduction of proteins in the diet. The babies improved with reduction of protein from 10-12 g/kg to 4 g/kg. They gained weight in spite of reduction of total calories to 120-140 per kg from pre-treatment intake of 250-300 per kg, per day, and gradually other symptoms regressed.

5. A BALANCED APPROACH TO CHILD NUTRITION
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   A study of Comparative Constitutional Law reveals that few nations of the world have included in the articles of their Constitutions, any provision or basic right which guarantees their populations minimum nutritional sustenance. And yet, there are few areas of human activity or concern which
parallel the need and search for adequate food; adequate food, principally in terms of quantity. Given the obvious lack of importance attached to national nutrition as reflected by the conspicuous absence of any mention of nutrition in most constitutions, it has been necessary for scientists and of late, planners, to establish nutrition in its rightful place and in the spectrum of national priorities, either by legislative act or executive order.

There is a slow but growing sense of awareness that nutrition is inexorably linked with not only the physical, but also the intellectual development of children, and ultimately the nation. Development Economics, in theory and practice, has been rudely neglectful of nutrition as a factor in the development equation. Illusive yardsticks such as per capita income, gross national income, and gross incremental output ratio, have been used over the past 25 years to measure the health of national economies. No one has bothered to measure and evaluate mortality rates or morbidity rates, as reflected in the cost of hospitalization, curative out-patient treatment, the cost of drugs and medicines and the over-all drain on the economy. This is unfortunate for such measuring devices may require us to drastically reverse national priorities.

6. A SURVEY OF DENTAL AND GINGIVAL CONDITIONS AMONG SCHOOL CHILDREN IN SUnderpur, VARANASI
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A Survey of dental and gingival condition among school children was undertaken with emphasis on dental caries. In all 400 children belonging to 6-17 year age group were examined. The analysis revealed:

1. Among 400 children 233 were non-vegetarians and 167 vegetarians with 77 and 57 cases of caries ($X^2 = 0.26, P < 0.50$).

2. The overall incidence of caries was 34.0%. Incidence was high in students who ate sweets frequently ($X^2 = 22.80, P < 0.001$, highly significant).

3. Maximum incidence was in 6-7 yr. age group with a predilection for molars. 17.5% children had hyperplastic gingivitis and 3.25% had pockets.
4. 67% people were using datoon, 23.5% fingers only, 6% both powder and abarasives, and 3.5% tooth brush for cleaning teeth.

Fluoride content of the water could not be determined due to non-availability of laboratory facilities.

The above study attempts to define the extent of caries in a slum harbouring people of lower socio-economic group. The authors have suggested that for areas where fluoridation is not possible the only therapy is intensive nutrition education & oral hygiene as part of total health care.

7. HAEMATOLOGIC VALUES OF BLOOD SAMPLES OF PREGNANT AND NON-PREGNANT WOMEN IN UBOLRAJTHANI

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The haematologic status of women in the villages of Ubolrajthani Province in Thailand was studied. Ninety-two pregnant women and 84 non-pregnant women, ranging in age from 20 to 46 years were selected. A haemoglobin value of 11 gm %, haematocrit of 32% and MCHC of 29% (wintrobe) were considered as normal during pregnancy. The mean values of haemoglobin and haematocrit in pregnant women were significantly lower than those in the non-pregnant women. The values also gradually decreased from the first to the third trimester. From the data obtained, it was observed that 50% of the pregnant women and 37% of the non-pregnant women were anaemic. The tendency to develop anaemia progressed as the pregnancy advanced.

8. AN EPIDEMIOLOGICAL STUDY OF NUTRITIONAL DISORDERS IN CHILDREN BELOW 5 YEARS OF AGE IN KALYANPUR

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401 children between 0-5 years age were selected randomly from the two diverse communities. 202 children were drawn from the villages of a Rural
Field Training Centre, and 199 from the campus of Indian Institute of Technology.

Though single families formed the bulk of study in both the communities, joint families were more in villages. 21.11 per cent of the children in I. I. T. were in age group 6-12 months, while in villages 36.82 per cent were in age group 1-2 years. Males were in preponderance at both the places.

30.22 per cent of the children in villages manifested nutritional disorders in comparison to 9.55 per cent from I. I. T. Anaemia was present in 11.32 per cent in villages and only in 7.04 per cent in I. I. T. Vitamin deficiencies were observed 8.9 per cent in villages and 1.5 per cent in I. I. T. Vitamins A and B deficiencies were prominently seen in villages. Protein-calorie malnutrition was noticed in 1.98 per cent of the children in villages and in 0.50 per cent in I. I. T.

Nutritional disorders were not seen in children below 3 months of age. The disorders dominated in villages after 1 year of age while in I. I. T. it was seen after 2 years. Nutritional disorders were seen mainly in social class III (11.9 per cent) in I.I.T. and social class IV (24.71 per cent) in villages.

Maximum nutritional disorders were seen in vegetarians, and the occurrence was 6.53 and 20.29 per cent in such families of I. I. T. and villages respectively. The disorders in single families were 6.03 and 17.08 per cent in I. I. T. and villages. Children of 2nd birth orders had maximum nutritional disorders of 10.89 per cent in villages. In I. I. T. maximum disorders (3.01 per cent) were seen in 3rd birth order. Past morbidity for other devitalising diseases was seen more in villages.

9. APPLICATION OF SOME BIOCHEMICAL METHODS IN DIAGNOSIS OF NUTRITIONAL DEFICIENCIES

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In this study, 750 pre-school children (1-5 yrs.) from urban and rural communities were selected for anthropometric measurements, clinical and dietary assessment. Every third child was investigated for biochemical values in blood. The data on incidence of anaemia, protein-calorie malnu-
trition, vitamin deficiencies will be discussed. These subjects have also been studied for evaluation of dispensable to indispensable amino acid ratios suggested by Whitehead and Bjornesjo in plasma and erythrocytes. It was demonstrated that fall in leucocytic free amino acids is the first to appear and consistent in protein deficiency. This was convincingly further demonstrated in pregnant women taken as a model of growing hypoproteinaemia.

10. INCIDENCE OF PROTEIN-CALORIE MALNUTRITION IN THAILAND

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Protein-calorie malnutrition is recognized as a major nutritional problem in the under-privileged segment of the world population. In Thailand, while the food products are rich, there are frequently nutritional deficiency diseases occurring especially in the North-East.

The improvement of protein intakes of the population, both quantitatively and qualitatively, can possibly be done by the use of protein-rich supplementary foods.

One of the best means tried so far to reach the pre-school children and their mothers is to organize a community day—care centre or Child Nutrition Centre. The people are invited to participate in the organization. This arrangement will enable simultaneous education of the mothers and feeding of children. The Child Nutrition Centre will be carried on by the midwives or health nurses.

The Government of Thailand, recognizing the importance of the problem, has undertaken to supply corrective measures by promoting the agricultural industry and increasing the quantity of food, among which is the programme to develop protein-rich foods utilizing local raw materials. From this programme the Protein Food Development Project was established. Begun in 1969, this project has good co-operation of the scientists and related officers in the Institute of Food Research and Products Development, Kasetsart University, and Nutrition Division, Department of Health, Ministry of Public Health.
11. EVALUATION OF AN APPLIED NUTRITION PROJECT FOR COMBATING PROTEIN CALORIE MALNUTRITION

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Protein Calorie Malnutrition is a major public health problem of pre-school children in our country. From the numerous surveys carried out in South India, the prevalence of protein calorie malnutrition in South India is about 1-2%. The solution to the problem obviously cannot lie in the treatment of such cases, but in its control and prevention.

A practical action programme of supplementary feeding of pre-school children in 2 villages, Kuntloor and Koheda, was started about two years back, the supplement being based exclusively on local resources. The community has been actively involved in all phases of the programme, viz. from the stage of procurement of foodstuffs to that of distribution of foods to the children. Thus, a considerable cost in transportation and distribution of food is avoided and the community is involved in all stages of the programme.

A study was undertaken to evaluate this supplementary feeding programme.

The nutritional status and dietary standards of this group of children were evaluated through (i) clinical nutritional surveys, (ii) anthropometric survey and (iii) diet survey. The results are compared with similar studies carried out on a control group of children from neighbouring villages.

12. INDUSTRIAL NUTRITION: SOME OBSERVATIONS ON CANTEENS IN INDUSTRY

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It is rightly said that what the industry can get out of the worker depends very much on what it puts into him. An industrial worker is one of the vital functionaries in the cycle of production and development of the industry and deserves assistance in every way to maintain his health to ensure optimum output. With India’s rapid industrial expansion, the importance of
adopting measures to improve the nutrition of the workers is engaging attention of the Governments and gradually inducing the progressive managements also to give an active support to the feeding.

As part of the welfare measures for the industrial workers the Factories Act (1948) of the Govt. of India lays down establishment of canteens in industry employing 250 workers or more, with the object of making wholesome food available to the workers within the factory premises, at reasonable rates. However how many managements have followed the real object of the canteen provisions?

At present there is a big gap between what is considered an adequate meal for the worker and what is actually served through majority of the canteens. Although the caloric needs are often met, the major deficiencies usually observed are in respect of some of the important nutrients like vitamins A & C, calcium, and good quality proteins. Moreover, the escalating prices and the chronic deficit of foods, the ignorance in food values of the persons responsible for planning and preparing the food, limit the maximum benefit that could be derived from foods for nutritional well-being.

The problem of providing nutritionally adequate meals and snacks acceptable to the palate of the cosmopolitan group of workers, such as in India, is no easy task and needs sustained efforts on the part of all concerned. The education of the workers themselves in proper selection of snacks and meal service through industrial canteens could be far reaching if the workers are made to realise the relative importance of foods for health.

13. CALORIE INTAKE OF PRE-SCHOOL CHILDREN WHEN FED AD LIBUTUM

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Accurate and reliable diet survey data on the pre-school children in several parts of India have indicated that the main bottleneck in their current diets is calorie insufficiency. The NDp Cals % of the diets of pre-school children in the various regions of India range from 4.8 to 8.8. These must be considered adequate on the basis of recommended protein allowances by WHO/FAO and ICMR Expert Group. The protein deficiency that exists in these communities may, therefore, be considered as being conditioned by
calorie inadequacy. It may, therefore, be argued that if the children consumed increased amounts of the type of food they are already consuming in quantities sufficient to meet the calorie requirements, a considerable impact could be made on the incidence of protein calorie malnutrition in this country. Doubts have, however, been raised whether the bulk of the food would permit the children to consume it in adequate amounts.

A study was, therefore, conducted on 14 children aged between 2 and 3 years living in a rural area near Hyderabad. Two diets patterned on their home diet were fed ad lib to the children four times a day. The first diet was based on rice, pulse and skimmed milk (NDp Cals 6.5%) and the second on rice, pulse and peanut (NDp Cals 5.5%). The first diet was fed for 15 days, followed by the second for 10 days.

The results showed that all the children were able to consume 1000 or more calories per day, the mean intake on the basis of body weight being 112 Kcal/kg. body weight. The food intake of children who were still being breast-fed was less than that of the groups not breastfed, but the total calorie intakes were similar when calories derived from breastmilk were taken into consideration.

These results suggest that pre-school children can consume their existing diets in amounts sufficient to satisfy their calorie needs, provided the food is offered to them frequently in small amounts.

14. ECONOMICS OF FOOD CONSUMPTION OF RURAL AND URBAN POPULATION

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Food consumption surveys were conducted to study how money was spent on food. Two regional groups—Maharastrian (M) and Gujarati (G) were included in the urban survey. Most of the urban families lived in two room apartments. The rural families (R) consisted of agriculturists with a land holding of three acres or less. All figures reported are paisa spent per day per consumption unit (C.U.).

The (M) and (G) families spent Rs. 1.84 and Rs. 1.70 respectively for
food. The rural families consumed the rice they produced and spent 33 paise for all other foods. The (M) and (G) families spent 25 and 20 paise for cereals respectively.

Negligible quantities of milk was consumed by the (R) families. The (M) and (G) families spent 71 and 56 paise respectively on milk.

The (R) families spent 8 paise on fish. The (M) and (G) families did not eat fish.

The (R) families spent 5 paise on pulses, the (M) families 9 and the (G) families 10 paise.

The (R) families did not buy fruits. The (M) and (G) families spent 4 paise each on vitamin C rich fruits and 8 and 5 paise respectively on other fruits.

The (R) families spent 6 paise on fats and oils, the (M) families 27 and the (G) families 34 paise.

The (R) families spent 2 paise, the (M) families 4 and the (G) families 3 paise on leafy vegetables.

The (R) families spent 7 paise on jaggery. The (M) and (G) families spent 13 paise each for sugar and jaggery.

The (M) and (G) families spent 11 paise each on readymade foods. The (R) families did not buy any.

15. BERI-BERI IN THAILAND
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It has long been known that beri-beri is a nutritional disease due to deficiency of thiamine (vitamin-B₁).

Thailand is an agricultural country. It is divided into four parts, North, South, Central and North-East. In each part of Thailand, eating habits and economic status of populations are quite different. Present Thailand
population is estimated to be thirty three millions. Eighty per cent of the people live in rural area, and almost all earn their livelihood through agriculture. Beri-Beri cases were found to have relationship with substitution of home pounded rice with highly milled rice. The old fashioned Thai-farmer of a few decades ago, who milled the rice himself, had a better supply of thiamine (0.12 mg./100 g edible portion); so the incidence of beri-beri was less. After the World War II, the disease seemed to have increased in some parts of Thailand, especially in the North and the North-East. That is probably due to the introduction of modern rice mills which made highly polished rice, devoid of thiamine, to the people. But through health education and widespread use of synthetic thiamine, obvious cases of beri-beri in adults and children have not been seen as often as some decades ago.

16. PROGRAMMES TO MEET THE PROBLEM OF VITAMIN-A DEFICIENCY IN INDONESIA

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In Indonesia as in other developing countries, vitamin A deficiency is still an important problem with a very high incidence rate in small children.

Vitamin A, because of its relation to growth and implication in xerophthalmia is particularly important in the young children, and in Indonesia, primary deficiency caused by inadequate intake of the vitamin or of carotene is the largest single case of blindness.

As in other developing countries, socioeconomic condition is the most important problem to solve, but until now such programmes are still not available in Indonesia. Common efforts which we still use in Indonesia for the prevention of vitamin A deficiency are:

1. THE SHORT TERM PROGRAMMES:

Plans directed toward improvement of vitamin A intake in pre-school age:

a. To give information, education and demonstration about foods rich in vitamin A or carotenes.
b. Distribution of foods rich in vitamin A/carotenes.
c. Distribution of vitamin A preparations.
d. Combating ascariasis and other infections diseases in children.

2. THE LONG TERM PROGRAMMES:

The attention of the Governments/National authorities should be drawn to the importance of planning for better food supplies for the people with the assistance of FAO/WHO and UNICEF participations.

17. GROWTH, DEVELOPMENT, FEEDING AND WEANING PATTERNS OF INFANTS IN SHIRAZ

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The results of a study of growth of 913 infants born in the Red Lion and Sun Maternity Hospital in Shiraz, during the first two years of life are to be reported. Weight and length curves were constructed from these measurements. A comparison with similar measurements published for infants in Western countries showed no significant difference in the birth weight or length. However, Shiraz infants had a slower growth rate and significant differences were noted at the age of 3 months for length and at 18 months for weight. These persisted during the age periods included in this study. Findings were similar for boys and girls. The role of genetic and environmental, including nutritional factors is to be discussed.

Some of the developmental milestones when compared with those described by Aldrich for American infants showed a tendency toward slightly retarded development in Shiraz infants. Observations of feeding and weaning patterns show that breast feeding is almost universal and that it is continued for long periods in this population.

18. WEANING HABITS OF INFANTS IN LOW SOCIO-ECONOMIC GROUPS OF POPULATION IN BOMBAY CITY

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The influence of socio-economic factors on weaning habits and nature of supplement introduced to children was studied in Bombay city.
The investigation was carried out in ten different centres by trained personnel using oral questionnaire methods, in a representative sample of the population. 400 children up to the age of five years, consisting of 216 boys and 184 girls were taken up for the study.

Food intake of the children was collected with the objective of studying (1) The quantity, quality and the manner of introduction of supplement. (2) Relation of mothers age and parity on supplementation.

The results show that the maximum percentage (42.8%) of children completely weaned are in the age group 12-24 months. As regards length of weaning period, majority, (36.2%) are in the age group zero to three months and 83.9% are in the age group zero to 18 months.

49% of children have breast milk for the first nine months. Reduced adequacy of breast milk with the parity of the mother has been observed.

Relation between the parity of the mother and the age at the complete weaning of the child has also been observed.

19. NUTRITION EDUCATION IN THE MATERNITY WARD
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Protein-calorie malnutrition is an endemic disease in the Commonwealth Caribbean, with a multiple aetiology. A predominant and important causative factor is the decline in breast-feeding in both urban and rural areas.

A study was undertaken in the post-natal wards of two hospitals in Jamaica. 85 women between the ages of 15 and 44 years from the lower socio-economic groups were interviewed. The results showed that owing to conflicting currents of opinions and practices in the wards, the newly delivered mothers were confused and expected to learn how to feed their infants on discharge from the hospitals. Advice would then be received from relatives, chemists, nurses employed by milk firms, and clinic nurses.

Soon after delivery, complementary feeds of an unspecified mixture were given to the new-born infant, although breast-feeding was attempted by most mothers, pamphlets regarding the use of artificial feeds were distributed.
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94% of the mothers interviewed had already decided they would complement breast-feeding on return home, either immediately or within the first few weeks of the child's life. Patterns of infant feeding, knowledge of sterilization of equipment, and cost of infant formulae are discussed as well as remedial steps to improve the content of nutrition education in maternity wards in an effort to promote breast-feeding as the ideal, appropriate, safe, and inexpensive infant food.

20. GROWTH STANDARDS FOR INDIAN CHILDREN
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The pattern of growth and development of children in a community provide reliable information regarding their nutritional status. So far, standards established for American children have been employed for comparison purposes. It is obviously essential to have standards for each community in order to decide the true deviation of a given group from the normal attainable by it in the light of given genetic potentialities. Data obtained with regard to growth and development of children belonging to the very well-to-do segments of the population in whom constraints imposed by inadequate food intake or frequent episodes of infection may be expected to form the basis of such standards.

In this investigation, data on growth and development have been obtained in a number of children belonging to two different income groups—normal, healthy children subsisting on adequate diets drawn from well-to-do sections of the community and children belonging to lower socio-economic group.

More than 7,000 school children belonging to the high socio-economic strata and about 2,000 children belonging to the low income groups were studied. All the anthropometric measurements of the well-to-do class of children were superior to those of children of low income groups. A health and nutrition survey revealed that while 20% of the children belonging to the low income groups had one or more deficiency signs, the children of high income group were free from any deficiency signs.
A comparison between the well-to-do children from different parts of this country and American children showed that the Indian boys and girls were as tall and as heavy as their American counterparts of corresponding ages up to a particular age, suggesting that given the proper nutrition and environment, the growth of Indian children is as good as those of American children.

