On writing scientific papers

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ON WRITING SCIENTIFIC PAPERS

By

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Foreword

When secrecy regulations were revoked after the war, many young scientists found themselves with a mass of valuable information and little experience in preparing it for publication. Partly by request and partly to aid reviewers and editors, some notes on the *Journal's* policies and on preparing manuscripts were rapidly assembled. When mimeographed and distributed, these notes produced a heartening response. We were therefore encouraged to examine them critically and to plan a more comprehensive article designed especially for those who have yet to write their first scientific paper.

We concluded that the original draft contained most of the information the young scientist required except advice on how to write the paper. To write about writing without the prestige of at least a chair of English is doubtless rash. Moreover, this task is the most exacting exercise in writing that can be devised; for the article should exemplify what it advocates. Though we may not have succeeded in doing this, we shall not mind criticism if what we have written is of any help to other authors.

Nothing new can be written about writing; it has all been said before in better ways by better men. We have read a few of the many books and articles on writing and gratefully acknowledge our debt to their authors. This article records our conception of the advice most helpful to those who must write scientific papers.

J. A. A.
M. W. T.

APRIL, 1947.

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ON WRITING SCIENTIFIC PAPERS

By J. Ansel Anderson[1] and M. W. Thistle[2]

Introduction

The *Canadian Journal of Research* publishes original papers on pure or applied research, written in English or French, and coming from Canadian or foreign sources. The *Journal* is issued in six sections, each with separate cover and pagination. These are:

A. Physical sciences,
B. Chemical sciences,
C. Botanical sciences,
D. Zoological sciences,
E. Medical sciences,
F. Technology.

The appropriate subjects for each section will be clear from the names, with the possible exception of Technology, which is designed primarily for applied research. In assigning papers to sections, the wishes of the author and the recommendations of Section Editors are considered. Though the *Journal* accepts papers on subjects such as nutrition, geology, and soils, suitable sections for these papers do not yet exist, and authors should consider the advisability of publishing them elsewhere. No limitation is placed on the length of papers, but they must be well organized, clear, and concise.

Manuscripts are sent by the Editor-in-Chief to the appropriate Section Editors, who in turn submit them to competent reviewers of their own choosing. Reviewers decide whether the paper makes a worthwhile contribution to scientific information, recommend changes required to make the manuscript meet publication standards, and may also suggest ways of improving the presentation.

When the Section Editor receives the reviews, he sends these and his own recommendations to the Editor-in-Chief, who decides whether the manuscript is to be accepted as written, accepted subject to revision, or rejected. As most papers require some revision, however slight, the original manuscript and reviews must generally be sent to the author. When the revised draft is returned, it is edited and then set in galley proof and page proof, both of which have to be corrected before the paper is ready for publication. Despite this time-consuming procedure, and the possibility of further delay because most sections appear only once in two months, the average interval between submission and publication is about 110 days, which compares favorably with intervals for other scientific journals.

Contributors who are annoyed by the time required for publication should bear in mind the work involved and that much of it is done gratis and as a

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sideline by busy men. Their loads could be lightened, many revisions avoided, and much time saved, if contributors would ask one or two competent friends to criticize manuscripts in draft before they are finally typed for submission to the *Journal*. But the time of one's friends is also valuable, and the amount consumed is increased if drafts are ill organized and poorly written. Moreover, a geometric progression is involved: if one paper is twice as badly written as another, the reviewer takes about four times as long to deal with the poorer one.

Writing for publication in scientific journals is an exacting and difficult art—a reasonably complete guide would require a thick volume, and this would need periodic revision. Nevertheless, experience does suggest that a few hints will aid the inexperienced author to improve rapidly and thus save his time, avoid much friction and correspondence, and help to raise the standard of the *Canadian Journal of Research*.

In the following sections, the work of writing a scientific paper is described in the order in which it is usually undertaken. Assembling of data in tables and graphs is discussed first. A section follows on other preparatory work: literature reviews, treatment of statistics, and selection of titles. Abstracts are considered with titles because they have much in common. When these preliminaries have been finished, and before the actual writing is started, a detailed plan should be made for the paper; so a section is devoted to this important step. The next section deals with the actual writing of the paper and is divided into subsections on the essentials of sound organization and on the essentials of good style. A final section gives information that must be kept in mind in typing the manuscript and preparing other copy. Those minutiae of editorial style that are most often treated erroneously are listed in the appendix.

Assembling the Data

As most scientific papers present and interpret quantitative data, assembling these is a logical first step. And even for those papers that contain no data, some preliminary listing or summarizing of information is generally required.

