THE SCIENTIFIC PAPER

How to Prepare It
How to Write It
Copyright 1947

THE WILLIAMS & WILKINS COMPANY

Made in the United States of America

Composed and Printed at the
Waverly Press, Inc.
for
THE WILLIAMS & WILKINS COMPANY
BALTIMORE, MD., U. S. A.
This manual is intended to meet the practical needs of students and research workers who are preparing papers on scientific or technical subjects. The student who is confronted with the arduous task of “writing up” his data will find in this book many suggestions that should not only lighten his work, but enable him to present his material in a more effective way.

Writing is an essential part of the scientist’s profession. The final and in some respects the most important stage in any scientific investigation is the preparation of the results for publication. After a scientific or technical worker has done a good piece of research work, he should present it to his colleagues in the best possible form. Failure to do so, as may be noted in many cases, may largely discount the value of the work itself. The average technical specialist tends to think that his work is done when the research project as such is finished, and to regard the publication as an unnecessary evil and a nuisance. As Charles Darwin expressed it, “A naturalist’s life would be a happy one if he had only to observe and never to write.”

Few people, in fact, like to write. Certainly few are able to write easily, and those who can sit down and dash off a good scientific paper in a few hours are indeed rare. The time factor is far more important than the beginner in science is likely to realize. Most candidates for the doctorate should devote at least three months to the writing of a dissertation running to the usual length of about forty typewritten pages. The scientist is judged solely by the quality of his final product. No one will criticize him for spending many hours on his manuscript.
and carrying it through several revisions to make it as nearly perfect as possible.

Unless research workers are willing to learn to write effectively, each scientific or technical institution may need to have on its staff someone whose duty it is to edit and, if necessary, ghost-write publications on work done in the institution. Few scientists, however, would welcome such a procedure.

It may be true that the average technical specialist is unwilling or unable to write properly. But this does not apply to leaders in science. If the student will survey the history of science, he cannot fail to note a high degree of correlation between ability in writing and achievement in science.

Proficiency in writing—like skill in laboratory manipulations—can be gained through study and practice. This should not be too difficult for the science student, once he realizes that with practice, and constant effort toward improvement, he can achieve success.

Every student who is preparing for work in science should realize as early as possible that such training is a highly important part of his education. In recording the results of laboratory experiments, the student has abundant opportunity for acquiring this skill. He should learn to write as accurately, clearly, and concisely as possible. To make rapid improvement, he should apply the knowledge he has gained in the study of English composition and should frequently consult a handbook that deals specifically with scientific writing. The benefit derived from this work will be increased if each report is carefully revised before it is submitted in its final form. No single factor is more important than daily practice. Translating from a foreign language and reading good books, slowly, are also helpful.
Several meetings of the departmental seminar for graduate students might profitably be devoted to a discussion of the preparation of scientific results for publication. Each member of the group could report on a phase of the subject in which he is especially interested or competent. To emphasize the points discussed, the reports should be illustrated with examples of good and of poor work selected from the current literature of the science. Techniques used in preparing graphs, drawings, and photographs could be demonstrated by members of the group or by other persons who have acquired skill in these arts. Visits to a printing plant and a photoengraver's shop, which may be arranged for a small party in nearly any city, would give the group first-hand information on the final steps in the production of printed matter.

The present guide to the preparation and writing of scientific papers should be a convenient aid to students and others engaged in scientific work. This manual is the result of a process of development and adaptation. Some of the suggestions and directions that it contains were originally prepared to aid students in writing theses at the College of Agriculture of the University of the Philippines. After the suggestions had been tested in mimeographed form, they were first published as a pamphlet that was adopted as the guide for College publications and was used as a supplementary textbook in the English courses. The earlier text, published under the title *Preparation of Scientific and Technical Papers*, has been thoroughly revised and largely rewritten. It is hoped that the handbook, in its new form, may continue to be of service to students in colleges and universities.

Although, in the main, the directions given in this manual are for the preparation of a thesis, or dissertation, they apply also to the writing of other types of
papers in science, agriculture, engineering, and medicine, and to the preparing of manuscripts of a more popular nature on scientific or technical subjects.

Many of the rules given in this book are based upon recognized authorities, listed in the bibliography at the end of the volume. Experience in reading students' manuscripts and journal copy has been the guide in selecting the rules and in making the suggestions. Some of the directions are given to secure uniformity. Two or more ways may be approved by usage, but it is convenient to adopt one form.

No attempt has been made to include rules of grammar and rhetoric, though a few are mentioned as reminders. These subjects are treated in so many handbooks and textbooks of English composition that their inclusion here would be superfluous. It is taken for granted that the student will have on his desk a good handbook of composition (Woolley, Scott, and Berdahl's *College Handbook of Composition* or Greever and Jones's *The Century Handbook of Writing*), a dictionary of synonyms (Soule's *Dictionary of English Synonyms*, Webster's *Dictionary of Synonyms*, or Roget's *Thesaurus*), and an authoritative dictionary (a large abridgment, at least, of *Webster's New International Dictionary*). A copy of *The Concise Oxford Dictionary* is also helpful because it gives many examples of the correct use of words and phrases.

In general, the style herein suggested conforms to that of the Waverly Press, a printing house that has developed a high standard in scientific and technical publications.

I am indebted to Professor Ronald A. Fisher and Messrs. Oliver & Boyd Limited, Edinburgh, for permission to reprint table IV from their book *Statistical Methods for Research Workers*. 
Valuable suggestions and help have come from Miss Estelle Brodman, Prof. Frederick E. Croxton, Dr. F. E. Denny, Dr. Gordon S. Fulcher, Miss Amy L. Hepburn, Prof. Burton E. Livingston, Miss Sally MacDonald, Mr. John W. McFarlane, Prof. Edwin B. Matzke, Prof. Francis J. Ryan, Miss Margaret C. Shields, and Dr. Morris Winokur. Special thanks are due Helen M. Trelease for advice and help during the revision of the book.

New York,

February, 1947.
## CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>v</td>
</tr>
<tr>
<td>Criteria for choosing a research problem</td>
<td>1</td>
</tr>
<tr>
<td>First steps in treating scientific data</td>
<td>2</td>
</tr>
<tr>
<td>Outline of a scientific paper</td>
<td>4</td>
</tr>
<tr>
<td>Writing the paper</td>
<td>7</td>
</tr>
<tr>
<td>Suggestions on subject matter and arrangement</td>
<td>8</td>
</tr>
<tr>
<td>General</td>
<td>8</td>
</tr>
<tr>
<td>Title</td>
<td>11</td>
</tr>
<tr>
<td>Introduction</td>
<td>11</td>
</tr>
<tr>
<td>Discussion of results</td>
<td>12</td>
</tr>
<tr>
<td>Abstract or summary</td>
<td>14</td>
</tr>
<tr>
<td>Logical presentation of ideas</td>
<td>15</td>
</tr>
<tr>
<td>Making the paper interesting</td>
<td>18</td>
</tr>
<tr>
<td>Use of tenses</td>
<td>20</td>
</tr>
<tr>
<td>Punctuation</td>
<td>21</td>
</tr>
<tr>
<td>Revision of the manuscript</td>
<td>22</td>
</tr>
<tr>
<td>Preparation of the typewritten copy</td>
<td>26</td>
</tr>
<tr>
<td>Correcting the typewritten copy</td>
<td>29</td>
</tr>
<tr>
<td>Estimating the length of the printed article</td>
<td>34</td>
</tr>
<tr>
<td>Kinds of type and their indication in the manuscript</td>
<td>36</td>
</tr>
<tr>
<td>Capitals</td>
<td>38</td>
</tr>
<tr>
<td>Italics</td>
<td>40</td>
</tr>
<tr>
<td>Numbers</td>
<td>42</td>
</tr>
<tr>
<td>Reliability and significance of measurements</td>
<td>46</td>
</tr>
<tr>
<td>Abbreviation of units of weight and measure</td>
<td>50</td>
</tr>
<tr>
<td>Names of plants and animals</td>
<td>56</td>
</tr>
<tr>
<td>Tables</td>
<td>58</td>
</tr>
<tr>
<td>Footnotes</td>
<td>66</td>
</tr>
<tr>
<td>Use of the library for research purposes</td>
<td>67</td>
</tr>
<tr>
<td>Indexing and abstracting tools</td>
<td>74</td>
</tr>
<tr>
<td>Literature citations</td>
<td>84</td>
</tr>
<tr>
<td>First method</td>
<td>86</td>
</tr>
<tr>
<td>Second method</td>
<td>89</td>
</tr>
<tr>
<td>Abbreviations of periodical publications</td>
<td>91</td>
</tr>
<tr>
<td>Abstracts and quotations</td>
<td>97</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>99</td>
</tr>
<tr>
<td>Preparation of an analytical table of contents</td>
<td>100</td>
</tr>
</tbody>
</table>
CONTENTS

Headings in the text of a paper............................................. 101
Illustrations................................................................. 103
  Correct proportions...................................................... 103
  Drawings........................................................................ 106
  Drawings from photographs............................................ 110
  Graphs........................................................................... 111
  Photographs................................................................. 124
  Lantern slides.............................................................. 132
  Preparation of illustration copy................................... 133
  Shipping illustrations.................................................... 135
Prepublication review and revision.................................... 135
Proofreading....................................................................... 137
Bibliography...................................................................... 142
Index................................................................................. 145
CRITERIA FOR CHOOSING A RESEARCH PROBLEM

In choosing a research problem, special knowledge of a particular field of science is indispensable. The selection of a problem requires study, thought, and planning—guided by all the imagination, originality, and critical judgment at the command of the investigator.

Many scientists find it helpful to accumulate a list, in the form of a card index, of promising research problems from which selection may be made. It is advantageous to make a preliminary analysis of each subject, indicating briefly the object, scope, general plan of investigation, and probable nature of the results that might be obtained.

The criteria given below should be useful in stimulating search and thought during the preliminary survey of possible research problems in an experimental phase of science. Although the criteria are purposely stated in the form of brief rules, it will be understood that they are to be regarded merely as hints or suggestions, which, though helpful in many cases, are obviously not universally applicable.

1. The problem should deal, usually in a quantitative way, with the relations between natural phenomena—or, more specifically, with the causal conditions that control observable facts or events.

2. It should be circumscribed, definite, and specific, but should preferably lead far into the literature.

3. It should be capable of statement in the form of several hypotheses, each of which may be tested in order.

4. It should be capable of experimental treatment with

---

1 Dr. Burton E. Livingston has helped in the preparation of this section.
the knowledge and facilities available, and it should give promise of yielding definite results within the allotted time.

5. It should have as its primary object the obtaining of new information in a specific field, preferably one possessing importance to the science as a whole.

6. It should give promise of leading to other interesting and important problems, and prepare the investigator for handling them.

7. It may test some proposition about which there is difference of opinion, or one that has secured acceptance upon logically insufficient grounds.

8. It should preferably deal with some relatively little-known principle, rather than with one that is better known and more thoroughly analyzed.

9. It may well treat some phase of the subject that has been relatively neglected.

10. It should deal with materials well adapted to the proposed experimentation, preference perhaps being given to those widely known or economically important.

FIRST STEPS IN TREATING SCIENTIFIC DATA

1. Tables. Check all calculations, and put experimental data in the form of tables. (See section on "Tables," page 58.) Make all calculations twice, preferably on different days, and, if practicable, by different methods. The second calculation should be made without reference to the first, and on a new page in your notebook. Notes on observational and descriptive work should be arranged and classified.

2. Graphs. Plot your data wherever possible. (See section on "Graphs," page 111). In most experimenta-
3. Conclusions. Examine the tables, graphs, and classified notes for conclusions and relations. Ask yourself, "What are the possible explanations of the facts?" If several explanations seem equally probable, do not emphasize only one. Consider all logical possibilities. Make written notes of tentative conclusions. If time is available, verify your conclusions by gathering more data or by making special test experiments; confirm your conclusions, if possible, by evidence from sources that are entirely different in character. Estimate the probable accuracy of your results by considering the sources of error. Conclusions from your results must be based upon a careful consideration of their accuracy and sufficiency. If you have enough data, use statistical methods to estimate their probable significance. (See section on "Reliability and Significance of Measurements," page 46.)

4. Revision of conclusions. Refer again to your data to see whether your tentative conclusions are actually justified. Discover in which cases these conclusions apply and in which, if any, they do not. Modify, if necessary, the statement of your conclusions, and see whether they are consistent with established facts or principles pertaining to the subject.

5. Exceptions. Examine the data for exceptions, inconsistencies, discrepancies, and anomalies. Record the exceptions, and check their values. Some of the most important scientific discoveries have resulted from apparent exceptions and abnormalities in data.

Formulate possible explanations for the exceptions. Study your conclusions again to see how the exceptions modify them.
6. \textit{Written notes.} It is advisable to record on paper all the ideas that occur to you. The mechanical process of preparing a paper is a matter of mere detail, subject to endless variation. Some writers like to use a standard size of cards (5 by 8 inches) for all preliminary work on a paper. The cards may be filed in a box, under appropriate headings. Only one topic is put on a card, and this topic is expanded later to make a paragraph. This method allows topics to be added, eliminated, and rearranged whenever necessary. Other writers prefer to use sheets of paper of standard size (8 1/2 by 11 inches), putting only one topic on a sheet and filing the sheets in folders, large envelopes, or loose-leaf notebooks. (Original observations and measurements are usually recorded in a notebook with permanent pages. A copy should be put in a safe place as soon as possible.)

OUTLINE OF A SCIENTIFIC PAPER

1. \textit{Nature of scientific writing.} A paper on a scientific or technical subject necessarily consists of (a) a report of facts, (b) an interpretation of facts, or (c) a combination of a report and an interpretation. The method of writing is governed by many conditions, including the nature of the subject, the purpose of the article, the characteristics of the writer, and the interests of the probable readers. Obviously, no set method or arrangement will be suited to all kinds of papers.

It is important that the plan of the composition be made very clear to the reader. The main topics and their subdivisions should be plainly indicated. In this respect scientific writing differs from literary composition. A scientific paper is intended to be studied and used as a reference; it is not merely to be read. Hence,
literary devices should be subordinated if they interfere with clearness. The plan should be self-evident throughout the composition.

2. General outline. The outline given below suggests a form that may be used for a wide variety of scientific papers. An examination of the papers published in scientific journals will show that the majority of them have this general arrangement and sequence of topics. This form of outline is suitable for most scientific papers that report investigations or experiments, and possesses the additional advantage of being familiar to the reader. The outline should be modified sufficiently to adapt it to the special requirements of the article that is to be written.

*General outline of a scientific paper*

**Title.** The title should consist preferably of few words, indicative of the contents that are most emphasized. Great care must be exercised to employ words that contain the elements both of brevity and comprehensiveness and permit of easy and accurate indexing.

**Abstract.** The abstract is a brief condensation of the whole paper.

**I. Introduction.**

A. Nature of the problem; its state at the beginning of the investigation.

B. Purpose, scope, and method of the investigation.

C. Most significant outcome of the investigation; the state of the problem at the end of the investigation.

**II. Materials and methods.**

A. Description of the equipment and materials employed.

B. Explanation of the way in which the work was
done. (Give sufficient detail to enable a competent worker to repeat your experiments. Emphasize the features that are new.)

III. Experiments and results.
   A. Description of the experiments.
   B. Description of the results. (If possible, these should be shown in tables and graphs.)

IV. Discussion of results.
   A. Main principles, causal relations, or generalizations that are shown by the results. (Choose one or several main conclusions which your evidence tends to prove.)
   B. Evidence (as shown by the data) for each of the main conclusions.
   C. Exceptions and opposing theories, and explanations of these.
   D. Comparison of your results and interpretations with those of other workers.

Outline of a paper that includes several series of experiments which it is advantageous to present separately

TITLE.
ABSTRACT.
I. General introduction.
II. General materials and methods.
III. Descriptive title of first series of experiments.
   A. Introduction.
   B. Materials and methods.
   C. Experiments and results.
   D. Discussion of results.
IV. Descriptive title of second series of experiments.
   A. Introduction.
   B. Materials and methods.
C. Experiments and results.
D. Discussion of results.

V. Descriptive title of third series of experiments.
   A. Introduction.
   B. Materials and methods.
   C. Experiments and results.
   D. Discussion of results.

VI. General discussion.

Outline of an engineering report

TITLE.

ABSTRACT. Condensed account of object of work, significant results, general conclusions, and specific recommendations.

I. Introduction. Definition of problem, object of investigation.

II. Apparatus and materials.


IV. Results. Tabulations, graphs, and description.

V. Discussion of results. Explanation and significance of results, together with evidence shown by data.

VI. Appendices. Calculations, technical data.

WRITING THE PAPER

1. Mechanical process. There probably is no best way to prepare a scientific paper, except as may be determined by the individual writer and the circumstances. With no notes at all, one might be able to start writing an article which, short or long, would be practically finished at every stage; or one might accumulate the facts in a great mass of verbiage, and then compress the paper to the required limit. It is the end product that counts, not the intermediate steps.
2. **Preliminary outline.** Most writers obtain best results by developing a preliminary outline before they start writing. The following steps may be employed:

(a) Prepare a brief outline of the topics to be treated in your article. This outline may be on a single sheet of paper.

(b) Make a second, enlarged outline showing an analysis, by headings and subheadings, of the article. This may be three or four times as long as the first.

(c) Prepare a third outline before beginning the actual writing. In this outline the topics should be shifted to the most effective order, and each topic should be enlarged and preferably expressed in the form of a concise topic sentence.

(d) Begin the actual writing. Spread out before you the outline, the tables, and the graphs. Expand each topic or topic sentence of the outline into a paragraph. Make a rough draft first. Concentrate on the subject matter, and write as rapidly as possible, without letting details of language interrupt the flow of ideas. Then, on another day, examine critically what you have written and begin to revise it. (See section on “Revision,” page 22.)

**SUGGESTIONS ON SUBJECT MATTER AND ARRANGEMENT**

**GENERAL**

1. *Unity.* A scientific paper should be a unit, treating a single definite subject; it may contain several main topics if these are logical divisions of one large subject. Make a careful selection of materials. Include only what is necessary to an understanding of the main ideas, but omit nothing that is essential.
Each paragraph should have unity. It may well begin with a topic sentence that indicates the idea to be developed in the paragraph. The use of topic sentences aids the writer in transforming his preliminary outline into paragraphs, and it helps the reader who looks through the paper for its salient contents.

2. Orderly arrangement of topics. Choose a logical sequence of topics, based upon a careful analysis of the subject matter. The order may be determined by relations of space, time, importance, similarity or contrast, complexity, or cause and effect. Use an order that serves best the needs of clearness, coherence, and emphasis. Discuss similar points in the same order, and use similar forms of expression. Indicate clearly the beginning of each new topic.

3. Development. Develop the main ideas until they are clear enough to be easily understood by the reader. For the sake of brevity in publication, it is usually necessary to address the paper to specialists in the particular field, rather than to the general reader. Use the style of the textbook—not that of the laboratory notebook. Present the material in a manner that will enable the reader to grasp it as quickly and easily as possible. Explain each topic clearly, point by point. Define, explain, illustrate, prove, and summarize your statements, if necessary. Give considerable thought to the relative importance of the various topics and their need of development. Treat briefly those topics that are too simple to require detailed explanation. Develop fully the more complex and the more important topics. Achieve completeness and clarity without sacrificing conciseness.

4. Examples. Illustrate the meaning of general or abstract statements by giving examples, particular instances, concrete data, amplifying details, or specific comparisons.
5. **Answers to reader's questions.** Consider what questions the reader will wish answered in your article. Always keep in mind the fact that the primary purpose of your paper should be to give the reader valuable information and new ideas.

6. **Topics of general interest.** Develop fully the topics that are of interest to many readers.

7. **Words.** Employ words that are approved by good usage. Be careful to avoid those that are obscure, ambiguous, or inappropriate. Consult *Soule's Dictionary of English Synonyms* or *Webster's Dictionary of Synonyms* when at a loss for the word or expression that most precisely fits your thought, and turn to *The Concise Oxford Dictionary* when in doubt regarding the idiomatic use of common words. With a large vocabulary at your command, one word may take the place of several in making your meaning clear. Try to use words that a foreigner will be able to find in a small dictionary. (For example, a foreigner might not be able to find the meaning of the word "tumbler," but he would understand if you described it as a "cylindrical glass vessel, 7 cm. in diameter and 10 cm. deep.")

Define all technical terms that the reader might not understand.

8. **Tone.** Skill may be developed in presenting material in a tactful way. Clear statements supported by evidence are better than positive assertions. Avoid pedantic or pompous language. Be careful also not to announce a well-known fact as if it were a discovery. Indicate clearly which of your results and conclusions are new. For completeness of discussion, it is often necessary to mention to the reader many things that he already knows; but this may be done skillfully, without annoying or confusing him.
TITLE

1. Choice of title. Choose a concise descriptive title, complete enough to include the main topics needed for making a subject index in an abstract journal. Select these topics with the aim of giving definite ideas as to the exact contents of your paper. In a biological study, it is desirable to give the name of the organism in the title. If necessary, sacrifice brevity in order to include all important nouns under which your paper should be indexed. Place the more important words near the beginning of the title.

2. Selection of topics. Ask yourself, "Under what topics would I naturally look in a subject index of an abstract journal if I were searching for the literature on the subjects treated in my paper?" The answer to this question will provide the topics for your title.

INTRODUCTION

1. Content. The function of the introduction is to make clear the subject of the article. The introduction should state the problem, describe its condition at the beginning of the study, and tell the reasons for investigating it. It should give the purpose, scope, and general method of the investigation.

Finally, the introduction should state clearly and definitely the most significant result of the investigation. With the main conclusion before him at the start, the reader is able, as he goes through the paper, to judge the development of evidence and inference brought forward in its support. If, on the other hand, the statement of the main point is deferred until late in the paper, the reader is unable to distinguish essential from non-essential evidence and may overlook or forget important features.
2. Pertinent literature. Cite in the introduction only those literature references that bear directly upon the introduction itself. The other references to the literature should be included in the parts of the paper to which they are most pertinent, chiefly the discussion of results.

The foregoing procedure is now favored by most writers. To be sure, a long historical review—often arranged merely chronologically—was at one time considered to be an essential part of the introduction. But the reader generally finds such a review dull, since he is not prepared so early in the paper to correlate past investigations with the specific problem in hand. The place for most of the literature references is in the discussion of results, where the new results and interpretations are compared with those of previous investigators.

DISCUSSION OF RESULTS

1. Interpretation. Show the meaning of the observed facts, their interrelations, their underlying causes, their effects, and their theoretical implications. Aim, where possible, to explain facts in the symbols or language of mathematics, and according to the laws of physics and chemistry.

2. Reference to tables and graphs. Keep the text free from mere repetition of the detailed data presented in the tables and graphs. Such repetition, except when necessary to show comparisons not obvious in the tables and graphs, confuses the text and makes dull reading. As far as possible, the text should be reserved for comparisons, relations, conclusions, and generalizations.

3. Unsettled points. Give particular attention to evidence that bears on points concerning which there is difference of opinion among scientists. But avoid personal or controversial language, or expressions likely to
excite controversy or retort. Above all, do not impugn the motives of others; motives are irrelevant.

4. Emphasis of general conclusions. Indicate the ways in which the results of your study are related to the science as a whole. Emphasize the additions that it makes, and stress conclusions that modify in a significant way any hypothesis, theory, or principle that has secured general acceptance. Develop with special clearness observations or inferences that seem to be of sufficient importance to deserve mention in a textbook on the subject.

5. Qualification of conclusions. To prevent misunderstanding, it is necessary to define as clearly as possible the precise conditions to which your conclusions apply. A conclusion should always be stated in such a way as to indicate its range of validity.

Confusion often results from failure to define adequately all influential experimental details. In any experiment or series of experiments the influential conditions may be analyzed conveniently into two groups: (1) those representing the variables specially studied, and (2) those representing the rest of the experimental complex—the influential background or prevailing conditions. The conditions of the first group are assumed to be adequately known and controlled; they are the conditions that are purposely made to differ in certain known ways. For an ideal experiment or experiment series, the conditions of the second group should be as thoroughly known and definitely described as are the primary variables; they should be maintained constant or at least not permitted to vary sufficiently to interfere with the influence of the primary variables.

6. Applications. Indicate the practical applications of your study to agriculture, industry, engineering, medicine, etc.
7. Stimulation. Try to stimulate the reader to further thought and research on the subject of your investigation.

ABSTRACT OR SUMMARY

1. Position and designation. Two practices are followed in the various journals: (a) One is to print an abstract (often in distinctive type and without heading) at the beginning of the article, just below the title, where it is most convenient for readers. The modern trend in scientific and technical journals is toward the adoption of this method. (b) The other procedure is to print a summary (under this heading) at the end of the article. This abridgment should be the same in content, whether it is designated as an abstract or as a summary.

2. Purpose. In preparing a title and abstract for an article, it is important to realize that the individual worker glances at many more articles than he has time to read. A title is necessarily short but should be as informative as possible. In cases where the worker is uncertain from the title alone whether the article contains material of interest to him, the abstract is there to help him by telling him more precisely what the article covers. Also in cases where he is interested only in the main results and conclusions, the abstract gives him this information in brief form and saves him the difficulty of reading the article.

The abstract fills a gap between the title, which may average only about ten words, and the article, which may be ten pages long. It is useful to readers who wish more information than is given by the title and less information than is given by the article. Its purpose, then, is to assist readers (a) by elaborating the title and (b) by condensing the article, thus saving the time of readers who do not require the full contents of the paper. Incidentally, if the abstract is well prepared by the author, it will be suitable for reprinting in an abstract journal.
3. *Nature.* To serve its purpose, the abstract should indicate clearly all the subjects dealt with in the article, so that no reader interested in only one of these subjects will fail to have his attention directed to it. The abstract should also summarize briefly but clearly the principal new results and conclusions, especially all new information likely to be of interest to readers who are not specialists in the field. The abstract should be well written, so as to be easily read and understood, and should be self-explanatory, complete and clear in itself.