21. THE EFFECT OF DIFFERENT SOCIO-ECONOMIC FACTORS ON SKELETAL MATURATION IN INDIAN PRE-SCHOOL CHILDREN

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This paper concerns the longitudinal study of skeletal maturation in 210 pre-school children in relation to different socio-economic status and nutrition. The skeletal developmental status of children was assessed by studying the radiographs of the left wrists of the same children when they completed 1, 2, 3, 4 and 5 years of age (±7 days). The nutritional status of children of different socio-economic groups was assessed as good and poor on the basis of the weight (kg), signs of vitamin deficiency, elasticity of subcutaneous tissue and tonicity of muscle. The radiographs of the children were analysed for the presence of carpal and distal radius epiphyseal ossification centres and the data are compared with the standards for American children. In both the Indian and American samples, the skeletal development was found to be more advanced in girls than in boys. The carpal ossification sequence of our series is capitate, hamate, triquetral, lunate, trapezium, trapezoid and scaphoid and this agrees with the findings of others. The difference with regard to the appearance of the carpal centres between the Indian and American children is relatively small up to 2 years and tends to widen thereafter. The skeletal maturation of our children from high socio-economic group with good nutrition almost corresponds to that of American children. The skeletal maturation of children of low socio-economic group with poor nutrition is considerably delayed as compared to American children. It appears that skeletal maturity in well-fed children of different countries of the world occurs at a similar rate. It indicates that nutritional factor plays more crucial role in skeletal maturation of children than racial factor.
22. A LONGITUDINAL STUDY OF GROWTH OF LOW INCOME GROUP BENGALI HINDU CHILDREN FROM BIRTH UPTO 18 MONTHS OF AGE

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This paper deals with the growth pattern of a homogenous group of children born to low income group Bengali Hindu parent, residing in a slum area of Calcutta. These children were registered at birth and were followed regularly at 14 ± 2 days interval for the first year and at 28 ± 7 day interval for the subsequent period. The growth pattern as indicated by weight, height, stem-length, cranial circumference and chest circumference has been presented. The growth of these children has been correlated with their feeding practice, maternal attitude towards health care and episodes of illness.

Two hundred and twenty five children were registered at the start of the study. At 18 months there were 156 children.

Five children remained persistently below the 25th percentile of weight. Five boys and 5 girls remained persistently above 75th percentile of weight. The rest showed considerable variation in their growth pattern. This growth variation is analysed in detail.

23. NUTRITIONAL STATUS OF A GROUP OF IRANIAN MOTHERS AND CHILDREN IN RELATION TO THEIR SOCIO-ECONOMIC BACKGROUND

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A comparative study of the birth weight of two groups of neonates indicates that at birth babies belonging to mothers of high socio-economic strata of the population were significantly heavier than those of lower socio-economic class. This could be attributed to the poor nutritional status of mothers before and during pregnancy.

From the low socio-economic group, 91 mothers who were attending Leila Welfare Clinic and live in a slum area in the south of Teheran, were studied. Information concerning family size, infant and child mortality, living conditions, literacy rates and family income in relation to food intake was collected. In order to evaluate the nutritional status of the mothers, some anthropometrical measurements and biochemical determinations were also carried out.
The results of longitudinal growth study of children of the above-mentioned families revealed obvious failure to grow right from the first few months of life. This growth retardation is the result of failure in breast feeding and an early weaning to a highly contaminated diet of low nutritional value and also repeated episodes of infection aggravating the poor nutritional condition of those infants and children.

24. COMPARATIVE DATA ON THE PHYSICAL STATUS, DIETARY INTAKE, CLINICAL AND BIOCHEMICAL STATUS OF THE SCHOOL CHILDREN (7-12 YEARS) IN THE LOWER AND UPPER CLASSES

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The aim of these investigations was to get data on the physical, nutritional and biochemical status of poor children in a selected village and compare the same with regard to norms obtained on upper class children.

Subjects from lower and upper classes were selected from rural and urban areas respectively. The parameters measured were height, weight, food intake, urinary excretion of creatinine, nitrogen, thiamine, riboflavin, N' methyl nicotinamide and vitamin C, blood hemoglobin, serum concentration of protein, albumin, carotene and vitamin C. Clinical assessment was made using the ICMR schedule.

The studies showed the unsatisfactory nutritional status of poor children as compared to the upper class children. The gap between the lower and upper class subjects with respect to the above parameters could be narrowed if adequate nutrition is provided to the lower class subjects.

25. ASSESSMENT OF NUTRITIONAL STATUS IN INDIAN SCHOOL CHILDREN

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Since 1965, over 5,000 school children have been studied for nutritional status in and around Delhi. The anthropometric and biochemical data demonstrate definite role of nutrition on physical and sexual growth of these children.
26. SOME METABOLIC AND DEVELOPMENTAL ASPECTS OF CARBOHYDRATE MALNUTRITION

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The clinical picture of carbohydrate malnutrition consisting of loss of weight, increased appetite, marked restlessness, polyuria etc., and occurring mainly among the high socio-economic group has been reported earlier. In the present series majority of children were under the age of one year. Because of the nonaddition of sugar to the milk or cereals and other solids in later infancy and early childhood, the carbohydrate intake on an average provided 22% of the total calories. Thus there was an increased supply of calories from proteins (mean 18%) and fats, (mean 63%). Depending upon the intake of calories from the diet, the cases could be divided into hypercaloric type (calorie intake more than 110 calories/kg.), isocaloric (intake from 90 to 109 calories/kg.) and hypocaloric (below 90 calories/kg.) per day. Treatment consisted of adding one teaspoon of sugar to 3 to 4 oz. of milk formula, and in later infancy and early childhood in the addition of supplementary foods rich in carbohydrates. With treatment, the milk intake was reduced in all children of hypercaloric type of condition. There was marked improvement in general condition, and rapid increase in weight from 1 to 1.5 kg. in the first month and 2.5 to 3 kg. in three months. With treatment the calories supplied from carbohydrate increased from 18.6 to 44.7%, that from fat dropped from 54 to 39% and of proteins from 17.8 to 15.7%. The syndrome does not occur if carbohydrate provides 32% or more of the total calories. In 3 children addition of carbohydrates in diet to provide 45 to 50% of the total calories produced effective weight gain and improvement in spite of addition of proteins and fats during treatment indicating that it is the lack of carbohydrate in the diet which is the most important cause of the condition.

27. EFFECT OF CALCIUM AND VITAMIN-D SUPPLEMENTATION ON THE GROWTH OF PRE-SCHOOL CHILDREN

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The poor growth and development of children belonging to the low socio-economic groups in our country is largely due to inadequate food intake,
Apart from dietary deficiency of calories and protein, deficiency of other nutrients like minerals and vitamins may also interfere with optimal growth.

The calcium content of diets of pre-school children is well below the recommended levels. An investigation carried out at this Institute earlier to determine the effect of supplementation of calcium on the growth of pre-school children failed to show any significant improvement on the growth of these children, when additional calcium was given either alone or with protein supplements. It was considered possible that vitamin-D could have been a limiting factor in those studies. An investigation was, therefore, undertaken in a rural area near Hyderabad to assess the effect of supplementation of vitamin-D given either alone or together with calcium, on the growth of pre-school children.

A total of 165 boys and 202 girls between the ages 1-4 years belonging to the low-socio economic group were selected; they were divided into four groups; the first received 300 mg. of calcium as calcium glycerophosphate, the second received 400 IU of vitamin D, the third received 300 mg. of calcium and 400 IU of vitamin D daily and the fourth group served as controls. They were fed for six days in a week.

Before the supplements were started, the nutritional status of the children was assessed and their heights and weights recorded. At the end of eight months of supplementation, the heights and weights were redetermined.

No significant difference was observed either in the height or weight between the four groups of children indicating that under the existing conditions, supplements of calcium and vitamin D do not promote better growth. The possible role of inadequate calorie intake in these children for the observed lack of beneficial effects is currently being investigated.

28. TRENDS IN SELECTION OF BODY-BUILDING AND PROTECTIVE FOODS

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A survey was conducted to study the trends in selection of protective foods in urban families. The foods included in the study were sources of
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protein (milk, eggs, meat, pulses and nuts) and sources of vitamins-A and C (leafy vegetables, carrots, tomato, papaya, orange, guava, sweet lime and amla (goose-berry).

The total number of families included in the survey was 134. The number of family members ranged from 2 to 9; 58 percent had 2 to 4 members; 39 percent had 5 to 6 members.

Thirteen percent of the families had an income less than Rs. 90 per month per head; 33 percent had between Rs. 100 and Rs. 160/- per month; 22 percent between Rs. 161 and Rs. 240; 21 percent between Rs. 241 and Rs. 400.

Only 18 families included meat, eggs and fish in their diet and 13 families included only eggs in their diet. The remaining 103 families were lacto-vegetarians.

All the families included milk and pulses in their diet. The average consumption of pulses per person per day varied from 40 to 44 g. in the various income groups. The consumption of milk increased with increase in income. Eighty-five families included on an average 5 to 10 g. of nuts per day in their diet.

126 families included green and yellow vegetables, the average frequency being 5 times a week. 124 families included vitamin-C-rich fruits. The frequency of consumption increased with income from 4 to 8 times a week.

29. IODISATION PROGRAMME IN THAILAND

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It was observed by survey and laboratory analyses that the prevalence of goitre in the Northern part of Thailand was indeed high, the percentage range approximately 30 to 90. The principal cause of disease is low iodine intake due to low environmental iodine supply. Therefore, iodisation
programme was considered with the iodation of salt as a method to implement the programme. In 1962 the iodation plant with a capacity of 4,000 tons per year was set up at Prak, one of the Northern Provinces, as a pilot project, and two years later, the big plant with a capacity of 14,000 tons per year, was established in Bangkok. The iodated salt was distributed to all the areas, especially the North. In 1969, a follow up resurvey in school children of same schools as the preceding surveys was made. It showed a dramatic reduction of goitre rate in iodated areas. It is expected, if iodisation programme is continued in proper way, goitre will not be a public health problem any more.

30. EFFECT OF BALANCED DIETS AND ZINC SUPPLEMENTATION ON HYPOGONADAL DWARFS

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A syndrome of impaired growth and hypogonadism often accompanied by hepatomegaly and anaemia and associated with lowered concentrations of zinc in plasma has an incidence of about 3.5% among 18 to 20 year old males in the rural population of Iran. It has been attributed to deficiency of zinc although evidence for this has been inconclusive. During the past two years, therapeutic trials with zinc have been made on dwarfs 18-20 years old, affected with the syndrome as volunteer subjects. By randomized selection they were given either a well-balanced diet with a placebo (Group I), the same diet plus 120 mg. of Zinc sulphate each day (Group II) or the Group I treatment for 6 months followed by Group II treatment. Although nearly all showed some increase in height during the period of study, the response was significantly greater in those receiving zinc with one exception. This subject had no teeth and in addition, showed intestinal malabsorption. Zinc treated subjects also showed an increase in gonadal function and development of secondary sexual characteristics to a greater extent than the controls.
Studies on Nutritional Anaemia in Thai Children: The Effect of Iron Supplement on Red Cell Haemoglobin and Growth of Pre-School Children

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Haemoglobin, packed cell volume (P. C. V.) and subsequently mean corpuscular haemoglobin concentration (M. C. H. C.) were determined for pre-school children (128 children) in 2 villages, Resettlement Village 14 and Non Bua Noy, in the Northeast of Thailand. The incidence of anaemia was high in children from both villages. The combination of low haemoglobin values below 30 suggesting iron-deficiency anaemia. This possibility was further investigated in a supplementation experiment carried out on the pre-school children in village 14 (48 children).

The children were divided arbitrarily into two groups. One group received iron as ferrous sulphate, 10 mg. per kg. per day, in a mixture containing 10 mg. ferrous iron per ml. The control group received the same mixture, containing only preservative, flavourings, etc. but no iron. The mixture was given for a period of three to four months.

There was a significant increase (P = 0.001) in the blood haemoglobin level of the children receiving the iron supplement. The increase in M.C.H.C. values was also significant (P = 0.001) but P.C.V. values were not influenced by the iron supplements. In the control group, the small rise in blood haemoglobin and M.C.H.C. were not significant.

Height and weight measurements were also examined to see whether iron supplementation stimulated growth of the children. Their height and weight were measured each month during the period of supplement and also during the following six months. Iron supplementation had no significant stimulatory effect on either height or weight.

Similar studies are being carried out in children from a Bangkok orphanage and the dietary intake is being studied at the same time.
The nutritional status of the mother is known to modify the course and outcome of pregnancy. The birth weights of infants born to mothers belonging to the poor income groups who subsist on inadequate diets are known to be lower than those of infants born to well nourished mothers. The influence of dietary supplements, given to expectant mothers during the last four to six weeks of pregnancy as also the effects of folic acid supplements given during the last 100 days of pregnancy on the nutritional status of the infants are reported here.

Improving the diets so as to provide 60 g. protein and 2500 kcal/day during the last six weeks of pregnancy resulted in significant increase not only in the birth-weight of infants, but also their serum albumin concentrations. It also brought about a greater gain in maternal weight, a rise in serum albumin and increased excretion of oestrogen in urine.

The birth weights of infants born to mothers who had received folic acid supplements in addition to iron during the last 100 days of pregnancy was significantly higher than the birth weights of infants born to mothers who had not received such folic acid supplements.

Three hundred and seventyfour babies weighing 2000 gram or less have been studied to evaluate their growth through the first two years of life. As far as possible, factors likely to affect the growth like birth anoxia, intracranial haemorrhage, neonatal morbidity, major congenital malformation, hyperbilirubinaemia, hypoglycaemia etc. have been excluded. The babies have been divided into 1) those weighing up to 1500 grams and 2) between 1501 and 2000 grams. These have been further subdivided into premature and small for dates babies. An attempt has been made to show the difference between the premature and small for date babies by bringing the premature babies to "term" (40 weeks gestation) as the starting point and assess intrauterine and extrauterine growth as a continuous parameter.
34. EFFECT OF PROTEIN DEFICIENCY ON PATHOLOGY OF MITE INFESTATION OF LUNGS IN MONKEYS

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Monkeys (M. mullata) are known to frequently suffer from infestation of lungs by mites in their natural habitat. A study was undertaken to determine the influence of the level of dietary protein on the course of the illness, and the pathology of the lung in such animals.

Forty six adult monkeys known to be harbouring the mite were divided into two groups, and maintained on either adequate (16%) or low (4%) protein diets for a period of 100 weeks. A large number of monkeys on the low protein diet either died or had to be sacrificed when moribund before the end of the experimental period. Animals on the adequate protein diet remained apparently healthy till the experiment was terminated at 100 weeks. Complete autopsies were performed on all animals and the organs examined for gross and histological changes.

The organ which was mainly and consistently infested by the mites was the lung. The essential pathology in the organ was bronchiectatic lesions. Striking differences were found not only in the degree and extent of lung damage but also in the type of cellular response to the parasite in the ectatic bronchi, between the animals of the two groups. A detailed account of the changes seen in the lungs will be presented and their significance discussed.

35. RENAL AND HEPATIC HISTOPATHOLOGY IN MALNOURISHED INFANTS AND CHILDREN

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The present study has been carried on 252 cases of malnutrition. The maximum incidence of the disease was in the age group of 6 months to
2 years. The etiological factors responsible were inadequate diet, gastrointestinal, pulmonary and skin infections. Anaemia was present in 91% cases while hypoproteinaemia in 68.5% cases.

Liver function tests were deranged in 70-75% cases and liver biopsy in 110 cases revealed various histopathological changes.

Regarding renal functions, urinary findings were present in 25% cases and electrolytes were disturbed in 40% cases. Renal biopsy was done in 110 cases. Histology was normal in 5 cases only. In the remaining 105 cases different histopathological lesions were detected. The correlation of histopathological changes and biochemical disturbances will be discussed.

36. THE POSSIBLE CORRELATION BETWEEN THIAMINASE ENZYME AND BERIBERI IN THAILAND
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Approximately 1300 units of thiaminase enzyme extracted from raw clams (Paphia sp.) can cause thiamine deficiency in rats when given orally, as measured by whole blood transketolase activity. The addition of thiamine pyrophosphate (TPP) to blood hemolysate of thiamine deficient animals resulted in a significant enhancement in transketolase activity and the effect progressively increased as the deficiency became more severe. The degree of stimulation of TPP added in vitro was not observed in the hemolysate of control animals. The result of this study indicates that thiaminase in fermented fish, which was found to be similar to that extracted from raw clams, can also cause thiamine deficiency. That people who live in the Northern and North Eastern parts of the country consumed a large amount (approximately 56 gm) of raw fermented fish in their daily diet. This amount of fermented fish is equivalent to 25 units of enzyme per day. A repeated consumption of this food material throughout their lives could certainly lead to a state of thiamine deficiency.
37. ERYTHROCYTE TRANSAMINASE ACTIVITY IN HUMAN VITAMIN B\(_6\) DEFICIENCY

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Signs of riboflavin deficiency like cheilosis, glossitis and angular stomatitis are frequently seen among the poorer sections of our population. It is however, seen that not all subjects with these manifestations fully respond to therapy with riboflavin alone; but need other B-complex vitamins, specially vitamin B\(_6\). Experimentally induced pyridoxine deficiency is known to produce signs similar to those of riboflavin deficiency. The pyridoxine nutritional status of population groups among whom angular stomatitis and glossitis are common was therefore investigated, employing transaminase activity in the erythrocytes as a biochemical parameter. Both the basal levels of EGOT and its stimulation \textit{in vitro} by addition of pyridoxal-5-phosphate as parameters were determined in normal subjects belonging to both the high and low income groups, in pregnant subjects and in pellagrins.

The results indicated that the enzyme activity in subjects of low socio-economic groups was significantly lower than that of the high socio-economic group. One third of the pellagrins investigated had low basal activity with increased \textit{in vitro} stimulation. In the other pellagrins who had signs of concomitant deficiencies of other B-complex vitamins, particularly riboflavin, the transaminase activity was high. Similar trends were also seen in pregnant women and adult men with oral lesions suggesting that riboflavin deficiency may lead to increased levels of transaminase activity. The results of these studies provide biochemical evidence for Vitamin B\(_6\) deficiency in apparently normal population groups and also indicate that signs attributable to riboflavin deficiency are similar to those of Vitamin B\(_6\) deficiency. These results also suggest that the level of transaminase activity in the red cell may be modified by riboflavin nutritional status.

38. THE INCIDENCE OF PROTEIN-CALORIE DEFICIENCY IN INDONESIA

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Protein-Calorie Deficiency is prevalent in many developing countries.
Basically the cause is the same—insufficient protein and calories to meet the requirements of the body.

However, its background, epidemiology, ecology and its manifestations differ from country to country.

In Indonesia Protein-Calorie Deficiency is considered one of the main nutrition problems.

It is found in various manifestations in the different age groups.

The incidence in the infant and toddler will be focused.

Early symptoms of Protein-Calorie Deficiency appear at approximately the age of 6 months. While full blown marasmus, kwashiorkor or marasmic kwashiorkor cases are found after the child is over one year of age. Various factors are responsible for this clinical picture—from food production down to menu pattern, food habits, food utilisation, and environmental sanitation.

39. NUTRITION, INTELLECTUAL ABILITY AND NATIONAL DEVELOPMENT
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The food and nutrition policy of developing countries must be based on the widespread occurrence of malnutrition in the area. Physical and mental growth retardation resulting from malnutrition, blindness from vitamin A etc. can cost millions in terms of work output productivity.

Our studies show that early malnutrition influences verbal abilities, abstract attention and concentration. These studies revealed that early malnutrition results in a significant lowering of intellectual abilities and poor sensomotoric performances. The intimately related physical, biological and socio-cultural factors to nutrition which may influence intellectual ability simultaneously demand further studies to prove a cause and effect relationship between malnutrition and mental development.
40. NUTRITIONAL ANTHROPOMETRIC STUDY OF WHITE COLLARED PUNJABIS AT SIMLA

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The mean values and standard deviations of height, weight, bi-cristal diameter, upper arm girth and wrist girth of 210 Panjabi speaking Hindu “Khatri” (an endogamous caste) clerks aged 20-55 years living at the hill station of Simla are presented. The mean values of these measurements are compared with the corresponding measurements of the people of the same occupation, caste and income group living in the plains (Delhi). Correlation matrix between the 5 variables is also presented.

Mean values of body weight and arm girth measurements of Simla subjects were significantly lower than those of Delhi subjects.

Correlation coefficient between arm girth and body weight was highest of all the correlations.

41. NUTRITION REHABILITATION: LIMITING FACTORS IN RURAL SOUTH INDIA

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An account is given of nutrition rehabilitation in a parent orientated programme where mothers participate in preparing food and feeding their malnourished children back to health using primarily locally available commodities.