The importance of preparing well organized tables and graphs can hardly be exaggerated. Groups of data thrown together at random cannot be logically presented and interpreted no matter how skilful the writer. Time spent on designing tables and graphs will be amply repaid by the greater ease with which the paper can be written and, what is more important, by the greater ease with which it can be understood.

More than three or four numerical data should always be presented either in a table or in a graph, but the same data must not be presented in both tables and graphs. The choice is often easy. If it is not, try the data first in tables, and if these are not clear and readily interpreted, try graphs. The experimental approach is strongly advocated: draw up several arrangements of the table headings without bothering to fill in all the data, and determine

which will prove best by considering these outlines from both the writer's and reader's viewpoints. Rough freehand sketches of graphs serve the same purpose. Finally, do not hesitate to change tables or graphs if improvements suggest themselves while the paper is being written. Imagination and a flexible mind are no less important in writing papers than in designing experiments.

*The Preparation of Illustrations and Tables**, by Anderson (1), deals in detail with principles. Excerpts from this article are included in the following subsections.

Preparation of Tables

Tables should present essential data classified and arranged to facilitate the main comparisons that the reader must make. One of the principal methods of helping the reader is to exploit trends in the data. All authors make use of natural trends caused by a series of different times, temperatures, concentrations, or the like, but the possibility of introducing trends by arranging data in order of increasing or decreasing magnitude is sometimes overlooked. Figures can be compared more readily in columns than in rows; so the principal comparison, or the one that is most difficult because it involves most figures, should preferably be put within a column. Many authors publish too many significant figures; this misleads the reader by creating a false sense of precision and also makes comparison of the data more difficult. All unessential data such as laboratory numbers, results of simple calculations, and columns that show no significant variations, should be omitted. The smaller the table, the more willingly will the reader examine it, and the more readily will he digest it. When only two or three short rows of data are required, leader tables are frequently useful; these are set without ruled lines and require no table number or main heading. Data from tables should not be repeated in the text unless some explanation is required to ensure clarity.

Few authors who do not habitually experiment with their data realize how many arrangements there are for complex tables. In the simplest tables with but two criteria of classification, only two arrangements are possible: criterion No. 1 goes in the box headings and No. 2 in the side headings, or vice versa. There are 12 possible arrangements for three criteria of classification, and 96 for four criteria; so considerable study is often required to select the best arrangement for complex tables. However, there is no sounder advice on the preparation of tables than that large ones should be split up if possible. This last point was emphasized by a reviewer who recently wrote, "Table I is large enough to make a shroud for the corpse of any reader's interest."

Tables should be self-explanatory, so titles, box headings, and side headings should be chosen with care. A headnote and footnotes may be added if they are essential to an understanding of the table. Every table must be referred

* *A special reprint of this paper and five others given at a symposium on writing may be obtained for 50 cents from the Managing Editor of Cereal Chemistry, University Farm, St. Paul 8, U.S.A.*

to in the text, and each should be introduced at the earliest point at which it will help the reader. When discussing a table refer to it as "Table II" (capital T, Roman number) rather than as "the following table", since the printer in setting the page may not be able to place it exactly where the author has suggested.

Preparation of Illustrations

The orthodox layout for a simple graph comprises a heavy curve with medium weight axes on the left and at the bottom. A complete frame is often used; some graphs look ragged without it, and some look empty with it. Light grid lines may be required to facilitate accurate evaluation of specific points on curves, but if curves are used only to illustrate trends and relations, grid lines are not necessary and may overcrowd the graph. The proper weight for lines and the size and weight of lettering should be carefully selected (see page 20), and overcrowding of lettering and scale numbers should be avoided. Variety in lettering and lines increases clarity and gives emphasis. Too many curves in one graph, and the use of a key in one corner, when curves might well be labelled, serve only to confuse the reader. A number of these faults are illustrated in Fig. 1, and have been corrected in Fig. 2.