4. *Preparation.* Keeping in view the dual purpose of the abstract, the writer should read his manuscript carefully, making notes (a) as to the subjects dealt with, particularly subjects concerning which new information is given incidentally, and (b) as to the new results and conclusions reported. Material relating to each subject should then be gathered together; sentences summarizing the material should be written; and finally these sentences should be put together so as to make a well-written abstract—brief, condensed, complete, yet readable.

5. *Models.* It will be useful to study as models the abstracts given in abstract journals and to try to make abstracts which would be acceptable to such journals.

**LOGICAL PRESENTATION OF IDEAS**

Many of the mistakes in scientific papers involve errors in logic. Their avoidance depends chiefly upon a thorough understanding and careful analysis of the ideas that are presented. The following rules apply to some of the most obvious, and yet commonest, mistakes of this type.

"However skeptical one may be of the attainment of universal truths, one can never deny that philosophic study means the habit of always seeing an alternative, of not taking the usual for granted, of making conventionalities fluid again, of imagining foreign states of mind. In a word, it means the possession of mental perspective."—William James.
1. *Requisites of a good hypothesis.* Is it new? Is it worthy of consideration? (a) Do not present as new a hypothesis that really is old. But defective hypotheses may be improved, and presented as modified hypotheses. (b) The hypothesis should give promise of explaining facts or relations that have not hitherto been explained. (c) The hypothesis should be consistent with itself and with well-established facts and principles. (d) Do not stress one hypothesis when another, or others, would fit the facts equally well. Employ the method of multiple working hypotheses. (e) Do not give a complex hypothesis when a simpler one would fit the facts equally well. (f) It is rarely useful to propose a hypothesis that cannot be tested or verified. (g) The hypothesis should aid the prediction of new facts or relations.

2. *Illusions.* (a) Be careful not to draw conclusions from data involving errors of observation, errors in arithmetic, compensating errors, systematic and personal errors. (b) Do not use mathematical formulae without clearly understanding their derivation and all the assumptions involved. (c) Be cautious in comparing conclusions based upon experiments in which the influential conditions have been improperly controlled, and therefore not duplicated. (d) Guard against drawing an illogical conclusion. (e) Avoid confusing facts with opinions or inferences, not only in the investigation itself but also in preparing results for publication.

3. *Too broad generalization.* (a) Do not draw a conclusion from too few data, nor too broad a conclusion from a limited series of data. (b) Be careful in drawing conclusions that are based on extrapolated curves. (c) Guard against failing to qualify a conclusion, so as to show the limits within which it applies, or the variation which is to be expected. (d) When you indulge in speculation,
be sure that you, and your reader, know that it is speculation.

4. False relation between cause and effect. (a) Do not infer merely because one thing has followed another that it is the effect of the other. (b) Do not argue that causes are the same because identical or indistinguishable effects have been observed. A certain phenomenon may have one cause in one case and another cause in a second case. (c) Be careful in making inferences by analogy. If two cases resemble each other in certain particulars, it is not safe to infer resemblance in another particular that has been observed in only one of them. (d) If two processes have the same mathematical expression (or yield the same sort of graph when plotted), it does not necessarily follow that the processes themselves are essentially alike.

5. Prejudice. (a) An attitude of intellectual honesty and devotion to truth is the foundation of scientific work. (b) Guard against prejudice; do not be influenced by preconceived opinions. (c) Do not decline to admit evidence because it necessitates an unwelcome conclusion. If a conclusion is unwelcome, it is a sign of a wrong mental attitude. (d) Biting, caustic comments are almost sure to be regretted later, and they invariably weaken the effect of one's arguments.

6. Ambiguity of terms. (a) Guard against misunderstandings of language. (b) Define terms as clearly and precisely as possible. Do not use technical terms, especially in a field not strictly your own, unless you are certain of their precise meaning, or unless their use has been checked by a specialist in the field. (c) Do not use a term in one sense in one part of your reasoning and in another sense in another part. (d) Do not mistake a general for a specific use of a term. (e) Be very critical of statements containing the words cause, determine,
control, influence, result, effect. Distinguish carefully between such words as force, agency, process.

7. Missing the point. (a) Do not ignore the question, evade the issue, or argue beside the point. Define clearly the points at issue. Try to determine the crucial point that will really decide the discussion. (b) Guard against reasoning that may correctly prove something but not the thing which you think it proves.

8. Begging the question. (a) Do not base a conclusion on an unproved proposition. (b) Avoid arguing in a circle—drawing a conclusion that merely states the assumptions in other words. (c) Do not assume the truth of a proposition that is not proved and may be false. (d) Do not assume that a certain thing is true because a prominent authority has said it is true. (e) Do not assume that a proposition is untrue because you are able to disprove the arguments that have been used to support it; there may be other, valid arguments that make it true.

MAKING THE PAPER INTERESTING

A mastery of the devices for attracting and holding the interest of the reader must be acquired by the writer of articles of a popular nature. These methods should of course be used cautiously by the writer whose purpose is to inform, rather than entertain, his fellow-workers in science. Rather let your style be characterized by unobtrusive simplicity than by inappropriate and labored ornamentation. Content is more important than style. The author should be more interested in the thing he is describing than in the words with which he describes it. Nevertheless, judicious use of some of the devices of the journalist may serve, without breach of propriety, to
give a scientific paper an attractive and interesting style. These devices include:

1. Beginning with a broad introduction that gives the reader the information necessary for an understanding and appreciation of the subject. Referring to the ways in which your subject may be related to the reader's previous knowledge or experience, and suggesting benefits to be derived from further information on the subject. Emphasizing the economic or practical importance of the subject.

2. Making the paper as easy as possible for the reader to comprehend.

3. Using photographs, drawings, charts, diagrams, and curves.

4. Linking each part of the paper with some preceding part by transitional words, phrases, or sentences, so as to make a continuous story—thus sustaining the reader's interest.

5. Omitting tedious details that are not essential for accuracy and completeness; keeping the text free from repetition of data presented in tables and graphs.

6. Emphasizing the new and the unusual—the features that have "news value."

7. Preceding every dull passage by a stimulating introduction.

8. Using colorful words and vigorous turns of expression.

9. Using forcible analogies, comparisons or resemblances, similes and metaphors.

10. Introducing striking or unexpected statements, contrasts, and paradoxes.

11. Asking provocative questions.

12. Leading the reader to feel that he is doing his own thinking—not merely following; stimulating his imagination and giving him a sense of achievement.
USE OF TENSES

1. Experimental facts. The experimental facts should be given in the past tense. (For example: The plants grew better in A than in B; the dry weight was greater in A than in B.)

2. Presentation. The remarks about the presentation of data should be mainly in the present tense. (For example: Diagrams showing yields are shown in figure 3. The second column of table 2 represents the dry weight of tops.)

3. Discussions of results. Discussions of results may be in both the past and present tenses, swinging back and forth from the experimental facts to the presentation. (For example: The highest dry weight is shown for culture A, which received the greatest amount of the ammonium salt. This may mean that the amount of nitrogen added was the determining condition for these experiments.)

4. Specific conclusions. Specific conclusions and deductions should be stated in the past tense, because this always emphasizes the special conditions of the particular experiments and avoids confusing special conclusions with general ones. (For example: Rice grew better, under the other conditions of these tests, when ammonium sulphate was added to the soil. Do not say: Rice grows better when ammonium sulphate is added to the soil.)

5. General truths. When a general truth is mentioned, it should, of course, be stated in the present tense. Logically, a general truth is without time distinction. For example, one may say, "Many years ago, scientists were convinced that malaria is caused by a germ carried by a certain species of mosquito." General conclusions, well-established principles of mathematics, physics, and chemistry, should be put in the present tense.
PUNCTUATION

Punctuation should follow current usage and should be uniform throughout an article. It is better to learn to apply a few simple rules than to puzzle over each case as a separate problem. The following general rules are among those most frequently applied.  

1. Coördinate statements. Put a comma before a complete statement introduced by and, but, for, or, nor, or neither. A semicolon or a period should be used if the statements are long or complicated.

2. Statements introduced by conjunctive adverbs. Put a period or a semicolon—never a comma—before a complete statement introduced by however, yet, still, nevertheless, therefore, so, hence, moreover, further, accordingly, besides, also, thus, then, indeed, otherwise.

3. Series of coördinate elements. A comma should precede and in a series of coördinate elements such as a, b, and c, in which the elements may be words or phrases.

4. Adverbial clauses. When an adverbial clause precedes its principal clause, separate the two clauses by a comma. But a comma is usually unnecessary when the adverbial clause follows. Adverbial clauses are introduced by when, after, while, if, although, since, because, unless, etc.

5. Relative clauses. A non-restrictive relative clause, which is merely explanatory of an antecedent, should be set off by commas. A restrictive relative clause (omission of which would change the meaning of the sentence) should not be set off by commas. Relative clauses are

*Also consult one of the handbooks of composition, such as Woolley, Scott, and Berdahl's *College Handbook of Composition* or *The Century Handbook of Writing*. A complete system of punctuation, which editors find extremely helpful, is contained in Woolley's *The Mechanics of Writing*. 
generally introduced by *that, which, who,* or *whose.* Similar rules apply to phrases.

6. *Erroneous junction.* Use a comma to separate two parts of a sentence that might be erroneously joined in reading.

7. *Interpolated elements.* Set off with commas, dashes, or parentheses an interpolated element that would make the meaning of the sentence obscure if no punctuation were used.

**REVISION OF THE MANUSCRIPT**

After writing the first draft of your paper, begin to revise it. Revise several times, having one principal object in mind each time. Learn to rewrite between the lines. In making corrections, insertions, and transpositions, follow the methods given on pages 30 to 33. If there is not enough space between the lines for a revision, a convenient method is to write the revised passage on a slip of paper of page width and to staple this to the margin of the manuscript page. The pages need not be copied until they have become crowded with corrections.

1. *Organization and consistency.* In the first revision, give attention to the order and development of the larger divisions of the paper—the sections and paragraphs. The order of the topics may need to be shifted, though this should not be necessary if a well-prepared analytical outline has been followed. If the paper is long, the first part may have to be rewritten to make it consistent with the last part. Irrelevant parts should be eliminated. Important parts may be expanded, and minor parts subordinated.

2. *Sentences.* In the next revision of the rough draft of the manuscript, focus attention on the sentences.
Many of these may need to be revised, because they may have been written hurriedly, without much concern about details of form. Study and revise the sentences in groups, rather than singly. Make each group of sentences develop the exact ideas you wish to express. See that the members of the group stand in logical relationship to one another. Achieve good organization of sentences through careful revision.

The following brief rules suggest helpful procedures:
(a) Use short sentences—rarely allowing them to exceed thirty words in length. (b) Choose sentence structures that require only simple punctuation. (c) Prefer the normal order of subject, verb, and object. (d) Prefer the active voice of verbs. (e) Keep the same subject and the same voice, and use parallel structure. (f) Transpose misplaced words or phrases. (g) Insert connectives and other reference words to show relationships. (h) Correct weak or vague reference of pronouns to their antecedents. (i) When advantageous, convert a loose compound sentence into a complex sentence, with a subordinate clause.

3. Clearness. Revise sentences and paragraphs with special attention to clearness. There should be only one possible meaning, and this should be easily understood by the reader. Find the right word or phrase to convey your idea.

4. Conciseness. As a rule, the first draft of a paper should be longer and more complete than the copy that will be offered for publication. Better results are usually obtained by condensing a long paper than by expanding a short one. In shortening a paper, condense or eliminate the parts that are least needed for clearness of presentation. Strike out idle words (especially superfluous adjectives and adverbs); replace a phrase with a word; combine related sentences; eliminate repetition of an idea. Omit
the obvious and the least important. Retain the essentials. Impartial counsel is valuable in aiding you to decide what is essential. In judging, put yourself in the place of the reader. It takes moral strength to "blue pencil" choice phrases, sentences, or paragraphs. But the results will justify the effort.

5. Repetition. Eliminate frequent repetition of the same sentence structure, or of the same word, particularly if close together and with different meanings.

6. Connectives. Give special attention to connectives: and, or, similarly, but, however, nevertheless, therefore, when, where, since, because, although, if, etc.

7. Euphony. Revise to make the article pleasing in sound when read aloud.


9. Style. Revise with special attention to consistency in the use of capitals and italics and in the style of headings. Consistency in these matters, as well as in punctuation and spelling, is essential in a manuscript prepared for the printer's use. The printer cannot depart from the rule to "follow the copy."

10. Accuracy. Read through the manuscript carefully, searching for inaccuracy or exaggeration of statement.

11. Length of printed paper. A paper may need to be shortened or divided to meet the limit specified by the journal in which it is to be published. (See section on "Estimating the Length of the Printed Article," page 34.) A long paper may often be divided into two or more short papers, and these may be published separately. Care should be taken, however, to make each paper a unit, treating one central topic. If there are two or more topics in a paper, these must be the logical subdivisions of a single large topic.
Check list of some common errors in writing

A. Inaccuracy.
   1. Misstatement or exaggeration of fact.
   3. Errors in data, terms, citations.
   4. Conclusions based on faulty or insufficient evidence.
   6. Failure to distinguish between fact and opinion.
   7. Contradictions and inconsistencies.

B. Inadequate presentation.
   1. Omission of important topics.
   2. Faulty order of sections or of paragraphs.
   3. Inclusion of material in wrong section or paragraph.
   4. Incomplete development of a topic.
   5. Failure to begin a section or a paragraph with a topic sentence.
   6. Weak beginning of a section or a paragraph.
   7. Inclusion of irrelevant or tedious details.
   8. Passages that are dull or hard to read.
   9. Failure to distinguish between the new and the well known.
   10. Inadequate emphasis of interpretation and conclusions.

C. Diction and style.
   1. Long sentences (more than 3 or 4 typewritten lines) and complicated grammar.
   2. Weak sentence beginnings—a string of weak or meaningless words.
   3. Lack of clearness—a sentence that requires re-reading to get the meaning.
   4. Long, complicated paragraphs (more than \( \frac{3}{4} \) page of typewriting).
5. Wordiness and padding—failure to come directly to the point.
6. General words rather than definite words.
7. Dull, weak, or awkward expressions.
8. Unnecessary repetition of the same word or the same sentence structure.
10. Unnecessarily technical language or too many strange words in a single sentence.

PREPARATION OF THE TYPEWRITTEN COPY

1. *Copy for typist.* Copy for the typist should be clearly written. All of the sheets should be of the same size, preferably numbered in the upper right-hand corner.

2. *One side of paper.* Write on only one side of the paper.

3. *Flat.* Never roll a manuscript. If possible, keep it flat; but when necessary, it may be folded.

4. *Clips.* The sheets should be fastened together with clips, which can be removed easily.

5. *Typewritten manuscripts.* The manuscript should be typewritten with a machine having clean type and a fresh, well-inked black ribbon. A typewriter with Pica characters (10 to the inch) places less eyestrain upon all who work on the manuscript than one with small, Elite characters (12 to the inch). The type should be kept clean; the carbon paper should be renewed frequently (usually after using for not more than eight pages); and the ribbon should be changed as soon as the original copy becomes perceptibly lighter than the copy made with fresh carbon paper.

Double-spacing must be used throughout the manu-
script, including footnotes, legends, and literature citations. Exception is made only in the case of a table that must be single-spaced in order to make it fit the page.

White paper of standard size (8½ by 11 inches) and ordinary weight (16 pounds) should be used.

6. Number of typewritten copies. Three typewritten copies should usually be made. The author should retain one fully corrected carbon copy. The original copy (from the ribbon) should always be sent to the publisher, since a carbon copy is easily erased and may become illegible. Some journals require, in addition to the original typewritten copy, one or more carbon copies, for examination by the editorial board.

7. Margins. There should be a blank space of about 2 inches above the title on the first page, 1 inch at the top of the other pages, and 1 inch at the bottom of each page. There should be a blank margin of 1 inch at the left side of each page and about 1 inch at the right side (but avoid dividing words at the ends of lines).

8. Page numbers. The pages of the typewritten copy should be numbered consecutively, preferably in the upper right-hand corner.

9. Models of style. The author should make a careful study of the journal in which his article is to be published, and he should prepare his copy so that it conforms to the best practice illustrated by current issues of the journal. Only carefully prepared, clearly typewritten manuscripts are acceptable.

10. Directions for proofs. The author's name and the address to which proofs are to be sent should be typewritten near the top of the first page of the manuscript and enclosed in a circle.

11. Title of the paper. The full title of the paper, including the author's name, should be typewritten 2
The following example shows a complete heading that may be modified to suit the style of almost any journal.

[Example of general heading]

INFLUENCE OF SULFONAMIDES ON GROWTH AND RESPIRATION IN BACTERIA

HENRY E. MILLER AND JOHN C. STEWART

Department of Bacteriology, School of Medicine, University of Pennsylvania, Philadelphia 4, Pennsylvania

Received for publication August 12, 1946

1 The authors are indebted to Dr. Edward M. Johnson for helpful suggestions during the course of the study.

12. Tables, footnotes, citations, headings, legends. See special directions for typewriting tables (page 58), footnotes (page 66), citations (page 84), headings (page 101), legends (page 134).

It is essential that the manuscript be prepared in a way that will allow economical composition on a typesetting machine. The machine cannot compose two sizes of type in one operation. To permit rapid work, the manuscript should be arranged so that material to be printed in small type may be separated easily from the text.

Each individual table and each quotation exceeding five lines should be typewritten on a separate sheet of paper; these pages should be numbered consecutively with the text pages.

* The author's complete mail address should be printed in the paper, so that readers can request reprints; it is most convenient if given on the first page of the paper, in the heading or in a footnote to the title.
Footnotes should not be typewritten with the text, but should be put on separate sheets (as many footnotes as convenient being written on a sheet); these should be placed at the end of the text copy, after the literature cited.

The literature citations should begin on a new sheet. The legends, or titles, of plates and figures should be written in numerical order on one or more sheets, and these should be placed after the footnotes.

13. **Condensed title for running headlines.** A condensed title of 35 letters or less should be given by the author for the running headlines of the pages. This may be placed on a separate sheet at the end of the manuscript.

**CORRECTING THE TYPEWRITTEN COPY**

After the manuscript has been typed, the author should read the typewritten copy for errors. All tables, figures, names, quotations, and citations in the copy must be verified by comparison with the original manuscript. A convenient method of checking is to have another person slowly read aloud from the original while you follow and correct the typewritten copy.

Assume that errors are present; find and correct them. The responsibility for uncorrected errors in figures, names, citations, and quotations rests entirely with the author, since the publisher has no means of discovering such errors. It is fatal to leave them for critics to discover, after the paper has been published.

The typewritten manuscript must be clear and legible, as well as correct. Symbols, signs, superscript letters and figures, etc., must be unmistakable. For example, the symbol "Cl" (for chlorine) must be marked with a handwritten "1" above it to show that it is not "C1," since the
The typewriter uses the same symbol for both the letter “l” and the figure “1”; and the multiplication sign “×” must be plainly marked or the words “multiplication sign” written in the margin, to distinguish it from the letter “X”. Greek letters or other unusual characters should be written clearly and, if necessary, explained by marginal notes. An ordinary dash (em dash) should be typewritten as two hyphens, without space before, between, or after them. If a hyphen occurring at the end of a typewritten line should be printed as a hyphen, mark it “= ”.

CORRECTIONS

1. Corrections in body of manuscript. If possible, write corrections in the body of the manuscript, not in the margin. If corrections are written in the margin, it will be difficult to make necessary transpositions, by cutting and pasting. Do not destroy legibility by writing too many words between the lines. When it is necessary to reconstruct a long sentence or a paragraph, typewrite the revision upon a separate slip of paper of page width and paste this directly over the section rewritten.

2. Corrections horizontal. Write corrections horizontally on the page.

3. Corrections above line. Place the corrections in the space above the line to which they apply so that the printer will see them before he reaches the words concerned.

4. Cancellation. To cancel a word, draw a horizontal line through it. To cancel a single letter, draw a vertical line through it.

5. Restoration. To restore a word that has been canceled by mistake, rewrite the word above the one you have canceled, or make a series of dots under the word and write “Stet” in the margin.
6. **Substitution.** To replace one word by another, cancel the first word by drawing a horizontal line through it, and write the new word immediately above. Never write the new word directly upon the first.

7. **Indicating a paragraph.** When a word should begin a new paragraph, place the "¶" sign immediately before the word.

8. **Canceling a paragraph.** To cancel a paragraph division, write "No ¶" in the margin, and draw a "run-in" line from the indented word to the last word of the preceding sentence.

9. **Period.** A period may be indicated clearly by enclosing it in a small circle.

10. **Space between words.** To separate two words that have been written together, draw a thin vertical line between them.

11. **Canceling space between words.** To indicate that two words are to be brought together, connect them by means of half-circles above and below them. (For example: Footnote.)

12. **Reduction of capital letter.** To indicate that a capital letter should be printed as a small (lower-case) letter, draw through it an oblique line sloping downward from right to left.

13. **Italic capitals.** Four lines under a letter or word indicate printing in *ITALIC CAPITAL* type.

14. **Capitals.** Three lines under a letter or word indicate printing in *ROMAN CAPITAL* type.

15. **Small capitals.** Two lines under a letter or word indicate printing in *SMALL CAPITAL* type.

16. **Italics.** One straight line under a letter or word indicates printing in *italic* type.

17. **Bold-face.** One wavy line under a letter or word indicates printing in *bold-face* type.
INSERTIONS

1. **Brief insertions.** To insert one word or a few words, write them above the line and indicate the place for their insertion by a caret (\(^\wedge\)) placed below the line.

2. **Permissible method.** To insert a passage of several lines in a page of an initial draft of the manuscript, the following method may be used: Suppose the insertion is to be made in page 12 of the manuscript. The passage to be inserted should be written on a fresh slip of paper of page width. Mark this "A, Insert in page 12" and draw a circle around the passage. In the margin of page 12 write "Insert A," draw a circle around it, and from the circle draw a line to a caret (\(^\wedge\)) at the place where the insertion is to be made. Paste this slip securely to page 12. If several inserts are made in page 12, mark these "Insert A," "Insert B," "Insert C," "Insert D\(^x\)," indicating the last insert by the mark \(^x\).

3. **General method.** To insert a passage of several lines in a page of a later draft of the manuscript, the following method may be used: Suppose the insertion is to be made in page 7 of the manuscript. The passage to be inserted should be written on a fresh sheet of paper (full size). In the upper margin write "A, Insert in page 7," and draw a circle around the passage. Number this sheet "7A" and place it after page 7. In the margin of page 7 write "Insert A," draw a circle around it, and from the circle draw a line to a caret (\(^\wedge\)) at the place where the insertion is to be made. If several insertions are made in page 7, mark these "Insert A," "Insert B," "Insert C," "Insert D\(^x\)," (indicating the last insert by the mark \(^x\)), and number the additional sheets "7A," "7B," "7C," "7D\(^x\)," placing them after page 7.
TRANSPOSITIONS

Transposition by cancellation and insertion. To trans­pose words, cancel them and insert them in the proper place by one of the methods just given.

RENUMBERING PAGES

Consecutive page numbers. The methods given above refer to insertions and transpositions made in the pre­liminary drafts of an article. Before the manuscript is submitted to an editor, or sent to a printer, all the material must be in proper sequence on full­sized sheets that are numbered consecutively.

Insertions and transpositions may be made by cutting and pasting. If smaller sheets were included with the manuscript, they might become separated and lost. The pages may be renumbered by canceling the original num­bers and writing the new numbers near the canceled ones. It is not necessary to have the manuscript pages filled with typewriting; the printer will not leave a space if the lower part of a manuscript page contains no writing.

FINAL REVISIONS

1. Finished manuscript. The author is expected to make all final revisions in the typewritten manuscript. Only genuine errors may be corrected in the proofs. Al­terations in the proofs are expensive and are likely to introduce inconsistencies and new errors.

2. Corrections in manuscript. A manuscript in which there are no corrections often indicates a careless author. If the changes are not too many and are made clearly, it will not be necessary to rewrite the pages.

3. Order of material. Before sending your manuscript to a publisher, be sure to have all parts in the proper order, as outlined below:
(a) Author’s name and address to which proofs are to be sent.
(b) Title, name of author, footnote to title.
(c) Text material (each table and each long quotation being on a separate page).
(d) Literature cited (on a separate page).
(e) Footnotes (on a separate page).
(f) Legends for illustrations (on a separate page).
(g) Condensed title of 35 letters or less (on a separate page).
(h) Copy for illustrations.

ESTIMATING THE LENGTH OF THE PRINTED ARTICLE

A fairly accurate estimate of the length of the printed article can be made by means of the following simple formula:

Number of printed pages =

\[
\frac{\text{Characters per MS line} \times \text{Lines per MS page} \times \text{Pages of MS}}{\text{Characters per printed line} \times \text{Lines per printed page}}
\]

Letters, punctuation marks, and spaces between words are counted as characters; short lines at ends of paragraphs are counted as full lines.

For example, suppose that a manuscript has an average of 63 characters per line, 27 lines to the page, and a length of 23 pages; and that the printed page has an average of 52 characters to the line and has 124 lines per page.

\[
\text{Number of printed pages} = \frac{63 \times 27 \times 23}{52 \times 124} = 6.1
\]

Allowance must, of course, be made for the space to be occupied by tables and illustrations; this may be difficult to
estimate accurately. If center headings are numerous, they should be taken into account also.

This method of estimating the length of printed material is easier and much more accurate than any method based upon word count. Words vary in length from “a” or “if” to “nitrobenzenesulfonamides.” So the number of words per line is much more variable than the number of characters. Character count is the basis of the system used by printers for copy-fitting.

To obtain a count of characters (including blank spaces) in a typewritten line, measure the length of the line in inches and multiply by 10 for Pica\(^5\) typewriting or by 12 for Elite typewriting. Measure a sufficient number of manuscript lines to obtain an average of the desired accuracy.

In the case of printed matter, it is necessary to make an actual count of the number of characters per line. Obtain an average based upon ten lines in the journal in which your article is to be published.

The space required for a legend may be calculated in a similar manner by taking into account the number of characters per line of such material and the number of lines per vertical inch on the printed page.