The most important aspect of this educational experience is for mothers to see their own children returning to health on a diet they have prepared and fed them. It includes active cooperation in careful marketing, cooking the food, and helping with the kitchen garden. Simple instruction is given in organizing a suitable diet, home management, child care and family planning.
Fifty children with protein-calorie deficiency syndromes who were admitted to the Nutrition Education Unit of the C.S.I. Hospital, Jammalamadugu, in a drought affected area of rural Andhra Pradesh, were studied and followed up. This reveals that the educational impact of the work is limited by:

1. Many medical complications of the malnutrition.
2. The severity of the condition before parents agree for admission. These two factors necessitated intensive medical treatment.
3. Poverty, a diet of adequate quality and quantity could not be given at home.
4. Inability of mothers to stay in hospital long enough to see their children completely better and the nutritional lesson firmly established.
5. Habituation of the family to restricted diet and cooking pattern, due to social custom and economic stress.
6. Food fads and fallacies.
7. Practical difficulties in cultivating kitchen gardens.

Suggestions are made as to how some of these difficulties can be overcome.

42. NUTRITIONAL HEALTH IN A CHANGING SOCIETY—STUDIES FROM ISRAEL

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Two trends of development have imprinted their marks on the nutritional health of the population of Israel during the last 20 years: a large immigration from technologically less developed countries, and a rapid progress in agricultural and industrial production. There has been an increase in the per capita consumption of meat, poultry, eggs, oils and fats, sugar and fruit, with an increase in intake of calories and animal protein. The accul-
turation of different communities has been intensive, with a rapid change in the food habits, as evinced from studies among immigrants from Yemen and Cochin.

At present, specific nutritional deficiency disorders, including protein-calorie malnutrition, are practically non-existent in Israel. Marginal forms of malnutrition are found, especially among children and pregnant women of low socio-economic status. This malnutrition is reflected in mild anemia, impaired growth and development, and mild clinical signs and biochemical abnormalities. Obesity, as a risk factor in the development of ischemic heart disease, in an important public health nutrition problem; morbidity and mortality from ischemic heart disease have increased markedly in Israel in recent years.

43. PHYTATE CONTENT OF IRANIAN BREAD AND ITS POSSIBLE RELATIONSHIP TO HUMAN ZINC DEFICIENCY

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The syndrome of impaired growth, hypogonadism and low plasma zinc concentrations occurs only in rural populations in Iran despite a close similarity of village diets to those of urban poor. Together with other evidence, this suggests that the village environment includes factors that impair zinc nutrition. It is postulated that these may have their origin in village breadmaking methods, particularly the omission of leaven or short duration of fermentation when leaven is used. The result should be the survival in bread of most of the phytate present in the largely whole meal flours used. Phytate complexes zinc and so decreases its availability for absorption from the gastrointestinal tract. Phytate contents of breads from village and urban sources are being examined. The relationship between phytate contents and breadmaking methods will be described.
Malnutrition abounds in every impoverished and illiterate community in Asia. Formal teaching methods will not influence this important group. Participation in practical nutrition programmes is the most effective way of teaching them.

The means of participation that are used at the Nutrition Education Unit of the C. S. I. Hospital, Jammalamadugu, Andhra Pradesh, India, are described:

1. **Maternal preparation of food for their malnourished children under supervision**: Mothers participate in preparing food and feeding their undernourished children back to full health using locally available commodities.

2. **Parent-retained weight cards with nutrition illustrations**: Parents are given the responsibility of keeping their children's weight cards and bringing them regularly for weighing. They are encouraged to keep the children's weight curves gaining upwards on "the road to health" by correct feeding.

3. **Parents rubber-stamp food pictures on nutrition cards to reinforce teaching and demonstration**: Parents milk their own pictures of the foods they have been taught about. Illustrations are rubber-stamped opposite appropriate pictures of the milestones of development of young children.

"If I hear, I forget.
If I see, I remember.
If I do, I know."

The message of the Chinese proverb is still important in all education, but it is vital in the education of illiterate mothers. More and different ways of participation must be devised.
2. TECHNIQUES IN RURAL NUTRITIONAL STUDIES

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Fresh medical graduates are stationed at one or the other Rural Health Training Centres, for a few weeks, as medical interns. In the absence of any orientation programme in field nutritional studies, they usually record Bitot’s spots, angular stomatitis, dental caries, dry skin, etc., as signs of malnutrition, without verifying their dietary origin. Realising the importance of correlating food intake with clinical malnutrition, particularly in a set-up wherein even weighing machine may not always be available, the author regularly visits such R. H. T. Centres in Maharashtra and demonstrates to them the simple techniques as to how to suspect early nutritional disturbance in different situations, with just a few questions on foods, as available and purchased; as cooked and consumed. With the help of pre-standardised local household measures, reasonably reliable food consumption data of a family (or a school child) is obtained. It is accurate enough to enable an on-the-spot correlation with the nature and extent of malnutrition observed clinically by the ‘doctor’ trainees.

These rather painstaking field studies, spread over years, have helped the author interpret the nutritional significance of what is termed ‘Clavicular’ sign (for fat deficiency) as also the ‘humerus’ sign (for protein-calorie malnutrition). Further, it will be explained how this experience can be utilised in training the young, receptive ‘doctors’ in scientific assessment of nutriture.

3. THE SIGNIFICANCE OF NUTRITIONAL DATA IN SOCIO-CULTURAL RESEARCH: EXAMPLES FROM SOUTHERN INDIA

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This paper discusses findings from a recently completed medical anthropological research project in rural Tamilnadu, Southern India, which has utilized detailed
nutritional and medical data for the elucidation of socio-cultural systems. Special attention is given to evidence indicating that analysis of behaviourally defined social groups regularly distributing and consuming foods (termed alimentary groups) permits better understanding of nutritional levels than does analysis of traditionally-studied named social groupings like family, household, kin, caste, or village. Indication is given of the varieties of membership that may be found in alimentary groups, the ways in which these groups cut across other social units, the kinds of foods which tend to be regularly distributed within the alimentary groups, and the measureable differences in nutritional level that relate to such memberships. Distinctions are noted between those nutritional values related to local socio-cultural contexts and those related to "outside" factors. Since development and supplementation programmes often require such data, closer consideration of the obtained quality is urged. Methods and foci of inquiry for improving the quality and relevance of socio-cultural data are discussed.

4. DAIRY MARKETING MODERNIZATION AS A MEANS OF NUTRITIONAL IMPROVEMENT

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It is gratifying to move from the 60's pre-occupation with avoiding starvation to the present wide-spread emphasis on nutrition. The problem of food shortage was relieved by concentrated food grains research and extension. These staple commodities met immediate needs and required relatively small investment in complimentary market development. Although nutritionists may specify improved diets, based on durable grains and pulses, developing country consumption expenditure data indicate improved diets will include large quantities of perishable commodities bearing increased marketing charges.

Improvement of perishables marketing and processing poses transfer and adaptation problems, as did improvement of grain production technology. A pool of conference participants would likely reveal a preference for milk as a nutritionally important perishable. Sound reasons exist for dairy development, in the interest of consumers and agriculturalists. However, rapid transfer to India of marketing technology long established in developed countries resulted in exceedingly low labour productivity and return to investment in comparison to traditional marketing systems.
Inter-country variability in transferability poses difficulties for marketing as well as production technology. Milk products consumption preferences in the Middle East create a different challenge from the South Asian. Internationally coordinated research on marketing technology for nutritionally important perishables seems in order.

5. PROGRESS OF APPLIED NUTRITION PROJECT IN THAILAND

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In 1961 UNICEF, FAO, WHO, in collaboration with Ministries of Public Health, Agriculture, Education and Interior launched an action program “Applied Nutrition Project” in 10 villages of Ubol province, with the objective to combat malnutrition and to raise general nutritional levels of the people in rural area. The project area was expanded to 29 villages in 1964 and 2 villages in Chiengmai were also started in 1967. The pilot program dealt on a small scale with several aspects of applied nutrition, baseline and periodic survey, training, production of foods, including vegetable, poultry and fish at the schools, midwifery centres, and communities, nutrition education and also the evaluation of the project were included. The results of evaluation in 1966 showed only slight changes in the nutritional status, there was also an over all reduction in the signs of deficiency diseases as compared with the original figures.

In 1968 the Department of Health through the Division of Nutrition revised the whole methodology of the project, based on previous experience in ANP villages of Ubol and Chiengmai. New targets for action were set up, protein malnutrition was regarded as top priority problem while pre-school children became target population, pulses and poultry were emphasized. Production of new infrastructure needed in implementing the program was desired in the form of Child Nutrition Centre where children were collected and fed a meal at lunch time. Mother’s education was another feature provided by the centre. Aiming to integrate nutrition activities at the village level with the program of rural health centres, nurses, midwives, food production aides and child care attendants were trained. Protein Food Development program are developed. At the end of December, 1970, 53 child nutrition centres have been organised in 26 provinces with the co-operation of local personnel.
Applied Nutrition Programme is purely an educational one which aims at making rural people nutrition conscious by giving necessary incentive for producing more of protective foods, demonstrating the value of these foods through selected feeding centres, training concerned people and imparting nutrition education through group discussions, demonstrations etc.

This is implemented in most of the States in India and is in progress in 50 C.D. Blocks of Kerala, covering nearly 30% of the total area and 32% of the population. Most of the targets were achieved in 25 of the above Blocks where the programme was in existence for more than three years. There are more than 7000 home gardens, 350 school gardens, 23 community gardens, 350 poultry units, 34 mechanised fishing boats, and two milk-chilling plants now functioning. Through 1,111 feeding centres under various Mahila samities more than a lakh of beneficiaries are given milk/CSM, eggs, fish, vegetables, etc., and these centres are utilised for nutrition education also. More than 4,000 people were trained in nutrition. It is proposed to conduct 10 women's camps in each block. Of these, 8 camps are now over in 8 blocks in which a follow-up study was made to find out how far the campers have put into practice what they studied at the camp. This reveals that in almost all families of the campers, home gardens have come up within two weeks after the camp. In 50% of the families small poultry units were started. Leafy vegetables, papaya, and groundnuts are given more importance in their daily diets than before, and improved methods of cooking were introduced in 25% of the families. In the distribution of protein rich foods (milk & eggs) preference is now given to the 0-4 year age group.

This clearly indicates that the programme is best suited as a media for mass communications.
7. TRAINING PROGRAMMES IN NUTRITION FOR MEDICAL PERSONNEL: EXPERIENCES AT THE NATIONAL INSTITUTE FOR NUTRITION

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The National Institute of Nutrition has been offering for the past eight years an advanced training programme in theory and practice of nutrition for medical graduates. The course covers work in the field, laboratory and the clinic. The objectives of the course are to provide appropriate nutrition orientation to senior public health workers and to teachers in the departments of paediatrics, social and preventive medicine, general medicine and other departments in medical schools. A programme leading to Master's degree in nutrition is also being offered for the past three years.

More than 70 participants from various South East Asian and Western Pacific countries and more than 90 participants from the various medical colleges in India have been trained in these courses which are supported by the W.H.O. and UNICEF. Apart from senior staff of National Institute of Nutrition, outstanding nutrition workers from abroad and India participate as guest lecturers in the courses.

These courses offer a forum for the mutual exchange of ideas among teachers in different specialists allied to nutrition and serve to expose the participants to the many modern techniques which will be useful in the field and in the hospital in the treatment and prevention of nutritional disorders. These courses have served to provide the necessary leadership among medical personnel for the implementation of public health nutrition programmes in many South East Asian countries.

8. TEACHING OF NUTRITION IN HOME SCIENCE COLLEGES

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Teaching of Nutrition is an integral and important part of the entire programme of the Home Science College. In a developing country like India, teaching of nutrition is very important because of the:
lack of knowledge among the people about the nutritive value of foods commonly consumed.

2. non-availability of low cost foods with high nutritive value.

3. improper methods of storing, cooking and preserving foods.

The Home Science Colleges are therefore imparting a scientific understanding of the food requirements and food in relation to health and hygiene harmonizing theoretical knowledge with practical work and application. Emphasis is placed on teaching better methods of cooking and preserving food, not only in terms of conservation of nutritive values of food at various stages of cooking but also improved taste and serving of food in an attractive manner.

The following suggestions are made to strengthen the teaching of nutrition in Home Science Colleges.

1. Co-operative and long term research projects have to be undertaken in various colleges of different regions.

2. Writing and publishing suitable literature.

3. Reviewing and revising the curriculum to meet the current demands.

4. Provide opportunities for higher training and specialisation in the field of nutrition.

9. TRAINING OF DIETITIANS IN INDIA—AN EXPERIENCE FOR MORE THAN TWO DECADES

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The Government of India, in 1949, instituted the first Diploma Course in Dietetics, at the All India Institute of Hygiene and Public Health, Calcutta. During the last twenty years, 217 candidates qualified as Dietitians (West Bengal, 41.5%; Andhra Pradesh, 13.8%; Delhi, 11.5%; Punjab, 6.9%; and U.P., 6.9%). Home Science graduates formed 38.7%, pure science graduates, 32.7%, Bio-Science graduates, 21.6% and Nurses, 6.9%. About 90% of the Dietitians were private candidates and the rest were deputed by their employers. The male/female ratio among the qualified Dietitians is 1:4.
The course contents included 450 hours of lectures and 550 hours of laboratory work, field work, visits, seminars and library assignments.

A follow-up study of the 217 Dietitians revealed that most of them have been gainfully employed in various categories, e.g., Hospital Dietitians (35.5%), Teachers and Scientists (6.4%), Field Nutritionists (3.6%), School Teachers (2.8%), engaged in higher studies (9.7%), and non-professional jobs (1.9%). Sixty Dietitians (27.6%) are not interested in jobs at present, 17 are still unemployed (7.8%), and information about the rest (4.6%) is not available. Seventeen Dietitians have returned with higher training from abroad.

10. PUBLIC HEALTH NUTRITION

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Public health nutrition connotes protection and promotion of health through the manipulation of population, social organization due to modernization, limited resources, insufficient infrastructures, illiteracy and ignorance of the majority of the population.

Developments during the last two decades: in medical and training facilities, improved services, the achievements in eradication of communicable diseases and training of planners and administrators through National Institutes, are noted. Programmes like school-feeding, production of weaning and supplementary protein rich food, fortification of salt with iodine for eradication of goitre, the composite nutrition programme, are ameliorative steps. However, the hazards of malnutrition are: a yearly, 4 million blind children, possibility of mental dwarfism in children, and maternal mortality of 30 to 40 percents due to nutritional anaemia; are depressing. The national cost estimates of maintaining victims of malnutrition are higher than in preventive measures.

As public health nutrition is essentially developmental, involvement of beneficiaries and public co-operation is essential for accelerating change, especially when gains are not immediately visible. The centralised programmes are less effective because of the logistics of distribution. Until decentralization is possible, available man power should be conscripted. Addition of home scientist to the primary health unit would augment the present domiciliary services. The voluntary N.S.S. should be compulsory during vacation on a remunerative basis, to undertake supervised programmes in public health.
nutrition. The budget could be supplemented by abolition of N.C.C. and utilization of its funds. The development of leadership among responsive young beneficiaries is an important strategy. Action research and built-in evaluation is an essential part of an effective programme.

11. NUTRITION TRAINING AT THE INSTITUTES OF CATERING TECHNOLOGY

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'Productivity through Nutrition' is the theme of result-orientated Nutrition Training in the Catering Institutes. The aim and scope of this programme are:

1. To develop an understanding that nutrition knowledge is dynamic and ever growing.

2. To establish habits of seeking reliable information.

3. To appreciate that food be consumed for nutritional benefits; to study tastes and develop skills and techniques so that food satisfied physical and psychological need and also provides nutrition.

4. To provide experience in the choice of foods for different age and socio-economic groups to ensure balanced feeding.

5. To bring about an awareness of the deficiency of diet in India brought about by ignorance and wrong feeding habits.

6. To develop a sense of responsibility for the improvement of nutrition on a national level and to understand and practise that elimination of waste at all levels bridges the gap between malnutrition and health.

7. To determine the different types of food commodities available in our country to meet our nutritional demands and to study the process each undergoes from farm to table.

8. To study the influence of cultural patterns on consumption of foods; how these patterns can be changed by motivation and education.
9. To diversify feeding habits by introducing new sources of food and develop acceptable recipes using these.

10. To understand that wholesome food also means safe food and to apply the principles of hygiene at all stages.

Although ambitious, these objectives can perhaps be achieved by an interdisciplinary approach in the teaching of nutrition.

12. IMPACT OF NUTRITION ON DIETS IN RURAL AREAS

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Nutrition Education is given through Maternal Child Health & Family Planning Clinics, and also through regular home visits.

A diet survey was done in Berh village in February, 1967, and 24 Families co-operated. These were mainly cultivators. On analysis the following was found.

1. They consumed cereals, green leafy vegetables and roots and tubers in quantities much larger than required.
2. Protein foods were consumed in negligible amounts.

Nutrition Education was continued as before, but with special stress on protein foods, particularly the cheap ones i.e. pulses, bengal gram, ground nuts, peas & beans, eggs and Gugli (snails).

In June 1970 another survey was done in the same village 15 of the same families co-operating. 23 Families were surveyed in all.

It was found that:

1. The cereal consumption went up by 8% (these are cultivators and perhaps having better production with A.N P. assistance. Also, cereals were cheaper in 1970 than in 1967).
2. Vegetables of all varieties were consumed in smaller quantities (probably
because it was summer and Vegetables were not in such abundance as in winter). The consumption of Roots & tubers came down to normal requirement.

3. The consumption of protein foods however showed a spurt though, it was still very much below requirement. Dal consumption went up 10 times, eggs 6 times.

13. MARKET AND NUTRITION ORIENTED FOOD HABIT STUDY IN WESTERN INDIA—SOME HIGHLIGHTS

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A food habit survey, sponsored by Protein Foods Association of India, was conducted in a sample of 3000 families spread over 13 towns and 26 villages in two states of India.

The main objectives of the survey were to find out:

(i) the nutrient intake, by persons in the different age groups and socio-economic levels.

(ii) extent of awareness of nutrient value of different food items.

(iii) food items taken by children and adults in the different socio-economic groups.

(iv) taboos and preferences regarding food items and ingredients.

The main finding of the survey were:

(i) though the overall level of calorie intake is fairly close to the requirement, large gaps are seen in the intakes by children up to 12 years of age.

(ii) the protein intake is less satisfactory than calorie intake. The protein gap is maximum for weaning and pre-school children.

(iii) the calorie and protein gap exists even in the higher income brackets.

(iv) though people were aware of words like vitamin, protein and calories,
they did not know specific significance of each of these, leave alone their associations with specific food items.

(v) while nursing mothers were aware that they need to take more protein foods, such awareness was lacking among the pregnant mothers.

(vi) solid food for weaning children was started much later than it ought to have been.

The survey results were helpful in developing a mass communication campaign recently launched by PFA.

14. A PILOT STUDY ON THE USE OF MASS COMMUNICATIONS MEDIA FOR NUTRITION EDUCATION

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The Protein Foods Association of India is conducting a one-year pilot study on nutrition mass communications in Maharashtra, to test many communications techniques, strategies and hypotheses in nutrition education. The objective of the campaign is primarily to bridge the information gap on nutrition in general and proteins in particular, and to motivate people to take corrective action.

The target audience for the campaign are the urban and semi-urban, with concentration on the lower and the middle income groups a practical solution to the conflict between vulnerability and reachability.

The message emphasizes the harmful effects, especially for children, caused by protein malnutrition and suggests practical solutions in terms of balancing the diets with inexpensive every-day foods.

The press, cinema, radio and outdoor hoardings are among the conventional media being used. Readership surveys and media habits research findings have been the basis of planning the media schedules to get the maximum reach among the target audience. Other non-conventional media like exhibitions etc. have been planned to improve the spread of the campaign.

Evaluative researches have been built into the project. A bench mark
research has preceded the campaign establishing the pre-campaign awareness levels. A mid-campaign and a post-campaign research have been planned to measure shifts in awareness levels which will be the criterion for judging the success of the campaign. Projective techniques such as "Thematic Apperception Test" will be used for recording sampled audience responses. The differential of the awareness levels by message-source will enable a comparative media evaluation. The research findings will be the starting point for planning national extension of the campaign.