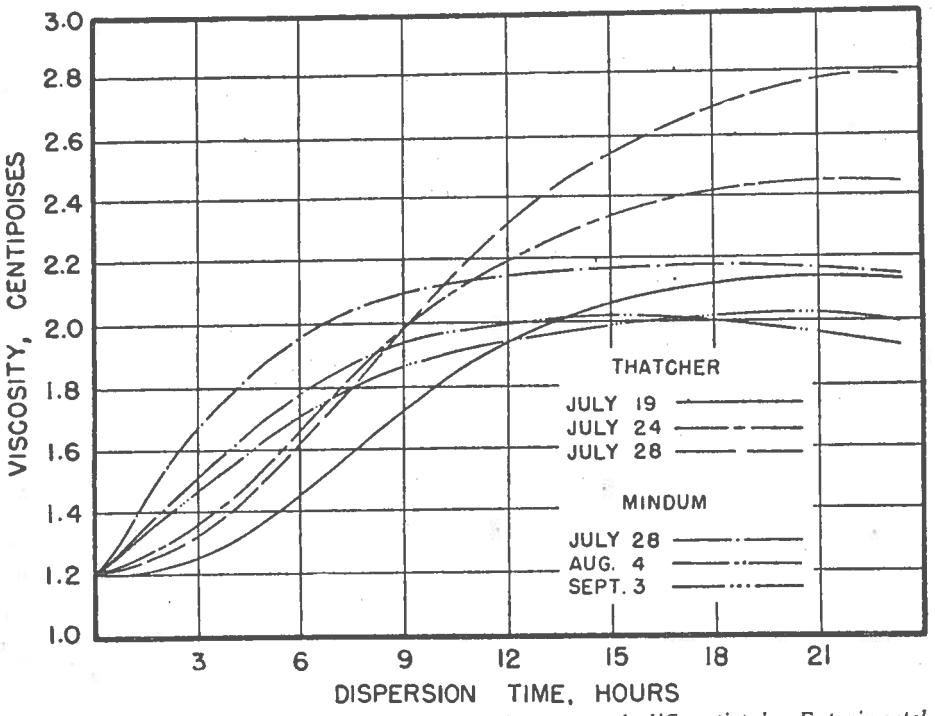

FIG. 1. *This graph has too many curves, and these are poorly differentiated. Experimental points are missing. A legend is used instead of labels, and weights of lines are poorly chosen.*

Certain conventions governing the preparation of graphs are widely recognized, and readers are helped if these are invariably followed. For instance, the dependent variable should always be allotted to the vertical axis. Discrete

factors, such as different properties, should be represented by bar graphs with spaces between the bars. Conversely, a variable that can change continuously should be shown as a histogram with no spaces between columns. Histograms are therefore similar to curves, but they are preferred when the data are few and disjointed, so that drawing a smooth curve would hardly be permissible. Scatter diagrams illustrating correlations and regressions are best drawn within a frame but without grid lines. The scatter of the points is of prime interest, and the points should therefore be as bold within reason as their number and concentration will permit.

When illustrating equipment, do not try to make shop drawings. It is impossible to do justice to these on the small scale to which they must be reduced for printing. Make a drawing that shows only what is required to illustrate the general design and operation of the equipment. The man who wants to construct a duplicate can always write the author for blueprints and specifications.

Photographs are often required in scientific papers, but little advice about their preparation need be given here since a multitude of good handbooks are available on the art and science of photography. The best photographs

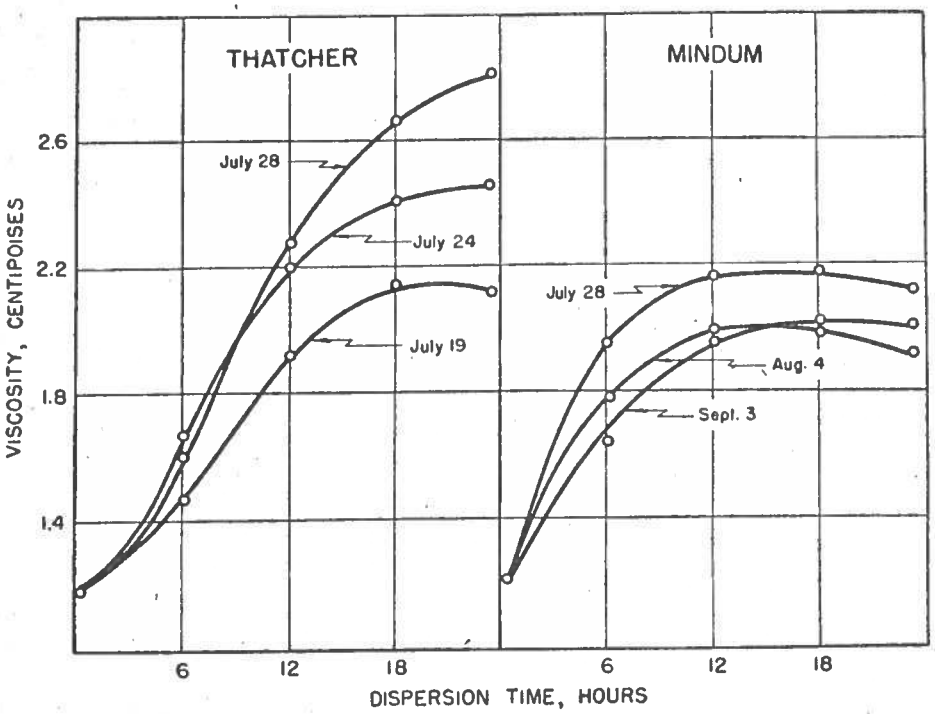

FIG. 2. *A corrected version of Fig. 1.*

for reproduction are obtained when the subject is lighted so that details show clearly. A bright print with considerable contrast reproduces best, but detail should not be sacrificed for contrast. All prints must be made on glossy

paper. When the subject is difficult, hire a professional photographer, or obtain the help of an experienced amateur.