It is sometimes desirable to typewrite a manuscript so that the average character count per line of typewriting is nearly the same as the character count per line of print. If the manuscript of the present book had been typewritten with 55 characters per line (i.e., with Pica typewritten lines 5\(\frac{1}{4}\) inches long), then the manuscript and printed matter would have almost matched line by line.

* The true pica, used in measuring printed matter, is \(\frac{1}{4}\) inch, not \(\frac{1}{6}\).
KINDS OF TYPE AND THEIR INDICATION IN THE MANUSCRIPT

1. Roman. The type in general use is called Roman. There are three kinds of Roman type: (a) CAPITALS (caps), which may be indicated in the manuscript by drawing three lines under the word or letter to be capitalized; (b) SMALL CAPS (capital letters about half as high as caps), which may be indicated in the manuscript by drawing two lines under the letter or word; (c) lowercase letters (ordinary small letters). A diagonal line may be drawn through a capital letter to indicate that it should be printed as a small letter.

2. Italics. In italic type, or italics, the letters slope up toward the right. To indicate italic type, draw a single straight line under the letter, word, or figure. If italic capitals are desired, underscore with four straight lines.

3. Bold-face. Type with a conspicuous or heavy face is called bold-face or black-face. To indicate bold-face type, underscore with a wavy line. This type should rarely be used.

4. Face and body of type. A single piece of type cast by a Monotype machine is a rectangular block of metal with a flat top which bears, in relief, a letter or other character. The upper or printing surface of the raised character is the face, and the block bearing the character is the body. The part of the flat top which projects beyond the base of the raised character is known as the shoulder. A whole line is cast in one piece, or slug, by a Linotype machine.

5. Size of type. The sizes of type are classified according to the dimensions of the bodies. When the top of the type is viewed, the height of the body indicates the size of the type, the raised character always being slightly
smaller than the top of the body. The following examples illustrate the common sizes, as they appear when printed:

This line is set in 6-point type.
This line is set in 8-point type.
This line is set in 9-point type.
This line is set in 10-point type.
This line is set in 11-point type.
This line is set in 12-point type.

The unit employed in sizes of type is the point, or \( \frac{1}{72} \) inch. Thus 10-point type has a body 10 points (\( \frac{1}{6} \) inch) high, and has a face, or raised character, slightly less in height, so that there will be a very small space between the printed lines. When 10-point type is used in composition without additional spaces between the lines, it is said to be set "solid." Usually, however, the lines are separated by additional spaces, or the type is "leaded." This may be done by thin strips of metal called "leads." But in the composition of books and periodicals the extra space generally is provided by casting the type on a larger body. In most work 10-point type is cast on a 12-point body, the effect being the same as if a 2-point lead were inserted between the lines. The type is then said to be 10-point leaded, or, more accurately, 10-point type on 12-point body. Scientific journals often employ 11-point type on 13-point body, with quotations set in 10-point on 12-point body; all other subsidiary matter (footnotes, bibliographies, tables, etc.) is usually set in 8-point type on 10-point body. This book is printed in 10-point on 12-point, with footnotes, etc., in 8-point on 10-point.

6. Size of type page. The unit employed in measuring the width and depth of the type page is termed a 12-point
em (this term is literal, being the exact width of the capital letter “M”), or a pica, which is 12 points ($\frac{1}{4}$ or $\frac{5}{6}$ inch) long. Thus a type page that is $3\frac{3}{4}$ inches wide is twenty-one 12-point ems in width ($3\frac{3}{4} \div \frac{5}{6} = 21$).

7. Spacing. The em is used as a unit for measuring printed matter. An em of 12-point type (12 set) is 12 points ($\frac{5}{6}$ inch) wide (and also 12 points high); an em of 10-point (10 set) is 10 points wide; an em of 8-point (8 set) is 8 points wide. The em and halves of the em are used for indentation and spacing, and also for expressing the lengths of dashes. An em quad is a block of type that is one em in width; the ordinary dash (—), or em dash, is the width of an em quad. An en quad is half of the width of an em, and an en dash (—), used to separate page numbers in citations, is an en in width.

8. Specifications. Complete specifications for a publication include the styles and sizes of type for body, subsidiary matter, tables, references, headings, etc., the dimensions of the type page (in picas), the margins, the paper, the binding, instructions regarding illustrations, etc. The publisher ordinarily takes care of these details, but an editor or an author who is preparing copy ready for the printer should give considerable attention to all these questions.

CAPITALS

The subject of capitalization is difficult to handle with definite rules, but capitals should be used according to a uniform style throughout a single article. For this reason a special revision of the manuscript should be made with the aim of making capitalization uniform.

1. Proper nouns. Capitalize a proper noun, designating an individual person or thing. Also, capitalize a
derivative of a proper noun if the derivative retains close association with the proper noun.

2. Words derived from proper nouns. Be consistent in the capitalization of words derived from proper nouns. The words volt, ampere, farad, ohm, coulomb, and watt should not be capitalized. It is better to capitalize India ink, Paris green, Prussian blue, plaster of Paris, Bordeaux mixture. Follow consistently a single unabridged dictionary, preferably Webster's New International Dictionary.

3. Manufactured products. Capitalize the significant parts of the name of a manufactured product. (For example: Pyrex glass, Cellophane membrane.)

4. First words. Begin with a capital: a sentence, a complete sentence directly quoted, a legend of a table or an illustration, a center subheading, a paragraph side heading, or a topic in a table of contents.

5. Titles of publications in text. In the text, capitalize all important words in titles of books and periodicals and in titles of chapters in books and of articles in periodicals. (For example: Chapter XII of Clark's *The Determination of Hydrogen Ions* is entitled "Theory of the Hydrogen Electrode." An article on "Cobalt and Nickel in Soils and Plants" appeared in *Soil Science*.)

In footnote citations and in lists of literature cited, capitalize only the first word and proper nouns in English titles of books and of articles in periodicals (page 84).

6. Scientific names. In botanical and zoological work, capitalize the scientific names of genera, families, orders, classes, subdivisions, and divisions of plants and animals. (For example: *Triticum*, Gramineae, Glumiflorae, Monocotyledoneae, Angiospermae, Spermatophyta.)

7. Common names derived from scientific names. Do not capitalize common names derived from scientific
names of plants and animals. (For example: ameba (amoeba), angiosperm, bacillus.)

8. Chemical and medical terms. Do not capitalize the names of chemicals, medicines, diseases, and anatomical parts.

9. Table, figure, plate. Do not capitalize table, figure, and plate. (For example: The results given in table 2 are shown as graphs in figure 3.)

10. Miscellaneous terms. Do not capitalize such words as plot, plat, series, class, exhibit, form, group, schedule, section, appendix, station, etc., even when immediately followed by a figure or a capital letter.

ITALICS

Indicate italic type in the manuscript by drawing a single straight line under the letters, words, or numerals that are to be italicized.

1. Algebraic symbols. Algebraic symbols and equations should be italicized. (For example: \( Ax + By + C = 0 \).)

   In equations, only the full-sized letters should be italicized; superscript and subscript letters should not be italicized. Numerals should not be italicized. (For example: \( T^a + D_t - H^b = 2L_o \).)

   Chemical symbols and certain other standardized symbols are not italicized.

2. Explanatory letters in illustrations. Some journals prefer to use italic or slant letters to designate points, lines, objects, etc., in diagrams, drawings, and graphs. Even if Roman or vertical lettering is used in the illustration, italics should always be used in the legend and in the text when reference is made to such explanatory letters. (Example of legend of diagram: Fig. 1. Diagrammatic cross section of coconut pinna, lines \( AB \) and
AC representing the two pinna wings, hinged to the midrib at A.)

3. Genera and species. In botanical, bacteriological, zoological, and geological work, italicize scientific names of genera, species, and varieties, and of genera alone. [For example: Phaseolus lunatus; Musa sapientum Linn. var. cinerea (Blanco) Teod.; Bacillus coli (Escherich) Mig.; Phytophthora.] But do not italicize names of classes, orders, and families. When used in tables and in titles of articles, scientific names are usually not italicized.

4. Common names derived from scientific names. Do not italicize common names derived from scientific names of plants and animals. (For example: Ameba (amoeba), angiosperm, bacillus, bacterium, paramecium, protozoan, streptococci.)

5. Books and periodicals. Italicize titles of books, pamphlets, and periodicals when these appear in the text. (For example: Fieser and Fieser's Organic Chemistry.) In footnote citations and in lists of literature cited, such titles are usually not italicized.

6. Subdivisions of books and periodicals. Use quotation marks—not italics—for titles of chapters in books or titles of articles in periodicals when these are given in the text. (For example: Chapter 1 of Yost and Russell's Inorganic Chemistry deals with "Nitrogen and Its Oxides and Sulfides." An article on "Absorption of Water by Plants" appeared in The Botanical Review.) In footnotes and in lists of citations, it is customary to use neither italics nor quotation marks.

7. Article. The word the or a should be italicized and

---

* Many zoological publications do not italicize scientific names. (For example: Mus musculus.)

* Some journals use quotation marks instead of italics for titles of books.
capitalized when it begins the title of a book or a periodical. (For example: Fisher's *The Design of Experiments*. An article in *The American Journal of Botany*.)

8. Technical terms. It is permissible to italicize a letter or word to which special attention is called. An unusual technical term, requiring formal definition, may be italicized the first time it appears in an article. When an expression is regarded as quoted, it should be enclosed in quotation marks. (For example: The term *atmometric index* will be used in place of the expression "evaporating power of the air." ) It is best to avoid over-use of italics, capitals, and other special devices for emphasizing ideas. They often lead to an exaggeration of an idea or fact. If used excessively, they do not even give emphasis or distinction.

9. Chemical and medical terms. Do not italicize the names of chemicals, medicines, diseases, and anatomical parts. (For example: Uranium hexafluoride, hydroquinone, atropine, penicillin, diabetes mellitus, esophagus.)


**NUMBERS**

1. General. Use figures for all *definite* weights, measurements, percentages, and degrees of temperature. (For example: 6.7 kgm., 2\(\frac{3}{4}\) inches, 15.6 ml., 112°C.) Spell out all *indefinite* and *approximate* periods of time and all other numerals that are used in a general manner. (For

---

8 This rule is often ignored in referring to the name of a periodical.

9 Some journals italicize foreign words or phrases that have not come into common use in English.
example: One hundred years ago, thirty years old, about two and one-half hours, ten instances, three times.) Judgment must be exercised in this matter; for instance, figures should be used in experimental data where periods of time are definite and of frequent occurrence. The conservative rule is to spell out numbers wherever possible. Some journals spell out only small numbers, those under 10 or under 100.

2. *Consistency.* Be consistent throughout the article in the use of figures. Do not express small numbers in words in one paragraph and in figures in another.

3. *Beginning of sentence.* Never begin a sentence with a figure. Revise the sentence; or, if this is impossible, write the number in words.

4. *Avoiding confusion.* Spell out numbers if confusion would be caused by the use of figures. (For example: Fifteen 200-watt Mazda lamps.)

5. *References to tables.* Use figures for all numbers taken from tabular matter.

6. *Metric system.* The metric system of weights and measures should usually be employed in scientific publications. Where it is customary to use a non-metric system, as in engineering, metric equivalents may be given in parentheses.

7. *Abbreviations.* Universally understood abbreviations of metric weights and measures may be used in tables, footnotes, and citations, and in the text when directly following figures. (For lists of abbreviations, see page 50.) Non-metric units should always be spelled out, except in engineering.

8. *Temperatures.* Temperatures should usually be expressed in centigrade degrees. The equivalent in the Fahrenheit system may be given in parentheses if desired.

9. *Time.* Employ figures for hours of the day, using a
colon to separate hours and minutes. (For example: 7:00 a.m.; 3:30 p.m.; 12 m.; 12 p.m.)

10. Dates. Use figures for days of the month, spelling out the name of the month and omitting d, th, st. (For example: September 21, 1946.)

11. Money. Use figures for sums of money written with a dollar sign. (For example: $15.65; $25, not $25.00; but definite precision sometimes requires the use of ciphers at right of decimal.)

12. Twenty-one to ninety-nine. Cardinal numbers from twenty-one to ninety-nine, inclusive, should be written with hyphens.

13. Hyphens in ordinal numbers. Ordinal numbers should be joined with hyphens. (For example: Thirty-fourth, one-hundred-and-eleventh.)

14. Comma in figures. In tabular matter, use a comma to separate a number of four or more figures, grouping three units to the right. In the text, omit a comma in a number containing four figures.

15. Fractions. Decimal fractions should be employed in the metric system. Common fractions used in an indefinite manner should be spelled out, joining the numerator to the denominator with a hyphen. (For example: One-half of the balance, two-thirds of the residue, about one-tenth of this quantity.) Use figures for common fractions when designating definite weights and measurements. (For example: 1/2-inch pipe.) Simple fractional expressions may be written with a slant line. Very large fractions should be expressed decimally.

16. Half and quarter. Compounds of half and quarter should be written with a hyphen. (For example: Half-full; quarter-past. But: One half was dried; the other was not.)

17. Per cent. Omission of a period after per cent is
favored by most writers. (Some journals use the symbol % in tables or even in the text.)

18. Per cent and percentage. Do not use per cent for percentage. Per cent should be preceded by a number. (For example: Three analyses gave the following percentages of sugar: 93.2, 93.1, and 92.9. There was an increase of 15 per cent in production.)

19. Basis for percentage. Always make clear the basis used for expressing percentages. (For example: The phrase “a 5 per cent solution of alcohol in water” correctly means 5 grams of alcohol in 100 grams of the solution, but some writers use it to mean 5 ml. of alcohol in 100 ml. of the solution.)

20. Standard error or probable error. Be careful to state whether standard error or probable error is meant in an expression such as “10.3 ± 0.21 grams.”

21. Plural. Use the plural form when referring to a quantity or measurement of more than one. (For example: About one and one-half kilometers; 1½ inches.)

22. Singular and plural forms of verbs. When total quantity is indicated, the singular verb may be used. (For example, it is permissible to write: To each culture 300 ml. of solution was added.) But it is better to recast the sentence and avoid the difficulty. (For example: Each culture received 300 ml. of solution.)

23. Mathematical expressions. To simplify printing, reduce mathematical expressions to a single line when possible. Use a slant line to signify division, and use fractional exponents instead of square-root and cube-root signs.

24. Verification. The use of statistical or mathematical formulae should be checked by a specialist in the field.

25. Significant figures. In publishing a computed number, retain no more significant digits than are con-
sistent with its accuracy. In statistical work the follow-
ing rule may be a useful guide: In the published con-
stant, retain no figures beyond the position of the first
significant figure in one-third the standard error; in all
computations, keep two more places. (For example: 129
\[ \pm \ 3.1, \textit{not} 129.2 \pm 3.1. \])

26. Roman numerals. Where possible, avoid the use
of Roman numerals, since they are not readily understood.

RELIABILITY AND SIGNIFICANCE
OF MEASUREMENTS

This section provides a brief introduction to some
aspects of statistical methods. It is hoped that the
reader will study the treatises by Croxton and Cowden,
in the bibliography of this book.

The following directions outline a working system for:
(a) computing the standard error of the mean of a series
of measurements obtained from a random sample, (b)
ascertaining the significance of the difference between
the population mean and the mean of a random sample,
(c) judging the significance of the difference between
two such sample means, and (d) estimating the size of
an adequate sample.

STANDARD ERROR OF THE MEAN

1. Write the readings in a vertical column. At the
bottom of the column, write the sum of the readings;
divide this by the number of readings \((N)\) and set down
the mean \((M)\).

2. In a second column, put opposite each reading the
difference between it and the mean.

3. In a third column, write the square of each difference;
and at the bottom of this column, put the sum of these squares ($S$).

4. Compute the standard error of the mean by taking the square root of the quotient obtained by dividing the sum of the squares by the product of the number of readings times one less than this number:

$$E_M = \sqrt{\frac{S}{(N(N-1))}}$$

5. Write the mean and its standard error in the form $M \pm E_M$. (According to the theory of probabilities, 68 per cent of many similarly determined means, based on large samples, should fall within $\pm E_M$ of the population mean, 95 per cent may be expected to fall within $\pm 1.96 E_M$, and 99 per cent within $\pm 2.58 E_M$.)

**SIGNIFICANCE OF THE DIFFERENCE BETWEEN A POPULATION MEAN AND THE MEAN OF A RANDOM SAMPLE**

1. Compute $n$ from:

$$n = N - 1$$

where $N$ is the number of readings upon which the mean of the random sample was based.

2. Compute the value of $t$ from:

$$t = \frac{(M-m)}{E_M}$$

where $M$ is the mean of the random sample, $m$ is the known or assumed value of the population mean, and $E_M$ is the standard error of the mean of the random sample.

3. In the accompanying table,10 find the smaller value

10 This table is reprinted from table IV of Fisher: *Statistical Methods for Research Workers*, Oliver & Boyd Limited, Edinburgh, by permission of the author and publishers.
of \( t \) corresponding to \( n \). If the computed value of \( t \) is greater than the value of \( t \) found in the table, the difference between the population mean and the mean of the random sample may be regarded as significant. If the computed value of \( t \) exceeds the larger value of \( t \) in the table, the

### TABLE 1

*Table for use in estimating the significance of a difference*

<table>
<thead>
<tr>
<th>( n )</th>
<th>( P = 0.05 )</th>
<th>( P = 0.01 )</th>
<th>( n )</th>
<th>( P = 0.05 )</th>
<th>( P = 0.01 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2.73</td>
<td>4.60</td>
<td>15</td>
<td>2.13</td>
<td>2.95</td>
</tr>
<tr>
<td>5</td>
<td>2.57</td>
<td>4.03</td>
<td>16</td>
<td>2.12</td>
<td>2.92</td>
</tr>
<tr>
<td>6</td>
<td>2.45</td>
<td>3.71</td>
<td>17</td>
<td>2.11</td>
<td>2.90</td>
</tr>
<tr>
<td>7</td>
<td>2.37</td>
<td>3.50</td>
<td>18</td>
<td>2.10</td>
<td>2.88</td>
</tr>
<tr>
<td>8</td>
<td>2.31</td>
<td>3.36</td>
<td>19</td>
<td>2.09</td>
<td>2.86</td>
</tr>
<tr>
<td>9</td>
<td>2.26</td>
<td>3.25</td>
<td>20</td>
<td>2.09</td>
<td>2.85</td>
</tr>
<tr>
<td>10</td>
<td>2.23</td>
<td>3.17</td>
<td>25</td>
<td>2.06</td>
<td>2.79</td>
</tr>
<tr>
<td>11</td>
<td>2.20</td>
<td>3.11</td>
<td>30</td>
<td>2.04</td>
<td>2.75</td>
</tr>
<tr>
<td>12</td>
<td>2.18</td>
<td>3.06</td>
<td>40</td>
<td>2.02</td>
<td>2.70</td>
</tr>
<tr>
<td>13</td>
<td>2.16</td>
<td>3.01</td>
<td>50</td>
<td>2.01</td>
<td>2.68</td>
</tr>
<tr>
<td>14</td>
<td>2.15</td>
<td>2.98</td>
<td>Infinity</td>
<td>1.96</td>
<td>2.58</td>
</tr>
</tbody>
</table>

* This table is reprinted from table IV of Fisher: *Statistical Methods For Research Workers*, Oliver & Boyd Limited, Edinburgh, by permission of the author and publishers. The reader is advised to consult this book and also Fisher's *The Design of Experiments*.

difference is highly significant. A significant difference indicates that the random sample was probably not drawn from a population having a mean of \( m \).

**Significance of the difference between means**

1. Subtract the smaller mean \( (M_2) \) from the larger mean \( (M_1) \) to obtain the difference \( (D) \).
2. Obtain the standard error of the difference between
the two means by taking the square root of the sum of the squares of the two standard errors of the means:

\[ E_D = [(E_{M_1})^2 + (E_{M_2})^2]^{1/2} \]

where \( E_{M_1} \) and \( E_{M_2} \) are the standard errors of the means. This expression for \( E_D \) should be used only when the two random samples are independent.

3. Write the difference and its standard error in the form \( D \pm E_D \).

4. Compute \( n \) from:

\[ n = (N_1 - 1) + (N_2 - 1) \]

where \( N_1 \) and \( N_2 \) are the number of readings upon which the means were based.

5. Compute \( t \) from \( t = D/E_D \). In the accompanying table\(^{10}\) find the smaller value of \( t \) corresponding to \( n \). If the computed ratio is greater than the value of \( t \) found in the table, the difference may be considered to be significant. If the ratio exceeds the larger value of \( t \) in the table, the difference may be regarded as highly significant. The \( P \) (probability) value indicates the probability of obtaining a plus or minus difference equal to or greater than that indicated by the value of \( t \).

**ADEQUACY OF SAMPLE SIZE**

1. An estimate may be made of the size of each of two samples needed in order that a certain percentage difference between the two sample means may be regarded as significant. For simplicity, it is assumed (a) that the two populations from which the random samples are

\(^{10}\) This table is reprinted from table IV of Fisher: *Statistical Methods for Research Workers*, Oliver & Boyd Limited, Edinburgh, by permission of the author and publishers.
drawn have the same degree of variability and (b) that the two random samples are independent.

2. Obtain an exploratory random sample of size $N$ (as large as practicable) of one of the two populations, and calculate the mean ($M$) and the standard error of the mean ($E_M$).

3. Compute the required sample size ($N_r$) for each of the two samples from the following formula:

$$N_r = 2 \times (2.16)^2 \times N \times \left(\frac{100 \times E_M}{M}\right)^2/d^2$$

where 2.16 is a value obtained from a $t$ table and corresponds to a probability of 0.03 for a large sample, and $d$ is the percentage difference desired to be significant.

4. It must be borne in mind that the procedure here outlined can give only a rough estimate of adequate sample size and should not be used for small samples.

ABBREVIATION OF UNITS OF WEIGHT AND MEASURE

The general rule regarding abbreviations is to employ only those abbreviations which you know are used by careful writers in your science, and to conform to the style of the publication in which your article is to appear. The names of chemical compounds, rather than their symbols, should be used in the text. It is a good rule always to spell out the names of units of weights and measurements of all systems except the metric; the metric abbreviations are understood in all parts of the world, and so cause little confusion. However, where brevity is essential.

For the sake of economy, The Journal of the American Chemical Society uses the abbreviations %, °A., cm., cc., ml., g., Å., m. p., f. p., b. p., cal., and kcal. rather than the words.
A SET OF STANDARD ABBREVIATIONS

Standard abbreviations of units of weight and measure are given in the accompanying table.