15. A CRITICAL STUDY OF 25 RESIDENTIAL BHU STUDENTS' MESSES
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Out of 101 residential student's messes in the BHU township, 35 messes were studied. The components of the study were as hereunder:

1. In depth studies of the functioning of the three systems of mess management i.e. contract, private and co-operative through their respective dynamics of 'mess formation', 'marketing', 'menu making', 'diet preparation' and other day to day management factors including mess hygiene.

2. Seven days diet survey in all 35 messes by weighment method.

3. Analysis of the variations in the socio-economic, cultural (including diet habits) and geographical backgrounds of the members of the respective messes.

In the paper, an effect is made to outline the inter-relationships of the above-mentioned components with a view to evolve guidelines for Action Research methodologies for effective improvements of BHU Students' Nutrition within their respective socio-economic and cultural circumstances.
1. METABOLISM AND BIOLOGICAL POTENCY OF β-APO-CAROTENALS

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β-Apo-carotenals, the oxidation products of β-carotene, are of significant importance in the colouration of food products. They are formed in small quantities in the animal system during feeding of β-carotene. The oxidation of β-carotene at the excentric positions, which are theoretically and chemically more susceptible to attack than the centre double bond, gives rise to different apo-carotenals.

A series of β-apo-carotenals were prepared by oxidation of a benzene solution of β-carotene with 30% hydrogen peroxide in the presence of 1.3% solution of potassium permanganate. The reaction mixture was chromatographed on 3% (v/w) water-deactivated alumina column and different β-apo-carotenals were eluted from the column by gradient chromatography. The different bands thus eluted were purified through MgO-Celite (1:1) column. Finally, the compounds were purified over 3% (v/w) water-deactivated alumina column. β-apo-8'-carotenal, β-apo-10'-carotenal, β-apo-12'-carotenal showed absorption maximum at 455, 437 and 414 nm, respectively. One new compound, with absorption maximum at 470 nm, was also obtained in 4-5% yield.

Bioassay experiments on rats taking β-carotene as a standard substance, showed relative biopotency of 31%, 76% and 44% for x-apo-8'-carotenal, x-apo-10'-carotenal and x-apo-12'-carotenal, respectively. The 470 nm compound showed biopotency of 38%. The different apo-carotenals alleviated vitamin-A deficiency symptoms and gave interestingly varying amounts of vitamin-A storage in the livers.

2. SERUM LOW DENSITY LIPOPROTEINS, TRIGLYCERIDES AND CHOLESTEROL LEVELS IN MALAYSIA

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The serum low density lipoproteins, triglycerides, cholesterol and total lipids have been determined for over 300 clinically healthy Malaysian subjects amongst
whom were aborigines and blood donors of the Chinese, Indian and Malay race. These values were compared, whenever possible, with those obtained for 172 hospital patients with ischaemic heart disease.

In the sera of the healthy subjects, a rise in the serum lipids and the low density lipoproteins with age was apparent up to about 50 Years of age.

Although no ethnic difference was observed in the levels between donors, their mean serum cholesterol, triglycerides, total lipids and low density lipoproteins were significantly higher than the corresponding mean levels of the aborigines who in addition were relatively older.

Patients below the age of 40, had significantly higher mean serum cholesterol and lipoproteins than donors of the same age. But no significant difference was observed between their serum triglycerides at all age groups.

There is a good correlation between serum levels of cholesterol, triglycerides and low-density lipoproteins. It is suggested that the level of 600 mg% for the latter, corresponding to 250 mg% cholesterol and 220 mg% triglycerides (non-fasting), may be a useful indicator of potential hyperlipoproteinaemia in Malaysia.

3. PROTEIN STATUS AND TURNOVER RATES OF STORED H³-RETINOL IN RAT LIVER
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A single massive dose of vitamin-A reportedly prevents the occurrence of vitamin-A deficiency symptoms in children for long periods. In the present investigation, the storage efficiency and turnover rate of a massive dose of labeled vitamin-A has been assessed in rats fed optimal and minimal amounts of protein.

When overnight fasted rats were administered 15µg H³-retinol and 30 mg unlabeled retinol by stomach tubing, it was observed that, in normal rats (20% casein diet), maximum storage in liver (75% of the dose) was reached at
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24 hours and that 50% of the initial activity disappeared in 55 days; only 35% could be recovered after 70 days. However, in the low protein groups (8% and 3% casein), only 60% of the dose was stored in liver, but the rate of disappearance of the stored dose was significantly reduced. Although serum levels of H-retinol were maintained more or less constant throughout the experimental period, the low protein groups always exhibited lower levels, in spite of relatively increased liver retinol levels. On chromatographic separation radioactivity excreted in urine and faeces, recovered in the terminal fraction representing vitamin-A metabolites, was considerably less in the protein malnourished animals. This points to a block in the overall metabolism of vitamin-A in protein deficiency.

4. STUDIES ON VITAMIN-A METABOLISM IN CHILDREN

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Vitamin-A deficiency is a major public health problem among the children belonging to the poor sections of the population. One of the important causes for this widespread prevalence is the poor dietary intake of the vitamin. Repeated episodes of infection are frequently seen among these children, and there is little information regarding the role of infection in aggravating deficiency of vitamin-A.

Vitamin-A metabolism was therefore studied in five normal children and eight children with infection. About 4μc of 11, 12-(3H)-retinyl acetate along with 3000 I. U. of cold vitamin was administered orally. Total and fat-soluble (3H)-excretion in urine and faeces was measured.

Less than 1% of the total administered label was found in the faeces of normal children indicating that the intestinal absorption of vitamin-A was complete. The radioactivity in urine was exclusively in the water-soluble fraction, accounting for 11 to 20% of the dose absorbed. In marked contrast, six out of the eight cases with infection had significantly higher excretion of label in faeces. Four of them also had increased excretion of the label in urine. These observations suggest that altered metabolism of vitamin-A brought about as a result of infection may adversely affect the vitamin-A nutritional status of children.
5. THE ROLE OF PROTEINS ON THE VITAMIN-D₃ TRANSPORT

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Vitamin-D₃ being insoluble in aqueous solution, the transport would take place in the associated form with some kind of proteins. Vitamin D₃ binding proteins (D₃-BP) were identified in rat plasma and intestinal mucosa by using gel filtration (Sephadex G-200), polyacrylamide gel disc electrophoresis and sucrose density gradient ultracentrifugation.

Vitamin D₃ binding activity was observed in several bands of plasma protein on the disc electrophoresis, and these proteins in 4.9—6.8 S fraction in sucrose density gradient ultracentrifugation. These proteins will participate in the vitamin D₃ transport in blood.

D₃-BP in cytoplasmic and nuclear fraction of rat intestinal mucosa were different from those in plasma. These proteins bind in vitro directly with vitamin D₃, 2₃H (2°C, pH 7.0). Cytoplasmic D₃-BP contained RNA, and nuclear D₃-BP RNA and DNA. Its sedimentation constant was calculated as about 10 S and 13 S respectively. However, in both cases the vitamin D₃ binding activity was not affected with equal amount of cholesterol, 17 x-estradiol and testosterone. In vitamin D₃ transport into the nuclei, it is necessary for the presence of cytoplasmic D₃-BP. D₃-BP of rat intestinal mucosa would participate in the intracellular traslocation of vitamin D₃.

6. THE EFFECTS OF LEUCINE AND ISOLEUCINE ON NIACTINAMIDE NUCLEOTIDE SYNTHESIS

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Earlier work had demonstrated that administration of leucine brought about various effects on the metabolism of tryptophan and niacinic acid. Leucine feeding brought about a reduction in the synthesis of niacinamide nucleotides. The role of isoleucine, if any, on this effect of leucine was studied.

The investigation was carried out in 3 sets of human volunteers. The first set received leucine alone for 5 days and leucine+isoleucine for 5 days more;
the second received leucine for 10 days followed by leucine+isoleucine for 10 days and the last group received leucine for 15 days followed by leucine+isoleucine for 10 days.

Leucine administration brought about reduction in niacinamide nucleotides synthesis. Partition of nucleotides by paper chromatography indicated that only NAD (Niacinamide adenine dinucleotide) was synthesised during pre-leucine period. During periods of leucine administration measurable amounts of NMN (niacinamide mononucleotide) were synthesised.

Administration of isoleucine along with leucine for 5 days brought about an increase in the levels of synthesised nucleotides and at the end of 10 days, the levels were similar to the levels synthesised on the basal diet alone. Partition of synthesised nucleotides suggested that there was no synthesis of NMN at the end of 5 days of isoleucine+leucine administration.

7. EFFECT OF ASCORBIC ACID ON IRON ABSORPTION BY SOUTH INDIAN COLLEGE WOMEN FED ON AN EXPERIMENTAL HOSTEL DIET

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An attempt was made to study the effect of ascorbic acid intake on iron absorption using South Indian College Women as subjects. A preliminary study of the hostel diet was conducted to estimate the iron balance of five subjects, consuming the hostel diet for two three-day periods. The average iron intake was 21.44 mg. per day and the faecal excretion ranged from 70.8 to 82.27% of the amount ingested.

An experimental diet using the kind of food-stuffs present in the hostel diet was planned with two menus. The experimental period was sixteen days. During the first half of this period, the subjects received, on an average, 13.87 mg. of iron estimated chemically and 88.0 mg. of ascorbic acid (calculated) in their diet per day. The absorption of iron was found to be 22.2 mg. During the second half of the period, the subjects were given 100 mg. of ascorbic acid in the form of Vitamin-C tablets, while the intake of iron was maintained at 13.87 mg. (same level). All except one subject were in positive balance. The average absorption of iron in this period was 4.57 mg. indicating a definite increase in absorption which was statistically significant at one per cent level (P<0.01).
8. POSSIBLE INFLUENCE OF TESTICULAR HORMONE ON KIDNEY PYRIDOXINE METABOLISM

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The effects of castration and administration of testicular hormone on pyridoxine metabolism in kidney have been studied in male albino rats. Castration has been found to lower the pyridoxal phosphate concentration of kidney. Administration of testosterone to castrated rats restored the pyridoxal phosphate level of kidney, while normal rats showed increased kidney pyridoxal phosphate level upon treatment with testosterone. Decreased pyridoxal phosphate concentration in kidney following castration was found to be associated with diminished kidney pyridoxine phosphate oxidase activity. Castrated rats upon receiving testosterone showed normal pyridoxine phosphate oxidase activity in kidney, while the same treatment enhances the pyridoxine phosphate oxidase activity in kidney of normal rats. Neither castration nor administration of testosterone seems to have an effect on pyridoxal kinase activity in kidney. It has been suggested that testosterone controls the pyridoxal phosphate formation in kidney by regulating the kidney pyridoxine phosphate oxidase activity.

9. ASCORBIC ACID DEGRADATION AND CATALASE ACTIVITY IN THE LIVER OF COLD-ADAPTED FROGS

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L-Ascorbic acid (ASA) and diketo-gulonic acid (DKA) levels were decreased in the liver of frog on cold-adaptation, whereas dehydroascorbic acid (DHA) level remained unaltered. Contrary to this, ASA level increased, whereas DHA and DKA levels decreased in the serum on cold-adaptation. Both the thermal categories of frogs were force-fed on earthworms and fresh water mussel slices on alternate days. These results show the occurrence of permeability changes of liver cells on cold-adaptation towards storage or synthesis or transport of ASA. Since ASA is known to accelerate or inhibit certain enzymatic activities, these changes may have some physiological signi-
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On 2.5% agar gels after high voltage electrophoresis, the liver catalase from both warm and cold-adapted frogs exhibited differential electro-mobilities; in that the enzyme from warm-adapted frogs moves at a faster rate. These studies further revealed that these two enzymes have different-Michaelis-Menten kinetics. The enzyme from warm-adapted frogs was inhibited by the substrate in contrast to that from cold-adapted ones. Besides, manometric studies revealed that the addition of ASA at the physiological concentration to the assay medium caused inhibition of catalase activity, the extent of which was greater in the warm-adapted frog. Protein synthesis is known to increase on cold-adaptation. Decrease in ASA content in the liver of cold adapted frogs compensates with the synthesis of catalase which shows less ASA inhibition and no substrate inhibition. In view of the changes in flavin metabolism on cold-adaptation, it is suggested that there must be greater demands on catalase to detoxify the resultant peroxides, which are met by the synthesis of catalase. Concomitant to this, the changing levels of ASA may be among the molecular compensatory mechanisms of cold-adaptation, in the spectrum of which the catalase functions.

10. IMPORTANCE OF CAROTENOID CLEAVAGE ENZYME IN VITAMIN A NUTRITION

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Carotenoid cleavage enzyme plays a pivotal role in the conversion of various carotenoids which are exclusively plant and microbial isoprenoid compounds into vitamin A which is so very essential for animal nutrition. It is only the animal organism so far known that is capable of bringing about this transformation and naturally it was of interest to investigate the carotenoid cleavage enzyme in various species in an attempt to correlate with their nutritional requirement of vitamin A.

The present report describes the specificity of carotenoid cleavage enzyme from the intestinal mucosa of guinea-pig, rabbit, tortoise, monkey, fresh water fish, chicken and cat towards β-carotene and β-apo-10'-carotenol. Universal distribution of the enzyme in various species is a clear indication of the importance of this enzyme for animal life and growth. The only notable exception is the cat which showed virtually no activity. The enzyme is seemingly specific for 15-15' double bond of carotenoids no matter from which species it is isolated. At the same time, it is relatively non specific so far as the length of the isoprenoid
chain is concerned. Guinea-pig and rabbit showed the maximal specific activity followed by tortoise, fresh water fish, monkey and chicken. The cat, on the other hand, showed no activity.

Significance of these findings with special reference to vitamin A nutrition in animals will be discussed.

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II. VITAMIN—A DEFICIENCY IN FAMINE CAMPS

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Famine provides an excellent opportunity to study the nutritional deficiency disorders in human population. Diets in famine relief camps are grossly inadequate in nutrients specially with regards to vitamins. Vitamin-A deficiency is quite frequent in such population and is the most important cause of preventable blindness in India. A clinical appraisal of vitamin-A nutritional status was carried out during medical aid operation in famine relief camps in Northwest part of Rajasthan.

From 12 famine relief camps 5346 persons of either sex and different age groups were examined for vitamin-A deficiency signs. As many as 16.12% (862) people were having one or more signs of vitamin-A deficiency. Night blindness was the commonest complaint (85.5%) in the cases examined. The other signs in the order of frequency were Bitot's spot (58.8%), Conjunctival xerosis (15.01%), Skin xerosis (17.4%), Corneal xerosis (15.43%), Keratomalacia (1.74%) and Follicular hyperkeratosis type 1 (0.8%).

Pregnant women and school children were the main victims to suffer. In all the cases vitamin A was given orally with butter fat in doses ranging from 50,000 to 300,000 I.U. according to severity of the lesion. Hemeralopia was cured within a week in all but 22 cases in which the dose was repeated on 7th day.
A study was undertaken to determine the effect of fasting and of protein starvation followed by refeeding on the lipid composition of brain in rat. Groups of albino rats 8-9 weeks old and 135 to 145 gm. body weight, were fasted for one day, four days or protein starved for one week. The starved rats were then reared on the complete diet for four days and one week to study the regeneration of the lipid constituents in the brain.

No change in the lipid composition of the brain was noted after one day fasting except with the free cholesterol content which was significantly decreased. At four days of fasting or one week of protein deprivation, the concentration of total phosphatidyl choline, phosphatidyl serine, cardiolipin, sphingomyelin and lysolecithin were significantly higher than in the unstarved animals. Esterified cholesterol increased with four days of fasting, but decreased significantly with one week of protein starvation. Phosphatidyl inositol and triglycerides remained unchanged during starvation as well as in protein fasting.

When the fasted rats were reared on complete diet, it was found that rats were able to restore normal brain weight but the recovery of the body weight was partial; and the different components of the brain lipids were restored to the levels found in normal animals.

Information on the chemical composition of human brain is scanty, particularly regarding the changes during intrauterine growth of the foetus. The pattern of biochemical changes during the development of human brain was, therefore investigated. Brains from foetuses of different gestational ages ranging from
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13 to 42 weeks were obtained and each brain was separated into the three anatomically distinct regions viz., cerebrum, cerebellum and medulla oblongata. The concentration of deoxyribonucleic acid (DNA), Ribonucleic acid (RNA), protein and lipids in each region was determined.

Nucleic acids, protein and lipids were found to increase linearly with advancement in gestation period till about 32 weeks. There was no significant net increase in any of these substances between 32 and 36 weeks. However, from 36 weeks onwards there was a sharp increase in all the constituents till birth suggesting that between 32 to 36 weeks there is a lag in the growth followed by a growth spurt between 36 and 40 weeks. The decrease in the rate of growth between 32 and 36 weeks was observed consistently in all three regions of the brain. Comparison of the present data with that reported by Western workers revealed that the 'lag period' followed by growth 'spurt' discussed above is perhaps a characteristic feature of human brain development. The pattern of development observed in the present studies, however, also showed that the occurrence of the lag period and therefore the growth 'spurt' was delayed by four to five weeks as compared to the Western data.

14. EFFECT OF DIETARY CELLULOSE SUPPLEMENTS ON THE BODY COMPOSITION AND CHOLESTEROL METABOLISM OF ALBINO RATS

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The effect of inclusion of microcrystalline cellulose (>300 mesh) in a 26% casein diet on the body composition and cholesterol metabolism of albino rats was studied. Inclusion of cellulose to the extent of 5 to 20% resulted in a gradual decrease of productive energy of the diet. Energy consumption rates progressively declined as dietary energy level was reduced and were reflected in corresponding changes in the fat content of the carcass. Increased plasma and liver cholesterol induced by cholesterol feeding in the rat could be largely counteracted by the concurrent feeding of cellulose at 20% level in the diet. Sulfaguanidine fed at the 1% level failed to modify the effect of cellulose administration. The increased excretion of bile acids in the faeces of rats on the 20% cellulose diet could be responsible for the cholesterol lowering effect of cellulose.
15. EFFECT OF LEUCINE ON SOME ENZYMES OF TRYPTOPHAN METABOLISM

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Dietary excess of leucine has been implicated in the pathogenesis of pellagra. Its precise biochemical role in the causation of pellagra has not been fully elucidated. Increased excretion of quinolinic acid in urine and impairment in the NAD synthesising capacity of erythrocytes have been reported to be two of the striking changes induced by excess leucine. It is, however, not clear whether this increased quinolinic acid excretion is due to an increased breakdown of tryptophan or a block in the utilisation of quinolinic acid for NAD synthesis.

To investigate this problem some of the enzymes of tryptophan metabolism were studied in the liver and the kidney. The enzymes studied were: Tryptophan pyrrolase, 3'OH' Anthranilic Acid Oxidase, quinolinate phosphoribosyl transferase (QPRT) and Picolinic carboxylase.

These studies were conducted on 28 days old male albino rats. Animals fed a marginal protein diet (9%) served as the control group. Experimental animals received this diet with leucine supplemented at different levels. At the end of four weeks of feeding the enzyme activities were estimated in the liver. The results of the study showed that the tryptophan pyrrolase activity had increased, the quinolinate phosphoribosyl transferase activity had decreased, there being no change in 3 'OH' anthranilic acid oxidase and picolinic carboxylase activities in liver as a result of leucine feeding. Picolinic carboxylase activity in the kidney, however, had increased considerably.

16. IN VITRO STUDIES ON AMINO ACID TRANSPORT FROM SMALL INTESTINES IN PROTEIN DEFICIENCY

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An in vitro study of transport of amino acids in small intestines was undertaken in young albino rats, fed on protein deficient diet (4% protein). The results
were compared with that of the control animals, fed on 18% protein diet. The everted sac technique was employed for the purpose with slight modifications. The amino acids studied were L-proline and L-lysine. First, both the amino acids L-proline and L-lysine were studied singly for their transport across the intestine at low concentrations. The inhibition of proline transport by other amino acid (like glycine) was studied in another group of animals. The effect of the presence of various amino acids, in concentration ratios, similar to that of egg-albumin, was studied on the transport of L-proline and L-lysine.