An explanatory caption is almost invariably required for each figure, and each figure must have a number (Arabic). Moreover, each figure and table should be referred to in the text; those not worth discussing are not worth including and should be omitted.

Other Preparatory Work

Before planning the paper in detail it is frequently advisable to decide how the literature citations will be treated and what provisions should be made for any required statistics. Most authors draft a title early, and some also write an abstract because this helps to outline the scope of the paper. These matters are considered in the following subsections.

Citation of Literature

Literature will have been reviewed before the research was started, but the author will often wish to refresh his memory and to select those references that may profitably be cited. If a complete and accurate list of references is prepared early, notes on the places at which each is to be cited can be made in the plan.

The *Journal* does not advocate a separate section entitled "Review of Literature" or the exhaustive survey of previous work that is suitable for theses. Nevertheless, the extent to which relevant literature is reviewed is left to the discretion of the author, with the advice that pertinent references be cited throughout the body of the paper where they have a bearing on the points under discussion. This does not mean, however, that previous reviews or a few outstanding papers should not be mentioned in the introduction.

Some details must be borne in mind. References are cited in the text by the use of key numbers in brackets, thus: (6). While this is sufficient, some writers prefer to use in the text either the names of authors, or the names and the year of publication. These practices are acceptable if the citation is always followed by a reference number:

"Viscosities have been determined (6) and are . . ."
". . . determined by Smith and Brown (6) and are . . ."
". . . by Smith and Brown (6) in 1947 and are . . ."

As there are other satisfactory variations similar to the foregoing examples, this method of citing references is very flexible and convenient.

References are listed at the end of the paper in alphabetical order of the authors' names, and numbers are also assigned in that order. Examples of reference lists illustrating punctuation, capitalization, the style for reference to books, and other matters, are given in the appendix. As a large amount of work is required to correct references that do not follow the prescribed styles, authors are implored to refer to the appendix when preparing reference lists.

Treatment of Statistics

When the results of an investigation have been subjected to statistical analyses, the place of statistics in the paper must be carefully considered. The *Journal* prefers that statistics be kept in the background, except in papers that deal directly with statistics or depend mainly on statistics for their value. In most technical papers the statistics play only a supporting role, and the writer should therefore feature and discuss the data, not the statistics. If an investigation deals with differences between materials or methods, the first requirements are the mean values and a discussion of them; if it deals with interactions, these may well be illustrated with tables or bar diagrams; if it deals with correlations, scatter diagrams may be in order. When the principal results are given and discussed first, with graphs as illustrations if these are advantageous, any statistical discussion that follows will be more intelligible to the average reader. Sometimes the statistical analyses may be omitted altogether, or their results summarized by a few sentences in the text. And even when detailed statistics must be used, they can often be relegated to a separate terminal section of the paper.

Manuscripts should not carry long descriptions of statistical methods—generally a sign that the writer has recently acquired this information himself and believes that his readers need similar enlightenment. The ordinary scientific paper is no more a suitable vehicle for lessons on elementary statistics than for lessons on elementary bacteriology or chemistry. Commoner statistical methods may be used without comment, but advanced methods may require support by reference to a published paper or textbook.

Titles and Abstracts

Many persons will read only the title of a paper; others will read title and abstract; and if these do not awaken interest, only a few specialists will read the full paper. Titles and abstracts should therefore be prepared carefully. Write them for the first draft of the paper, and reconsider them with each revision.

Titles should be as short as is consistent with adequate description of the investigation. Series titles with different subtitles for each part of the series have recently become more fashionable than is warranted by their usefulness. They may be suitable for large groups working on long-term projects, but individual authors should generally use single titles. Do not settle for the first title that comes to mind, but write several and choose the best.