The following general principles should be observed:

1. Period. A period should be used after each abbreviation, although it is omitted after certain symbols.\(^{12}\)

2. Singular and plural. The same form should be used for both singular and plural. (For example: 0.5 kgm., 12.3 kgm.)

3. Small letters. Small letters should be used for abbreviations; but a few symbols are capitalized.

---

**Most common units of weight and measure and their abbreviations**

<table>
<thead>
<tr>
<th>UNIT</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ångstrom</td>
<td>Å</td>
</tr>
<tr>
<td>are</td>
<td>a.</td>
</tr>
<tr>
<td>barrel</td>
<td>bbl.</td>
</tr>
<tr>
<td>board foot</td>
<td>bd. ft.</td>
</tr>
<tr>
<td>bushel</td>
<td>bu.</td>
</tr>
<tr>
<td>carat, metric</td>
<td>c.</td>
</tr>
<tr>
<td>centare</td>
<td>ca.</td>
</tr>
<tr>
<td>centigram</td>
<td>cg.</td>
</tr>
<tr>
<td>centiliter</td>
<td>cl.</td>
</tr>
<tr>
<td>centimeter</td>
<td>cm.</td>
</tr>
<tr>
<td>chain</td>
<td>ch.</td>
</tr>
<tr>
<td>cubic centimeter (milliliter)</td>
<td>cc.</td>
</tr>
<tr>
<td>cubic centimeter</td>
<td>cu. cm.</td>
</tr>
<tr>
<td>cubic decimeter</td>
<td>cu. dm.</td>
</tr>
<tr>
<td>cubic dekameter</td>
<td>cu. dkm.</td>
</tr>
<tr>
<td>cubic foot</td>
<td>cu. ft.</td>
</tr>
<tr>
<td>cubic hectometer</td>
<td>cu. hm.</td>
</tr>
<tr>
<td>cubic inch</td>
<td>cu. in.</td>
</tr>
</tbody>
</table>

---

\(^{12}\) The Government Printing Office and many journals omit the period after the abbreviations of metric units. For example: mm, kv, °C; but a. c., d. c., e. m. f.
<table>
<thead>
<tr>
<th>UNIT</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>cubic kilometer</td>
<td>cu. km.</td>
</tr>
<tr>
<td>cubic meter</td>
<td>cu. m.</td>
</tr>
<tr>
<td>cubic mile</td>
<td>cu. mi.</td>
</tr>
<tr>
<td>cubic millimeter</td>
<td>cu. mm.</td>
</tr>
<tr>
<td>cubic yard</td>
<td>cu. yd.</td>
</tr>
<tr>
<td>decigram</td>
<td>dgm.</td>
</tr>
<tr>
<td>deciliter</td>
<td>dl.</td>
</tr>
<tr>
<td>decimeter</td>
<td>dm.</td>
</tr>
<tr>
<td>decistere</td>
<td>ds.</td>
</tr>
<tr>
<td>dekagram</td>
<td>dkgm.</td>
</tr>
<tr>
<td>dekaliter</td>
<td>dkl.</td>
</tr>
<tr>
<td>dekameter</td>
<td>dkm.</td>
</tr>
<tr>
<td>dekastere</td>
<td>dks.</td>
</tr>
<tr>
<td>dram</td>
<td>dr.</td>
</tr>
<tr>
<td>dram, apothecaries'</td>
<td>dr. ap.</td>
</tr>
<tr>
<td>dram, avoirdupois</td>
<td>dr. av.</td>
</tr>
<tr>
<td>fathom</td>
<td>fath.</td>
</tr>
<tr>
<td>foot</td>
<td>ft.</td>
</tr>
<tr>
<td>firkin</td>
<td>fir.</td>
</tr>
<tr>
<td>furlong</td>
<td>fur.</td>
</tr>
<tr>
<td>gallon</td>
<td>gal.</td>
</tr>
<tr>
<td>hectare</td>
<td>ha.</td>
</tr>
<tr>
<td>hectogram</td>
<td>hgm.</td>
</tr>
<tr>
<td>hectoliter</td>
<td>hl.</td>
</tr>
<tr>
<td>hectometer</td>
<td>hm.</td>
</tr>
<tr>
<td>hogshead</td>
<td>hhd.</td>
</tr>
<tr>
<td>hundredweight</td>
<td>cwt.</td>
</tr>
<tr>
<td>inch</td>
<td>in.</td>
</tr>
<tr>
<td>kilogram</td>
<td>kgm.</td>
</tr>
<tr>
<td>kiloliter</td>
<td>kl.</td>
</tr>
<tr>
<td>kilometer</td>
<td>km.</td>
</tr>
<tr>
<td>link</td>
<td>li.</td>
</tr>
<tr>
<td>liquid</td>
<td>liq.</td>
</tr>
<tr>
<td>liter</td>
<td>l.</td>
</tr>
<tr>
<td>meter</td>
<td>m.</td>
</tr>
<tr>
<td>metric ton</td>
<td>t.</td>
</tr>
<tr>
<td>microgram (0.001 mgm.)</td>
<td>µg, γ</td>
</tr>
<tr>
<td>UNIT</td>
<td>ABBREVIATION</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>micron</td>
<td>(\mu)</td>
</tr>
<tr>
<td>mile</td>
<td>mi.</td>
</tr>
<tr>
<td>milligram</td>
<td>mgm.</td>
</tr>
<tr>
<td>milliliter</td>
<td>ml.</td>
</tr>
<tr>
<td>millimeter</td>
<td>mm.</td>
</tr>
<tr>
<td>millimicron</td>
<td>(\mu)</td>
</tr>
<tr>
<td>minim</td>
<td>min.</td>
</tr>
<tr>
<td>ounce</td>
<td>oz.</td>
</tr>
<tr>
<td>ounce, apothecaries'</td>
<td>oz. ap.</td>
</tr>
<tr>
<td>ounce, avoirdupois</td>
<td>oz. av.</td>
</tr>
<tr>
<td>ounce, fluid</td>
<td>fl. oz.</td>
</tr>
<tr>
<td>ounce, troy</td>
<td>oz. t.</td>
</tr>
<tr>
<td>peck</td>
<td>pk.</td>
</tr>
<tr>
<td>pennyweight</td>
<td>dwt.</td>
</tr>
<tr>
<td>pint</td>
<td>pt.</td>
</tr>
<tr>
<td>pound</td>
<td>lb.</td>
</tr>
<tr>
<td>pound, apothecaries'</td>
<td>lb. ap.</td>
</tr>
<tr>
<td>pound, avoirdupois</td>
<td>lb. av.</td>
</tr>
<tr>
<td>pound, troy</td>
<td>lb. t.</td>
</tr>
<tr>
<td>quart</td>
<td>qt.</td>
</tr>
<tr>
<td>rod</td>
<td>rd.</td>
</tr>
<tr>
<td>scruple, apothecaries'</td>
<td>s. ap.</td>
</tr>
<tr>
<td>square centimeter</td>
<td>sq. cm.</td>
</tr>
<tr>
<td>square chain</td>
<td>sq. ch.</td>
</tr>
<tr>
<td>square decimeter</td>
<td>sq. dm.</td>
</tr>
<tr>
<td>square dekameter</td>
<td>sq. dkm.</td>
</tr>
<tr>
<td>square foot</td>
<td>sq. ft.</td>
</tr>
<tr>
<td>square hectometer</td>
<td>sq. hm.</td>
</tr>
<tr>
<td>square inch</td>
<td>sq. in.</td>
</tr>
<tr>
<td>square kilometer</td>
<td>sq. km.</td>
</tr>
<tr>
<td>square meter</td>
<td>sq. m.</td>
</tr>
<tr>
<td>square mile</td>
<td>sq. mi.</td>
</tr>
<tr>
<td>square millimeter</td>
<td>sq. mm.</td>
</tr>
<tr>
<td>square rod</td>
<td>sq. rd.</td>
</tr>
<tr>
<td>square yard</td>
<td>sq. yd.</td>
</tr>
<tr>
<td>stere</td>
<td>s.</td>
</tr>
<tr>
<td>troy</td>
<td>t.</td>
</tr>
<tr>
<td>yard</td>
<td>yd.</td>
</tr>
</tbody>
</table>
It will be noted that no abbreviations are given for "gram" and "grain." In medical work especially, these two words should always be spelled out, because errors are likely to result from the use of such abbreviations as "g.," "gr.," and "grs.," and misinterpretation of such an abbreviation can lead to serious harm.

ABBREVIATIONS USED IN ENGINEERING

The following list shows abbreviations used in many engineering publications.

<table>
<thead>
<tr>
<th>TERM</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>alternating current</td>
<td>spell out, or a-c. when used as compound adjective</td>
</tr>
<tr>
<td>amperes</td>
<td>spell out</td>
</tr>
<tr>
<td>boiler horse power</td>
<td>boiler h.p.</td>
</tr>
<tr>
<td>brake horse power</td>
<td>b.h.p.</td>
</tr>
<tr>
<td>British thermal units</td>
<td>B.t.u.</td>
</tr>
<tr>
<td>candle power</td>
<td>c.p.</td>
</tr>
<tr>
<td>centigrade</td>
<td>cent.</td>
</tr>
<tr>
<td>centimeters</td>
<td>cm.</td>
</tr>
<tr>
<td>circular mils</td>
<td>cir. mils</td>
</tr>
<tr>
<td>counter electromotive force</td>
<td>counter e.m.f.</td>
</tr>
<tr>
<td>cubic</td>
<td>cu.</td>
</tr>
<tr>
<td>diameter</td>
<td>spell out</td>
</tr>
<tr>
<td>direct current</td>
<td>spell out, or d-c. when used as compound adjective</td>
</tr>
<tr>
<td>electric horse power</td>
<td>e.h.p.</td>
</tr>
<tr>
<td>electromotive force</td>
<td>e.m.f.</td>
</tr>
<tr>
<td>Fahrenheit</td>
<td>Fahr.</td>
</tr>
<tr>
<td>feet</td>
<td>ft.</td>
</tr>
<tr>
<td>foot-pounds</td>
<td>ft-lb.</td>
</tr>
<tr>
<td>gallons</td>
<td>gal.</td>
</tr>
<tr>
<td>grains</td>
<td>gr.</td>
</tr>
<tr>
<td>gram-calories</td>
<td>g-cal.</td>
</tr>
<tr>
<td>grams</td>
<td>g.</td>
</tr>
<tr>
<td>high-pressure cylinder</td>
<td>spell out</td>
</tr>
<tr>
<td>Term</td>
<td>Abbreviation</td>
</tr>
<tr>
<td>------</td>
<td>--------------</td>
</tr>
<tr>
<td>hours</td>
<td>hr.</td>
</tr>
<tr>
<td>inches</td>
<td>in.</td>
</tr>
<tr>
<td>indicated horse power</td>
<td>i.h.p.</td>
</tr>
<tr>
<td>kilogram-calories</td>
<td>kg-cal.</td>
</tr>
<tr>
<td>kilogram-meters</td>
<td>kg-m.</td>
</tr>
<tr>
<td>kilograms</td>
<td>kg.</td>
</tr>
<tr>
<td>kilometers</td>
<td>km.</td>
</tr>
<tr>
<td>kilovolts</td>
<td>kv.</td>
</tr>
<tr>
<td>kilovolt-amperes</td>
<td>kv-a.</td>
</tr>
<tr>
<td>kilowatt-hours</td>
<td>kw-hr.</td>
</tr>
<tr>
<td>kilowatts</td>
<td>kw.</td>
</tr>
<tr>
<td>magnetomotive force</td>
<td>m.m.f.</td>
</tr>
<tr>
<td>mean effective pressure</td>
<td>spell out</td>
</tr>
<tr>
<td>meter-kilograms</td>
<td>m-kg.</td>
</tr>
<tr>
<td>meters</td>
<td>m.</td>
</tr>
<tr>
<td>microfarad</td>
<td>spell out</td>
</tr>
<tr>
<td>miles</td>
<td>mi.</td>
</tr>
<tr>
<td>miles per hour per second</td>
<td>mi. per hr. per sec.</td>
</tr>
<tr>
<td>milligrams</td>
<td>mg.</td>
</tr>
<tr>
<td>millimeters</td>
<td>mm.</td>
</tr>
<tr>
<td>minutes</td>
<td>min.</td>
</tr>
<tr>
<td>ohms</td>
<td>spell out</td>
</tr>
<tr>
<td>per</td>
<td>spell out</td>
</tr>
<tr>
<td>percentage</td>
<td>per cent (or % in tabular matter)</td>
</tr>
<tr>
<td>pounds</td>
<td>lb.</td>
</tr>
<tr>
<td>power-factor</td>
<td>spell out</td>
</tr>
<tr>
<td>revolutions per minute</td>
<td>rev. per min. (or r.p.m. in tabular matter)</td>
</tr>
<tr>
<td>seconds</td>
<td>sec.</td>
</tr>
<tr>
<td>square</td>
<td>sq.</td>
</tr>
<tr>
<td>square-root-of-mean-square</td>
<td>r.m.s.</td>
</tr>
<tr>
<td>ton-mile</td>
<td>spell out</td>
</tr>
<tr>
<td>tons</td>
<td>spell out</td>
</tr>
<tr>
<td>volt-amperes</td>
<td>spell out</td>
</tr>
<tr>
<td>volts</td>
<td>spell out</td>
</tr>
<tr>
<td>watt-hours</td>
<td>watt-hr.</td>
</tr>
<tr>
<td>watts</td>
<td>spell out</td>
</tr>
<tr>
<td>watts per candle power</td>
<td>watts per c.p.</td>
</tr>
<tr>
<td>yards</td>
<td>yd.</td>
</tr>
</tbody>
</table>
1. Complete name. A complete plant name should include the name of the genus (in italics), the name of the species (in italics), and the abbreviated designation of the person who named the plant (in Roman type). (For example: *Oryza sativa* Linn.) It is often desirable to add the common name of the plant and the name of the family (both in Roman type). [For example: *Shorea polypetperma* Merr. (tanguile), Dipterocarpaceae; *Hemileia vastatrix* Berk. and Br. (coffee rust), Pucciniaceae.] Unfortunately, a plant may have received several common and scientific names. Where scientific names differ in standard or commonly used works, one is chosen and the others are treated as synonyms. If a synonym is much used, it is customary to insert it in parentheses after the accepted name. In an index, accepted names are usually printed in Roman type, and synonyms in italics. In tables and in titles, names of genera and species should be printed in Roman type.

2. Omission of family name. The family name may often be omitted, especially if the plant is well known.

3. Necessity of scientific name. The scientific name, in addition to the common name, should be given when the plant is first mentioned in a paper. Use names that will be understood by foreign readers, many of whom must translate an article before they can understand it. For example, *Manihot utilisima* is universally understood; but the common name camoteng cahoy would be unintelligible to readers in many parts of the world. The scientific name may be enclosed in parentheses after the common name. [For example: The experiments described in this paper deal with the growth of rice (*Oryza sativa* Linn.).]
4. **Use of common name.** In papers dealing with agriculture, the scientific name of a well-known plant need not be repeated; after the scientific name has been given once, the plant may be referred to by its common name in the rest of the paper.

5. **Capitalization.** The generic name should be capitalized, and the specific name usually should not be capitalized. There is good authority, however, for capitalizing names of species derived from generic names, or from names of persons. (For example: *Acer Negundo*, *Ustilago Zeae*, *Magnolia Soulangeana*.)

6. **Variety name.** Capitalize the vernacular names of plant varieties (Yellow Dent corn, Binocol rice, Carabao mango, New Era cowpeas), but not the latinized names of varieties (*Lathyrus palustris* Linn. var. *linearifolius* Ser.).

**ANIMALS**

1. **Complete name.** In papers on zoology or one of its branches, such as entomology, names of animals should be given in a form similar to that used for plant names. (For example: *Agromyza destructor* Malloch (bean fly), Family Agromyzidae, Order Diptera; *Bubalus bubalis* Lyd. (carabao), Bovidae; *Equus caballus* Linn. (horse), Equidae.)

2. **Use of common name.** In an agricultural paper well-known kinds of animals may be referred to by their common names; the complete scientific name may be given only at the beginning of the paper, or it may be omitted entirely. (For example: Berkshire swine, cattle, horse, Barred Plymouth Rock fowls.)

---

13 The Government Printing Office never capitalizes the specific name. (For example: *Ustilago zeae*.)

14 Many zoological publications do not italicize scientific names.
TABLES

1. Importance. The first step in the analysis of experimental data is to arrange them in the form of tables. This part of the work requires a great deal of study before the best scheme for bringing out relationships is found. Two general types of tables should usually be prepared: (a) those which contain the original data, including actual observations and measurements, and (b) those which contain derived data, bringing out special points and conclusions. A large part of the work of interpretation of the data will have been completed when well-arranged tables have been made.

2. Unity. Each table should be a unit. A table is a short-cut means of presenting facts to the reader, and a table (like a sentence, paragraph, or article) should present one subject with distinctness. Do not attempt to bring out in a single table several comparisons of very different kinds. Avoid large tables; they are confusing.

3. Clearness. The form of the table should be arranged to secure greatest clearness. For each kind of comparison of data, there is usually one form of table which brings out the comparison most clearly and systematically. In addition to the absolute figures representing original observations, the table may include percentages, ratios, totals, averages, etc.; the latter are often of great value in making comparisons.

4. Accuracy. Every item in the table must be checked for correctness.

5. Economy. Since tables cost much more per page than text material, they should be used only when needed and should not be made unnecessarily large. For a two-column page, they should be designed, if possible, to fit within a single column. Abbreviations should be
used to keep the column heads of the table small. A column should not be devoted to only one or two entries,

**TABLE 2**

*Isotonic molalities and activities of water for solutions of orthophosphoric acid at 25°C. Reference standard, sulfuric acid.*

<table>
<thead>
<tr>
<th>$\text{H}_3\text{PO}_4$</th>
<th>$\text{H}_2\text{SO}_4$</th>
<th>$\alpha_1$</th>
<th>$\text{H}_3\text{PO}_4$</th>
<th>$\text{H}_2\text{SO}_4$</th>
<th>$\alpha_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0675</td>
<td>0.5973</td>
<td>0.9782</td>
<td>23.524</td>
<td>10.146</td>
<td>0.3528</td>
</tr>
<tr>
<td>1.7602</td>
<td>0.9694</td>
<td>0.9633</td>
<td>24.854</td>
<td>10.619</td>
<td>0.3289</td>
</tr>
<tr>
<td>2.9858</td>
<td>1.6192</td>
<td>0.9331</td>
<td>28.202</td>
<td>11.746</td>
<td>0.2778</td>
</tr>
<tr>
<td>4.3541</td>
<td>2.3082</td>
<td>0.8962</td>
<td>28.768</td>
<td>11.861</td>
<td>0.2732</td>
</tr>
<tr>
<td>5.1875</td>
<td>2.7320</td>
<td>0.8690</td>
<td>29.995</td>
<td>12.068</td>
<td>0.2649</td>
</tr>
<tr>
<td>9.1862</td>
<td>4.5623</td>
<td>0.7367</td>
<td>31.044</td>
<td>12.536</td>
<td>0.2470</td>
</tr>
<tr>
<td>9.5130</td>
<td>4.7401</td>
<td>0.7231</td>
<td>31.982</td>
<td>12.827</td>
<td>0.2366</td>
</tr>
<tr>
<td>10.284</td>
<td>5.0404</td>
<td>0.6999</td>
<td>33.305</td>
<td>13.224</td>
<td>0.2230</td>
</tr>
<tr>
<td>10.903</td>
<td>5.3309</td>
<td>0.6774</td>
<td>34.099</td>
<td>13.414</td>
<td>0.2167</td>
</tr>
<tr>
<td>11.070</td>
<td>5.4010</td>
<td>0.6720</td>
<td>35.773</td>
<td>14.064</td>
<td>0.1963</td>
</tr>
<tr>
<td>11.197</td>
<td>5.4660</td>
<td>0.6669</td>
<td>37.824</td>
<td>14.428</td>
<td>0.1857</td>
</tr>
<tr>
<td>11.938</td>
<td>5.7441</td>
<td>0.6452</td>
<td>41.184</td>
<td>15.283</td>
<td>0.1625</td>
</tr>
<tr>
<td>12.647</td>
<td>6.0190</td>
<td>0.6237</td>
<td>43.035</td>
<td>15.733</td>
<td>0.1518</td>
</tr>
<tr>
<td>13.550</td>
<td>6.4432</td>
<td>0.5915</td>
<td>50.010</td>
<td>17.268</td>
<td>0.1202</td>
</tr>
<tr>
<td>14.057</td>
<td>6.6349</td>
<td>0.5765</td>
<td>57.265</td>
<td>18.766</td>
<td>0.0957</td>
</tr>
<tr>
<td>15.685</td>
<td>7.2422</td>
<td>0.5323</td>
<td>64.420</td>
<td>20.024</td>
<td>0.0791</td>
</tr>
<tr>
<td>15.912</td>
<td>7.3646</td>
<td>0.5237</td>
<td>64.659</td>
<td>20.064</td>
<td>0.0786</td>
</tr>
<tr>
<td>18.034</td>
<td>8.1749</td>
<td>0.4677</td>
<td>74.726</td>
<td>21.660</td>
<td>0.0627</td>
</tr>
<tr>
<td>19.006</td>
<td>8.5554</td>
<td>0.4432</td>
<td>120.56</td>
<td>27.01</td>
<td></td>
</tr>
<tr>
<td>20.708</td>
<td>9.1841</td>
<td>0.4084</td>
<td>134.00</td>
<td>29.37</td>
<td></td>
</tr>
<tr>
<td>21.327</td>
<td>9.3940</td>
<td>0.3937</td>
<td>217.4</td>
<td>33.69</td>
<td></td>
</tr>
<tr>
<td>21.608</td>
<td>9.5043</td>
<td>0.3874</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


to a repetition of the same entry, or to data that may be easily calculated from data in another column. Such
cases can usually be cared for in footnotes or in notes following the title.

6. Size. The table must be compiled so as to fit the page of the publication. On a two-column page, tables

<table>
<thead>
<tr>
<th>TABLE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distances progressed at different times by three strains of Neurospora crassa growing on agar medium containing a limiting concentration of l(+)leucine (0.0075 mg./ml.)*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME</th>
<th>DISTANCE COVERED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prototrophic h1 (adapted)</td>
</tr>
<tr>
<td>days</td>
<td>mm.</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>0.45</td>
<td>40</td>
</tr>
<tr>
<td>0.97</td>
<td>89</td>
</tr>
<tr>
<td>1.00</td>
<td>140</td>
</tr>
<tr>
<td>1.47</td>
<td>72</td>
</tr>
<tr>
<td>1.52</td>
<td>182</td>
</tr>
<tr>
<td>1.88</td>
<td>246</td>
</tr>
<tr>
<td>1.98</td>
<td>148</td>
</tr>
<tr>
<td>2.47</td>
<td>123</td>
</tr>
<tr>
<td>2.51</td>
<td>147</td>
</tr>
<tr>
<td>3.03</td>
<td>148</td>
</tr>
<tr>
<td>3.10</td>
<td>148</td>
</tr>
</tbody>
</table>


may occupy a single column, or, if necessary, the full width of the page.

When large tables are required, the method of handling them should be left to the judgment of the printer. If a table is too large to come within the width of the page, it may be possible to set it lengthwise on the page. If it will fit neither crosswise nor lengthwise, then it may be
possible to keep it within bounds by setting it in 6-point type, the smallest size used for book and periodical work. If this method fails, the table may be spread across two facing pages.

**TABLE 4**

*Mean number of aleurone dots on seeds with three \( a_1 \) genes and seeds with two \( a_1 \) genes from eight ears of crosses* 

\( a_1a_1DtDt \times a_1a_1Pdtdt \) or \( a_1a_1dtdt \times a_1a_1PdDt^* \)

<table>
<thead>
<tr>
<th>PEDIGREE</th>
<th>MEAN NO. DOTS ON ( a_1a_1Dd ) CLASS</th>
<th>NO. OF SEEDS IN CLASS</th>
<th>MEAN NO. DOTS ON ( a_1a_1Pd ) CLASS</th>
<th>NO. OF SEEDS IN CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2676 (1) ( \times ) 2511a</td>
<td>15.2</td>
<td>46</td>
<td>10.0</td>
<td>48</td>
</tr>
<tr>
<td>2500 ( \times ) 2511b</td>
<td>9.0</td>
<td>32</td>
<td>6.2</td>
<td>49</td>
</tr>
<tr>
<td>4345 (4) ( \times ) 4344 (1)</td>
<td>10.2</td>
<td>152</td>
<td>6.1</td>
<td>172</td>
</tr>
<tr>
<td>4345 (6) ( \times ) 4344 (7)</td>
<td>7.4</td>
<td>61</td>
<td>5.0</td>
<td>62</td>
</tr>
<tr>
<td>4345 (8) ( \times ) 4344 (1)</td>
<td>5.6</td>
<td>70</td>
<td>4.2</td>
<td>76</td>
</tr>
<tr>
<td>4345 (9) ( \times ) 4344 (2)</td>
<td>11.5</td>
<td>16</td>
<td>9.6</td>
<td>19</td>
</tr>
<tr>
<td>4345 (11) ( \times ) 4344 (2)</td>
<td>3.5</td>
<td>39</td>
<td>2.6</td>
<td>42</td>
</tr>
<tr>
<td>4345 (12) ( \times ) 4344 (8)</td>
<td>2.9</td>
<td>20</td>
<td>1.4</td>
<td>27</td>
</tr>
<tr>
<td><strong>Observed</strong> =</td>
<td>8</td>
<td>55.3</td>
<td>436</td>
<td>8</td>
</tr>
<tr>
<td><strong>Theoretical</strong> on 3:2 ratio</td>
<td>8.16</td>
<td>5.64</td>
<td></td>
<td>8.28</td>
</tr>
</tbody>
</table>

*Data from: Rhoades, M. M. 1938. Effect of the \( Dt \) gene on the mutability of the \( a_1 \) allele in maize. Genetics 23: 377-397.*

A folder should not be used unless it is absolutely unavoidable. Folders are not only very costly, but are unwieldy for the reader and are likely to be torn when handled in the library.

7. **Large tables in manuscript.** If a table requires a larger sheet than that used for the text of the manuscript, the sheet may be folded and inserted in place as one of the manuscript pages.
8. Each table on separate page. Each individual table should be typewritten on a separate sheet of paper, without any of the text on the same page. This is necessary to facilitate typesetting. When the place for a table is reached in typewriting a manuscript, the text sheet should be removed from the typewriter (no matter where the typewriting ends), and a new sheet should be inserted; only the table (preceded by its heading and followed by its footnotes) should be written on this sheet. The text should be continued on a fresh sheet of paper. If, through oversight or otherwise, it becomes necessary to insert a table in a full page of text material, it should be treated as an insert (p. 32).

9. Open and ruled tables. Tables may be either open or ruled; the former generally are used in tables of only two columns, though they are employed exclusively in some periodicals (for example, in The Journal of the American Chemical Society). The suggestions given below refer specifically to ruled tables.

10. Examples. Sample tables are given on pages 59–65. Care should be taken to prepare each table in exactly the proper form.

11. Heading, or title. Note the way in which the heading is made. The tables are numbered consecutively throughout each article. The word "Table," followed by an Arabic number, appears as a center heading (printed in 6-point caps). The legend, or description, of the table is centered above the body of the table; only the first word and proper names have capital initials; the legend is printed in 8-point italics. Each word of the legend is underscored with a single straight line to indicate italic type to the printer. The legend should be self-explanatory and should enable the reader to understand the table without referring to the text of the article. It should be
broad enough to include all the data in the table. Make it definite—allow only one meaning.

12. **Box heads.** The box heads, at the tops of columns in a table, appear in small caps (6-point). The secondary heads, when present, are printed in ordinary type (6-point lower-case).

### TABLE 5

*Average dry weight of tops and selenium content of corn grown in culture solutions containing various concentrations of sodium selenite or seleniferous Astragalus extract*

<table>
<thead>
<tr>
<th>SELENIUM IN CULTURE SOLUTION</th>
<th>AVE. DRY WT. OF TOPS</th>
<th>SELENIUM CONTENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sodium selenite</td>
<td>Astragalus extract</td>
</tr>
<tr>
<td>ppm.</td>
<td>grams</td>
<td>grams</td>
</tr>
<tr>
<td>0</td>
<td>1.36</td>
<td>1.36</td>
</tr>
<tr>
<td>1</td>
<td>1.25</td>
<td>1.28</td>
</tr>
<tr>
<td>2</td>
<td>1.06</td>
<td>0.94</td>
</tr>
<tr>
<td>5</td>
<td>0.68</td>
<td>0.68</td>
</tr>
<tr>
<td>10</td>
<td>0.42</td>
<td>0.37</td>
</tr>
<tr>
<td>20</td>
<td>0.19</td>
<td>0.20</td>
</tr>
</tbody>
</table>


13. **Units of measurement.** Units of quantity are given below the line under the box heads and printed in 6-point italics. (In the stub, or first column, such units are placed on the right, according to a rule sometimes followed.)

14. **Body of table.** Columns consisting of words in the body of the table should appear in ordinary type. Figure columns should be aligned on the right; reading columns, on the left. Figure columns should be separated from perpendicular rules at least an em space; decimals
should be aligned; figures should be centered in the columns. Omissions should be indicated by blank spaces; the reasons for omissions of important data should be explained in footnotes. If possible, the body of the table is printed in 8-point type; it is sometimes necessary to use 6-point type.