17. VITAMIN-E BINDING TO CELLULAR PROTEINS

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Association of vitamin E (α-tocopherol) with low density serum lipoproteins has been shown by several workers. The present study has been undertaken to examine possible binding of α-tocopherol with cellular proteins in relation to its functional significance.

Intracellular distribution pattern of α-tocopherol in rat liver indicates that it is largely present in mitochondria, 105,000 × g supernatant (cell sap) and microsomes. This distribution pattern remains unchanged after administration of large doses of 3H-α-tocopherol. Most of the recoverable radioactivity in the cell sap is associated with two lipoprotein fractions on Sephadex gel filtration. The elution pattern of one of these resembles closely to the very low density lipoproteins (VLDL) carrying most of the orally fed α-tocopherol in the serum.

A time study of the appearance of 3H-α-tocopherol activity in serum and in liver cell particulates following oral administration indicates parallel increases in specific activity which reaches a maximum in 4 hours. The results suggest that VLDL acts as carrier of the orally fed vitamin.

These results are discussed in relation to protein status of the animal.
18. CYTOGENETIC STUDIES ON ENDEMIC GOITER POPULATION

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In the villages of Mae Jog and Wung Poong, Prae, Thailand, about 80% and 90%, respectively of the population were goitrous. Among these there were about 2% in each village who suffered from mental retardation or deafmute. The two control groups for this experiment showed 3.3% and 1.9% of chromosome aberration respectively. The deaf-mutes in endemic villages showed 4.0% abnormality while their counterparts living outside the villages showed no aberration at all. Average abnormality of this group was 2.5%. The mentally retarded probands living in Wung Poong where iodated salt had been supplied for a period of one year showed 33.3% abnormality, while those of Mae Jog where there had been no iodation showed 18.6% of chromosomal aberrations.

Aberrations were not uniformly present and were variable from cell to cell. There was breakage, translocation, isochromosome formation and endoreduplication in the same population of cultured cells. This evidence can be concluded as somatic cell mutation.

Aberrations were classified as aneuploidy, hyperploidy, endoreduplication, gaping, breakage, unusual translocation and isochromosome formation. Percentage of abnormality corresponded to the degree of severity of mental retardation, which was true in those who had received iodated salt and had regressive goiter. The aberrations were strikingly similar to those found in a non-treated sporadic cretin from the Mental Institute in Bangkok.

19. BIOCHEMICAL CHANGES IN THE DEVELOPING RUMEN OF BUFFALOES

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Thirty-two milk-fed Murrah buffalo-calves of three weeks of age were randomly allotted to four dietary groups-milk (CoRo), concentrate berseem hay 1 : 1
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(C1R1), 1:3 (C1R3) and berseem hay alone (CoR4). Milk was gradually reduced and completely stopped after the sixth week of age in the groups on solid feeds. Two calves from each group were slaughtered at 6, 9, 12 and 15 weeks of age. In addition, four buffalo-calves at 21 days of age were slaughtered for comparison.

Concentration of total volatile fatty acids (VFA) in the rumen liquor was maximum at nine weeks of age. The proportions of acetic acid increased with hay in the diet as well as with age. In the milk-fed, ruminal VFA had a narrower acetic/propionic ratio than in other groups. At nine weeks of age, the level of non-protein nitrogen in rumen liquor increased, while that of protein nitrogen fell, indicating the onset of typical microbial activity.

It is concluded that the rumen of buffalo calves given solid feeds from the seventh week of age becomes functionally developed by nine weeks of age, whereas it remains under-developed in buffalo-calves fed milk up to 15 weeks of age.

20. ROLE OF VITAMIN-C IN PIGMENTATION OF TOAD (BUFO MELANOSTICTUS)

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Effects of vitamin-C have been studied on melanin formation in liver, skin and vocal sac of normal and hypophysectomized toad. After hypophysectomy melanin content was diminished in the skin and vocal sac but increased in liver. Vitamin-C administration in normal and operated animals on the second day after hypophysectomy, increased the melanin pigments in liver, skin and vocal sac. It is concluded that vitamin-C regulates melanin formation independent of pituitary gland in toads.

21. EFFECT OF LATHYRUS SATIVUS FEEDING ON BIOCHEMICAL CHANGES IN GUINEA PIGS

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Lathyrism, a disease that not only cripples the victims but the entire economy in the geographical region, has been a threat since centuries in Central and
Northern India. The disease is caused by the excessive consumption of the pulse *Lathyrus sativus*, and is a vital nutritional problem in India which deserves immediate attention. The present study has been undertaken in order to understand and interpret the biochemical and physiological alterations undergone by the tissues, especially liver, as a result of excessive consumption of *Lathyrus sativus*.

Healthy guinea pigs weighing 203-250 g. were selected and divided into two identical groups. One group was fed on control diet and the other on experimental diet for 6 weeks. The experimental diet was prepared by replacing Bengal gram of the control diet by 50% *Lathyrus sativus*. The animals kept on the *Lathyrus sativus* consumed less food and showed retarded growth as compared to controls. There was an inflammation of hind and forepaws after the 3rd week but no obvious paralysis, although they were reluctant to move. The blood glucose was observed to be appreciably higher whereas the hepatic glycogen and protein were significantly lower than the controls. These observations indicate that excessive consumption of *Lathyrus sativus*, probably, disturbs the carbohydrate and protein metabolism. The total lipid and phospholipid contents of liver in the two groups did not show any significant differences although the animals fed on *Lathyrus sativus*, showed a tendency towards a decrease.

22. PURIFICATION AND PROPERTIES OF AN AMYLASE INHIBITOR FROM COLOCASIA (*Colocasia esculenta*) TUBERS

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A method of isolation and purification of an amylase inhibitor from colocasia (*Colocasia esculenta*) tubers is described. The purified amylase inhibitor is a white, amorphous, hygroscopic powder containing 15.6% nitrogen. It is deficient in methionine and tryptophan. The amylase inhibitor gives a typical protein spectrum with a maximum at 280 and minimum at 252 mu. Electrophoretically it is homogeneous over a wide range of pH.

The amylase inhibitor is stable to boiling temperatures and specifically inhibits salivary amylase. The nature of inhibition is non-competitive. The activity of the inhibitor is destroyed by proteolytic enzymes ficin and pepsin.
23. DIETARY NITROGEN AND ITS METABOLITES IN BUFFALO RUMEN
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In four adult male buffaloes with permanent rumen fistulae, the effects of four sources of dietary nitrogen (groundnut cake, cottonseed cake, guar meal and urea) were studied in a 4 X 4 Latin-square-cum-switch over design. Each animal, on each diet received iso-nitrogenous and probably, iso-caloric feeds.

After the animal was adapted to each diet for a month, samples of rumen `liquor' (Fluid) were collected at 0, 2, 4, 6 & 8 hours post-feeding and analysed for total N, protein N, ammonia N, NPN and residual N.

In the rumen liquor, cotton seed cake produced the maximum levels of protein N, while guar meal resulted in the lowest levels. Urea liberated the highest levels of ammonia followed by groundnut cake; guar meal gave rise to prolonged uniform levels of it.

These results will be discussed in relation to the relative values of these proteinaceous feeds.

24. STATUS OF SUCCINIC DEHYDROGENASE IN IRON DEFICIENCY
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Studies on 57 subjects with iron deficiency anaemia showed a depressed activity of the enzyme succinic dehydrogenase in blood of nine. This defect was also present in the bone marrow and skin in a significant number of subjects. That the depression in the activity of the enzyme was due to lack of iron was proved by in vitro activation of the enzyme by addition of elemental iron. Re-evaluation of the enzyme activity following oral iron therapy showed improvement in the status of enzyme activity.
25. COMPOSITION OF THE BRAIN IN PROTEIN CALORIE UNDERNUTRITION IN CHILDREN

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It has been generally thought that certain organs occupy a position of privilege in the economy of the body. Thus, in response to chronic protein calorie undernutrition in children, brain was thought to be spared in preference to organs like the liver which undergoes profound changes in composition. The present investigations report observations on the composition of three organs the brain, liver and spleen in children aged 1-2 years, dying of kwashiorkor, marasmus and nephrotic syndrome. Water, lipids, protein, DNA, RNA, total mucopolysaccharides and hyaluronic acid and chondroitin sulfates were estimated in aliquots of the respective organs, which were weighed and homogenized without the addition of water. Results show that the water protein and lipid contents of the brain were similar in the three diseases; but the RNA contents in kwashiorkor was markedly below those in marasmus which were lower than those in nephrotic syndrome. The DNA contents of the brain in marasmus and nephrotic syndrome were the same and higher than those in kwashiorkor; but considering the matched brain weights there was a reduction in the total DNA contents in the brain in marasmus. The total mucopolysaccharide contents of the brain was higher in kwashiorkor than in nephrotic syndrome but the relative fractions of hyaluronate vis-à-vis the chondroitin sulfates were the same. These results along with the compositions of the liver and spleen indicate that in protein calorie undernutrition in children there is a profound change in composition of the brain and the brain is not spared in the response to the undernutrition.

26. CERULOPLASMIN LEVELS IN PRE-SCHOOL CHILDREN

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Protein-calorie malnutrition (PCM) is one of the major public health problems in many developing countries. While, it is easy to identify subjects in advanced states of PCM, there is as yet no satisfactory index either biochemical or anthropometric for detecting children in the early states. There is, therefore an urgent need to identify a parameter which is simple, independent of age and applicable under field situations.
Serum ceruloplasmin—a copper containing protein of the plasma, has been shown to be markedly low in children with kwashiorkor and this level seems to fall comparatively earlier than serum albumin. Also, serum ceruloplasmin levels have been shown to be constant beyond one year of age. A study was, therefore, undertaken to determine if serum ceruloplasmin levels could be used as a biochemical index to detect mild and early cases of PCM.

More than 150 pre-school children belonging to the low-middle socio-economic groups and children belonging to the upper socio-economic group were studied. Anthropometric data like height, weight, arm length and arm circumference were recorded. Total protein and ceruloplasmin levels were estimated in a finger prick sample of blood (5μl plasma), using a micro-method. A clinical examination was also done and the major ailments were noted for each child.

The results of the study showed that the levels of ceruloplasmin in the undernourished children were not in any way different, indicating that it can not be used as a parameter to detect early cases of PCM.

27. ANTIDIURETIC HORMONE IN PLASMA AND URINE OF MALNOURISHED CHILDREN

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Though oedema is a central feature of advanced states of protein calorie malnutrition (PCM), the exact mechanism of its pathogenesis is as yet incompletely understood. Starling’s classical concept, that physico-chemical alterations brought about by low plasma protein levels could explain oedema formation, is no longer considered as satisfactory. The importance of endocrines in water balance has been recognised in recent years, particularly the role of adrenocortical secretions and of the antidiuretic hormone (ADH). Several investigations reported from these laboratories have suggested that oedema of PCM is mediated through altered metabolism of ADH.

There have so far been, no studies on the actual levels of this hormone in circulation in subjects suffering from nutritional oedema. Levels of ADH in plasma and urine in children suffering from kwashiorkor at the height of oedema and after its disappearance were determined. Similar studies were done in children who were grossly marasmic but who did not have oedema.
Levels of ADH in plasma and urine of oedematous children were found to be significantly higher than in normal children, while in children with marasmus, the levels were essentially normal. Following on the disappearance of oedema, levels of the hormone had returned to normal, thus providing direct evidence for an aetiological role for ADH in oedema of PCM.

28. PLASMA AMINO ACID PATTERNS IN PRE-SCHOOL CHILDREN
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Serum amino acid profiles and rates of growth of pre-school children on vegetarian diet have been studied. A comparison of the amino acid patterns is made with children with protein-calorie malnutrition.

29. THYROID FUNCTION IN KWASHIORKOR
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As part of a study designed to evaluate the endocrine alterations in protein-calorie malnutrition in children, the functional status of the thyroid gland in kwashiorkor was investigated. Thyroidal uptake of $^{131}\text{I}$ and plasma protein bound iodine (PBI) levels were determined in children suffering from kwashiorkor as well as in apparently normal children. The mean $^{131}\text{I}$ uptake in normal children was 10.8, 12.6 and 17.9% at 1, 2 and 24 hours respectively, after the oral administration of 5 mc. Na$^{131}\text{I}$. The corresponding values in children with kwashiorkor were 13.0, 13.3 and 18.2%. There was no difference in the thyroidal $^{131}\text{I}$ uptake between the normal children and those with kwashiorkor.

The mean plasma PBI level in normal children was 6.2 ug/100 ml. Of the 22 kwashiorkor children investigated, the mean plasma PBI level in ten was 5.4 ug and this did not change after nutritional rehabilitation. In the rest, the levels were below 3.5 ug/100 ml with a mean of 2.2 ug/100 ml and the levels rose to normal after nutritional rehabilitation. The perchlorate discharge
test was performed on 11 children. Five of these children had a response and the plasma PBI levels in all of them were below 3.5 \( \mu g/100 \text{ ml} \).

These results indicate that the uptake of \(^{131}I\) by the thyroid is normal in kwashiorkor. However, 50\% of the children had low plasma PBI levels associated with a positive perchlorate discharge test indicating a possible impairment of organification of iodide within the thyroid gland.

30. STUDIES OF ANTIBODY RESPONSE AND RATE OF MORTALITY IN HYPOPROTEINEMIC RATS

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The present work was designed to study some factors involving the complex interrelationship between nutrition and infection in experimental animals. It includes data on rats divided in different groups and kept on either a 16\% or a 4\% casein diet.

The antibody responses against known antigenic stimulus (Salmonella typhimurium with adjuvant) in the two groups of rats were compared during the 8 weeks period of observation. Different tests were performed to demonstrate the antibody response which consisted of agglutination reaction, tanned cell haemagglutination test, paper electrophoresis, gel electrophoresis and gel precipitation. Data showed decreased level of total protein and serum albumin, loss of weight and decreased level of haemoglobin and total W.B.C., in rats kept on protein deficient diet. But no significant difference in the antibody response in the protein depleted and the control group of rats was noticed.

Comparing the mortality rate in the two groups it was observed that there was increased rate of mortality in the protein depleted rats.

These experiments do not suggest that there is any correlation between ability to produce antibodies and resistance to fatal infection.

This experimental situation parallels that of children in developing countries and provides an animal model for further work.
31. ELECTROPHORETIC CHANGES IN THE FRACTIONS OF SOLUBLE LENS-PROTEINS IN PROTEIN-DEFICIENT RATS AND THE EFFECT OF REALIMENTATION WITH AN ADEQUATE DIET

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Changes in the proportions of the different fractions of the soluble proteins of the lens tissue have been observed in different types of cataracts, in man as well as in experimental animals. In view of the reported relationship between protein depletion and cataract formation in animals, this study was undertaken to determine, whether in protein-deficient rats, the pattern of the soluble lens-proteins show any change.

Rats were kept on 2%, 4% and 18% protein diets for 5 weeks and then killed, leaving a few rats in the 2% protein group for the refeeding experiment. These rats were put on an 18% protein diet for further 5 weeks and then sacrificed. Paper electrophoresis was done with the supernatant proteins of the centrifuged lens-homogenates and the curves for the soluble fractions of the lens-protein, drawn by densitometry. The relative percentages of the different fractions were also measured colorimetrically after elution. In the rats on 2% and 4% protein diets, there was appreciable reduction in the proportion of alpha and beta crystallins and marked rise in the gamma crystallin fraction. On refeeding some rats of the 2% protein group with an 18% protein diet for further 5 weeks, the altered pattern of the soluble lens-proteins were almost restored to normal.

32. GLYCOGEN SYNTHESIS AND BREAKDOWN IN THE LIVERS OF CHILDREN WITH PROTEIN CALORIE UNDERNUTRITION

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Severe protein calorie undernutrition in children is associated with alterations in carbohydrate metabolism. The changes are more profound in kwashiorkor than in marasmus. The present investigations report observations on the synthesis and breakdown of glycogen by homogenates of the liver in kwashiorkor and marasmus. Results are compared with the data obtained after recovery of the children from the malnutrition. In kwashiorkor, the glycogen synthetase
activity of the liver was approximately half to a third of the normal hepatic glycogen content in the same age period and the glycogen synthetase activity on admission was a third of the values obtained after recovery. In two severe cases of kwashiorkor the synthetase activity could not be demonstrated at all; both of them died within 48 hours of admission. The phosphorylase activity of the liver in kwashiorkor on admission was found not to be significantly different from the values obtained after recovery, but there was a reduction in glucose-6-phosphatase activity. In the two children who died of kwashiorkor both phosphorylase as well as glucose-6-phosphatase activities were found higher than normal. Only two cases of marasmus could be studied because of the limitations of biopsy materials that can be obtained by needle biopsy in marasmus. The synthetic and phosphorolytic activities were found within normal limits in these two children. These findings would be discussed in relation to sugar homeostasis in protein calorie undernutrition in children.

33. RESPONSE OF LIVER AMINOTRANSFERASES TO PROTEIN LEVELS OF DIET IN RATS

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Earlier work has shown that the activity of L-aspartate 2:oxoglutarate aminotransferase isoenzyme of liver supernatant was higher in groups of rats supplemented with pyridoxine. A similar effect of pyridoxine was now observed in livers of rats fed low levels protein (6-8%). The activity of the mitochondrial L-aspartate 2:oxoglutarate aminotransferase was found to be high in groups fed the higher level of protein. The addition of pyridoxine to the diet at the same protein level (16 or 8%) does not appear to have any effect on the levels of the mitochondrial isoenzyme. The activity of the hepatic L-alanine 2:oxoglutarate aminotransferase was high when the diet at either protein level was supplemented with pyridoxine.

34. EFFECT OF LYSINE FORTIFICATION OF WHEAT ON CARBOHYDRATE METABOLISM IN RATS

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Impaired carbohydrate metabolism in protein deficiency has been described by several workers. While considerable work has been done on the effect of a
quantitative deficiency of proteins on carbohydrate metabolism. comparatively little is known about the effect of a qualitative deficiency. In the present investigation, the effect of lysine fortification of wheat flour on carbohydrate metabolism has been studied in weanling albino rats fed for 8 weeks. Animals kept on unfortified wheat showed hypoglycemia and elevated liver glycogen as compared to casein control animals. On fortifying the diet with lysine the blood glucose level increased significantly from 36.81 to 50.21 (mg/100 ml) but it was still lower than that found in the casein group (58.73 mg/100 ml). The liver glycogen, however, decreased appreciably from 144.8 to 61.76 (mg/100 g. bodyweight), a level comparable to that observed in the control group. The P. E. R. of the unfortified diet increased significantly from 1.253 to 1.826 on lysine fortification but did not come up to the P. E. R. 2.784 of the casein diet. These observations suggest that protein quality probably has a direct effect on carbohydrate metabolism. The low blood sugar level and increased hepatic glycogen observed in the animals fed on the wheat diet are possibly due to its poor protein quality and the tendency of these levels to approach near normal on lysine fortification, can be attributed to the subsequent improvement in protein quality of the wheat diet.

35. OXYGEN COST OF EPILEPTIC CONVULSION

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Epileptic convulsion is believed to be originated from the heightened excitability of cerebrospinal neuraxis resulting into transient loss of consciousness followed by generalised tonic and clonic twichings of the body musculature and is associated with substantial increase in the oxygen uptake. In a series of studies of oxygen consumption, CO₂-output, metabolic rate, blood oxygen tension (pO₂) in experimentally epileptic cats at different phases of epileptic seizure with or without convulsive movements conducted in this laboratory, it has been demonstrated that the increased O₂-consumption, metabolic rate accompanied by a fall of cerebral blood pO₂ are closely associated more with the enhanced energy requirements of the nerve tissue, rather than the muscles. Further, the concomitant increased CO₂-output and its retention retarded the kinetics of oxidative metabolism of brain tissue thereby initiated the arrest of seizure activity. Comparative studies of O₂ consumption during seizure discharge induced by topical application of penicillin, systematic administration of
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pentyleneetetrazol or strychnine in different preparations like intact, decerebrate and spinal conditions closely correlated with the above observation that excess oxygen utilization was entirely due to the demands of the neuronal substrates responsible for such hyperexcitable discharges and the increased muscular activity would have required an additional oxygen usage which ultimately helped in the subsidence of seizure discharges.