In the *Canadian Journal of Research*, the title is followed by an abstract of about 200 words. This should indicate the scope of the work and the principal findings. A mere expansion of the title is not very helpful, and a long detailed account in a series of scrappy paragraphs is little better. Do not describe what was done, but tell specifically what was found. Consider the following beginning of an abstract:

> F_1 tetraploids grown in pots had larger but fewer leaves and inflorescences than control diploids. Increase in size of the organs was offset by reduction in number, so that leaf area was no greater and total number of florets per plant was much lower in tetraploids than in diploids. Fertility varied inversely with genetic relationship and was much reduced in the tetraploids. No significant differences were noted in root size . . .

This is excellent; each sentence tells what was found and in so doing clearly implies what was done.

Drafting the abstract first is good discipline. In preparing a concise statement, the author clarifies his own conception of the information he intends to present to the reader.

Planning the Paper

No more than the title and a draft abstract should be written until a plan has been made for the complete paper. The main sections will present little difficulty since they will generally follow one of two traditional arrangements:

Introduction	Introduction
Materials	Topic I
Methods	Topic II
Results	Topic III
Discussion	Discussion
Acknowledgments	Acknowledgments
References	References

The left-hand plan is suitable for single investigations made throughout with the same materials and methods. If descriptions of materials and methods are short, a single section will suffice for them. Moreover, as results can often be best discussed as they are presented, a single section for "Results and Discussion" is sometimes advantageous and may prevent unnecessary repetition. The conventional arrangement can still be followed when special sections are required on equipment, plan of the investigation, or statistical analyses.

The right-hand plan is suitable for a wide variety of descriptive papers. It is also the better plan for papers on a group of related studies each made with different materials or methods. In these papers, the reader is helped if the materials or methods peculiar to each study are described at the beginning of the section on it.

These two plans may be combined and modified in various ways to meet special needs. Much simpler arrangements may also be used for short papers. For instance, many papers on organic chemistry contain only two sections: an introductory part that also contains the main results and discussion, and an experimental part that gives the details.

Planning should proceed far beyond the mere outline of major sections. There must be careful consideration of the need for and arrangement of subsections; and under each of these, topics for the main paragraphs should be

noted. Provision must be made for necessary literature citations, and possibly for dealing with statistics. Photographs or drawings may be required. Finally, as the main function of most papers is the presentation of data, tables and graphs must be fitted into the plan.

The best method of making a plan is to start by noting each topic on a separate card. These can then be sorted into groups, each containing related topics. Further sorting serves to arrange topics within each group. When a logical sequence has been devised, the several topics that will form one section or subsection of the paper are transferred to a single card on which a draft heading for the section is written. Subsequent sorting of section cards provides a plan for the whole paper, and this is finally copied on one sheet in the form of a table of contents. The alternative method of trying to work out the plan at once on a single sheet hinders the experimenting required to develop the best arrangement. Time spent on making a detailed plan will be amply repaid later. Beginners generally scamp this work, possibly because they see that experienced writers frequently use only a general plan. The truth is not that experienced writers do less extensive planning but that they are able to do most of it mentally.

The principles involved in preparing detailed plans for sections and paragraphs might have been discussed here, but it seemed better to do this in the next section. One point cannot be emphasized too much: in making a plan, as in writing the paper, the reader's viewpoint must be continually kept in mind. The guiding principle is not that the writer should be able to get information into the paper, but that the reader should be able to get the information out.

Writing the Paper

With the tables and graphs drafted, and with a detailed plan before him, the author is ready to start writing the paper. It is not such a formidable task. He should be full of his subject, and writing should come easily. Start anywhere, with the introduction, with a section on methods, or with the presentation and discussion of the main results, wherever fancy chooses; the idea is to get going, to write. Plan for enough time to complete the selected section at one sitting; and in a series of sessions, complete the whole paper from title to reference list, including abstract, table headings, figure captions, and all other details, before starting to rewrite any part of the draft.

Writing and rewriting is strongly recommended as the fastest method of producing a polished paper. When the ideas are on paper there is something concrete to work with, and reorganization and rephrasing are simplified. The alternative method, of aiming at perfection in each sentence and paragraph as it is written, is generally a frustrating experience that hinders rather than facilitates expression. It requires a mastery of the art of writing, and an ability to marshal ideas in the mind and to foresee and overcome the difficulties of presenting them, that few persons possess. And those who can follow this

method do not necessarily complete their work faster than those who write several drafts.

Write the first draft rapidly without bothering about details like punctuation, spelling, or finding the best word—leave a blank if necessary. Give the creative faculties full play, and give the critical faculties a rest; they will be needed later. Strive only to put down thoughts in sequence according to the plan. Detailed advice on writing will facilitate production of a better first draft only when its application becomes ingrained habit. The tyro will best forget the advice until he starts to criticize, rewrite, and polish his draft. This is the time when a clear conception of those qualities that make writing good or bad is invaluable. For, though writing is mainly an art, criticism is mainly a science, and can therefore be undertaken systematically if one knows what to look for.