15. Footnotes. Explanatory footnotes to tables are indicated by means of standard footnote reference marks (*, †, ‡, §, etc.) placed after the words or the numbers to which the footnotes refer. The footnotes are typewritten on the sheet bearing the table. Each footnote is preceded by a symbol and is indented as a paragraph. Footnotes are printed in 8-point type, leaded.

16. Special type. Bold-face and italic type may be used to distinguish different classes of data in a table. Uniform type treatment, however, is desirable. In general, it is well to avoid unnecessary multiplicity of sorts of type.

17. Cross rules. Care should be taken that as few cross rules as possible are used. A cross rule is necessary at the top of the table, another is needed below the box heads, and a third is needed at the bottom of the table. Any additional cross rules increase the cost of printing. Where a line of demarcation is necessary, it can be indicated effectively and inexpensively by a blank space, which can be composed by the typesetting machine.

18. Spacing. In the printed table, the figure columns should be cast to cover the normal requirements of the figure entries or wording of box heads; spaces between

---

15 Lower-case superscript letters are used instead of symbols by many journals. The letters are usually placed after the words or before the numbers to which the footnotes refer. The Government Printing Office uses superscript Arabic numerals.
perpendicular rules should, if possible, be the same; the balance of the space may be put in the stub (first column) or other reading columns. Tables should be set leaded. In long tables, grouping the horizontal lines of figures in groups of four lines, by a double lead,

**TABLE 6**

*Comparison of microbiological and chemical method for determining methionine, and effect of presence of an equal weight of carbohydrates during hydrolysis of protein*

<table>
<thead>
<tr>
<th>MATERIAL ANALYZED</th>
<th>METHIONINE FOUND IN PROTEIN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Microbiological method with Streptococcus faecalis R</td>
</tr>
<tr>
<td></td>
<td>Leuconostoc mesenteroides</td>
</tr>
<tr>
<td>Beef loin†</td>
<td>2.52</td>
</tr>
<tr>
<td>Beef liver†</td>
<td>2.34</td>
</tr>
<tr>
<td>Casein†</td>
<td>2.72</td>
</tr>
<tr>
<td>Casein and sucrose</td>
<td>2.42</td>
</tr>
<tr>
<td>Casein and arabinose</td>
<td>2.49</td>
</tr>
<tr>
<td>Casein and starch</td>
<td>2.45</td>
</tr>
</tbody>
</table>

† Protein content calculated as nitrogen content × 6.25.
‡ Difco isoelectric casein; values not corrected for moisture and ash.

makes the table easier to read and aids in preventing inaccurate reading.

19. References in text. References to tables should be made by number. (For example: By reference to table 10; the data presented in table 3.)
1. *Reference numbers in text.* Footnotes pertaining to the text should be numbered consecutively (from 1 up) throughout each article and indicated by superscript numerals (¹, ², ³, etc.). The reference numeral to the footnote should be placed in the text after the word or sentence to which the footnote refers. (It is placed after a punctuation mark if one occurs.) Indicate the superscript numeral by typewriting it above the line and placing a V-shaped mark under it. Observe that these references apply to the text only; tabulations employ a separate series of symbols for each table. If mathematical formulae containing exponents appear in the text, care should be taken to avoid confusing exponents and footnote reference numbers.

2. *Footnotes at end of manuscript.* Footnotes should not be in the body of the text; the text should have the reference numbers only. Footnotes should be typewritten double-spaced on one or more separate sheets (as many footnotes to a sheet as convenient). Each footnote should be indented as a paragraph, and should be preceded by a superscript numeral corresponding to the reference number in the body of the manuscript. The sheets bearing footnotes should be put at the end of the text copy, each sheet bearing the word “Footnotes,” enclosed in a circle.

This method is necessary in order to facilitate composition on the typesetting machines. When printed, each footnote will be inserted at the foot of the proper page.

3. *Misuse of footnotes.* Use footnotes only where they are indispensable. Include important material in the text; omit irrelevant material.
For a research worker, the library plays a very important role. Original investigation must be supported by a review of the literature published by others in the same field. This section endeavors to give an introduction to the use of the library and to draw attention to some of the important works to be found there.

1. The catalogue. The catalogue is the key to the library collections. The card catalogue is most popular, although some libraries have their catalogues in book form. When the cards are alphabetized in a single file under author, title, and subject, the name dictionary catalogue is used. Large libraries often have separate catalogues for certain collections. This is confusing to the user. For example, medicine and law may not appear in the general catalogue; collections of doctoral dissertations may be found in special libraries with a separate card index; and manuscripts may be in a file by themselves. It is best to inquire at the reference desk if you fail to find what you wish.

When consulting the card catalogue, it would be advantageous to find out what special filing rules may have been followed. For example, one would expect to find the cards alphabetized word by word. Thus, New York should come before Newfoundland. But some catalogues have the cards filed letter by letter; in these, Newark would appear before New York. Libraries also differ in the case of Mc and Mac. It seems simpler to have all under Mac, but this method is not always followed. Usually
libraries do not file under prepositions in surnames, as *von* and *de*; but a preposition and an article, as *du*, is recognized as preceding the rest of the surname. To make doubly sure when in doubt, try both ways. Hyphenated names generally come under the first part of the surname, as *Page-Wood, John*. When an author changes her name by marriage, the name under which the author first wrote is most commonly used; but there should be a cross reference under the married name. Libraries differ in regard to the German umlaut; *Müller* may be filed under *Muller* or *Mueller*.

In locating serials—a term which includes periodicals, journals, magazines or publications of societies, institutions, etc.—the best rules to follow are those which appear in the first part of the *Union List of Serials in Libraries of the United States and Canada*. To quote:

A serial not published by a society or a public office is entered under the first word, not an article, of the latest form of the title.

A serial published by a society, but having a distinctive title, is entered under the title, with reference from the name of the society.

The journals, transactions, proceedings, etc., of a society are entered under the first word, not an article, of the latest form of the name of the society.

Learned societies and academies of Europe, other than English, with names beginning with an adjective denoting royal privilege are entered under the first word following the adjective (Kaiserlich, Königlich, Reale, Imperiale, etc.).

If you have an abbreviated title that is difficult to understand, consult the *World List of Scientific Periodicals*, published by the Oxford University Press, and also the volume listing abbreviations. This list is arranged alphabetically by the first word of the title, not an article. It is especially useful when a puzzling foreign reference is involved. Special subjects have their own lists of
explanations of abbreviations, as those in *Chemical Abstracts, Biological Abstracts,* and *Science Abstracts.*

Government documents present a complexity all their own in the catalogue. The United States probably issues more publications than any other nation. The comprehensive cumulative indexes published by the Government should be used in locating a difficult reference. Monthly lists with a yearly index bring the file up to date. In spite of this aid an appeal often has to be made to the reference department for assistance in locating a document in the card catalogue; so too much time should not be expended before soliciting help.

2. *Classifications.* Libraries are classified in order to bring publications on a particular subject together. The two most familiar classifications are the *Dewey decimal system* and the *Library of Congress system.*

*The Dewey decimal system* is a numerical arrangement whereby a number can be expanded by means of a decimal. For example, *General Science* is designated by the number 500, *Chemistry* by 540, *Organic Chemistry* by 546, while further divisions would make use of the decimal as 546.1, 546.2, etc. There are infinite possibilities for expansion. Under this *class number,* as it is called, a symbol is added, called the *Cutter number,* which stands for the author. If the author is *Smith,* you will find *Sm 5* or *Sm 55.* These numbers are decimals. *Sm 55* would stand just before *Sm 551.* Thus a book on organic chemistry might have a number like this:

546.11  
Sm 55

*The Library of Congress system* classifies by the use of letters. The first letter indicates the class; the second a division of the class; and further sectioning is made by
the use of numbers. For example, the letter Q stands for Science, QC for Physics, and QC 252-333 for Heat.

Although both schemes may look complicated, they afford the library a means of bringing together on the shelf the publications on a certain subject. This is particularly valuable to the research worker who has an opportunity to visit the shelves to consult familiar books and become acquainted with those that are new to him.

It is most important that the call number, the number appearing in the upper left-hand corner of the catalogue card, be copied in full when requesting a book. An F under the Cutter number, as:

546.2
D15
F

would mean folio size, and this very large book would undoubtedly be shelved in another place from books of medium size. Sometimes, a volume number is added, as:

590.6
Un 33
vol. 7

This means that the reference you have found is in a certain volume of a series, and the volume number must be included when requesting the book.

3. Subject headings in the catalogue. The subject approach to the catalogue should be more generally emphasized. The subjects that appear at the top of the card are selected by specialists in certain fields. But as time goes on, the headings may not be revised; so new developments may be filed under antiquated headings. Under the subject heading, the person using the catalogue
will find grouped together the works on the particular subject in which he is interested. Thus publications on the intricate life processes of plants are under *Botany—Physiological*. Again, the reference department should come to your aid if you are doubtful under which subject heading you should look. Most libraries depend upon the headings selected by the Library of Congress, but some choose their own.

In this brief introduction to the catalogue, an attempt has been made to show that catalogues vary. Failing to find your reference in one place, try other possibilities and then ask someone in the reference department. Difficult foreign names or obscure abbreviations for periodicals may present problems in which only the reference department can help you.

4. Reference works supplementing the card catalogue. There are general reference works that supplement the card catalogue. Chief among these is the *U. S. Library of Congress, Catalog of Books* in over 166 volumes at the present time. *The British Museum, Catalogue of Printed Books* is an equally comprehensive series; every scientist should know this most scholarly of catalogues. A section on the Natural Sciences, consisting of five volumes with several supplements, has been published separately. There is also the great French catalogue of the collection in the *Bibliotheque Nationale*, which has been completed to *R*. This important series published in Paris should not be overlooked in searching for a foreign reference. A useful feature is the listing of titles under the author's name showing in what volume or edition a work may be found.

The current record of books published in the United States, with listing of prices, is to be found in the *United States Catalog* and its supplements, the *Cumulative Book*
Index. A working set of this series consists of the *U. S. Catalog: Books in Print* 1928, the three five-year cumulations of the *Cumulative Book Index* covering 1928–1932, 1933–1937, 1938–1942, and the biennial, annual, semi-annual, and monthly cumulations which bring the record down to date. Since 1928 the *Cumulative Book Index* has listed all books published in English in this and other countries.

A reference series not so well known is that of the *Royal Society of London, Catalogue of Scientific Papers 1800–1900*, in nineteen volumes. It forms an author index of publications that appeared in periodicals throughout the world, especially in publications of academies and learned societies. Three subject indexes have been brought out to date: pure mathematics, mechanics, and physics. In the first volume of the author index a list of abbreviations is found which is helpful in tracing difficult references.


5. Aid to writing papers. Nearly every branch of pure or applied science has issued a style book of its own rules. It is advisable to have this at hand before commencing to write. The *U. S. Government Printing Office Style Book* is a general type. *Suggestions to Authors of Papers Submitted for Publication by the United States Geological Survey with Directions to Typists* is an example of a special type. Another is the *Wistar Institute Style Brief*, which states that it is "A Guide for Authors in
Preparing Manuscripts and Drawings for the most Effective and Economical Method of Publishing Biological Research."

6. Affiliated libraries. In a large city the libraries of the various institutions are usually closely affiliated. Thus the libraries of the New York Botanical Garden and of the American Museum of Natural History are affiliated with the Columbia University Library. Special libraries have become so numerous that their staff members have found it advantageous to organize in groups, under medicine, biology, etc., as a means of becoming better acquainted with the resources of all similar libraries. Ask your librarian concerning affiliated libraries and their regulations for outside users. Before visiting another library, it is best to ascertain the hours during which visitors may consult the collection, especially on Saturdays, Sundays, and holidays.

In Philadelphia a plan is now being developed whereby the holdings of all the important libraries in the city will be represented in a union card catalogue. When you consider the rich collection of works on natural history in the Academy of Natural Sciences of Philadelphia, you will realize the importance of this union catalogue.

7. Inter-library loans. Since it is impossible for a library to have all publications, a system of interchange of material, termed inter-library loan, is carried on by most libraries. This has developed into a very important service about which the research worker should know. There is usually a library assistant in charge of inter-library loans, and it is best to make arrangements directly through this person. Present your citation in printed form, complete and accurate in all details.

8. Photographic services. Reproductions of rare or
unusual books, as well as of papers in scientific periodicals, may be secured as Photostats or microfilms. A microfilm may be obtained for a nominal sum. Photostats are much more expensive even in negative form. The disadvantage of the microfilm is that it has to be magnified or projected. A magnifier, provided with a simple lens, costs a few dollars; a complicated microfilm reading machine is worth several hundred. Most large libraries have several machines that are available for use; it is best to find out which gives the clearest projection and is least difficult to handle.

9. Map collection. A map is sometimes a very important asset. It would be well to find out where the map collection is housed, and the rules for borrowing. In such a collection the best atlases and gazetteers, as well as large-scale maps of important countries, may be consulted.

INDEXING AND ABSTRACTING TOOLS

Before starting a new research project or preparing the results of research for publication, an investigator needs to find out what other workers have done in the same field. To make the literature of a particular science available to the scientist, several different types of publications have been developed. The chief of these are (1) the index journal, (2) the abstract journal, (3) the annual review book, (4) the recent advances series, and (5) the review journal. While not all sciences have all these forms of publications, nearly every science has at least several of them. The examples given here are intended merely to call the reader's attention to the possibility of using such publications in his own field.

Prepared by Miss Estelle Brodman, of the Library of the College of Physicians and Surgeons, Columbia University.
1. **Index journals.** Search for literature is usually begun by making a list of previous books and journal articles on the subject. To prepare such a list, the research worker has to consult an index to the literature—a publication that lists by author, subject, or both, all the books or articles in the science that have appeared within a certain period. Examples of such indexes are the monumental *Index-Catalogue of the Library of the Surgeon-General’s Office* and the *Quarterly Cumulative Index Medicus*. These works give a more or less complete listing of all the books and articles on a particular subject, regardless of the worth of the writings.

2. **Abstract journals.** To find out exactly what these articles say, without having to read each article in toto, the research worker can go to an abstract journal that summarizes the methods used and conclusions reached by the writers of the individual articles. A great many such abstract journals were published formerly in German; but some of the better-known abstract journals in English are *Biological Abstracts*, *British Abstracts* (formerly the *British Chemical and Physiological Abstracts*), *Chemical Abstracts*, *Science Abstracts*, *Tropical Diseases Bulletin*, and *Engineering Index*. In these abstract journals, each article is summarized individually, with little or no reference to other literature and no editorial comment.

3. **Annual reviews and yearbooks.** Frequently what is needed is a critical review of the articles that have appeared on a subject during the year, with some indication of the relative importance of the individual articles. To supply this need, a group of publications has sprung up under the general title of *annual review* or *yearbook* (German, *Jahresbericht*; French, *année*). Examples are the *Annual Review of Physiology*, the *Annual Review of Biochemistry*, and the *Yearbook of Dentistry*. These
books, by authorities in their fields, give critical reviews of the work reported during the year and are especially useful in pointing out important articles. They save the time of the research worker, who would otherwise be obliged to read an abstract of each article published to see which ones were worth investigating further.

4. Recent advances series. According to the procedure outlined above, a person investigating the literature in his field starts by using an index journal to compile a list of the articles published during the year. He could then go to an abstract journal to find short summaries of each of the articles published, or he might go to an annual review for a critical review of the entire year. It will readily be seen, that by using this system, anyone wishing to cover the literature for ten or twenty years would have to peruse a very large number of volumes. Fortunately, however, this may not be necessary, since summaries of the literature covering several years—sometimes everything of importance that is known on a particular subject—have been developed. There are two such classes of long-term reviews: the recent advances series and the review journals.

The recent advances series summarizes progress in particular fields during a period of several years by reviewing the literature from the publication date of the previous edition to the publication date of the latest edition. For example, the first edition of Recent Advances in Physiology appeared in 1925; the second edition reported the knowledge obtained during the period from 1925 to 1926; similarly, the third edition added the knowledge obtained from 1926 to 1928. It thus cumulates and integrates the information found in the annual reviews. It is usually critical and selective.

5. Review journals. The review journal, such as Medi-
cine, Chemical Reviews, or Physiological Reviews, has as its object the summarizing of the knowledge in a particular field from the beginning of any work on that subject to the date of publication. Thus, an article on “Water Balance” in Physiological Reviews would discuss the early, now historical literature, as well as the newer advances being made at the time the article appeared. Each article is an entity in itself; and, in contradistinction to the recent advances series, no further reference is needed to earlier editions. For rapidly surveying a segment of a larger field, the review journal is without peer. It usually covers a longer period of time than the annual review or the recent advances series, and is more critical than the index journal or abstract journal. But it must not be forgotten that the review journal is, by its very nature, more selective in the articles it calls to the reader’s attention than any of the other tools discussed here. Since it covers a longer period of time, it can only touch the most important high-lights. For details the other tools must be used; and finally, of course, the investigator must study critically—in their original, complete form—all the articles that bear directly upon his own research problem.

6. Summary. To recapitulate, a person attempting to get a complete review of the literature on a particular phase of physiology would go to (1) the Index-Catalogue of the Library of the Surgeon-General’s Office or the Quarterly Cumulative Index Medicus, (2) Biological Abstracts or British (Chemical and Physiological) Abstracts, (3) the Annual Review of Physiology, (4) Recent Advances in Physiology, and (5) Physiological Reviews. Which one of these he should go to first, and in what order the others should be consulted, depends entirely upon the purpose for which the review of the literature is being made. It
is suggested that a discussion with the reference librarian will frequently point the way to a logical search of the literature.

7. List of indexing and abstracting tools. The list that is given below, though by no means complete, contains some of the most useful of the literature sources in a number of fields of science.

AGRICULTURE

Reference sources.

Agricultural Index. 1916 +.
United States Department of Agriculture. Library.
   Bibliography of Agriculture. 1942 +.

Card index.

United States Department of Agriculture. Card Index.

Abstract journal.

United States Department of Agriculture. Experiment Station Record. 1889 +.

ANTHROPOLOGY

Reference sources.

Anthropos. 1914 +.
Ethnographic Bibliography of North America. (Yale Anthropological Studies.) 1941 +.

Review journal.

Anthropologischer Anzeiger. 1924 +.

BOTANICAL AND ZOOLOGICAL SCIENCES

Reference sources.

Botanisches Zentralblatt. 1880 +.
   Zoological Record. 1864 +.

18 Prepared by Miss Amy L. Hepburn, of the Columbia University Library.
Card indexes.

Concilium Bibliographicum. 1896–1934.

Abstract journals.

Berichte über die Wissenschaftliche Biologie. 1926 +.
Biological Abstracts. 1926 +.
Review of Applied Mycology. 1922 +.

Annual reviews.

Annual Review of Physiology. 1939 +.

Recent advances.

Advances in Genetics. 1947 +.

Review journals.

Biological Reviews. (Cambridge Philosophical Society.) 1923 +.
Botanical Review. 1935 +.
Physiological Reviews. 1921 +.
Quarterly Review of Biology. 1926 +.

CHEMISTRY

Reference sources.

Beilstein, F. Handbuch der Organischen Chemie. 1913 +.

Abstract journals.

Chemical Abstracts. 1907 +.
British Abstracts. 1945 +. (Supersedes British Chemical and Physiological Abstracts. 1926–1944.)
Annual reviews.


Recent advances.

Advances in Colloid Chemistry. 1942 +.
Advances in Colloid Sciences. 1942 +.
Advances in Protein Chemistry. 1944 +.
Advances in Enzymology and Related Subjects. 1941 +.
Advances in Carbohydrate Chemistry. 1945 +.

Review journal.

Chemical Reviews. 1924 +.

ENGINEERING

Reference sources.

Industrial Arts Index. 1913 +.
Technical Book Review Index. 1935 +.

Card index.

Engineering Index Card Service.

Abstract journals.

Engineering Abstracts. 1910 +.
Engineering Index. 1906 +.

Review journal.


GEOGRAPHY

Reference sources.

Bibliographie Géographique Internationale. 1891 +.
Annual review.

Geographisches Jahrbuch. 1866 +.

Review journal.

Geographical Review. 1916 +.

GEOLOGY

Reference sources.

Bibliographie des Sciences Géologiques. (Société Géologique de France.) 1923 +.
Bibliography and Index Exclusive of North America. (Geological Society of America.) 1933 +.
Bibliography of North American Geology, 1785–1945, in 7 parts. (Issued as Bulletins of the United States Geological Survey.)

Abstract journals.

Neues Jahrbuch für Mineralogie, Geologie und Paleontologie. 1830 +.

Annual review.


HISTORICAL, ECONOMIC, POLITICAL, AND SOCIAL SCIENCES

Reference sources.

Cambridge Ancient History, Medieval History, Modern History. (Comprehensive series of many volumes published by Macmillan Co.)
New York Times Index. 1913 +.
Review journals.

American Academy of Political and Social Sciences. Annals. 1890 +.
American Economics Review. 1911 +.
American Historical Review. 1895 +.

MATHEMATICS

Reference sources.

Mathematical Reviews. (American Mathematical Society.) 1940 +.
Zentralblatt für Mathematik und ihre Grenzgebiete. (Deutsche Mathematiker-Vereinigung.) 1931 +.

Abstract journals.

Jahrbuch über die Fortschritte der Mathematik. 1868 +.

MEDICINE

Reference sources.

Index Medicus. 1879-1926.
Quarterly Cumulative Index Medicus. 1927 +.
United States Surgeon-general's Office. Index Catalogue of the Library. 1880 +.

Abstract journals.

Biological Abstracts. 1926 +.
International Abstracts of Surgery. 1913 +.
International Medical Digest. 1920 +.
Quarterly Review of Medicine. 1943 +.
Tropical Diseases Bulletin. 1912 +.

Annual reviews.

Annual Review of Physiology. 1939 +.
Yearbook of Dentistry. 1936 +.
Yearbook of General Medicine. 1933 +.
Yearbook of General Therapeutics. 1934 +.
Yearbook of Neurology, Psychiatry, and Endocrinology. 1933 +.
Recent advances.

Advances in Internal Medicine. 1942 +.
Advances in Pediatrics. 1942 +.
Recent Advances in Medicine. 1924 +.
Recent Advances in Physiology. 1925 +.
Vitamins and Hormones. 1943 +.

Review journals.

Medicine. 1922 +.
Physiological Reviews. 1921 +.

PHYSICS

Abstract journals.

Physikalische Berichte. 1920 +.

Annual review.


Review journal.

Reviews of Modern Physics. 1929 +.

PSYCHOLOGY

Abstract journals.

Psychological Abstracts. 1927 +.

Annual review.

L'Année Psychologique. 1894 +.

Review journals.

Psychoanalytic Quarterly. 1932 +.
Psychological Bulletin. 1904 +.
SCIENCE IN GENERAL

Reference sources.

Encyclopaedia Britannica.
Mudge, Isadore G. Guide to Reference Books. (Supplements by Winchell, Constance M.) 1936 +
Naturwissenschaften. 1913 +.
Science. 1883 +.

Annual review.

American Yearbook. 1910 +.

Review journal.

Science Progress in the Twentieth Century. 1906 +.

LITERATURE CITATIONS

Citations to literature are given in a bibliography at the end of the paper or in footnotes distributed through the paper. The method of handling text references and of writing citations differs in detail in the various scientific journals. A uniform economical standard, though highly desirable, has not been adopted. It may be noted, however, that there is a modern trend away from the use of Roman numerals, which are not readily comprehended, as well as from the use of italic and black-face types, which make much unnecessary work for author, editor, and printer.

In preparing references in the library, it is most important to write the citations in detail, so that they include the full title and all other essential information. In the final revision, the references should be made to conform to the exact style employed by the journal in which the paper is to be published.
THE SCIENTIFIC PAPER

Verify each item in every citation, preferably by going to the library and looking up all the publications. You must assume full responsibility for the accuracy and completeness of your citations. Although the editor may make minor revisions in the form of the citations to suit the style of the journal, he cannot be expected to look up spelling, figures, etc., nor supply data that you have omitted.

When the citations are printed at the end of the paper, the heading "Literature cited" is usually employed. It is customary to use the heading "Bibliography" only in books or in articles of a general or popular nature, where specific reference to the citations is not made in the text.

Be sure to have the citations typewritten double-spaced throughout.

As a final precaution against error, check all text references to citations just before submitting the paper for publication.

Directions are given below for two methods of handling citations. Each of these methods has wide usage. The first method has some advantages not possessed by the second. Reference by author and year of publication gives the reader the information he wants in the text and enables him to locate the citation easily in the alphabetical list at the end of the paper, or to use the list independently as a source of literature. This method of reference is most convenient for the author because it allows him to add or delete citations during the revisions of the manuscript, without the necessity of repeatedly renumbering the series or inserting interpolated numbers. Furthermore, this style avoids the use of troublesome Roman numerals and black-face and italic types. A colon between volume number and page numbers gives clear separation and is readily understood by everyone.
FIRST METHOD

1. Text reference to citation. Reference to a citation is made by means of the author’s name followed by the year of publication in parentheses. [For example: Foster (1945).] Where the author’s name does not form a part of a sentence in the text, reference is made in parentheses after an important word or at the end of the sentence. [For example: (Bailey, 1932), (Allen, 1940; Dodge, 1928; Thompson, 1946).] If reference is made to several papers published in the same year by one author, the suffixes a, b, c, etc., are used after the year number, the suffixes being chosen according to the order of reference in the text.

2. Arrangement of citations. The citations are typewritten double-spaced throughout and placed at the end of the article. They begin on a new sheet of paper bearing the center heading “Literature cited,” in capitals. The citations are arranged alphabetically according to authors’ names. The author’s name is typewritten flush with the left-hand edge of the writing, and second and succeeding lines are indented 10 spaces on the typewriter. A number of papers by the same author are listed in chronological order, according to the year of publication; a long dash is used in place of repetition of the author’s name.\(^{19}\)

**Journals with numbered volumes**

3. Items and form. Each citation of a paper in a journal includes the following items:

\(^{19}\) Where greater brevity is required, text reference is made by superscript numerals or by numerals in parentheses. These refer to citations at the end of the article, numbered in the order of text reference, or preferably alphabetized and then numbered. Extreme brevity is achieved by omission of titles of papers.
(a) **Surname of author** followed by a comma and initials, in large and small caps. (Underscore with two lines to indicate the small caps.) (For example: **WILLIAMS, R. R.**) If there are several authors, only the name of the first is inverted. (For example: **GARNER, W. W., AND H. A. ALLARD.**) 

(b) **Year of publication** followed by a period. (For example: 1945.) If several papers published in the same year by one author are cited, the year number is followed by a, b, c, etc., in the order of reference in the text. (For example: 1946a, 1946b, 1946c.)