36. SERUM COPPER AND CERULOPLASMIN LEVELS IN MATERNAL AND CORD BLOOD

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Serum copper levels and serum ceruloplasmin values (P.P.D. Oxidase activity) were estimated in the maternal venous blood and corresponding cord blood of 18 women belonging to low socio-economic group and of 12 women belonging to the high income group.

In the high income group, the mean level of serum copper was 230.5±9.30 µg/100 ml. as against the mean level of 223.6±7.37 µg/100 ml. of the low income group. The mean ceruloplasmin values were 0.22±0.003 O.D./100 ml. and 0.20±0.010 O.D./100 ml. in the high and low income groups respectively. The difference in copper as well as ceruloplasmin levels between the two socio-economic groups was statistically not significant.

On the contrary, the mean levels of both copper and ceruloplasmin in the cord serum of the low income group were significantly lower. The mean value of copper in cord serum was 83.6±3.3 µg/100 ml. in the high income group as against a mean of 43.9±2.27 µg/100 ml. in the low income group. The mean ceruloplasmin values in cord serum were 0.07±0.005 O.D./100 ml. and 0.04±0.003 O.D./100 ml. in the high and low income groups, respectively. Since transplacental transfer of ceruloplasmin does not occur, the low ceruloplasmin values in the new born of the low income group might possibly reflect an impaired synthesis of ceruloplasmin by the liver at birth in that group.

A direct correlation between birth weight and cord ceruloplasmin value was observed \((r=0.57, P<0.02)\). The low levels of ceruloplasmin are suggestive of an effect of maternal malnutrition on the new born.
Magnesium deficiency has been reported to cause reduced growth, neuro-muscular and central nervous system changes, marked electrocardiographic changes etc., giving a suggestive evidence for the disbalance of energetics of the living cells and tissues.

The object of the present work was to elucidate certain molecular mechanisms involved in the action of magnesium in the energetics of living cells. Oxidative phosphorylation and swelling of mitochondria in presence of various reagents were studied in detail.

Magnesium deficiency was produced in rats, by feeding animals a low magnesium synthetic diet (2-4 mg %) and quadruple glass distilled water.

After 15-21 days, symptoms observed were poor growth, hyperemia and dazed appearance.

In the deficient animals P : O ratio was significantly lowered with both succinate and α-ketoglutarate, although oxidation rate remained same or slightly increased with succinate. Oxidation decreased in case of α-ketoglutarate accompanied by decreased phosphorylation. The effect was present in all the tissues taken. Magnesium content of the tissues was also significantly lowered.

Supplementation of magnesium to the diet resulted in restoring P : O ratio to normal values with both α-KG and succinate. Tissue magnesium also showed a tendency to return to normal levels.
SPECIAL LECTURES
The accomplishments that develop from this Congress will reach high ground if we do justice to the persons whom we are here to honor. Sir Robert McCarrison, father to the Nutrition Laboratory in Coonoor, combined a strong personality with a vivid imagination and an intense interest in the welfare of mankind. As a true pioneer he lighted lamps that still guide us in many areas of research and in human service.

My only personal contact with Dr. McCarrison was during his lectures and discussions at the University of Pittsburgh. He left a permanent impression on students and faculty alike. In the language of modern writers, it was a “forecast” of later years when an opportunity came to visit the Nutrition Laboratory in Coonoor with his worthy successors, Dr. W. Aykroyd and Dr. V. N. Patwardhan, and finally, with Dr. C. Gopalan in the new laboratories here in Hyderabad.

THE FUTURE

It is gratifying to see the new national developments such as the Indian Nutrition Society and the increasing public awareness of the need for both research and practical application in the use of food. We can look forward with greater confidence toward the essential integration of nutritional goals with resources in agriculture, medicine, food science and technology, the public health agencies, food distribution systems, and education of the public.

The foreground today is not lacking in tough problems. The specter of mass starvation has been tempered for a time by the dramatic success of the Green Revolution. The yields of rice, wheat, corn, sorghum, potatoes and other crops will be doubled and tripled in nation after nation. But unless the rate of population increase can be kept in balance with essential food resources the outlook for the future will again grow dim. Even though we are not classified as social scientists, we have a responsibility as citizens to share in
turning back two additional threats to all humanity, namely, the risk of war and the risk of moral decay in human relationships. In this very real situation, it was an occasion for thanksgiving and great encouragement when Dr. Norman Borlaug received the Nobel Peace Prize in 1970 in recognition of his dramatic contributions toward more and better food. Dr. George Harrar, the plant pathologist who initiated and guided much of the work in Mexico and from there into cooperative worldwide programs is keenly aware of the need for increased yields of many crops. These will include animal feed in addition to human food. Increases in dairy and poultry production will be particularly important, in parallel with increases in high quality legumes to supply protein. Another great advantage will be the wider understanding of what the experimental sciences can do for society in terms of human service.

CONTRAST

To reach reasonable goals, we need pioneers of many types. For example, from a worldwide point of view, we are in fact contending with two major but opposite kinds of malnutrition. They are both extremely destructive.

Among populations that are most advanced technologically their most damaging form of malnutrition is a result of long continued excessive intake of total calories. It starts early in life but the evidence of disease is slow in development. At the other extreme, among populations that are least developed technologically, the greatest nutritional damage results from protein-calorie deficiency which becomes evident very early in life and reaches a peak in sickness and death during the second and third years. Among those that survive, at least a part of their normal growth and development is never regained.

MISSPENT ENERGY

The close association of excess body fat with 7 or 8 of the 10 leading causes of death in the most advanced countries has been well established. A similar relationship is indicated among the affluent individuals in the less developed areas. The kind of research currently underway by such scientists as Dr. R. Luft, Dr. J. P. A. L. Christophe, Dr. A. E. Renold, Dr. G. H. Cahill, and others working with the International Union of Nutritional Sciences merits greater recognition by nutrition scientists and by fund-granting agencies. They are searching for the earliest and most specific trends in the metabolic patterns that identify the beginnings of diabetes, cardiovascular diseases, and related breaks in health. Each step forward will improve the prospect for prevention or deferment of these diseases by food practices.
The food industry also has good reasons for being concerned with the hazards imposed by consuming too many calories. The first is simply a genuine interest in public health. The second is an economic interest. An adult who lives longer and works actively will consume more food than one who gets fat, lazy and dies prematurely. Although major attention is centered on the carbohydrates and fats in this area of research, the details of metabolism do not preclude consideration of other nutrients. I am hopeful that commission IV in the International Union of Nutrition Sciences will make a substantial contribution in this area of research and education.

NEEDLESS DEFICIENCIES

The deficiency diseases that continue to plague the technologically advanced countries most often are the mild or moderate degrees of anemia, endemic goiter, and excessive tooth decay. Many aspects of these problems still require research for improved understanding and management, but corrective measures have been introduced with considerable success. The best examples are enrichment of cereal foods with iron and three vitamins, table salt with iodine, and water supplies with flourine. Vitamin D milk and vitamin A in butter and margarine have greatly lowered the risk of deficiency in these two vitamins. Although these procedures are safe, economical and can be reasonably effective, the enforcement practices have not been adequate to meet public needs.

TRAGEDY IS HERE

The above picture is essentially reversed when one looks at the countries that are handicapped technologically, economically, educationally, and by population density. Then the problems of malnutrition center with great intensity on the education of mothers and the feeding of infants and preschool children. More specifically, the most critical age period follows immediately upon weaning from breast milk and continues through the second and third years. Protein-calorie deficiency is recognized as the most important problem, followed frequently by severe deficiencies of vitamin A and other essential nutrients. Anemias and goiter are common and frequently severe. Complications imposed by infections add greatly to the injuries. A dramatic summary of the current situation was given recently by Alan Berg in stating that in many areas, the chance that a newborn infant would reach five years of age was about the same as the chance a child born in more favourable countries would have of reaching age 55 or 60. Malnutrition does not account for all the difference but it is certainly one of the largest contributors.

Failure to provide enough good quality protein food and total energy for mothers during gestation and lactation, and for their infants and children up
to age 5 is clearly one of the greatest causes of sickness, retarded development, and death within countries that contain more than one-half of the world's population. Economic development and social progress are penalized accordingly. This area of research is one of the most challenging for interpretation and support in the world today.

I would like to quote from a recent paragraph by Dr. Myron Winick and his associates (Am. J. Cl. Nutrition, 23, 1275 (1970)) : "It is becoming increasingly clear that severe early malnutrition will curtail brain growth. Undernutrition during the first 2 years of life will reduce head circumference and total brain weight and retard the rate of cell division in whole brain and in specific brain regions. Moreover, animal studies strongly suggest that these changes may be permanent. At the same time evidence is accumulating that suggests that brain development and ultimate function may be permanently impaired by severe early undernutrition. The lipid components of brain are important in both total growth and functional development since myelin is a major component of the adult brain and myelination is accompanied by a progressive increase in brain function. In animals, undernutrition during the nursing period will reduce the rate of net lipid synthesis and result in a brain with a reduced content of phospholipids and cholesterol. This reduction is paralleled by a reduction in certain enzyme activities necessary for the synthesis of myelin. Total lipid content in the brains of four children who died of severe malnutrition has also been found to be reduced. Thus, present evidence would indicate that malnutrition during the first 2 years of life will retard brain growth by curtailing the rate of net protein synthesis, myelin synthesis, and cell division."

**ACTION CHALLENGE**

Even though this research frontier of evaluating the damage inflicted by protein-calorie deficiency is relatively new and very complex, enough is known to make it desperately urgent to find and support pioneers in human engineering who can develop and manage programs that will prevent this destruction of human life. Dr. Paul Gyorgy and his associates in commission III of the IUNS are devoting their energies to this area of research and its application. Likewise Dr. V. Ramalingaswami and his committee are working on the problems of endemic goiter, Dr. H. Lehmann and his committee on the anemias Dr. C. Gopalan and his committee on the evaluation of protein-calorie malnutrition, and Dr. N. S. Scrimshaw and his committee on biological and clinical evaluation of protein foods.

Action programs immediately raise the question of approximately how much of each nutrient is needed at each age and circumstance to meet requirement
for health. The environment does not always supply them automatically, but the nursing infant comes closest to having the perfect answer. In this area of planning it is deplorable that we do not have worldwide agreement as such standards. In part, the cause is a lack of basic information. The IUNS committee on recommended dietary allowances under the chairmanship of Dr. W. H. Sebrell is working toward solution of the problem in cooperation with WHO, FAO and other responsible agencies. As the situation now stands, some groups make recommendations largely on the basis of their present food supply, others give weight to the per capita national income and others would add quantities of specific chemicals that are regarded as unnecessary or dangerous. Iron, folic acid, and vitamin C are good examples of this tendency. In the latter instance some groups would accept an intake of 10 to 15 mg. per day as adequate, many groups believe 50 to 100 mg. per day is a better range, and another is clamoring in the press for intakes as high as 2,000 to 10,000 mg. per day.

LEADERSHIP

In part because the science of nutrition is broadly inter-disciplinary and is closely related to day-to-day living, our national societies need to be especially careful to maintain standards of research, training and publication that compare favourably with other scientific societies. Basically, nutrition scientists have three major areas of interest and responsibility. First, they are interested in the complete composition of materials consumed as food. In this respect they have much in common with organic chemists, agriculturalists, and those who manage the processing, distribution, and service of food. Secondly, they are concerned with the functions of nutrients and accompanying materials inside the body. In this area they have much in common with biochemists and physiologists. And thirdly, they have an intense interest in the effects of food practices on the health of the consumer on a lifespan basis. In this area they share interests with the general public and with physicians—particularly in pediatrics and public health.

INDUSTRY

Fortunately, most leaders in the food industry are increasingly conscious of the need for great care in selection, processing, and storage of food materials. In several countries, including at least the United States, the United Kingdom, Sweden, and Switzerland they are cooperating in support of basic research that is completely in the public interest. But unless they and government agencies have adequate and reliable information to work with the public cannot be well served. Close liaison with leaders trained in food sciences and technology should be maintained in relation to industrial practices.
Pioneers are critically needed to design, direct, and interpret the kind of research that reveals a clear picture of the relationships to health. This aspect of investigation and practical service is "the proof of the pudding". It is expensive in time, money, and highly trained manpower, but unless it is given vigorous support, mankind will suffer costs that are far greater in human values.

We also need pioneers who can accurately inform and persuade the public to follow good nutritional practices and we need others who will, with skill and courage, battle the forces that resist actions that are needed in the public interest.

The International Union of Nutritional Sciences is organized to assist their profession and others with whom they work to promote research and service to mankind. We are organized in commissions and committees to strengthen our efforts and to facilitate our cooperation with other groups who share in our interests and responsibilities.
MALNUTRITION AND THE ADMINISTRATOR

G. DARTER

UNICEF
New Delhi, India.

Dr. Gopalan and the organizers of this Congress have conferred an honour on UNICEF in inviting me to read one of the special lectures. Of course, the choice of the subject was left to me but the organizers, assuming that I would deal with the matter from an administrator's point of view, have thereby confirmed the importance which they attach to the practical angles of the problem of malnutrition and to its solution.

I shall deliberately avoid any discussion of the scientific and technical aspects of malnutrition as I am no better equipped to deal with them than the average administrator. Furthermore, like the administrator, I have a number of responsibilities in areas other than nutrition and can only deal with the essential, action-oriented issues in any one of these areas.

Almost against my better judgement, as I did not want to inflict a progress report on UNICEF on you I have agreed to say a few words about the background against which I shall speak, which is the Organization's involvement in food and nutrition in Asia. You will, therefore, be able to judge for yourselves how adequately or otherwise this experience can serve as a baseline for the views which follow.

For many years UNICEF helped to re-distribute protein food surpluses, primarily milk powder, to the children of developing countries. Very substantial school- and later pre-school feeding schemes were carried out in a number of Asian nations. When CARE and other voluntary agencies came on the scene, and more recently with the advent of the World Food Programme, UNICEF very deliberately began to phase out of the supply of imported foods, handing over to agencies specifically established and equipped to handle activities of this type. In the Region for which I am responsible, all such ventures have now been taken over by the agencies mentioned.
Less is known about other programmes, contemporary to that just mentioned. UNICEF tackled the build-up of national dairy industries in four countries of West Asia and three in Middle Asia.* Now in the final stages of helping to put these industries on a self-sustaining basis, the record will show that UNICEF and FAO had the foresight as early as 1949 to realise that the distribution of imported milk powder, while necessary at the time (and still necessary in some cases), had to be matched by a greater and more fundamental effort to develop, in the countries themselves, the production and processing of milk in various forms.

Whereas milk was at the time the obvious commodity for a mass distribution of protein food (technology about other potentially abundant protein-rich substances was in its infancy), UNICEF, in collaboration with FAO, WHO and other international and national bodies collaborating in the Protein Advisory Group, tackled the very long-range task of coming up with protein-rich foods based on the actual or potential availability in large amounts of relatively low-cost sources of vegetable protein: groundnut, soya, cottonseed flour. A number of projects were assisted in different parts of the world, the more successful of which have been the Incaparina and Superamine schemes in Central America and in Algeria respectively and nearer to the local scene, the Saridele venture in Indonesia.

In India, various groundnut flour processes were supported in earlier years and two major schemes are under way: Bal-Amul, a weaning food, the manufacture of which will go on an industrial scale later this year, and the first soya bean processing plant for human consumption, to be built in Northern India. Smaller scale, simple technology for weaning foods is also being assisted in Taiwan and Thailand.

Specialised projects have also been set up: plants in India to iodate salt for the entire Indo-Nepalese goitre-prone Himalayan belt, as well as in Burma, Taiwan and Thailand and a shark-liver oil encapsulating plant in Thailand.

These schemes may be broadly described as interventions decided and implemented for those in need of a healthy diet, but hardly by them. The applied nutrition programme—maligned by some, commended by others—aims at correcting this no-participation-of-those-in-need imbalance and acts as a village extension service in nutrition education, rendered more meaningful and useful by the practical production components built into it.

*Iran, Iraq, Israel, Syria, Ceylon, India, Pakistan.
The applied nutrition programmes most in view in Asia are those in India, Indonesia, the Philippines and Thailand. With respect to the first-mentioned, which comprises a very wide range of activities from ice-plants for fisheries, regional poultry farms, state vegetable seed farms and processing units, to cash grants to village women's groups to set up simple pre-school feeding centres, thousands of powered pumpsets for village gardens, and which has enrolled a hundred thousand people in its orientation and training programme over the past eight years, suffice it to say that it is being assessed by the Indian Institute of Management (Ahmedabad) and that protagonists and detractors alike will have an interesting time later this year deciding what is succeeding and what is not.

Lastly I must apprise you of the Organisation's emphasis on the infrastructure. The picture of UNICEF's contribution to furthering nutrition would be seriously incomplete if I did not mention our support to training at university and post-graduate level. In some Asian countries, this has taken the form of support to national institutes of nutrition and offering fellowships for international training courses. Two examples: the well known London-Ibadan course; and the less well known fellowship programme for 100 Ceylonese home-science teachers at the Universities of Allahabad and Lucknow.

But we are going a stage further: before the Executive Board of UNICEF this coming April is a submission to continue grants for the certificate and applied nutrition M.Sc. course in the National Institute of Nutrition, Hyderabad and to develop basic and selective courses in nutrition and food policy in most of the agricultural, veterinary and home-science colleges in India, under the aegis of the Indian Council of Agricultural Research and in co-operation with the agricultural universities themselves.

Now coming to the heart of the issue, what are the problems which the administrator face in trying to cope with malnutrition. I use the word "faces" in its internal sense as well: malnutrition stares most administrators in the face, in many parts of Asia. I have, you see, not so much in mind the senior national level administrator, a number of whom are with us in this Congress, as I do the general purpose administrator at "face level", namely the provincial, zonal, district, block or local level official, who spends his life among the hungry and the malnourished and who is the one who will influence or even determine, in the penultimate or final analysis, just what will get done.

INFORMATION AND UNDERSTANDING LEAD TO CONFIDENCE:

The first, and I feel overriding, issue is a sense of inadequacy at being able to deal with something which the administrator little comprehends, namely a
vague awareness that there is some connection between low mental and physical efficiency and chronic nutritional deficiencies. Even when he does know rather more about it, he boggles at the thought of having to himself manoeuvre the multitude of parties which should join forces into a situation where he can bring these forces to bear at his level, in a particular way. While the specifics of course differ at various levels, the feeling that all too many individuals have is that at their level they really can't get to grips with widespread malnutrition.

This, in my mind calls for something which has hardly been tried in Asian countries, if at all, namely a systematic briefing of administrators, from national planning bodies to district and local levels, on the hard and essential facts of malnutrition, i.e. of marasmus, kwashiorkor, anaemia, keratomalacia, on the basic principles of nutrition, on solutions which are possible, on their own country's programme and on their specific role.

This briefing should initially be built into pre-service training of national administrative cadres, in terms which they can understand. Once on the job, the channels and means which are used to regularly update administrative officers at various levels of government should provide for reference to their important role in nutritional programmes, and should encourage them to practice the art of the possible, rather than to shy away from something which, they wrongly feel, is outside their scope or ability.

Two channels for reaching the public at large and administrators in particular are of course the radio and the press. These are in India showing a growing interest in the problems of malnutrition, as the editorial columns of certain national papers will testify to (a seminar on nutrition for editors has just been held in the National Institute of Nutrition, Hyderabad, two weeks ago and All India Radio is broadcasting regularly about applied nutrition from 21 stations). These media could and should be more deliberately used to involve the administrators in these matters.