The essential qualities of a well written paper can be divided into those that pertain primarily to the organization of the whole paper and of its major parts, and those that pertain primarily to details of phrasing. Good style is based largely on well constructed sentences, but even so small a unit as a sentence can be well or ill organized. So good phrasing and sound organization are interrelated and have some qualities in common. In spite of this overlapping, a division seems useful, and the two groups of qualities are discussed separately in the following subsections.

Essentials of Sound Organization

The first steps in organizing information that is to be communicated in writing are identical with those in organizing material for any other purpose; the information must be classified and grouped according to similarities and other relations; and an orderly arrangement of the groups must then be devised. By comparison with tables or graphs, writing is severely handicapped. From a well organized table or graph, the reader can obtain at a glance some conception of the whole of the information represented. No similar total conception can be rapidly obtained from writing, which suffers from the limitation that the reader must absorb information a phrase at a time. Comprehending a table would be equally difficult if the data, instead of being arranged in rows and columns, were strung together in lines like words in a paragraph. It follows that the sequence in which information is presented in writing is of fundamental importance. Indeed, the chief difference between good and bad writing in scientific papers frequently relates merely to sequence. In good writing the ideas and information are invariably presented in a systematic order based on a sound principle.

By far the most important and widely used principle is to proceed from the general to the particular. The broad plan of an investigation, and the relations of its parts, must be presented first. Reactions on which analytical methods are based, or major parts and functions of equipment, are briefly outlined before details are described. Mean results are discussed before individual results, and broad conclusions are drawn before specific ones. This is merely

another way of stressing the importance of introductions, topic paragraphs, and topic sentences; for these have the vital function of presenting the general as an introduction to the particular. When skilfully used, they ensure that readers need never wrestle with detail until they have been given a general theme to which this detail can be related.

Another almost equally important principle is to proceed from the known to the unknown. The advantages of this are so obvious that they need no amplification.

Examples of other commonly used sequences can readily be listed: Steps of a method may be given in chronological order, symptoms in order of importance, effects in order of magnitude, family relations in order of closeness, and phenomena in order of frequency of occurrence. Equipment may be described systematically according to its arrangement in space, and machinery according to the sequence of the operations performed or the order in which power is transmitted from one part to another.

Several principles must frequently be used in combination. Thus the description of a complicated piece of equipment would start from the general and proceed to the particular: a broad outline of its parts and functions would first be given. Detailed descriptions would come next, and these might follow spatial arrangement with a counterpoint of comment on operational functions. Finally, descriptions of individual parts might be required, and these might be based on classes of materials from which parts were made, starting with the most important parts or with the largest group made from one material.

These examples deal mainly with descriptions of concrete things, but sequence is equally important in discussing abstract ideas. Logic generally demands that one train of thought be carried to its conclusion before another is begun. Thus complex discussions are often similar to a description of a river system. An orderly description might involve starting at the source of the main river and continuing to its mouth, and then returning to take each tributary from source to mouth; or starting at the source and continuing to the first tributary, and then describing this tributary from source to mouth before continuing with the main river. Other sequences will suggest themselves, but each must be consistent; there must be no haphazard jumping about from one tributary to another. This analogy can usefully be kept in mind when deciding the course any discussion should follow.

Selection of a logical sequence is only a first step; the sequence must also be made clear to the reader. He must not get halfway through the description of the river system before he realizes how it is being described. In the scientific paper, well chosen headings help to guide the reader, but topic paragraphs that give a preview of what is to come are also extremely useful. These are particularly important when presenting lines of thought that parallel rather than follow each other. This relation is best emphasized by similarity of treatment, which often extends to similarity in the wording of headings for parallel sections. When necessary, the relations between

parts are made clear by specific statements such as, "The three reasons for adopting this hypothesis are discussed in the following three paragraphs"; the paragraphs might then start with firstly, secondly, and finally. In short, the selected sequence must be repeatedly drawn to the reader's attention.

Aside from systematic sequences, a well written scientific paper will have unity, proper proportion among its parts, due emphasis, and a fitting climax. Moreover, these qualities should be shown by each section and subsection and are also attributes of most well written paragraphs.

Unity in writing is second in importance only to logical sequence. There must be unity within the sentence—one thought, or two or three closely related thoughts. There must be unity within the paragraph—one topic considered in a series of related thoughts. There must be unity within the subsection or section—one group of related topics. And there must be unity within the paper—one theme, or possibly two or three related themes, treated in separate sections, and unified by a common purpose expressed in the introduction and by a drawing together in a common terminal discussion. Unity is clearly a function of the success achieved in grouping the information and ideas presented in the paper.