(c) **Title of paper**, exactly like the original in wording and punctuation. A period follows the title. Only proper names are capitalized, except in Danish, Dutch, or German.

(d) **Abbreviated name of serial publication** in the approved form.

(e) **Volume number** in Arabic figures followed by a colon.

(f) **Page numbers.** The number of the first page of the paper is separated by an en dash (indicated by a hyphen) from the number of the last page, and the latter is followed by a period.


**Books**

4. *Items and form.* The copyright date is used as the year of publication. The following examples illustrate the form used:


**Yearbooks**

5. *Items and form.* An example illustrates the form used:


Yearbooks are not numbered as volumes, but only by years. The actual time of publication—as shown in the example—is usually in the year following the period covered by the yearbook.

**Experiment station bulletins**

6. *Items and form.* In citing experiment station bulletins and other issues of serial publications bearing an individual number but no volume number, the following form is used:

SECOND METHOD

1. *Text reference to footnote citations.* The citations are given as footnotes, numbered consecutively (from 1 up) throughout the paper (in the order in which they are given in the text) and indicated in the text by superscript numerals. If other footnotes occur (except those in tables), they are numbered in the same series with the citations. A repeated reference is given the number of the original reference. The superscript reference numeral to each footnote is placed in the text after the word or sentence to which the footnote refers; it is put after a punctuation mark if there is one. The superscript numeral is indicated by typewriting it above the line and putting a V-shaped mark under the numeral.

2. *Footnotes.* The footnotes are not inserted in the text, but are typewritten on separate sheets (as many as convenient on a sheet). Each footnote is indented as a paragraph and is preceded by an Arabic numeral in parentheses corresponding to the reference number in the text. The sheets bearing footnotes are put at the end of the text copy, each sheet marked with the word "Footnotes," enclosed in a circle.

---

20 The *Journal of the American Chemical Society* requires each footnote to be inserted as a separate line (or lines) immediately following the line of text containing the word to which it refers. The footnote may be set off by short rules from the text material above and below it.

21 Superscript numerals are used in many journals for both text references and footnotes.

In some journals, numerals in parentheses in the text refer to citations at the end of the article, which are numbered in the order of text reference or are alphabetized and then numbered.
Journals with numbered volumes

3. Items and form. Each citation of a paper in a journal includes the following items:

(a) *Arabic footnote reference number* in parentheses.
(b) *Initials and surname of author* followed by a comma.
(c) *Abbreviated name of serial publication* in italic type (indicated by underlining with a single straight line), followed by a comma. (Some journals use Roman, not italic.) In the journals published by the American Chemical Society, the abbreviations given by *Chemical Abstracts* in its "List of Periodicals Abstracted" are used.
(d) *Volume number* followed by a comma, both in black-face type (indicated by underlining with a single wavy line).
(e) *Number of the page cited*—usually that of the first page of the article.
(f) *Year of publication of the article*, in parentheses, followed by a period.

(3) (a) C. S. HANES, *Roy. Soc. (London), Proc.*, B128, 421 (1940); (b) B129, 174 (1940). (Note the part designation B.)

Books

4. Items and form. In citing books, the form shown by the following examples is used:


Yearbooks

5. Items and form. The following example illustrates the form used:


Experiment station bulletins

6. Items and form. In citing experiment station bulletins and other issues of serial publications bearing an individual number but no volume number, the form shown by the following example is used.


ABBREVIATIONS OF PERIODICAL PUBLICATIONS

In preparing literature citations, the author should base abbreviations of serials upon a careful study of those used by the publication in which his paper is to be printed. Capitalization, in particular, varies in different journals. A uniform style must be used throughout a single bibliography.

The rules given below are intended to make it as easy as possible for the readers of your article to look up the literature references in the library.

22 Miss Margaret C. Shields, of the Fine Hall Library of Princeton University, has helped in the preparation of this section.
1. Each abbreviated name should be based upon the complete name of the publication, as used in library catalogues and as given in the *Union List of Serials* (a reference volume available in most libraries).

2. The name of a periodical publication should always begin with the key word under which the name is entered in all library lists. The sequence of words should therefore follow the rules used in the *Union List of Serials in Libraries of the United States and Canada* (Second edition, 3065 pages. Winifred Gregory, editor. New York: The H. W. Wilson Company. 1943). With permission of the publisher of the *Union List*, these rules are quoted below:

(a) "A serial not published by a society or a public office is entered under the first word, not an article \([a, an, the, or equivalent]\), of the latest form of the title."

Annalen der Physik...................... Ann. d. Physik  

(b) "A serial published by a society, but having a distinctive title, is entered under the title, with reference from the name of the society."

American Journal of Botany (published by  
Chemical and Engineering News (published  
by the American Chemical Society)...... Chem. and Engineer.  
News  
Science (published by the American As-  
sociation for the Advancement of Science). Science

(c) "The journals, transactions, proceedings, etc., of a society are entered under the first word, not an article, of
the latest form of the name of the society.” This rule, which
is italicized here for emphasis, applies also to publications
of an academy, an institution, or a university.

  Comptes rendus ....................... Acad. des sci. Paris,
  Compt. rend.

American Medical Association.
  Journal ....................... Amer. Med. Assoc.,
  Jour.

Cambridge Philosophical Society.
  Proceedings ....................... Cambridge Philo-

Deutsche chemische Gesellschaft.
  Berichte ....................... Deut. chem. Gesell-
  sch., Ber.

National Academy of Sciences.

Torrey Botanical Club.
  Bulletin ..................... Torrey Bot. Club,
  Bull.

U. S. Bureau of Standards.
  Bulletin ....................... U. S. Bur. Standards,
  Bull.

U. S. Bureau of Standards.
  Journal of Research ................ U. S. Bur. Standards,
  Jour. Res.

U. S. Bureau of Standards.
  Technical Papers ................ U. S. Bur. Standards,
  Tech. Papers

(d) “Learned societies and academies of Europe, other
than English, with names beginning with an adjective
denoting royal privilege are entered under the first word
following the adjective. These adjectives, Kaiserlich,
Königlich, Reale, Imperiale, etc., are abbreviated to
K., R., I., etc., and are disregarded in the arrangement.”

(e) “Colleges and universities having a geographical
désignation are entered under the name of the city, state,
or country contained in the title.”

(f) “Observatories, botanical and zoölogical gardens,
etc., not having a distinctive name, are entered under
the name of the place in which they are located, unless
they are affiliated with a university, in which case they
are entered under the name of the university.”

3. The vernacular should be used, not a translation.
(Just as one looks for a book by Felix Klein under Klein
and not Small or Little, so one must look for the Polish
academy under its Polish name; even though one can
not pronounce it, it should be used in written citations.)

Use Lund. Observ. Meddel.; not Contributions of the Observatory
of Lund.

Do not use Acad. for Akad. or Accad.

4. An editor's name should be avoided unless it is
officially in the title.

Annalen.

But Pflüger's Archiv is correct.

5. When publications of an institution are organized in
parts, the section or division designation should be in-
cluded.

Math.-Phys. Kl., or Sect. I, etc.

6. The series number should always be given in case
the set is numbered in series.

Philosoph. Mag., ser. 7, or Philosoph. Mag. [7].

7. Abbreviation of words—particularly the first—
should not be carried too far. (In such cases as “Ann.,”
“Biol.,” or “Geol.,” when this is the first word, either
the rest of the title should be written so as to give a clue to the language, or else the first word should be written in full. "Annalen," "Annals," and "Annual," are far apart in a large catalogue; "Ann. d. Phys." might be either French or German.

*Use* Amer. Chem. Soc., Jour.; *not* J. A. C. S.  
*Use* Arch. f. tech. Mess.; *not* A. T. M.

8. All important words in the full title should be included in the abbreviated title, unless a key is readily available in the library. (For example, an abbreviated title consisting only of "Ber.," "Ann.," or "Compt. rend."—as used in *The Journal of the American Chemical Society*—may be meaningless to a student until he learns that a key is given by *Chemical Abstracts* in its "List of Periodicals Abstracted.")

9. Prepositions and articles should be omitted when their omission does not lead to obscurity.

*But use* Soc. de Biol., *not* Soc. Biol., *for* Société de Biologie, *to avoid confusion with* Société Biologique.

10. Names of places and persons should not be abbreviated.

Liebig's Ann. Chem.  
Inst. Pasteur, Bull.

But note that Amer. (for American), Brit. (for British), Deut. (for Deutsche), and U. S. (for United States) are commonly used.

11. The following list shows some common abbreviations of words in the names of periodical publications:

<table>
<thead>
<tr>
<th>Abstracts</th>
<th>Absts.</th>
<th>American</th>
<th>Amer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academy</td>
<td>Acad.</td>
<td>Analects</td>
<td>An.</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Agric.</td>
<td>Analytical</td>
<td>Analyt.</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------</td>
<td>----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Annalen</td>
<td>Ann.</td>
<td>Ergebnisse</td>
<td>Ergebnn.</td>
</tr>
<tr>
<td>Anthropological</td>
<td>Anthropol.</td>
<td>Experiment</td>
<td>Exper.</td>
</tr>
<tr>
<td>Anzeiger</td>
<td>Anz.</td>
<td>Experimental</td>
<td>Exper.</td>
</tr>
<tr>
<td>Association</td>
<td>Assoc.</td>
<td>Experimentale</td>
<td>Exper.</td>
</tr>
<tr>
<td>Arch.</td>
<td>Arch.</td>
<td>für</td>
<td>f.</td>
</tr>
<tr>
<td>Archives</td>
<td>Arch.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beiträge</td>
<td>Beitr.</td>
<td>Geographical</td>
<td>Geogr.</td>
</tr>
<tr>
<td>Berichte</td>
<td>Ber.</td>
<td>Geological</td>
<td>Geol.</td>
</tr>
<tr>
<td>Biochemical</td>
<td>Biochem.</td>
<td>Gesellschaft</td>
<td>Gesellsch.</td>
</tr>
<tr>
<td>Biological</td>
<td>Biol.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biologie</td>
<td>Biol.</td>
<td>History</td>
<td>Hist.</td>
</tr>
<tr>
<td>Botanisches</td>
<td>Bot.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botany</td>
<td>Bot.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centralblatt</td>
<td>Centralbl.</td>
<td>Magazine</td>
<td>Mag.</td>
</tr>
<tr>
<td>Comptes</td>
<td>Compt.</td>
<td>Medicine</td>
<td>Med.</td>
</tr>
<tr>
<td>Contributions</td>
<td>Contr.</td>
<td>Monographs</td>
<td>Monogr.</td>
</tr>
<tr>
<td>Deutsche</td>
<td>Deut.</td>
<td>Morphologisches</td>
<td>Morphol.</td>
</tr>
<tr>
<td>Diseases</td>
<td>Dis.</td>
<td>Morphology</td>
<td>Morphol.</td>
</tr>
<tr>
<td>Economics</td>
<td>Econ.</td>
<td>Natural</td>
<td>Nat.</td>
</tr>
</tbody>
</table>
ABSTRACTS AND QUOTATIONS

1. Form. Reference to a cited publication should usually be made in the form of an indirect quotation or a brief abstract that summarizes the discussion presented in the original publication.

2. Credit. Always give credit for ideas taken directly from any publication.

3. Citation. A citation of each article mentioned must appear in your literature cited or in a footnote.

4. Punctuation. Indirect quotations should not be inclosed in quotation marks.
1. Permissions. Written permission must be obtained from the copyright owner before printing or otherwise reproducing material from a copyrighted publication.

2. Form. When direct quotations are needed, they should be enclosed in quotation marks, and should reproduce the exact words of the original publication, including all details of spelling, capitalization, and punctuation. Corrections or remarks inserted by the one who quotes must be placed in square brackets [ ]. Omissions must be indicated, by a series of four periods. The author should carefully compare the typewritten copy with the original printed matter; this should be done each time the manuscript is copied.

3. Short quotations. A short quotation should not appear as a separate paragraph. It should be enclosed in quotation marks, and included in a paragraph of your manuscript.

4. Long quotations. A quotation of more than five or six lines should be given as a separate paragraph. In the manuscript a quotation of this kind should be enclosed in quotation marks. The publisher usually will omit the quotation marks and print the quotation in smaller type than that used for the text.

Each long quotation should be typewritten upon one or more separate sheets of paper that are numbered consecutively with the text pages. The method of preparing the copy is as follows: When the place is reached where a long quotation occurs, remove the text sheet from the typewriter and begin the quotation upon a separate sheet numbered as a new page. Finish typewriting the quotation, using as many sheets as necessary and numbering them as manuscript pages. Then put
a new sheet of paper in the typewriter, and continue with the text.

The reason for using this method is that it allows the article to be composed economically on the typesetting machine, which will not set two different sizes of type in one operation. When the manuscript is not prepared in this way, it is necessary for the compositor to handle all of the copy twice, thus causing needless waste of valuable time.

It is advisable to mark clearly the sheets bearing quotations; this may be done by writing the word “Quotation,” enclosed in a circle, in the upper left-hand corner.

5. Quotation within a quotation. Use single quotation marks for a quotation within a quotation.

ACKNOWLEDGMENTS

Acknowledgments of help received from others should be made with simplicity and tact. An effusive acknowledgment may be very embarrassing to your critic or adviser. It is fitting, of course, that mention be made of suggestions, criticisms, or other forms of help that you have received, but this should be done in an appropriate way. The form of acknowledgment and its place in the paper should be determined by the usual practice in the journal in which your article is to be published. Acknowledgment may be made by a brief statement appearing in a footnote to the title of the article. The form for a thesis may be “Prepared in the Department of ____________, under the direction of Professor ______________.” If persons other than the adviser have helped, mention of the fact may be made in the form of footnotes in the parts of the paper concerned. Another suitable place for acknowledgments is in the introduction to the paper.
PREPARATION OF AN ANALYTICAL TABLE OF CONTENTS

1. Analytical outline. Before a manuscript is offered for publication, an analytical outline, or table of contents, should be prepared. The outline is of advantage in two ways: (a) It aids you in making the final revisions of your paper, especially in preparing correct headlines. (b) It is almost indispensable to anyone reading your manuscript with the object of criticizing it.

2. Form of outline. The outline that follows will serve as an example of an analytical table of contents. The rank of the headings for the various divisions of an article should be indicated in the table of contents by graded indentations. Note that the principal divisions are begun flush with the left-hand edge of the writing; the subdivisions of the principal divisions are indented 5 spaces on the typewriter, and smaller subdivisions are indented 10 spaces.

Indicate properly the comparative values of the topics. If two topics are logically coordinate, do not make one topic subordinate to the other. On the other hand, if one topic is logically subordinate to another, do not give them equal value.

Example of analytical table of contents

CONTENTS

Abstract................................................................. 1
Introduction....................................................................... 1
Materials and methods.................................................. 2
    Plants........................................................................ 2
    Culture methods....................................................... 3
    Measurement of climatic conditions............................ 4
Experiments and results................................................ 6
    Plant yields............................................................. 7
    Climatic data.......................................................... 8
HEADING IN THE TEXT OF A PAPER

1. Use of outline in revising headings. The analytical outline, prepared as described above, should be used as a basis for revising, if necessary, the headings that appear in the text of your paper, and for indicating the rank of the headings. The editor will mark the manuscript to indicate the sizes and styles of type for headings.

2. Indication of center headings in text. In the text, or body of the paper, the headings indicating principal divisions of the article should be typewritten in capitals as center headings. In the example, “Introduction,” “Materials and methods,” “Experiments and results,” “Discussion of results,” and “Literature cited” indicate the headings of the main sections of the paper.

3. Indication of center subheadings in text. The headings indicating subdivisions should be typewritten as center headings in small (lower-case) letters; only the first word and proper nouns should have capital initials. In the sample outline, “Plants,” “Cultural methods,” “Measurement of climatic conditions,” etc., indicate the center subheads.

4. Indication of paragraph side headings. Still smaller subdivisions should appear as side heads, indented as paragraphs. The side head is “run in”—that is, run together in a continuous line with the paragraph to which it belongs. Only the first word and proper nouns should
have capital initials. A single straight line should be drawn under each side head to indicate that it is to be printed in italics; a period should follow the side head. In the example, “Temperature,” “Rainfall,” and “Evaporation” indicate the paragraph side heads.

5. Over-minute subdivision. Excessive subdivision of the text should be avoided, since it confuses rather than aids the reader; three grades (center heads, center subheads, and paragraph side heads) are enough.

In the early drafts of a paper, it is desirable to show clearly the principal divisions and their subdivisions, and so these three grades of headings are usually employed. But in making the final revision for publication, try to avoid the use of center subheads; let the main divisions of the paper appear as center heads, and the subdivisions appear as paragraph side heads. Even center heads should be used sparingly.

6. Styles of type for center headings. As a rule, the author should not mark the manuscript to indicate the styles of type for center headings, unless he is preparing copy ready for the printer. The author should indicate only the rank of the headings, as suggested above. The following outline summarizes a style often used. This style has the advantages of being pleasing to the eye, and economical because composed with the text, in one operation.

CENTER HEADINGS (SMALL CAPS OF TEXT TYPE)

Center subheads *(lower-case italics of text type)*

Another style avoids the use of center headings. Only paragraph side headings are used—small caps for main headings and lower-case italics for subheadings.
ILLUSTRATIONS

Illustrations form an integral part of the concise and effective presentation of scientific material. They serve as a short-cut means of presenting descriptive matter and of showing relationships among data. By looking at an illustration, the reader gains information that he would otherwise have to procure from a long verbal explanation. He is able to obtain from an illustration a clear conception of objects or relationships that are too complex to be adequately described in words. If the paper is suitably illustrated, the text may be largely devoted to discussion of principles, comparisons, and inferences. Photographs and drawings are especially important in the descriptive phases of science. Diagrams of apparatus and graphs of data are mainly required in the experimental and quantitative phases.

The first impression a reader gets of an article is greatly influenced by the appearance of the illustrations. He is likely to receive an unfavorable impression of the whole article if the illustrations are poor. But he is attracted to the article if the illustrations are accurate, clear, and artistic. It is very important, therefore, to devote much time and study to the planning and preparation of illustrative material. Special attention should be given to uniformity in style, tone, and lettering. For putting drawings and graphs into final form, the services of a professional artist or draftsman are likely to be needed.

CORRECT PROPORTIONS

An illustration with dimensions approximating $1 \times 1\frac{1}{2}$ is most pleasing to the eye. The appearance of the page is best and the printer's work is facilitated if every illustration has the same width as the type page or type
Fig. 1. Diagram showing method of securing correct proportions for an illustration.
column. For a journal printed in two columns, illustrations should usually be designed to occupy the width of a single column, and should therefore be tall rather than wide.

A convenient graphical method of securing the correct proportions for a page-size illustration is shown in figure 1. On a large sheet of Bristol board construct, in pencil, a rectangle $ABCD$ which is the size of the desired reproduction. This is usually the same width as the type page or column but is enough shorter to allow space for the printed legend. Extend the diagonal $AC$ as far as you wish on the Bristol board. Any point on the diagonal will determine a rectangle that has the correct proportions of width and length. For example, the point $C'$ determines the correct rectangle $AB'C'D'$; the point $C''$ determines the correct rectangle $AB''C''D''$, etc.

A similar procedure is used if the reproduction is to occupy only a part of the height or width of the type page. The original, small rectangle is always made the exact size of the intended reproduction.

A completed illustration may easily be checked to determine whether its width or its height must determine the reduction. Cut a rectangular piece of cardboard to the exact size of the type page or type column. Place it on the illustration in the position of $ABCD$ in figure 1, and lay a long ruler on the illustration so as to extend the diagonal $AC$. Then: (a) if the ruler intersects the side of the illustration, the height must be reduced to that of the type page or column; or (b) if the ruler intersects the top of the illustration, the width must be reduced to that of the type page or column.
DRAWINGS

1. Methods of reproduction. Drawings are usually reproduced by means of zinc etchings, or by the more expensive half-tone and photo-gelatine processes. Before the original drawing is made, it is necessary to know what method of reproduction will be used, how much the drawing will be reduced, and on what type of paper it will be printed. Where possible, drawings should be prepared in a way that will allow them to be reproduced by the relatively inexpensive zinc etchings. Half-tones cost about twice as much, and photo-gelatine prints (also called heliotype or collotype) usually cost from five to fifteen times as much as zinc etchings.

2. Plates and text figures. Drawings may be used either as plates or as text figures. Plates are often printed on glossy paper as separate pages and may be put at the end of the article. Text figures are printed on the same paper as the text and often have text material above or below them. Many journals use the same paper for all illustrations and prefer to treat them all as text figures. As many figures as desired may be grouped together.

3. Paper and ink. Pure white three-ply Bristol board and undiluted black waterproof India ink should be used in preparing drawings. If a drawing has been made on thin paper, it should be transferred to Bristol board by blackening the back with a soft pencil and tracing over the drawing with a hard pencil. Drawings should first be worked out in detail in pencil and later inked in.

4. Size of drawing. The width or length of the original drawing should be from two to four times that of the

Three excellent books on scientific drawings are Mueller's *A Manual of Drawing for Science Students*, Ridgway's *Scientific Illustration*, and The Wistar Institute *Style Brief*.
reproduction. Slight inaccuracies in lines become invisible when reduced. Standard enlargements should be used for drawings in the same article, so as to insure ready comparability.

5. Shading for zinc etchings. For reproduction by zinc etchings, any shading that is desired should be done by means of black dots or lines made with undiluted India ink. Darker shades are best produced by putting the dots closer together, rather than by increasing the size of the individual dots. Very fine lines or extremely small dots cannot be reproduced by this process; they will be lost unless they are clear and distinct. If they are placed too close together, they may blur and appear as solid blotches when the drawing is reduced in size. There is a greater tendency for blurring to occur when the drawing is printed on a soft or rough-surfaced paper than when it is printed on a hard or glossy-surfaced paper. In the original drawing, the shading should be kept rather open. A light drawing is more attractive than a dark one. Many of the best drawings are mere outlines, made with very few, carefully chosen lines. Elaborate drawings are rarely necessary.

Rather delicate shading can be obtained if the size and spacing of the dots are properly adjusted to the degree of reduction in the zinc etching and to the type of paper used in printing. If possible, sample drawings that have given good results should be studied. Each laboratory should preserve original drawings, together with their reproductions, for the guidance of other workers. Examination of the drawing through a reducing lens is helpful, but the final test is the reproduction itself. In case of doubt, it will pay to have one of the drawings reproduced before proceeding with the preparation of the rest.

Copper etchings, which cost about twice as much as
zinc etchings, permit the reproduction of somewhat finer lines and smaller dots.

6. **Shading for half-tones.** If it is essential to show gray tones or extremely fine details, very delicate shading may be done with several dilutions of India ink, and the drawings can be reproduced by the half-tone process (p. 106) or by the photo-gelatine process. Wash and brush drawings, made with water-color or diluted India ink, can be reproduced in the same way. India ink, once applied, cannot be lightened; but water-color can be partially removed by strokes with a brush dipped in water. Pure white Bristol board should be used—never cardboard with a cream or yellow tint.

Many beginners are most successful in shading with so-called carbon pencils, which come in several grades. The effect of gradation from light to dark may be attained by “smudging” the border region between two shades with the aid of a “stub”. But the range of shades obtainable with pencils is more limited than that with India ink or water-color. And it must not be forgotten that the finished drawing may be blurred and ruined by careless handling. This may be avoided by spraying the finished drawing with a colorless shellac (without any yellow tint).

7. **Economy in grouping.** As many as possible of the illustrations should be grouped and mounted close together on heavy white cardboard, so that they may be reproduced as a single cut. Each plate may include a number of figures, and several text figures may be mounted in a group. Grouping is economical because the photo-engraver’s charge for one-half page is about three-quarters of that for a full page; and his minimum charge, for small figures, is about one-half the charge for a full page.

8. **Grouping for zinc etchings.** For reproduction by a
zinc etching, the separate drawings should be trimmed and arranged carefully within a rectangle, of proper size and proportions, drawn in pencil on a sheet of stiff white cardboard (about $\frac{1}{16}$ inch thick). The trimmed edges of the drawings will not appear in the zinc etching. When the best arrangement has been secured, the figures should be pasted to the cardboard, using rubber cement or thick white paste that will neither discolor nor wrinkle the Bristol board.

Figure numbers and explanatory letters should be put in proper places. Capital letters (for major parts or units) and lower-case letters (for minor parts or units) are used to designate points, lines, objects, etc., in drawings. Care should be taken to have the numbers and letters set straight and duly separated from the drawings. They should be neat; avoid heavy, black-face characters. Their size should be such that they will be $\frac{1}{16}$ or 65 thousandths of an inch high in the reproduction. It is best to paste on printed characters, or to put them on the drawing in ink, with the aid of Wrico lettering guides or Leroy lettering equipment (see table 7).

9. **Grouping for half-tones.** Special precautions need to be taken in the trimming and mounting of a group of drawings for half-tone reproduction. The trimmed edges always show in the half-tone, usually as dark lines. If possible, the pieces of Bristol board bearing the drawings should be cut into rectangles or polygons that fit together perfectly and completely cover the stiff white cardboard on which they are mounted. The size and proportions of the whole group should be determined as described on page 105. In mounting the figures, use rubber cement or thick white paste. The photoengraver will cut thin white lines to separate the individual rectangles or polygons. If mounting is done improperly, it will be necessary
to have the whole background routed out or to use high-light half-tones, thus doubling or trebling the cost of reproduction. Failure to observe proper precautions in trimming and mounting is the most common cause of untidy appearance and unnecessary expense in half-tone reproduction.