The second hurdle is the multiplicity of parties involved. In large countries, with decentralised government, this is rather formidable. But even in small countries, there are proportionately more bodies which bear, or should bear, an important measure of responsibility for action in nutrition than in many other areas of development. While we all realise the very many deterrents to planning a national nutrition programme, is it still too soon to expect that governments, which are setting up fairly sophisticated machinery, institutional and electronic laiike, to plan rationally for various aspects of economic development, can mount something similar—even if "first generation"—to decide how to tackle
major nutritional problems effectively? The farming ef national food and nutrition policies is a commendable exercise per se. But why is it left to commissions and committees to do so on the basis of assumptions (often arbitrary) when systems analysis is being utilized more and more to cope with similar complexities in other fields?

Surely the sequence of goal-setting, “planning, programming, budgetting and actuation,” with built-in information feed-back aimed at the correction of errors, is within the grasp of national administrations which are determined to really get at malnutrition. The cascade effect, diagonally across various ministries and agencies and vertically down the tiers of the administrative structure of a country of the right or the wrong decision at the start will be multiplied many times. The administrator—at any point in the cascade—needs to know that he is being called upon to do something based on a sound premise rather than contribute to something the origins of which he does not know or even is suspicious of.

A distracting aspect of nutritional programmes is that there are as many particular objectives, distinct channels of communication, separate personnel cadres, budget allotments, forms of material involvement (food items, cash, processing plants, garden tools, transport, stipends, etc.) as there are agencies in the field. (I will readily admit at this point that the international bilateral and foreign voluntary organizations involved have not done much to ease this particular aspect of nutrition programming. Indeed, they have rather tended to complicate it!).

The administrator, usually fully expended by his various responsibilities, cannot reasonably be expected to cope with such a dispersion of efforts. It is all very well for those at the top of the pyramid to deal out a mix of programmes and procedures but quite unrealistic on their part to expect the official who has to help implement all of this at the field level, to be able to sort things and to explain them coherently to others.

I, therefore, appeal to those who plan these programmes to agree to a certain conceptual unity of purpose, to pool resources and employ common logistic systems as far as possible, and where pooling is not possible, to use common sources of supply of bulk commodities and to agree on essentially similar means of delivering the programmes to the beneficiaries and on their reporting thereon.

Everybody’s objective should be to reach those in need through the simplest possible procedure. It is fallacious to equate an increase in efficiency with an increase in resources per se.
Entire volumes are being written on the subject of communications. Here is however an area where communications are at their weakest. I mentioned a moment ago the importance of feedback. To entrust nutritional planning to cybernetics, the study or science of systems of control and communications, may be moving ahead rather fast, but surely the administrator, if he is going to successfully carry such a nutrition programme through, must be involved in a two-way flow of information. He must be in regular and intelligible communication with those "above" who convey the policies and instructions to him and to whom he reports on performance and in close touch with those "besides" and "below" him to whom he must interpret the guidelines and who must in turn apply them.

My experience in a number of countries is that instructions often take such a stultified and impersonal form that they defeat their purpose. Administrators galore at lower echelons complain about the one-way traffic, i.e. the very occasional hearing which they get when they really back through channels information about what is actually happening—or not happening.

My short lecture is an appeal to you to take the administrator into your confidence. McLaren and Pallett said, "If the planners will only consult the nutritionists". I say: "If the nutritionists will only consult the planners (of course) but also the administrators". Recognize the administrator as a key element in the practical application of all that you discover, profess and postulate. Malnutrition is not going to take care of itself because the technology to deal with it is available in scientific and ministerial milieus, nor as Alan Berg has demonstrated in his "Shibboleth examined", merely because average income levels are very slowly improving.

With the technology to back him up, malnutrition must be tackled energetically, rationally and tenaciously by the administrator and the team of technical extension people who work with him. He must be aware of and bring about the interactions at his level, such as appreciating the less obvious significance of: growing food crops, including namely peas, beans and lentils, rather than, or in addition to, cash crops; or better storage to cut down on food contamination or spoilage; or the malefic role of worm infestation linked to poor sanitation; or the contribution of better nutrition to family planning, as compared to, say, the very much more obvious mass child feeding programmes. More, he must look for and be able to recognize the openings which are available to him. He must determine at what point he can make his moves. He must often decide how the limited money available is to be spent. He must know when and where to call for advice.
Sound programmes which the administrator can sell to the local politicians and to those whom he administers alike, require him to be fully in the picture.

I submit, Mr. Chairman, that until the scores of more senior administrators and thousands of middle-rung officials, indeed in India the tens of thousands, are fully involved in this work—indeed committed to it—malnutrition, the greatest sorrow before their eyes, before our eyes, will not depart from this continent.
Coronary heart disease is well known to be a frightening killer, which especially strikes middle-aged men in Western countries. There has been considerable progress in reducing the prevalence, incidence and mortality from some other cardiovascular diseases but with CHD the situation has in general become only worse during the last decades. This is evident from several statistical data as well as from the practice of many experienced physicians. The diagnostic means to prove this disease have greatly improved in recent years but this is obviously not the only explanation to its observed great prevalence. This appears from the fact that in the U.S.A. for men aged 40-50 years the death rate ascribed to coronary disease increased by 11 per cent between 1950 and 1965. For women of the same age, on the other hand, the death rate during the same period did not change although certainly same diagnostic criteria were used. The famous American cardiologist Dr. Paul D. White who has devoted his long life to the study and treatment of heart diseases recently emphasized both the greatly increased prevalence and incidence of coronary diseases and the fact that the disease manifests itself now in younger and younger males.

Fig. 1 shows the mortality of men aged 50 to 54 years due to arteriosclerotic heart disease according to WHO statistics of 1964 in a number of countries. Although the category B 26 is not exactly synonymous with coronary heart disease, it is the closest approach to it in official vital statistics. We can see that there are very great differences between the countries listed. My own country Finland has the questionable honour of being in the lead while Japan and Mexico have the lowest mortality. It is interesting to note, e.g., the difference between Finland and its close Scandinavian neighbours Sweden and Norway, the general conditions in which are very similar to those in Finland. Fig. 2 shows mortality in other age classes in six countries; and we can see that the relative differences between countries are very similar in other ages, too. The high mortality in Finland and particularly our special position among the Scandinavian countries makes it known that we also have tried to make our contribution to the studies concerning the aetiology of coronary heart disease and to its prevention in particular.
RISK FACTORS

It is generally accepted by now that coronary heart disease is a multifactorial disease having not only one specific cause but being influenced simultaneously by several different factors. This, of course, makes the picture quite complicated and at least partly explains the controversial results and conclusions so abundantly found in the literature.

Hereditry evidently plays only a minor role in the incidence of coronary disease. There are families, true, which have a genetic disposition to angina pectoris or infarctions but these are rather rare. Nowadays, when the disease is so very common in the Western countries, the environmental factors seem to dominate over the hereditary ones.

The role of serum lipids in atherogenesis has been intensively studied and much evidence has accumulated but the situation is not yet clear. The lipids incriminated include cholesterol, triglycerides, phospholipids, free fatty acids.
Fig. 2. Age-specific mortality (per 100,000 annually) due to arteriosclerotic and degenerative heart disease. (FIN = Finland, ENG = England, SWE = Sweden, FRA = France, JAP = Japan).

and different kinds of lipoproteins. What is the basic role of different lipids in the process of atherosclerosis is not clear, but from the practical point of view it is important that the total cholesterol content has at least as good a prediction value as any other serum lipid. Many extensive longitudinal epidemiologic studies have shown that determination of total cholesterol is sufficient to give a rather reliable picture about the future risk of coronary
Dietary Prevention of Coronary Heart Disease

Dietary Prevention of Coronary Heart Disease. In all studies, the new cases of disease have in average been more common with people having high serum cholesterol levels than with those with low levels. Although there is no clear-cut agreement as to which values are to be considered as "high" and which as "low", it is evident that the risk is very much higher with values of, say, 250 mg.

In general, the higher the serum cholesterol level, the greater the risk of coronary disease.

The serum cholesterol level is clearly dependent on the diet. Many studies have conclusively shown that the quality and quantity of dietary fats are in this respect decisive. The saturated fatty acids containing 12-17 carbon atoms raise the cholesterol level while the polyunsaturated acids have an opposite, although weaker effect. The saturated acids with fewer than 12 or more than 17 carbon atoms, as well as the monounsaturated acids have practically no effect. In practice this means that the chief dietary "enemies" are lauric, myristic and palmitic acids. To counteract their effect one needs about twice as much polyethenoid acids of which linoleic acid is the most abundant in the vegetable oils commonly used. Dietary cholesterol also affects the serum cholesterol level but this effect is so small that for practical purposes a restriction of dietary cholesterol has a very limited value.

The contribution of carbohydrates and especially that of sucrose to atherosclerotic disease has recently been discussed. It is well known that dietary carbohydrates can induce hyperlipidemia and it has been stated that about half of hypercholesterolaemias are at least partially carbohydrate-inducible or carbohydrate-sensitive. However, isolated cholesterol abnormality of this type is relatively uncommon so it is probable that too much emphasis has been placed on this entity. A recent report of the Medical Research Council in Great Britain summarizes the findings of extensive studies saying that "the evidence in favour of a high sugar intake as a major factor in the development of myocardial infarction is extremely slender".

Many minerals especially the deficiency of magnesium have also recently come into the picture. For quite a long time the hardness of water, a deficiency of iodine etc. have been involved, but the evidence of their roles is not conclusive and more research on these aspects is needed.

Further factors which are certainly known to contribute to atherogenesis and which are also to some extent connected with nutrition are hypertension and diabetes. It has been shown that development of atherosclerotic cardiovascular disease and subsequent mortality are obviously related to blood pressure levels. Heyden in a recent review states that a simultaneous
treatment of hypercholesterolaemia and hypertension gives the best chances for a successful retarding of infarctions in later life. The frequent coexistence of diabetes and coronary heart disease has been known for several decades. According to Epstein there is much room for research in this respect but anyway “there is good case for believing that diminished glucose tolerance increases the risk of coronary heart disease and that the mechanism involved holds a major clue to the basic etiology of atherosclerosis.”

For the sake of completeness three additional aetiological factors should be mentioned. Cigarette smoking is generally accepted as one of the causes of coronary heart disease. Although the mechanism of this cause-and-effect relationship is not clear, there is much circumstantial evidence from many extensive epidemiologic studies showing that heavy cigarette smokers have essentially a higher rate of myocardial infarction and sudden death than the non-smokers.

The role of physical inactivity is far less conclusive. There are investigators who claim that physical inactivity is a certain cardiovascular risk factor, and others who consider this very doubtful. Obviously much more research is needed to find the independent role of inactivity, separated from the other factors usually involved. The same holds for emotional stress. The popular belief that men with high responsibility are more prone to coronary disease, in this connection also called "manager disease", than e.g. ordinary workers, has not been conclusively confirmed by scientific studies. It is understandable, however, that men who have been stricken by an infarction rather blame their demanding work with high responsibility than simply admit having eaten too much and too fatty foods or possibly smoked too much.

PREVENTION

From all that has been said before, it is evident that there are many coronary risk factors, some of which have been rather firmly established and some whose real effects are still doubtful. The more atherogenic traits are present in the same person, the greater is his risk of getting a heart attack. Because prevention is always better than cure, and especially in this case where cure is very uncertain, it seems wise to advocate elimination or diminishing risk factors even when a complete evidence of such a procedure is not quite conclusive. The present state of our knowledge already makes preventive effort justified, but, of course, more direct experimental evidence is needed to bring indisputable proof of the value of preventive measures. This kind of evidence is not easy to obtain. Animal experimentation can give valuable clues but the final answers concerning men are obtainable only from studies on human beings. Here, of course
The principle of experiments planned to show whether the coronary heart disease can be prevented by dietary means, is to select a large number of subjects, keep them on a diet the composition of which has been in some respect changed, and follow the development of manifestations of coronary heart disease for a long enough period. An otherwise comparable population among which no dietary changes are made is required as a control. The study can be made either on free-living or institutionalized subjects. In the former case larger groups of subjects are required since the individual variations in many influential factors are necessarily quite large and the experimental conditions cannot be very accurately controlled. However, if the populations studied are large enough the results obtained are evidently directly applicable to normal free-living population. If the study is made, on the other hand, on institutionalized subjects, the experimental conditions can be more rigidly controlled, the experimental and control groups can be made more homogenous, and a smaller number of subjects is needed. In both cases the study should concentrate on coronary-prone subjects, because it is probable that they will react more clearly and rapidly to the change in the diet.

The experiments may be of two main types. First: attempts at primary prevention, that is, prevention among a presumably healthy population, healthy at least in the respect that it has not experienced manifestations of this disease, and secondly: attempts at secondary prevention, that is, prevention among survivors of one or more attacks of coronary disease.

Studies of both types have been published. Those of the second type are easier to carry out. It is easier to find cooperative subjects among those who have already experienced coronary events and live under a risk of a recurrence, than among healthy persons. Another advantage is that the incidence rate of new coronary events is much higher among survivors of a previous attack than among healthy persons, and hence a smaller number of person-years of experience will suffice for statistically valid conclusions.

These two types of studies may not necessarily lead to concordant results.
A priori it seems that the chances of prevention should be better among healthy persons and it could even be argued that a coronary event as such indicates a pathologic process too far advanced to be appreciably influenced by dietary or any other means.

The dietary studies aiming at primary prevention of coronary disease which I am going to review are three: the Anti-Coronary Club Project of New York, the Mental Hospital Study of our group in Helsinki, and the clinical trial at Los Angeles Veterans Administration Center.

In addition, I wish to mention briefly a fourth, more recently started study, which is being carried out in Minnesota Mental hospitals with Franz as the principal investigator. This dietary trial involves about 3000 subjects, which have been divided by random allocation. No published results are available as yet.

ANTI-CORONARY CLUB IN NEW YORK

The diet and Coronary Heart Disease Study Project in New York, usually known as the Anti-Coronary Club, has been conducted by Jolliffe, Christakis, Rinzler and several coworkers since 1957. The experimental group consisted of 941 free-living men aged 40 to 59 years free of prior evidence of clinical coronary heart disease. During the study about half of the subjects did not return regularly to the club and in the following only the active participants are dealt with.

The control group consisted of 457 men of the same age, who had appeared for examination at the cancer detection clinics, and who were offered an annual comprehensive cardiovascular examination. They were not told that they were part of a diet and heart disease study. These men did neither show an initial evidence of coronary heart disease.

The two groups were quite comparable with regard to initial hypercholesterolaemia, but the experimental group started with higher proportions of initial obesity and hypertension than the control group, so it could be expected that the experimental group might experience a higher frequency of coronary heart disease.

The experimental group consumed a so-called Prudent Diet in which foods containing predominant or significant amounts of saturated fatty acids were partly or totally replaced by unsaturated fatty acids. The experimental diet averaged 33 per cent of calories from fat, in which the proportions of saturated
fatty acids and of polyunsaturated acids were about the same: 33–34%. The total fat content of the control diet was 40 per cent and the proportion of saturated fatty acids 46 per cent and that of polyunsaturated acids 14 per cent. The P/S ratio i.e. the ratio of polyunsaturated to saturated fatty acids in the Prudent diet exceeded 1 while in the usual American diet it is only 0.3–0.4.

Fig. 3 shows the trend in the average level of serum cholesterol in both groups. There is a highly significant drop in the experimental group while the level in the control group remains rather constant. The average difference between the groups during the experiments has been approximately 25 mg%. The composition of the adipose tissue of the experimental subjects changed markedly towards a more unsaturated direction. Particularly, this was seen in the case of linoleic acid, which increased from a mean of 9.7% initially to 18.9%, at the expense of myristic, palmitic and oleic acids.

Fig. 3.

Average serum-cholesterol levels of men 40 to 59 years old with no prior coronary heart disease in active experimental and control groups by years in study.
The new coronary events were assessed according to the classification used by the Cooperative study of the American Heart Association. The results are shown in Table 1. During the 3954 person-years of active experience accumulated by the 941 experimental subjects 17 new coronary events occurred, representing an over-all incidence rate of 430 per 100,000 person-years. The 457 men of the control group had accumulated 3122 person-years of experience and 32 new coronary events, resulting in an over-all incidence of 1025 per 100,000 person-years.

**Table 1**

<table>
<thead>
<tr>
<th>New coronary disease events and incidence in study and control subjects free of coronary heart disease, 40 to 59 years of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
</tr>
<tr>
<td>Number of subjects</td>
</tr>
<tr>
<td>Years of experience</td>
</tr>
<tr>
<td>Confirmed new events</td>
</tr>
<tr>
<td>Incidence per 100,000 person-years of experience</td>
</tr>
</tbody>
</table>

Rinzler summarizes the study as follows: “The nutritional adequacy of the Prudent Diet, its acceptance by free-living ambulatory subjects, its capacity to lower serum cholesterol and triglyceride levels and, most important, its apparent influence on the significant reduction of new clinical coronary artery disease events make it, in our opinion, an important public health modality for primary prevention of coronary heart disease”.

**Mental Hospital Study in Helsinki**

Our own study conducted by Turpeinen, Karvonen and myself with several coworkers was started in 1958 in two mental hospitals in the vicinity of Helsinki. The larger hospital had about 1100 and the smaller one about 640 beds, which gave us a total of 327 male experimental and 254 control subjects, for the first six years of the study. The subjects were initially aged from 34 to 64 years. In the first 6-year part of the study the larger hospital, designated Hospital N, served as the experimental hospital in which the diet was changed, while the control hospital K continued on its normal Finnish diet. In 1965 the diets were crossed over, the previous control hospital K serving from then on as the experimental hospital, and hospital N as the control (Fig. 4).
Before the start of the study the diets in the two hospitals were normal Finnish diets, with large quantities of saturated fats mainly derived from whole milk and butter. The change of the diet aimed to replace the saturated fatty acids as far as possible by polyunsaturated acids. This was achieved by three means—

1. whole milk was replaced by an emulsion of soyabean oil in skim milk,
2. butter was replaced by a soft margarine containing high amounts of poly-thenoid fatty acids derived from unhardened soyabean oil, and,
3. butter and other "hard" fats in food preparation were to a great extent replaced by soyabean oil.

Fig. 5 shows the mean fatty acid composition of the hospital diets during the whole 6-year period. We see that the quantity of polyunsaturated fatty acids in Hospital N is about 3-fold and that of saturated acids only about half as
compared with Hospital K. The amount of total fat was originally somewhat higher in Hospital K and the difference did not change during the experiment. In addition, the amount of dietary cholesterol was about twice as high in Hospital K than in Hospital N.

<table>
<thead>
<tr>
<th>HOSPITAL N</th>
<th>HOSPITAL K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Diet</td>
<td>Normal Diet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fat Energy</th>
<th>31%</th>
<th>36%</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>M</td>
<td>P</td>
</tr>
</tbody>
</table>

Fig. 5. Fatty acid compositions of the diets in the two hospitals (S = saturated, M = monounsaturated, P = polyunsaturated).

An interesting unintentional difference between the hospitals at the beginning and during the whole experiment is the higher consumption of sugar in the control Hospital K, about 100 grams per day as compared with 60 grams per day in Hospital N. Since this difference has continued also after the crossing of the diets we have an interesting situation: during the first six years the higher intake of sugar was combined with high intake of saturated fatty acids and later with high intake of polyunsaturated acids.

The experimental diet caused a lowering of the cholesterol level and the difference between the hospitals remained practically stable throughout the first six years (Fig. 6). The average level after the change of the diet in Hospital N was 217 mg % and in Hospital K 268 mg %. After the crossing of the diets the cholesterol levels also changed, but the difference has not become quite as large as during the first phase of the experiment.
The triglycerides were also lower in the experimental hospital during the first 6-year phase, although the difference was smaller than for cholesterol. However, in contrast to the serum cholesterol, triglyceride values did not change with crossing of diets (Fig. 7). This finding is in agreement with the concept that serum triglyceride is determined more by the dietary carbohydrate than by the dietary fat, and, as I said before, the sugar intake was all the time higher in Hospital K.