In a well written paper there must be a proper proportion between parts. The trivial must not be discussed in detail while the important is left largely to the reader's imagination. Lengths of sections and paragraphs should not depend on the writer's whim, but should bear some relation to the importance of the contents.

Emphasis is related to proportion but is also obtained in other ways. A proper proportion in treating topics provides some emphasis, which is reinforced by stressing novel parts of equipment or methods, principal results, and important conclusions. There are many ways of emphasizing a word or phrase—inversion, repetition, italics, choice of novel words and arrangements, and so on—and these are sometimes required in scientific papers. But the important point to remember is that the beginning and end of a section or paragraph carry most emphasis. A good idea should not be buried in the middle of a section, when it might be drawn emphatically to the reader's attention in a full paragraph at the beginning of the section. Papers that lack emphasis are flat and uninteresting.

Finally, good writing, like good music, has a fitting climax. Many a paper loses much of its effect because the clear stream of the discussion ends in a swampy delta. The author appears to run out of ideas, tacks on a few afterthoughts, and ends rather than finishes his paper. So strong terminal sections should be provided. Moreover, a measure of climax is required in the individual sections and also in paragraphs. Indeed, climax is a prime quality of many well written sentences. Particular attention should therefore be paid to terminal sections, last paragraphs, and final sentences.

Systematic criticism of a draft manuscript requires an answer to this question: Does the writing show fitting climax, due emphasis, proper propor-

tion, unity, and logical sequence? If any one of the first three qualities is lacking, a certain amount of patching, rearranging, and rephrasing will be required. If either of the last two qualities is lacking, nothing will serve but a drastic reorganization.

Essentials of Good Style

Authorities are agreed that the prime essentials of good style are clarity, conciseness, and simplicity. Unfortunately, to tell a man that the secret of good style is to write clearly and concisely is as useless as to tell him that the secret of good golf is to hit the ball firmly and accurately. As for simplicity, it is as difficult to achieve in writing as elsewhere. It is not easier to be simple than to be anything else; in truth, it is easier to be anything else than simple. Save in the occasional genius, ability to write well is not a God given talent but a hard won attainment.

A more precise synonym for clarity in writing was thus defined by Quintillian, "By perspicuity care is taken, not that the reader *may* understand, if he will, but that he *must* understand, whether he will or not." How shall this end be achieved? The first rules have already been given; clarity is most certainly a function of organization, especially of unity, of logical sequence, and of the care taken to keep the reader continuously informed of the trend of thought.

Readers most frequently lose their way between paragraphs. And this often happens merely because the first sentence is poorly phrased; so topic sentences, besides introducing new subjects, have the important function of providing articulation. When skilfully worded, with appropriate forward or backward references, these transitional sentences are invaluable for showing the relations between parts of the presentation. Danger points occur especially when the train of thought is broken; the topic sentence must then give the reader an unmistakable warning. Too often he reads a paragraph about Table I and is halfway through the next paragraph before he realizes that the author is no longer discussing Table I but Table II. Nor can the need for careful articulation between paragraphs be overlooked when the change in topic is less abrupt; a joining word or phrase may still be required. The reader must be kept continuously oriented within the unknown country of the author's mind; transitional paragraphs and sentences are the landmarks and roadsigns by which the reader finds his way.

Some specific advice can also be given for the detailed task of phrasing thoughts clearly. Firstly, write short sentences. These are inherently lucid. But they have their drawbacks. Periods are their main punctuation. They suffer from the "spot plague". Monotony cannot be avoided. But the knack of joining or condensing the occasional pair of sentences without losing clarity can be readily acquired.

Secondly, use the direct statement and the active verb. Write, "Table II shows that . . .", not, "It will be seen from consideration of the data in Table II that . . .". Write, "Fig. 1 shows that A is inversely related to B", not,

"There is an inverse relation between A and B, as shown in Fig. 1". But strings of modifiers, particularly when these are improperly hyphened, cannot be excused on grounds of directness; "A corn-soybean meal-5% alfalfa-salt ration" should be written, "A ration of corn, soybean meal, 5% alfalfa, and salt".

Thirdly, use concrete rather than abstract phrases. Whenever possible, deal with "things that you can touch and see", with the materials with which you work and their tangible properties, with the data in tables, and with the curves in graphs. Do not write about such abstractions as "the nature of the problem" or "the characteristics of the curve". Problems that are susceptible of laboratory study can be discussed in concrete terms. Curves have shape, slope, maxima, inflexions, and these are the specific qualities that support hypotheses and conclusions. Use of concrete phrases is not always possible, for abstract ideas must often be discussed. Yet it is surprising how often a choice between the abstract and the concrete can be made, and how much more masculine, vivid, and clear, the style becomes when the concrete is invariably chosen. Remember too, that the best method of explaining abstract ideas is to use concrete examples.