Figure numbers and explanatory letters may be put directly on the original drawings, with the aid of a Wrico or a Leroy guide (see table 7). Printed characters, attached with rubber cement, may be used if all the slips of paper bearing them are of the same size, trimmed square, and set straight.

**DRAWINGS FROM PHOTOGRAPHS**

A line drawing may be made from a photograph. For illustrating a piece of scientific apparatus, such a drawing may be much better than a photograph, because the drawing shows only the points that are essential and omits unnecessary and confusing details. Hidden parts can be shown by cut-away sections. A very natural perspective may easily be obtained in a drawing based on a photograph. The technique is simpler and quicker than the freehand method. This method may be used for any type of subject matter, and the drawing may be a simple outline or a realistic picture. The final result is limited only by the skill of the draftsman. An excellent drawing may be made from a relatively poor photograph. The line drawing is reproduced by means of a zinc etching. It costs less to publish than a half-tone, and the quality of the reproduction can be better predicted. If a limited number of copies of a report are needed, a line drawing

---

24 Mr. John W. McFarlane, of the Eastman Kodak Company, has helped in the preparation of this section.
can be reproduced well by Photostat copies and other photographic methods.

The simplest method of preparing such a drawing is to trace it from a print made on 8 × 10 inch or larger single-weight paper. A sheet of translucent drawing vellum is placed over the print, and a light is put below it for transillumination (see description of table for tracing, page 119). The desired lines are then traced in pencil on the drawing vellum. Details that are not wanted are not traced. It is easy to study the progress of the drawing and to disassociate it from the photograph merely by turning off the light and observing the drawing by reflected light alone. Any shading that is desired may be put in with stippling or hatching, as in making ordinary pen drawings. Measurements, explanatory letters, and labels may be inserted. After the drawing has been completed in pencil, it is inked in. The width of the ink lines must be properly related to the reproduced size of the drawing.

GRAPHS

Graphs are designed to portray relationships existing among data. They must be accurate, and they should also be clear. Since the ease with which the relationships may be seen depends upon balance and other features of good composition, graphs should be constructed so as to be pleasing to the eye. The suggestions given below are intended as guides in the achievement of effective presentation.26 Figures 2–8 exemplify some of these suggestions.

25 Professor Francis J. Ryan, of Columbia University, has helped in the preparation of this section.

26 A comprehensive discussion of the representation of data by tables, graphs, and equations is given in Worthing and Geffner’s Treatment of Experimental Data.

Plotted from data of table 2, page 59.

A graph should always be drawn first in pencil and then inked in. In this way the most satisfactory composition may be attained before the graph is made permanent.
1. **Paper and ink.** Curves and other types of graphs are reproduced as zinc etchings, and should be made with black waterproof India ink on coordinate paper or tracing cloth ruled with blue lines. In reproduction the blue lines will be "screened out," leaving only the black ink lines. Any coordinate lines that are to appear in the reproduction must be drawn in black ink. Paper for graphs should be of good enough quality to take India ink well and stand erasure. A satisfactory paper is a sheet 16 by 21 inches ruled with broad blue lines into 1-inch squares, each of which is subdivided by thin blue lines into 1/16-inch squares (Eugene Dietzgen no. 360 or Keuffel and Esser no. 280G). Coordinate paper ruled into equal squares is suitable for most types of graphs, including logarithmic graphs, in which only the principal coordinates are to be shown. For some purposes, paper with semi-log or log-log rulings is necessary or more convenient. Papers ruled with green, orange, red, yellow, or black lines are unsatisfactory unless it is desired that all lines be reproduced, or unless the graph is to be transferred to white illustrating or Bristol board, white paper, or tracing cloth. If all coordinate lines are to appear in the reproduction, special care should be taken to use a paper in which the lines (preferably black) contrast sharply with the white background.

2. **Size and proportions of the graph.** The suggestions made regarding the size and proportions of drawings apply also to graphs. Proportions of length to width approximating 1:1 ½ are most pleasing in appearance. The length or width of the original graph should be from two to four times that of the desired reproduction. This size is convenient for the use of lettering guides. Many journals prefer to have the reproduction occupy the full width of the type page or the full width of a single column
of a two-column page. A part or all the height of the type page may be utilized. The final reproduction should have a large enough scale to show essential details and accommodate necessary numbers and labels.

![Graph](image)

Fig. 3. Growth rates of a heterokaryon of leucineless and adapted *Neurospora crassa* and of the separate components on a limiting concentration of l(+)leucine (0.0075 mg./ml.) at 25°C. (Ryan, F. J., and J. Lederberg. 1948. *Nat. Acad. Sci., Proc.* 34: 163-173.)

Plotted from data of table 3, page 60.

3. *Choice of coördinates.* It is customary to plot the independent variable on the horizontal axis and the dependent variable on the vertical axis. But it is not always possible to distinguish between the two kinds of variables. Intervals of time are usually plotted on the horizontal axis.

4. *Scale of coördinates.* The scale of coördinates should be chosen so that the graph, when reduced to the size
required for printing, will be neither crowded nor wasteful of space. It is desirable to use the same scale in a series of comparable graphs. If the graph is to be used as a source of quantitative data, the scale and precision should be such as to allow the coordinates of any point to be read quickly and accurately. But if the graph is presented to illustrate the nature of the relationship between two variables, a smaller scale may be used. Many of the graphs in scientific papers are of this type, especially where the original data are presented in tables.

It may be desirable to try to find a method of plotting that will give a straight line; if this can be done, it may give a clue to the nature of the relationship between the

![Graph]

Fig. 4. Growth rates of heterokaryons of leucineless and adapted Neurospora crassa and of the separate components on minimal agar medium devoid of leucine at 25°C. (Ryan, F. J., and J. Lederberg. 1948. Nat. Acad. Sci., Proc. 32: 163-175.)
two variables. If the ordinary graph is straight, the relationship follows the linear law \( y = ax + b \); if a log-log graph is straight, it follows the power law \( y = Kx^n \); or if a semi-log graph is straight, it follows the compound-interest law \( y = Pe^{rt} \). In many cases, of course, none of these graphs is straight, and the mathematical relationship between the two variables is more complex.

It is desirable to choose the coördinates so that the important part of the curve approximates a slope of unity—i.e., makes an angle of about 45° with the horizontal axis.

Round numbers—multiples of 5, 10, 20, etc.—are put on the heavy lines of coördinate paper ruled in the decimal system. In logarithmic plots, either the logarithms of the numbers or the numbers themselves may be used, depending upon which scheme is clearer or more useful. The coördinate scales should be labeled so as to indicate clearly the name of the quantity plotted and the unit of measurement. These labels should be balanced near the middle of the axes and should not be crowded too close to the numbers on the scale. The label on the vertical axis should be oriented so that it is read upward along this axis.

5. Plotting the points. The points are plotted with a sharp pencil, each point being surrounded by a circle or other symbol. Different symbols, such as open and closed circles, triangles, and squares, may be used to distinguish several curves in the same graph, or several sets of data for a single curve. After the points have been plotted, all should be carefully checked. Observed points should
always be clearly shown on the curves. But computed points, plotted from a mathematical equation, should not be shown.

Fig. 5. The final growth of a heterokaryon of leucineless and adapted *Neurospora crassa* and of the leucineless mold alone on different concentrations of l(+)leucine in liquid medium at 25°C. (Ryan, F. J., and J. Lederberg. 1946. *Nat. Acad. Sci.*, Proc. 32: 163-173.)

6. Drawing the curve. Where possible, a smooth curve should be drawn to represent the plotted points. Smoothing shows relationships most clearly and minimizes errors. Of course, if the points are widely or irregularly distributed, all that can be done is to connect them with straight lines.

In drawing a smooth curve by hand, use light sweeping
strokes with a pencil. Obtain a satisfactory curve by erasure and correction. The smoothed curve need not pass through all the points, but it should be drawn so that about half the points in a group fall on each side of it. To detect kinks that require correction, sight with one eye along the curve.

Some workers like to draw the smoothed curve on a
piece of tracing paper held over the graph with drafting tape or rubber cement. The curve may then be transferred to the original by blackening the back of the paper with a soft pencil and tracing over the curve with a hard pencil. Another method of transferring the curve involves mounting the tracing paper with rubber cement on a piece of moderately thick cardboard and then cutting with scissors along the curve. The cardboard template is used in drawing the curve in pencil on the original graph. A very regular curve, free from waviness, may be obtained in this manner.

Several curves may be drawn in the same graph, but they should not be so numerous or so crowded as to make the graph difficult to decipher. The curves may be distinguished by different symbols representing the points and by different kinds of lines—solid, long dash, short dash, dot and dash, etc. The individual curves may be designated by capital letters (usually italic) or preferably by distinctive labels along the curves. The curves can be identified by means of a key placed in a balanced position in the graph, or by reference in the figure caption to the explanatory letters or to the types of lines and symbols.

If it has been necessary to plot the graph on coordinate paper ruled with orange or green lines that are not wanted in the reproduction, the graph must be transferred to white illustrating board or three-ply Bristol board (by means of needle pricks), or to translucent bond paper or tracing cloth, before it is inked. A convenient table for use in tracing graphs may be easily constructed by cutting a rectangular opening (17 by 22 inches) in a table and mounting above the opening a countersunk sheet of ground plate-glass (20 by 25 inches); the glass may be illuminated by a 300-watt lamp in a goose-neck
stand resting on the floor. (A small illuminated desk, designed for tracing illustrations on mimeograph stencils,

![Graph](image)

**Fig. 7.** Selenium accumulation by maize in relation to sulfur/selenium ratio (in ppm.) in the culture solution. (Log scale of abscissas except the zero.)

Cultures received 2, 5, and 10 ppm. of selenium as selenate (A), selenite (I), or organic selenium (O) from an *Astragalus* extract. Sulfur supplied as sulfate. (*Trelease, S. F.,* and *S. S. Greenfield.*)

may be purchased in stationery stores.) The graph and paper or cloth may be held together and fastened to the glass with drafting tape or rubber cement.
7. Inking the graph. Inking in the graph is the part of the work that is best done by a professional draftsman. India ink must always be used. The symbol surrounding each point is inked first; it should be about three times as wide as the curve that will be drawn; the point at the center of the symbol is not inked. Circles are made with a compass, preferably of the type known as a drop bow pen; squares and triangles are made with a lettering pen and guide. Lines are drawn with a ruling pen or Wrico lettering pen. Straight lines are drawn with the aid of a transparent triangle or straight-edge. Difficulty caused by the ink's running under the triangle may be avoided by putting some strips of adhesive tape on the lower side of the triangle.

Smoothed curves may be drawn most easily with the aid of a flexible curve ruler, which may be obtained from either the Eugene Dietzgen Co. or the Keuffel and Esser Co. This ruler may be bent to the shape of almost any curve and will retain its form until further distorted. It has the added advantage of being so constructed that the ink will not run under its edge. Curves may also be drawn with the aid of French curves, elevated from the paper by strips of adhesive tape. For best appearance, the curve should not run through the point symbols but should be drawn to join them, or it may even be separated from them by short breaks.

Points falling on the axes should rest in small gaps left in these lines. Where a series of points fall along the horizontal axis, it is best to depress the line representing that axis to some negative value.

The lines representing the axes of the graph should be about the same in width as the heaviest curve, and wider than the coördinates. The lines should be uniform in all the graphs appearing in one article. Full coördinate
lines may be drawn, or the coordinates may be indicated by short stubs running in from the axes. The appearance is usually best if the entire graph is framed in a rectangle;

![Graph showing the relationship of growth to selenium content of maize supplied with selenium as selenate, selenite, and organic selenium (derived from extract of Astragalus). (Log scale of abscissas except the zero.)](image)

but in some cases it may be preferable to leave the graph open at the top and at the right.

Letters and numbers should be made with lines that are somewhat thinner than those used for the axes and...
curves. They are best made with the aid of Leroy lettering equipment or Wrico lettering guides and pens, obtainable from dealers in draftsmen’s supplies. The size of the letters and numbers should be such that they will be \( \frac{1}{16} \) or 65 thousandths of an inch high in the reproduction. Table 7 will be found helpful in the selection of the proper lettering guides and pens to be used to obtain well-formed letters of this size after various degrees of reduction.

Corrections in the inked graphs may be made by careful erasing and redrawing, or by pasting a strip of paper over the original and then redrawing. Small irregularities may be removed with an etching knife or by application of pure white water-color pigment (Chinese white). Retouching may be done in India ink with a Crow quill pen. After the graph is finished, it should be gently cleaned with a soft eraser, being careful not to lighten the ink lines.

**TABLE 7**

*Lettering guides or templates to be used for various degrees of reduction, to give letters \( \frac{1}{16} \) or 65 thousandths of an inch high in the reproduction*

<table>
<thead>
<tr>
<th>FOR REDUCTION OF HEIGHT TO:</th>
<th>DESIRED HEIGHT OF ORIGINAL LETTERING</th>
<th>WRICO</th>
<th>LEROY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>thousandths of an inch</td>
<td>Guide</td>
<td>Pen</td>
</tr>
<tr>
<td>.15</td>
<td>435</td>
<td>425</td>
<td>3</td>
</tr>
<tr>
<td>.20</td>
<td>325</td>
<td>350</td>
<td>3</td>
</tr>
<tr>
<td>.25</td>
<td>260</td>
<td>290</td>
<td>4</td>
</tr>
<tr>
<td>.30</td>
<td>215</td>
<td>240</td>
<td>4</td>
</tr>
<tr>
<td>.35</td>
<td>185</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>.40</td>
<td>165</td>
<td>175</td>
<td>6</td>
</tr>
<tr>
<td>.45</td>
<td>145</td>
<td>140</td>
<td>7</td>
</tr>
<tr>
<td>.50</td>
<td>130</td>
<td>140</td>
<td>7</td>
</tr>
</tbody>
</table>
Some publishers take care of all numbering and lettering on graphs. In this case, the author is expected to provide each graph with a tracing-paper overlay, fastened with cellulose tape, rubber cement, or paste to the upper margin of the back of the copy and folded down over the face. Numbers and letters should be written in pencil or ink on the overlay in the exact places where they are to appear on the graph. The style of letters, whether Roman or italic (vertical or slant), should be indicated by instructions written on the margins of the graph or tracing-paper overlay.

Other publishers (for example, *The Journal of the American Chemical Society*) expect the author to care for numbering and lettering within the graph, but have the numbers and labels on the coordinate axes set up in type by the printer. The author should place them in pencil outside the axes.

PHOTOGRAPHS

1. Preparation of photographs. Making a good photograph for scientific illustration usually requires some knowledge of photographic technique, and skill gained through experience. The camera should preferably be focused by a ground-glass screen; and unless flash bulbs are used, it must be firmly supported on a tripod. A suitable type of camera for most scientific subjects is one having a double-extension bellows and using sheet films and film packs of medium size, $3\frac{1}{4} \times 4\frac{1}{4}$ inches. Everyone who does photographic work should have a copy of the Eastman Kodak Company's *How to Make Good Pictures* (240 pages, seventy-five cents) and of *Basic Photography* (War Department Technical Manual

---

*28 Mr. John W. McFarlane, of the Eastman Kodak Company, has helped in the preparation of this section.*
no. 1-219, 342 pages, fifty cents). There are many excellent photographic books and other aids, such as the series of Kodaguides. Owing to the complex nature of the problem, only a few suggestions can be given here.

The principal subject of the photograph should be shown as clearly and sharply as possible, and non-essential objects should be subordinated or excluded. The background should be unobtrusive; it should be free from distracting lines or spots and preferably of a uniform tone—white, gray, or black—that contrasts sufficiently with the subject. Light backgrounds are usually more attractive than dark ones. Even a light-toned object may show its form and detail best on a white or gray background. The objects in the picture should be arranged so as to give a simple and effective composition. Tones of light and shade should be balanced. Point of view and perspective are important. A worm’s-eye or a bird’s-eye view may sometimes be both effective and pleasing.

Modeling and texture should be brought out by differential lighting. In photographing scientific specimens, left-hand illumination is recommended, because we are accustomed to visualize objects as lighted in that way. If photographs of a series of specimens are to be mounted together, illumination in all should come from the same direction; otherwise, elevations may be mistaken for depressions, or vice versa. The following conventional arrangement of lights is excellent for many scientific subjects: The stronger light (twice the weaker) is placed about 45 degrees to the left of the camera and 45 degrees above it, and the weaker light is placed at the same distance from the object, but level with the camera and considerably less than 45 degrees to the right of it. The same arrangement
of lights may be used when the camera is in either the horizontal or vertical position.

Although this simple system of illumination is usually satisfactory, it should be modified as much as necessary to suit the particular subject. The important point is to arrange the illumination so that the negative will faithfully record the outline, form, tone values, and details (in both shadows and highlights) of the original subject. Control of tones in photographing colored subjects requires the use of fully panchromatic film and a suitable filter. Natural tone contrasts are obtained with a filter that gives full color correction, with the particular emulsion and light source used. When desirable, exaggerated contrasts may be secured with a properly chosen filter. A filter lightens the rendering of objects of its own color as compared with objects of other colors. The effect of strong filters—that is, orange, red, blue, and green—can be seen through the filter beforehand. The Kodak Contrast Viewing Guide simplifies selecting the appropriate filter.

Extreme close-ups of small objects are often needed in illustrating scientific articles. These may be made with a simple camera if a positive supplementary lens is added to the camera lens and a "focal frame" is attached to the camera base (see article on Portra Lenses and a Technique for Extreme Close-Ups, available on request to the Eastman Kodak Company). The "focal frame," which is easily constructed, surrounds the field photographed and assures correct focus. This technique is especially useful for both outdoor and indoor work with a 35 mm. camera and is adaptable to a wide range of subjects—flowers, insects, small animals, apparatus, and medical subjects, such as skin, teeth, eyes, and pathological specimens. Since the camera is used with the normal lens-to-film distance, ordinary exposure guides apply.
Cameras with an extensible bellows and ground-glass focusing may be used for natural-size photography, or for enlargements if a positive supplementary lens is added. Magnifications of from 1 to 25 or more diameters, which require a very long bellows draw, may be obtained by means of a series of special lenses—the Bausch and Lomb Micro-Tessars, the Goerz Dagors, and the Kodak Projection Lenses—having focal lengths ranging upward from 16 mm. A lens with a focal length of 50 mm. is especially suitable for magnifications up to 5 or 10 diameters. For magnifications greater than unity, it is best to use a vertical camera on a sturdy rod support, such as the photomicrographic cameras of the American Optical Company and of the Bausch and Lomb Optical Company, or the Kodak Precision Enlarger with a camera-back adapter. When the bellows of the camera is extended, for subjects closer than about 8 times the focal length of the lens, the exposure must of course be multiplied by the correct factor. This may be ascertained with the aid of the Kodak Lens Guide, or it may be calculated by means of the following formula:

Exposure factor = \((\text{Lens-to-film distance})^2 + (\text{Focal length})^2\)

Other optical formulae, useful in this type of photography, are the following:

**Magnification**

\[
= (\text{Lens-to-film distance} - \text{focal length}) \div (\text{Focal length})
\]

**Lens-to-subject distance**

\[
= (\text{Focal length} + \text{magnification}) + (\text{Focal length})
\]

In all close-up photography, correct exposure time can best be attained by a series of trial exposures. A good procedure is to make an estimate of the correct exposure,
preferably with the aid of a meter, and then to try four exposures—$\frac{1}{3}$, $\frac{2}{3}$, $\frac{4}{3}$, and $\frac{5}{3}$ times the exposure estimated to be correct. The negatives should then be developed, and, if necessary, a new range of exposures may be tested.

2. Copy for reproduction. Photographs are reproduced as half-tones, in which the picture is broken up into minute dots. The photograph for copy should be as clear and sharp as possible. It may be considerably larger than the reproduction, or the same size, but should never be smaller. If a print needs to be retouched, it should be of large size—$5 \times 7$ or $8 \times 10$ inches.

Glossy white ferrotyped paper is best for prints intended for reproduction. A paper with a pebbled or rough surface, or a cream color, should never be used. If much retouching is necessary, some workers prefer a print with a smooth or semi-matte surface. But a glossy print may be prepared so that it will accept retouching. The purpose of such preparation is chiefly to remove any invisible greasy finger marks that have come from handling. The simplest method is to sift Fuller's earth or talc on the print and then to rub this lightly over the whole surface of the print with a dry cotton tuft or soft cloth. Rubbing must be very light, or the print may show scratches. This method is suitable for prints that already bear retouching and for those that are either mounted or unmounted. Those who do much work of this kind prefer to prepare glossy prints by rubbing over the whole surface with a moist cotton swab that has been previously rubbed on a cake of gelatin. The cake is prepared by dissolving ordinary gelatin (obtainable at a drugstore) in boiling water, adding one drop of glacial acetic acid to about 30 grams of gelatin, and allowing the solution to evaporate in a small container so that it forms a cake. This treatment can be used only on a mounted print that has had no previous retouching; moisture of
course would make an unmounted print curl and would smudge one that had been retouched.

The print for reproduction should preserve as closely as possible the details that exist in the original subject. It is desirable to have the print show a wide range of tone values, with detail in both shadows and high-lights. A good procedure is to make a series of prints on several contrast grades of paper, and then to select the print that seems best. The usual method of selecting the proper contrast grade of paper for a normal print is to make a test print that gives the desired high-light gradations. Then: (a) if the shadows are also correct, the paper is of the right contrast grade; (b) if the shadows are blocked by overexposure, use a less contrasty paper; (c) if the shadows are not dark enough, use a more contrasty paper.

Special requirements of the half-tone process indicate the desirability of a slight modification of the usual procedure in print making. A print for reproduction should not make use of the full range of tone values from clear white to jet black. The reason for this recommendation is that the rendering of detail at both ends of the tone scale is unavoidably degraded; the density-exposure gradient is less at the extremes of the characteristic curve of papers than in the middle-tone region of the curve. A print of slightly softened quality is therefore recommended.

The best method of making such prints is to use the same contrast grade of paper that would serve for a normal print, but to adopt the following procedure: Adjust the printing exposure so that the lightest important high-light detail is a very light gray, not a clear white. After obtaining this exposure by trial, make the final print in such a manner that the extreme shadow regions are held back by dodging to such an extent that the darkest important shadow detail is not quite a full black. When dodging is
impracticable, the next best procedure is to use a contrast grade of paper that is one lower than would normally be used in making the best print for viewing. The exposure should be adjusted so that the high-lights are slightly gray and the shadows are not quite a full black. The use of a slightly softened print for reproduction does not result in reproduction that is too soft. In the hands of a good photoengraver, the tone scale is expanded so that a much better reproduction will be obtained than could result from a normal print.

Blemishes in a print will be conspicuous in the reproduction. Imperfections of this sort include blurred images, muddy high-lights, fog, spots, scratches, dents, cracks, and stains. A defective print should be replaced by one that is perfect. If this is impossible, skillful retouching by an artist may remove minor defects; but this work is expensive and the results are likely to be unsatisfactory.

If it is necessary to write on the back of a photograph, lay the print on a smooth, hard surface (such as a sheet of glass) and write very lightly with a soft pencil; unless care is taken, the writing will show in relief on the face of the print. A better method is to write on a separate strip of paper and attach this with dry mounting tissue to the margin on the back of the print.

The print should be mounted on a piece of smooth flat cardboard large enough to leave a margin of about an inch around the print. Dry mounting tissue is best for this purpose. Rubber cement is convenient for temporary mounting; but after some time it is likely to discolor the photograph, and such discoloration will show in the halftone. Paste, glue, or mucilage should not be used, because they are likely to wrinkle or stain the print. It is usually best not to trim the print, before mounting, to the
exact size desired. Cropping lines should be drawn in pencil on the margin of the cardboard mount, extending to the print but not across its face; the photoengraver will include only the indicated part of the print, and will square it. The mounted photograph should be covered with a protective flap of brown paper, attached with paste to the upper edge of the rear surface of the cardboard and folded down over the face of the print.

3. Arrangement in groups. If a number of separate photographs are to be arranged together for half-tone reproduction in a single plate, they should be carefully matched for uniformity of density and contrast; if the group consists of some light and some dark prints or includes prints that differ in contrast, these differences may be accentuated in the reproduction. The selected prints should be trimmed and mounted with special care. (Some publishers prefer to do the mounting in groups; in this case, the prints should be supplied untrimmed and un-mounted.) Rubber cement is most convenient for such mounting because it allows the position of each print to be accurately adjusted. The cut edges of the prints always show in the half-tone reproduction; and unless the edges are straight, the background will have to be routed out, thus doubling or trebling the cost of reproduction. This extra cost is usually chargeable to the author. If possible, the photographs should be fitted together perfectly, so as to cover completely the cardboard on which they are mounted. The photoengraver will cut a white line where they join.

Figure numbers and explanatory letters may be put directly on the photographs in black ink or white ink, using a Wrico or a Leroy lettering guide. (See table 7.) Printed characters may be attached with rubber cement;
care should be taken to have all the slips of paper the same size, trimmed square, and set straight in mounting.

4. Models. It will be useful to study as models the photographs that are published in the scientific journals. Critical examination will show good and poor pictures that serve to emphasize the points briefly discussed here. Perhaps the best examples of highly effective photography are those that appear in current advertising material and inexpensive booklets issued by manufacturers of apparatus, instruments, and photographic materials.

LANTERN SLIDES

In preparing lantern slides to illustrate scientific and technical lectures, it is important to remember that a slide should contain much less material than may be adequately shown in a printed illustration or table. The slide should be so simple and clear that persons with normal eyesight sitting in the back of the room can see it easily and grasp its meaning completely. It is just as important to have slides that are visible to everyone as it is to speak so that the whole audience can hear. Slides should show essential features very clearly, and should be as free as possible of non-essentials that distract the eye.

It would be a mistake to attempt to show, in a single slide, a full-page comprehensive table of data. Even if it were possible to have the words and figures visible to persons in the back of the room, the table would be too complicated to be readily understood. It is much better to divide such a table into a series of smaller tables. A useful rule is never to include in a single slide a larger table than can be typewritten, double-spaced, on a card with dimensions of 5 by 8 inches.