It is well known that the fatty acid composition of adipose tissue reflects the fatty acids of the diet over long periods. Studies of the adipose tissue affords thus a useful check on the subjects' adherence to the diet. Therefore, near the end of the first phase of the experiment, samples of subcutaneous fat were taken by the needle biopsy technique from patients, who had been in the hospital at least five years, and then repeatedly after the crossing of the diets. In Hospital N the adipose tissue contained much more polyunsaturated fatty acids, mainly linoleic acid, and less saturated acids (Fig. 8). The changes of the adipose tissue after the crossing of diets is shown in Fig. 9. Here only two fatty acids are included, linoleic and myristic acids, the two with greatest relative difference between the hospitals. It is seen that the crossing of these characteristic acids occurred within a year after the dietary change, and the
curves are then continually diverging. While the serum cholesterol level adjusts to a dietary change within weeks, adjusting of the composition of the adipose tissue thus seems to take years.

The assessment of incidence of coronary heart disease in the two groups studied is the most important aspect of our study. It is also the most difficult one, since no fully satisfactory system for establishing criteria for the diagnosis of coronary heart disease has yet been developed. The use of mental patients as subjects poses special problems. Subjective symptoms cannot be relied upon; e.g. a myocardial infarction may be noticed only if careful attention is paid to the daily spontaneous activity of the patient. Therefore, to achieve standard criteria, the diagnosis of new events was based on an annual electrocardiographic (ECG) examination and mortality alone. All ECGs were read by the same member of our team without knowledge of the hospital where they had been recorded. In the classification of records, the so-called "Minnesota Code" was used, which provides a method for relatively objective classification.

Fig. 7. Mean triglyceride levels of men in the two hospitals.
The incidence of ECG patterns presumably due to coronary heart disease is shown in Table 2. Two criteria having different levels of discriminative power, based on the Minnesota Code are shown. First, Q items and, second, Q, S-T and T items, combined into one category. Furthermore, a system of criteria used by Epstein et al.\textsuperscript{14} is also included at the two levels of discrimination. The results show that the incidence of electrocardiographic patterns presumably due to coronary heart disease was by all these criteria markedly and significantly lower in Hospital N.

When the information from the ECGs is pooled with the coronary mortality figures we get a still better measure for the incidence. Table 3 shows that in the control hospital the incidence was more than twice as high as in the experimental hospital.

Table 4 shows that after the diets had been crossed the incidence of ECG signs of coronary heart disease has also crossed. The number of new cases of coronary heart disease has in the second phase of the study been smaller in the new experimental hospital (K). However, up to now the number of cases has remained so small that the difference between the two hospitals since the crossing has not yet reached statistical significance.
Fig. 9. Changes in linoleic and myristic acid contents of adipose tissue in the two hospitals after the reversal of the diets.
## TABLE 2

Incidence of certain electrocardiogram signs

<table>
<thead>
<tr>
<th>ECG Signs</th>
<th>Patients Initially healthy</th>
<th>Incidence rate per 1000</th>
<th>Significance of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q Changes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital N</td>
<td>282</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hospital K</td>
<td>219</td>
<td>7</td>
<td>7.9</td>
</tr>
<tr>
<td>Q, S-T, T Changes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital N</td>
<td>269</td>
<td>25</td>
<td>22.8</td>
</tr>
<tr>
<td>Hospital K</td>
<td>210</td>
<td>35</td>
<td>43.4</td>
</tr>
<tr>
<td>CHD, &quot;Probable I&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital N</td>
<td>284</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hospital K</td>
<td>218</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>CHD, &quot;Probable&quot; and &quot;Suspect&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital N</td>
<td>270</td>
<td>25</td>
<td>22.7</td>
</tr>
<tr>
<td>Hospital K</td>
<td>209</td>
<td>35</td>
<td>44.0</td>
</tr>
</tbody>
</table>

## TABLE 3

Incidence of coronary heart disease

<table>
<thead>
<tr>
<th></th>
<th>Hospital</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>K</td>
<td></td>
</tr>
<tr>
<td>Patients at risk</td>
<td>313</td>
<td>241</td>
<td></td>
</tr>
<tr>
<td>CHD : ECG or Death</td>
<td>17</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Annual incidence per 1000</td>
<td>14.4</td>
<td>33.0</td>
<td></td>
</tr>
</tbody>
</table>

Significance of Difference:
\[ X^2 = 7.75 \quad P < 0.01 \]


**TABLE 4**

Incidence of electrocardiogram signs of coronary heart disease

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>Rate per 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>K</td>
</tr>
<tr>
<td>1959-65</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>1965-68</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

It can be noticed that our results do not support claims made by some workers that the blood triglyceride level and/or the sugar intake would be essential determinants of the CHD incidence of a population. Although the difference in the sugar intake and the triglyceride level remained in the same direction as before crossing, the incidence of the disease nevertheless changed.

Finally it must be pointed out that our experimental design is not ideal in the respect that the two groups were not drawn from the same population by random allocation. We have tried to assess their comparability considering a number of known risk factors such as age, prevalence of hypertension, smoking habits and the ECG status at entry to the study. The differences seem insufficient to account for the marked difference in the incidence of coronary heart disease. The only significant factor which can explain the lower incidence in the experimental group is the cholesterol-lowering special diet. However, we do not want to draw final conclusions until more data from the second phase of the study become available.

**VETERANS ADMINISTRATION CENTRE STUDY IN LOS ANGELES**

The Los Angeles study was conducted by Dayton and his colleagues and started in 1959. The subjects were volunteers from the domiciliary population, aged 54 years and above, with mean age 65.5 years. The study started with 846 men divided at random into experimental and control groups, quite comparable to each other. The study lasted 8 years during which time about 20% of the subjects withdrew for different reasons.

The experimental diet low in saturated fat and supplemented with unsaturated fat, contained almost four times more polyunsaturated fatty acids and correspondingly less saturated acids (Fig. 10). The cholesterol content was also much lower than that of the control diet. In other respects the diets were very similar.
Dietary Prevention of Coronary Heart Disease

Fig. 10. Major nutrients of control and experimental diets; values shown are mean daily intakes for the individual.

The mean starting level of serum cholesterol was 233 mg % and the mean difference during the study has been about 30 mg % (Fig. 11). At the end of the experiment, the linoleic acid content in the adipose tissue was about three times higher than in the beginning (Fig. 12).

From the published data, it is not possible to calculate the incidence rates of coronary heart disease, but since the groups have been of equal size and since the mean length of experience in both groups presumably has also been the same, the numbers of coronary events are evidently comparable. As is seen from Table 5 there is a difference of about 25% in favour of the experimental group. This difference as such is not significant but if the coronary events are pooled with cerebral infarction, the difference becomes highly significant.

Summarizing the three primary prevention studies of New York, Helsinki and Los Angeles, it can be said that their arrangements as well as results are
Fig. 11. Changes in serum cholesterol level of control and experimental groups. Each point is the mean of all values for the given interval\(^5\).

Fig. 12. Linoleic acid content of subcutaneous tissue in participants on the experimental diet. Subjects were selected for good adherence, defined as 80\% or more of possible meals taken in the dining room. Values at day 0 are mean±S.D. of 120 individual values\(^6\).
Dietary Prevention of Coronary Heart Disease

TABLE 5
Major cardiac and cerebral events

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definite myocardial infarction, overt or silent</td>
<td>44</td>
<td>35</td>
</tr>
<tr>
<td>Sudden death</td>
<td>37</td>
<td>18</td>
</tr>
<tr>
<td>Definite cerebral infarction</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Definite MI—overt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and/or Sudden death</td>
<td>83</td>
<td>52</td>
</tr>
<tr>
<td>and/or Definite cerebral infarction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

in many respects similar. In all these studies the diets were relatively high in fat and the major change made in the experimental groups was to produce a considerable increase of polyunsaturated fatty acids at the expense of saturated acids. This change brought about a remarkable, lasting reduction in the serum cholesterol values and a great change in the adipose tissue towards a higher content of linoleic acid. And, most important, the incidence of coronary heart disease was markedly reduced about 50% in New York and Helsinki and about 25% in Los Angeles, with the older subjects.

SECONDARY PREVENTION STUDIES

The number of secondary prevention studies is greater than that of the primary prevention. I am going to review those where the whole set-up of the study seems to have been most thoroughly planned and the different angles of the work carefully carried out. In the lead of this list are evidently the study of Leren in Oslo and the study conducted by a Research Committee headed by Morris in London.

The material in the Oslo study consisted of 412 males, aged 30-64, survivors of a myocardial infarction. They were allocated at random to the experimental diet group and to the control group, one to two years after their infarction. The groups were strictly comparable except for blood pressure which was slightly higher in the diet group. The experimental diet had 39 per cent calories deriving from fats, which due to the consumption of 75 grams of soyabean oil daily were very unsaturated containing 22 per cent saturated and 53 per cent polyunsaturated fatty acids.
At the start the mean serum cholesterol level in both groups was 296 mg %; in the diet group it decreased in average by 52 mg %, in the control group by 11 mg %.

The number of myocardial reinfarctions was found to be lower in the diet group, the difference becoming statistically significant during the third year of the trial. The number of the acquired angina pectoris was also significantly lower in the diet group, whereas the frequency of sudden deaths was the same in both groups. Subdividing the material into age groups, those below 60 years and those 60 years and older, the difference in the coronary heart disease relapse rate was statistically significant only in the patients below the age of 60.

The London study consisted of 393 male patients aged under 60 years who had recovered from their first myocardial infarction. They were randomly allocated to the experimental group of 199 men and to the control group of 194 men, and the trial lasted from 2 to 7 years. The experimental group had a diet low in saturated fatty acids and containing 85 gram of soybean oil daily, the P/S ratio being about 2 : 1. The diet lowered the serum cholesterol from a mean initial figure of 272 to 233 mg %; the average difference between the control and experimental groups during the year of trial was 33 mg %.

The coronary relapses were less frequent on the test diet but the difference was not statistically significant and it was entirely due to those classified as minor relapses, including acquired angina. The number of major relapses was virtually the same, and there was no difference in the total number of deaths ascribed to coronary heart disease. In summary, the authors state that there is no evidence from the London trial that the relapse-rate in myocardial infarction is materially affected by the unsaturated fat content of the diet used.

Thus there appears to be some disagreement between the results of the Oslo study and the London study. That this disagreement is not very grave is apparent from the London report, which I quote: “Taken together with the results of the Oslo trial there is no indication that this type of diet affects mortality. The combined evidence, however, suggests that a proportion of non-fatal reinfarctions might be prevented, though more evidence is required to confirm this effect, and to make a useful estimate of its size.”

Many other secondary prevention studies have been carried out and in the majority of these the special diet, which may have been simply a low-fat diet or a low-saturated diet with increased quantity of polyunsaturated acids, appears to have reduced the recurrences of coronary events. Bierenbaum et al fed a diet low in total fat but with a high ratio of polyunsaturated to saturated...
fatty acids to a group of young male outpatients with coronary disease for several years. When compared with a corresponding non-dietary-managed control group it was found that reinfarction rate in the dietary group was 62 per cent and mortality rate only 43 per cent of the corresponding figures in the control group.

SUMMARY

In summarizing the studies reviewed it appears that the results of primary prevention studies are in rather good agreement with each other and justify the conclusion that a proper adjustment of the dietary fats has a beneficial effect in the prevention of coronary heart disease. In secondary prevention the picture is not as clear, since in addition to clearly positive results also results showing no significant effect have been obtained. Much laborious and careful research is still needed to get final answers to the many complicated questions involved. Anyway, it is encouraging to realize that a change of the prevalent Western diet seems to be beneficial also in middle-aged subjects in whom considerable atherosclerotic changes are already likely to exist in the arterial system. More effective prevention could probably be achieved if a non-atherogenic diet would be used throughout life. In this respect the Asian countries are, evidently, in a good situation, and one must only hope that they can avoid the deleterious dietary developments so characteristic to the Western welfare states.

REFERENCES


ADDRESS AT THE CLOSING SESSION

PROF. P. N. WAHI

Director-General,
Indian Council of Medical Research,
New Delhi, India.

Mr. President and distinguished delegates,

I feel honoured to have been asked to preside over the closing session of the Congress, and Mr. President I would request you to convey to the Organising Committee my grateful thanks for this fine gesture. During the deliberations it was emphasised by a number of speakers that if nutrition research workers have to deliver the goods in the form of improved standard of health, they have to work hand in hand with administrators and planners. May be that is why I am here.

Two remarks that I heard from some of the participants sum up the general impression (1) that the Congress could serve as a model for similar organisations in future, and (2) academically it was an intellectual feast. To Dr. Gopalan and his untiring team of workers, this should give immense satisfaction. They deserve our sincere appreciation and grateful thanks, and on your behalf and my own behalf I feel happy in conveying to them these feelings of the Congress.

Five hundred and fifty two delegates had registered for the Congress of whom 481 were regular or associate delegates and 61 student delegates.

The following countries were represented:

- Afghanistan
- Burma
- Carribean
- Ceylon
- Egypt
- India
- Indonesia
- Iran
- Israel
- Italy
- Japan
- Lebanon
- Nepal
- New Guinea
- Philippines
- Switzerland
- Thailand
- U.K.
- U.S.A.
- Yugoslavia
As you are aware, ten symposia have been held, 18 special reports have been presented and nearly 80 research communications selected from a very large number of papers submitted were actually presented.

The packed halls which we have witnessed during the sessions should have provided ample proof of the enthusiasm which the scientific programmes of the Congress had generated amongst the participants. These included a very wide spectrum of specialities and disciplines. Thus the delegates have included, planners, policy makers, administrators, nutrition scientists, sociologists, agricultural scientists, medical and public health workers. There was also a happy blend of both basic as well as applied aspects of nutrition, and it goes to the credit of the organisers that the sessions were so arranged as to satisfy the diverse interests of the participants to the maximum extent possible.

The theme of the Congress was “Nutrition and National Development” and in keeping with the theme it was forcefully brought home to us both in the Presidential address by Dr. Gopalan and the Keynote address by Mr. Boerma that the nutritional uplift of a nation was an integral part of its economic development. It was, however, emphasised that the developing countries cannot wait for substantial improvement of their economic standards to take place before undertaking nutrition programmes. Further, it is not certain economic development alone can ensure satisfactory nutrition.

The importance of our ensuring nutrition orientation in our programmes was again a major point made in the special lectures by Mr. Gordon Carter, Chief of the UNICEF Office at New Delhi.

The importance of the Green Revolution and the need for building a nutrition dimension into it were also emphasised. In one of the symposia on the first day we consider the present attempts at agricultural development in Asian countries from the context of nutritional improvement of our people. The present pattern of availability of different nutrients in Asian dietary were discussed in that symposium. The exciting possibilities with regard to the genetic improvement of foodgrains, and the prospects of the production of animal proteins were considered.

The whole question of the organisation of nutrition programmes of school and pre-school children and the Applied Nutrition Programmes in the light of the experiences in different countries formed the subject of another symposium. During the discussions the present bottlenecks in the implementation of nutrition programmes were high-lighted and the possible approaches towards elimination of such bottlenecks were touched upon.
The important question of the population dynamics and its impact on nutritional situation were elaborated both in the opening address as well as in the symposium on "Nutrition and Family Planning". The current attempts to implement family planning programmes among malnourished populations were ably reviewed. Specific studies on the interrelationship between nutrition and the family size were presented. Stabilisation of population growth and augmentation of food production were considered as two important facets which must go hand in hand for the proper economic development in the Asian region. The practical importance of integrating family planning programmes with maternal and child programmes and nutrition programmes was advocated by a number of participants. This would serve as an introduction of the concept of Family Health.

The present pattern of food consumption in Asian countries and the relative importance of nutritional constraints particularly of calories and proteins was the subject matter of another important symposium. The feasibility and scope of improving cereal proteins by agronomic practices was seen in reports on different strains of wheat and rice. The importance of upgrading the quantity and quality of protein in such basic staple foods in most Asian countries was emphasised.

Recent advances in nutrition sciences especially in the field of vitamins and proteins were also discussed in separate symposia. The symposium on "Aspects of vitamin nutrition" dealt with the interesting subjects such as metabolic studies on vitamin A, absorption and metabolism of retinoic acid, studies on folic acid and riboflavin.

The important question of human protein requirements and evaluation of protein quality were discussed and the current gaps in our knowledge were highlighted. It is to be hoped that this will stimulate further research in this important area.

Protein-calorie malnutrition, a favourite subject for research and discussion, and one of the important problems besetting the developing world, formed a full component of another symposium.

The Role of Food Technology and its contribution in combating malnutrition in developing countries were also covered. The effective utilisation of vegetable protein food, and the prevention and control of food losses also received due attention. Two special reports were devoted to the problems of storage of foodgrains and their preservation.
It is clear that the whole subject of malnutrition has to be considered in its socio-cultural context. The ecology of malnutrition, an oft-neglected subject received its due consideration in a special symposium.

It was to be expected that the Asian Congress of Nutrition will devote some time for consideration of "Special Nutrition Problems of Asia", and this it did, in a special symposium. It was obviously not possible to cover the whole range of these problems but some specific disease processes were covered. These disorders still pose many academic considerations and call for practical solutions.

The Special Reports in this Congress covered the proceedings of the Second World Food Congress and some important nutritional Seminars held in this region. Also some problems of practical interest like lactase deficiency, and current nutritional programmes in different Asian countries formed the subjects of special reports.

The Research Communications also included a wide range of topics—both on the basic and applied aspects of nutrition and food technology. It was unfortunate that due to pressure of time we were unable to accommodate all the papers, but the enthusiasm evinced, specially by younger scientists was most encouraging.

Perhaps, the most heartening feature about this Congress was that so many Asian scientists had gathered together to discuss the common problems confronting this region. This Congress has helped thus to forge a common front and it is to be hoped that as a result of this exercise joint collaborative action by Asian nutrition scientists in the field of nutrition will become possible. The nutrition problems which afflict the different Asian countries have so many similarities and there is much to be gained by collaborative action and pooling of our resources. Speaking as the Director-General, Indian Council of Medical Research, I also hope that it will be possible for us to develop collaborative research programmes on common problems of mutual interest.

It was emphasised by the Governor in his inaugural address that we should employ a global strategy in combating malnutrition. I am, therefore, happy that in this Congress, we have had besides Asian scientists a number of top ranking nutrition scientists from different parts of the world. As the Governor emphasised in his opening remarks the Congress is Asian in the sense that the emphasis in the discussions here was on Asian problems and not in the sense that the participation was restricted to Asians alone. We may still have to go a long way before the available material resources of the whole world can
be pooled for the benefit of mankind as a whole. But at least we can hope
that the intellectual resources of the world can be pooled today for fighting
malnutrition. I was very happy indeed to see that this spirit prevailed during
the entire deliberations of the Congress.

I realise that a Congress of this kind would be really meaningful if there
should be a follow-up action. I am sure that you can depend on the President
of this Congress and on the able and dedicated nutrition scientists of Asia to
see that the momentum which has been imparted by this Congress is maintained
in the years to come.

Now that the initiative for collaborative action has at long last been taken,
I hope that we will take every available opportunity to intensify these efforts
for the achievement of the goal, which has been at the forefront of this Congress,
namely, the eradication of malnutrition from this part of the globe and achieve­
ment of positive health for the Asian people.

Ladies and Gentlemen, I crave your indulgence if I have not been able to
present a panoramic view of the Congress at the short time at my disposal.
This was not possible and this was not my intention. To improve the nutritional
standard of our people is our committed goal which would ultimately lead to
desired economic development. Fall in population growth and the rise in
nutritional status of our population alone, cannot, however lead to our desired
economic development, unless accompanied by education, urbanisation,
industrialisation, sanitation and good health. Such a multilateral approach
backed by sound technical development is likely to bring us towards this achieve­
ment. This Congress has very wisely discussed and advocated such an
approach.

I would again thank the participants for attending the Congress. I hope
they found their participation fruitful. We wish you all a safe journey home
with happy memories of this country and this Congress.
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