Graphs to be used as slides should be very simple, with
broad lines and clear numbers and letters. Numerous, crowded curves in a slide cannot be deciphered by the audience.

When illustrating complex three-dimensional objects by lantern slides, it is best to give first a comprehensive view for orientation, and then to show a series of close-ups in which the individual features are presented on as large a scale as possible.

**PREPARATION OF ILLUSTRATION COPY**

1. *Number and reduction.* For purposes of identification, the figure number, the author’s name and address, and the title of the article should be written on the margin or back of each piece of illustration copy, or on a piece of paper attached securely with paste to the lower margin of the copy. The “top” of the illustration should be indicated if there is any possibility of misunderstanding.

   Clear directions for reduction should also be written on the margin or back. (See section on “Correct Proportions, page 103.) In giving directions, it is best to specify the final width or height. (For example: “Reduce width to 4½ inches” or “reduce height to 6 inches.”) In designating fractional reduction, it is better to say “reduce width to ¾” than “reduce ¼” or “⅜ off.”

   If the illustrations are larger than 8½ by 11 inches, duplicate photographic prints or Photostats of smaller size should accompany the manuscript, to facilitate sending the article to referees, or reviewers.

   Retain a good photographic copy of each illustration, for use if the original is lost in the mail.

   The original is best for making a photoengraving. A very clear photographic copy may be used. But a copy that is out of square (not rectangular) or faint is not acceptable.
2. Legends. The legends, or titles, of plates and figures should be self-explanatory. They should be typewritten *double-spaced* in numerical order upon one or more sheets of paper, placed at the end of the manuscript following the literature cited. Always supply a short title for the illustration. Any descriptive matter should follow directly after this title, in the form of paragraphs.

The legend of each text figure is printed below the figure. A short title appears below each plate, and complete descriptions of all plates are usually given in a separate section of the paper, following the literature cited and preceding the plates.

3. Place of insertion. The place of insertion of each text figure must be marked in the manuscript and in the galley proof. (For example, write in the margin: "Insert figure 2.")

4. Numbering text figures and plates. Text figures should be numbered from 1 up in each article. Plates should be numbered 1, 2, 3, etc., in each article; and figures in plates should be numbered from 1 up, beginning a new series either in each plate or in each article. Some journals number all figures (in text and plates) consecutively from 1 up in each article; this simplifies text reference to the figures.²⁹

5. Reference in text. In the text, the figures and plates should be referred to by number; the words *figure* and *plate* should not be capitalized. (For example: Examination of figure 5 of plate 3 shows that . . . . . . . ) If the reference is made parenthetically, the words *figure* and *plate* should be abbreviated, using the forms "fig." and "pl." for both singular and plural. [For example: The

²⁹ Some journals use Arabic numbers for figures and Roman for plates. The numbering of plates in some journals is consecutive throughout each volume.
data of table 7 are shown as graphs in figure 4, in which the method of plotting is the same as for series A (fig. 1).

Be sure to check all text references to illustrations after the manuscript has been completed.

SHIPPING ILLUSTRATIONS

Photographic prints or drawings intended for half-tone reproduction are likely to be damaged when sent by mail or express unless they are well protected, especially at the corners. The following method of wrapping gives good protection: Place the prints between sheets of thin cardboard, cut to a size slightly larger than the prints. (If the prints are mounted, cover them with a sheet of thin cardboard of the same size as that on which they are mounted.) Bind the cardboard sheets together on all four sides with short strips of cellulose tape. Anchor this packet securely, with more strips of cellulose tape, to a piece of stout corrugated board about two inches larger all around than the original packet. This will keep the packet from slipping to an edge or corner. Place another piece of corrugated board of the same size on top (preferably one with the corrugations running at right angles to those of the other), and bind the two firmly together with strips of cellulose tape. Finally, wrap in heavy paper, and seal all loose edges with gummed tape or tie securely with string. Send by first-class mail, registered, or by express, whichever costs less.

PREPUBLICATION REVIEW AND REVISION

1. Purposes. Many scientific journals have adopted the plan of having every paper that is submitted for publication read and criticized by two competent reviewers selected by the editor or the editorial committee. The purposes of this procedure are (1) to improve the quality of the papers that are printed in the journal; and (2) to
avoid the acceptance of material more rapidly than it can be published with the funds available—by promoting condensation of text and tabular material and elimination of unessential illustrations, as well as by declining the papers that make the least distinct contributions to the particular field of science. Since all papers are sent to reviewers, this procedure implies no reflection on the merits of the papers. Prepublication review represents an editorial service that the authors appreciate in the majority of cases.

2. Work of reviewers. Each reviewer is asked to give his general opinion regarding the suitability of the paper for publication in the journal, and to make specific suggestions regarding possible errors, lack of clearness, parts that may be condensed, omitted, or improved in form and arrangement, etc. The reviewer may be asked the following questions:

(a) Would you grade the paper A, B, C, D, or E, on the basis of its relative merit as a scientific contribution—if C represents the average rank of papers in recent volumes of the journal? (b) Has the material been published previously? (c) Has the work been carried far enough to warrant publication? (d) Is there some other journal for which the paper would be more suitable? (e) Are the conclusions logical and are they based on accurate and sufficient data? (f) Is the arrangement logical? If not, suggest improvements. (g) Which, if any, of the main ideas are not developed with sufficient emphasis? (h) What parts may be condensed or omitted? (i) Have you found any errors in the paper? (j) Is there lack of clearness? If so, where? (k) Where does the literary form need to be improved? (l) What improvements, if any, do you regard as necessary in the illustrations? (m) Which, if any, of the illustrations could be omitted?

3. Author's revision. If the reviews indicate that the article would be acceptable but needs revision, it is returned to the author with the comments of the reviewers (quoted anonymously so that the matter of personalities
will not enter) and a note that asks the author to study the paper again with regard to revision in accordance with the reviewers' suggestions. The author is told that of course he may not consider it desirable to adopt all the recommendations of the reviewers, and that the reasons for his preference in such cases should be explained. When the paper has been revised by the author, it is returned to the editor.

4. Judgment of a third reviewer. Advice of a third reviewer may be asked by the editors if the two reviewers disagree as to whether the paper would be acceptable after revision, or if the author is unwilling to revise the paper in accordance with the reviewers' recommendations. The opinions of reviewers are advisory, and final responsibility for the selection of papers rests with the editors.

5. Publication after acceptance. After its acceptance the paper is published in its proper turn, according to the original date of receipt, unless revisions necessitate unavoidable delay.

6. Rejection of manuscripts. The editor may decide, after seeing the reviewers' comments and reading the paper himself, that the paper could not be accepted even if it were revised. In this case he returns it to the author with a brief note of regret, containing suggestions, if possible, regarding suitable journals to which the article might be submitted. The editor obviously must not accept material more rapidly than it can be published with the funds available. With the aid of the reviewers and the editorial committee, he selects the papers that seem to be best, and he is compelled to reject the others.

PROOFREADING

1. Galley proofs. Galley proofs, on sheets about 18 cm. wide and 60 cm. long, are submitted to the author,
Cancellation
Delete, or take out, character or the word marked.

Insertion
Insert word, letter, or punctuation mark written in the margin.

Spacing
Insert space between words, letters, or lines.
Close up, or take out the space.
Close up, but leave some space.

Position
Turn a reversed letter.
Carry farther to the left.
Carry farther to the right.
Move down a letter, character, or word.
Move up a letter, character, or word.
Indent one em.
Straighten a crooked line.
Straighten lateral margin of printing.
Transpose of order words or letters.
Correct uneven spacing.

Paragraphing
Make a new paragraph.
No paragraph.

Miscellaneous
Push down a space or quadrat that prints.
Question to author. Is this right?
Allow to stand as it is.
Kinds of type

l. c. Put in lower case.
caps Put in capitals.
\ Use a capital.
s.c. Put in small capitals.
\ Put in small capitals.
rom. Put in Roman.
ital. Put in italics.
l-f. Put in bold-face.
l-f. Put in bold-face.
w-f. Wrong font (wrong size or style).
\ Superscript \.
\ Superscript \i.
\ Subscript \.
\ Type is broken or imperfect.

Punctuation

\ Period.
\ Comma.
:\ Semicolon.
\ Colon.
\ Apostrophe.
\ Quotation marks.
\ Hyphen (-).
\ One-en dash (-).
\ One-em dash (—).
\ Two-em dash (——).
\ Parentheses.
\ Brackets.
together with the manuscript. The author is expected to correct the proofs; he should see that the proofs agree with the manuscript, and should correct all genuine errors. The proofs should be returned to the editor as soon as possible.

2. Marks. All corrections must be made by means of proofreader's marks in the margins of the proof sheets. Corrections should be made clearly and neatly, using a red pencil for printer's errors and a black pencil for changes from copy. They should be made horizontally on the page, and opposite the printed lines in which the errors occur.

METHOD

1. Two persons. If possible, have another person slowly read aloud from the manuscript, while you follow the galley proofs and make the necessary corrections and changes. The one who reads aloud should call your attention to every paragraph, mark of punctuation, capitalized word, italicized figure or word, bold-face figure or word, etc. If you cannot secure the services of another person in this work, then it will be necessary for you to compare carefully the galley proofs with the manuscript, line by line or sentence by sentence.

2. Two readings. Always read the proofs twice, at least.

MISCELLANEOUS SUGGESTIONS

1. Special attention. Give particular attention to tables, figures, names, quotations, and citations. Check text references to illustrations. Assume that errors are present; find and correct them.

2. Questions. Be sure to answer questions, or queries, made by the printer.

3. Instructions to printer. If you do not know how to
indicate a correction, simply draw a horizontal line through the word that needs to be changed and then write clear instructions in the margin, enclosing the instructions in a circle.

4. Omissions. Watch for words or lines that may have been omitted.

5. Reading for meaning. After you have read the proofs twice, as suggested above, it is well to read them a third time, paying particular attention to the sense, or meaning, of the statements. You will not be permitted to make revisions; but genuine errors must be corrected, of course, whenever they are discovered.

6. Tables. Check to make sure that the tables have been properly distributed, or that their positions have been correctly marked in the margin of the proof.

7. Illustrations. The approximate place for inserting every illustration should be clearly marked in the margin of the proof. (For example, write in the margin: Insert figure 1.) Check the magnifications of drawings and photographs in the photoengraver's proofs, and correct the legends if necessary.

8. Headings. Look through the proofs for the purpose of correcting errors in all headings.

9. Expense of alterations. Alterations, or changes from the original copy sent to the printer, are very expensive, and some journals charge them to the author.

PAGE PROOFS

After the corrected galley proofs have been received by the editor and have been read and marked by him, they are returned to the printer. The corrections marked on the galley proofs are made, and then the type is divided into pages of the required length. Page proofs are sent to the editor, who compares them with the galley proofs to
see that all the corrections have been made. The editor then reads the page proofs critically, searching for inconsistencies or errors. The page proofs are returned to the printer, who makes the necessary changes and begins the actual press work.

BIBLIOGRAPHY


DARTMOUTH COLLEGE. AMOS TUCK SCHOOL OF ADMINISTRATION AND FINANCE. 1931. Manual on research and reports, with special application to the investigations in the field of business, economics, and public affairs. 108 p. Baltimore: Williams & Wilkins Co.


GILL, R. S. 1940. The author-publisher-printer complex. 76 p. Baltimore: Williams & Wilkins Co.


INDEX

A (article) in titles, capitalized and italicized, 41.
Abbreviations, of names of periodical publications, 91.
of units of weight and measure, 50.
Abstract, preparation of, 14.
Abstract journals; 74.
Abstracts and quotations, 97.
Accuracy, of calculations, 2.
of citations, 85.
of quotations, 98.
of statements, 24, 25.
of tables, 58.
of typewritten manuscript, 29.
Acknowledgments, 99.
Address, author's, on copy for illustrations, 133.
on text copy, 27.
Adequacy of sample size, 49.
Affiliated libraries, 73.
Agriculture, literature sources, 78.
Algebraic symbols and equations, 40.
Alignment, in proof, 138.
in tables, 63.
Alterations, in manuscript, 29.
in proof, 141.
Ambiguity of terms, 10, 17.
Analysis of data, 2.
Analytical table of contents, 100.
Anatomical parts, names of, 40.
Animals, names of, 57.
Annual reviews, 75.
Answers to reader's questions, 10.
Anthropology, sources of literature, 78.
Arrangement, of manuscript, 33.
of topics, 8, 9, 22.
Article (a, an, the) as part of the title, 41.
Articles, printed, estimating length of, 41.
Articles, titles of, capitalizing, 39.
in quotation marks, 41.
Author's address and name, on copy for illustrations, 133.
on text copy, 27.
Author's corrections, 141.
Begging the question, 18.
Bibliography, 85, 142.
Biological terms, 38, 41, 56.
Black-face or bold-face type, 36.
Body of type, definition of, 36.
Books, citation of, 88, 90.
titles of, in text, 39, 41.
Botanical sciences, literature sources, 78.
Botanical terms, capitalizing, 39.
italicizing, 41.
rules for, 56.
Box heads of tables, 63.
Bulletins, experiment station, citation of, 88, 91.
Calculations, 2, 45, 46.
Cameras for scientific subjects, 124, 126, 127.
Cancellation, in manuscript, 30, 31.
   in proof, 138.
Capitals, indication of, 31, 36.
   reduction of, 36.
   use of, 38.
Carbon copies, 26, 27.
Carbon pencil drawings, 108.
Cardinal numbers, hyphen in, 44.
Cards for notes, 4.
Caret, 32.
Catalogue, library, 67.
Cause and effect, false relation, 17.
   Center headings and subheadings, 101.
Centigrade degrees, 43.
Chapters, titles of, capitalizing, 39.
   in quotation marks, 41.
Characters, number per page, 34.
Check list of errors in writing, 25.
Checking manuscript, 29.
Chemicals, names of, not italicized, 42.
Chemistry, literature sources, 79.
Citations to literature, 84.
Clearness, of manuscript, 29.
   of sentences and paragraphs, 23.
   of tables, 58.
Comma, in numbers, 44.
   use of, 21.
Common names of animals and plants, 39, 41, 57.
Composition on typesetting machine, 28, 36, 62, 66.
Compound-interest law, 116.
Conciseness, 23.
Conclusions, 3, 13, 16.
Connectives, 24.
Consistency, of discussions, 22.
   of style, 24.
Contents, analytical, 100.
Controversial language, 12.
Coördinates for graphs, 114.
Copper etchings, 107.
Copy, for illustrations, 133.
   typewritten, preparation of, 26.
Copy-fitting, 34.
Copyrighted material, 98.
Corrections, in manuscript, 29.
   in proofs, 137.
Criteria for choosing research problem, 1.
Curves, 2, 111.
Cutter number, 69.
Dash, 38.
Dates, 44.
Decimal fractions, 44.
Definition of technical terms, 10.
Degrees of temperature, 43.
Development of topics, 9.
Dewey decimal system, 69.
Diagrams, letters in, 40.
   preparation of, 111.
Diction, 10, 25.
Dictionaries, viii, 10.
Difference between means, significance of, 47, 48.
INDEX

Discussion of results, 6, 12.
Diseases, 40.
Divisions of paper, indication of, 4, 101.
Dollars, 44.
Drawings, letters in, 40.
from photographs, 110.
preparation of, 106.

Economic sciences, literature sources, 81.
Em, definition of, 38.
Em dash, definition of, 38.
Emphasis of general conclusions, 13.
En, definition of, 38.
En dash, definition of, 38.
in citations, 87.
Engineering, abbreviations for, 54.
literature sources, 80.
report, outline of, 7.
use of non-metric system in, 43.
Equations, mathematical, 40, 45.
Erasure in manuscript, 30.
Errors in manuscript, 25, 29.
Errors in writing, check list of, 25.
Estimating length of printed article, 34.
Euphony, 24.
Examples, use of, in illustrating abstract ideas, 9.
Exceptions and abnormalities in data, 3.
Experiment station bulletins, 88, 91.

Explanatory letters in illustrations, 40, 109, 122, 131.
Exponents, 40, 45.
Exposures, trial, for photographs, 127.

Fahrenheit degrees, 43.
Family names of animals and plants, 39, 41, 56.
Figure, not capitalized, 40.
Figures (illustrations), 103.
Filters, photographic, 126.
Folders for tables, 61.
Footnotes, to tables, 64.
to text, 66.
Foreign words, not italicized, 42.
Fractions, 44.

Galley proofs, 137.
Genera, 39, 41, 56, 57.
General science, literature sources, 84.
Generalization, too broad, 16.
Geography, literature sources, 80.
Geology, literature sources, 81.
Geometric symbols, 40.

Grain, 54.
Gram, 54.

Graphs, for analyzing data, 2.
letters in, 40.
preparation of, 111.

Half, compounds of, 44.
Headings, for divisions of text, 101.
running, 29, 34.
for tables, 62.
Historical sciences, literature sources, 81.
Hours of day, 43.
Hyphen, in fractions, 44.
in numbers, 44.
Hypothesis, requisites of, 16.
Ideas, logical presentation, 15.
Illumination in photography, 125.
Illusions, 16.
Illustrations, preparation of, 103.
Inaccuracy in writing, 25.
Indentation, 38.
Indexing and abstracting tools, 74, 75.
Influential conditions, 13.
Ink for drawings and graphs, 106, 113.
Insertions, in manuscript, 32.
in proofs, 138.
Interest, in scientific articles, 18.
Inter-library loans, 73.
Interpretation of data, 2, 12.
Introduction, 11, 19.
Italics, indication of, 31, 36.
use of, 40.

Journals, abbreviations of names of, 91.
abstract, 74.
citation of articles in, 86, 90.
review, 74.

Lantern slides, 132.
Latin names, of anatomical parts, 40, 42.
of animals, 39, 41, 57.
of diseases, 40, 42.
of plants, 39, 41, 56.

Laws, scientific, 115.
Leaded, definition of, 37.
Legends, of illustrations, 134.
of tables, 62.
Length, of paper, 22, 23, 24, 34.
of paragraphs, 25.
of sentences, 23, 25.
Lenses, photographic, 127.
Lettering equipment, Leroy and Wrico, 123.
Letters, in illustrations, 40, 109, 122, 131.
subscript and superscript, 40.
Libraries, affiliated, 73.
Library, photographic service, 73.
use for research, 67.
Linear law, 116.
Linotype machine, 36.
Literature citations, 84.
Literature sources, library, 78.
Loans, inter-library, 73.
Logarithmic plotting, 113, 116.
Logical presentation of ideas, 15.
Lower-case type, 36.

Manufactured products, capitalization of, 39.
Map collections, 74.
Margins in manuscript, 27.
Marks, proofreader's, 138.
Mathematical expressions, 40, 45.
Mathematical relationship between variables, 116.
Mathematics, sources of literature, 82.
INDEX

Mean, standard error of, 45, 46.
Measurements, how written, 42.
Medical terms, 40, 42.
Medicine, literature sources, 82.
Metric system, 43.
Microfilms, 74.
Missing the point, 18.
Money, sums of, 44.
Monotype machine, 36.
Mounting photographic prints, 130.
Multiplication sign, 30.
Names, of anatomical parts, 40, 42.
    of animals, 57.
    of chemicals, 40, 42.
    of diseases, 40, 42.
    of plants, 56.
Nouns, proper, capitalization of, 38.
Number of typewritten copies, 27.
Numbers, of citations, 86, 89.
    of footnotes, 66.
    of illustrations, 134.
    of pages, 26, 27.
    of tables, 62.
    representation of, 42.
Omission, in quotation, 98.
    in table, 64.
Optical formulae, 127.
Order, of material in manuscript, 33.
    of topics, 9.
Ordinal numbers, hyphen in, 44.
Organization, 22.
Outline, analytical, 100.
    of engineering report, 7.
    of scientific article, 4, 5, 6.
    preliminary, 8.
Overlay, tracing-paper, 124.
Page, type, 37.
Page numbers in manuscript, 26, 27.
Page proofs, 141.
Paper, for illustrations, 100, 111, 113.
    for manuscripts, 27.
    for photographs, 128.
Paragraph side heading, 101.
Paragraphs, how indicated, 31, 138.
Parentheses, in names of animals and plants, 56.
    in reference to citations, 86.
    in reference to illustrations, 134.
Past tense, 20.
Per cent and percentage, 45.
Periodicals, titles of, abbreviations for, 91.
    in citations, 86, 90.
Permission to reproduce copyrighted material, 98.
Photo-gelatine process, 106.
Photographic services, library, 73.
Photographs, preparation of, 124.
Photostats, 74, 111, 133.
Physics, literature sources, 83.
Pica, in printing, definition of, 38.
    in typewriting, 26, 35.
Plan of composition, 4.
Plants, names of, 56.
Plate, not capitalized, 40.
Plates, 106.
Plotting points in graphs, 116.
Point, definition of, 37.
Political sciences, literature sources, 81.
Power law, 116.
Prejudice, 17.
Preliminary outlines, 4, 8.
Preparation review and revision, 135.
Present tense, 20.
Presentation, inadequate, 25.
Prints for half-tone reproduction, 128.
Probable error, 45.
Problem, research, criteria for choosing, 1.
Proceedings. See Periodicals.
Proofreading, 137.
Proofs, galley, 137.
page, 141.
photoengraver's, 141.
Proper nouns, capitalization of, 38.
Proportions for illustrations, 103.
Psychology, literature sources, 83.
Publications. See Books, Bulletins, Journals, Periodicals, Yearbooks.
Punctuation, revision of, 24.
rules for, 21.
Query, printer's, 140.
Questions, reader's, answers to, 10.
Quotations, 97.
Reader's questions, answers to, 10.
Recent advances series, 76.
Reduction, of capital letter, 31, 139.
of illustrations in reproduction, 133.
of letters and numbers in illustrations, 123.
Referees, 135.
Reference sources, 71, 78.
References, to citations, 86, 89.
to footnotes of tables, 64.
to footnotes of text, 66.
to illustrations, 12, 134.
to tables, 12, 65.
Rejection of manuscripts, 137.
Reliability and significance of measurements, 46.
Repetition, revision to eliminate, 24.
Report, engineering, 7.
Research problem, criteria for choosing, 1.
Restoration of words, 30, 138.
Results, discussion of, 12.
Review journals, 76.
Reviewers, 135.
Revisions, final, 33.
of conclusions, 3.
of headings, 101.
of manuscript, 22.
prepublication, 135.
Roman numerals, 46.
Roman type, 36.
Run in, definition of, 31.
Running headlines, title for, 29, 34.

Sample size, adequacy of, 49.
Science in general, literature sources, 84.
Scientific data, first steps in treating, 2.
Scientific names, 39, 41, 56.
Scientific writing, nature of, 4.
Semicolon, use of, 21.
Sentences, revision of, 22.
Sequence of topics, 9.
Serials. See Periodicals.
Series number in publication, 94.
Shading in drawings, 107, 108.
Shipping illustrations, 135.
Side headings, 101.
Significance, of difference between means, 47, 48.
of measurements, 46.
Significant figures, 45.
Size, of drawing, 103, 106.
of sample, 49.
of tables, 60.
of type, 37.
of type page, 37.
Slides, lantern, 132.
Small caps, 36.
Small type for subsidiary matter, 37.
Smoothing curves, 117.
Social sciences, literature sources, 81.
Solid, definition of, 37.
Spacing, in manuscript, 26.
in printing, 38.
in proofs, 138.
in tables, 64.
Species of plants and animals, 41, 56, 57.
Specifications for publication, 38.
Standard error of the mean, 45, 46.
Statistical methods, 3, 46.
Stimulation, 14.
Stub, definition of, 63.
Style, consistency of, 24.
 literary, 9, 18, 25.
 models of, 84.
Subje ct matter and arrangement, suggestions on, 8.
Subscript letters, 37, 66, 139.
Subsidiary matter, type for, 37.
Substitution in manuscript, 31.
Summary, 14.
Superscript letters, 37, 66, 139.
Superscript numbers, in citations, 89.
in mathematical equations, 45.
referring to footnotes, 66.
Symbols, mathematical, 40.
chemical, 50.
in graphs, 119.
reference, 64.
Synonyms of scientific names, 56.
Table, not capitalized, 40.
Table for tracing graphs, 119.
Table of contents, analytical, 100.
Tables, preparation of, 58.
Technical terms, definition of, 10.
when italicized, 42.
Temperature, 43.
Tenses, uses of, 20.
Terms, ambiguity of, 17.
   engineering, abbreviation of, 54.
   technical, definition of, 10.
   technical, when italicized, 42.
Text figures, 106.
Textbook, observations to be mentioned in, 13.
The, capitalized and italicized, 41.
Time, 43.
Title, condensed, for running headlines, 29, 34.
Titles, of articles in periodicals, 39, 41.
of books, 39, 41.
of chapters in books, 39, 41.
of illustrations, 134.
of paper, typewritten, 27.
of papers, choice of, 11.
of periodicals, 41.
of tables, 62.
Tone, 10.
Topics, for title, selection of, 11.
   order of, 9.
Tracing graphs, table for, 119.
Transactions. See Periodicals.
Transpositions, in manuscript, 33.
in proofs, 138.
Type, kinds and indication in manuscript, 36.
Type page, 37.
Typesetting machines, 28, 36.
Typewriting, character count in, 35.
Typewritten copy, preparation of, 26.
correction of, 29.
Typist, copy for, 26.
Units, of measurement in tables, 63.
of weight and measure, 50.
Unity, in compositions, 8.
in tables, 58.
Unsettled points, 12.
Variables, experimental, 13.
   mathematical relationships, 116.
Variety names, capitalization of, 57.
Vernacular names, 57.
Wash drawings, 108.
Water-color drawings, 108.
Weights and measures, abbreviations for, 50.
Words, 10, 25.
   foreign, 42.
Wrico lettering guides, 123.
Writing a scientific paper, 7.
Yearbooks, 75, 88, 91.
Zoological sciences, literature sources, 78.
Zoological terms, capitalizing, 39.
   italicizing, 41.
rules for, 57.