Finally, the importance of punctuation as an aid to clarity must be stressed. Indeed, the only reason for punctuating scientific papers is to increase clarity, and complete and accurate stopping is therefore essential. Though the modern trend is towards sparse punctuation to permit faster reading, no licence is given for omitting essential stops. The sentence in which grammar demands several commas is generally worsened rather than improved by omitting some of them; it should be recast. Accordingly, he who aspires to punctuate lightly must construct his sentences so that few obligatory commas are required. And this is a worthwhile goal; for a clear and flowing style that needs few commas is ideal for scientific papers.

Conciseness is next in importance to clarity. The greatest deterrent to concise writing is the habitual use of those trite phrases and circumlocutions which Quiller-Couch called Jargon. Avoid the *in* and *with* phrases:

In the case of	*In the instance of*
In respect of	*With respect to*
In regard to	*With regard to*
In connection with	*With reference to*
In the matter of	*In view of the*

Other common circumlocutions are:

The great majority of	for	*most*
At an earlier date	for	*previously*
During the course of	for	*during* or *while*
The question as to whether	for	*whether*

Though required occasionally, the *it is* construction also invites verbosity:

It is apparent that	for	*apparently*
It is admitted that	for	*admittedly*
It is clear that	for	*clearly*

There are dozens of these phrases, particularly conjunctional and prepositional phrases, for which single words can be advantageously substituted.

Certain abstract nouns should be deliberately avoided. Beware of *case*, *instance*, *nature*, *condition*, *degree*, *extent*, *character*, *characteristic*, and all other nouns ending in *-istic*; these nouns have their proper uses, but they are so often a symptom of vague thinking that it is wise to eschew them. Lastly, when the trite phrases, the circumlocutions, and the unnecessary abstractions have been deleted or replaced, the final polishing should remove each unnecessary *the*—for example, four from this sentence.

At the end of his lecture on Jargon, Quiller-Couch (8) has a paragraph that every scientist should read frequently:

> So long as you prefer abstract words, which express other men's summarized concepts of things, to concrete ones which lie as near as can be reached to things themselves and are the first-hand material for your thoughts, you will remain, at the best, writers at second-hand. If your language be Jargon, your intellect, if not your whole character, will almost certainly correspond. Where your mind should go straight, it will dodge: the difficulties it should approach with a fair front and grip with a firm hand it will be seeking to evade or circumvent. For the Style is the Man, and where a man's treasure is there his heart, and his brain, and his writing, will be also.*

By striving to avoid jargon, rapid progress can be made in learning to write concisely. But the young writer should aim not so much to achieve conciseness while writing as to remove verbosity while revising. The following sentence from a recent article (its origin masked by certain changes) will serve as an example:

> Despite the colloidal nature of the precipitates given by the new reagent with most extracts of plant materials, and the subsequent clogging during filtration, it is suggested that study might well be devoted to the feasibility of adapting the method to such extracts by making efforts to secure greater rapidity either by the addition of filter aids or by the use of a centrifuge. (64 words.)

This excretion of words can be changed into English prose by removing the jargon and condensing what remains:

> With most plant extracts, the new reagent yields colloidal precipitates that clog filters. But adapting the method to these extracts—by adding filter aids or by centrifuging—may be feasible and merits study. (33 words.)

If the original sentence contains extraneous ideas as well as excess words, it can be condensed still further:

> The new reagent yields filter-clogging precipitates with most plant extracts; filter aids or a centrifuge may overcome this difficulty. (20 words.)

* *Quiller-Couch, A. On the art of writing. Lecture V, p. 91. Pocket ed. Cambridge Univ. Press, Cambridge. 1923. Permission to quote this paragraph is gratefully acknowledged.*

Condensing also has its dangers. Too few words may be as bad as too many; for clarity is more important than conciseness, and clarity demands complete and precise expression of each thought. A long statement is not necessarily verbose, nor is a short one invariably concise. Enough words must always be used to make the meaning abundantly clear; otherwise, the writing will be obscure or even ambiguous. "Our style bewrays us"; and for a scientist it reveals a limitation that can scarcely be admitted if it shows inability to think clearly.

Simplicity, the last of the three essentials, and the very essence of good style, is the most difficult to analyze. In its broader aspects, simplicity has its source in clear thinking. But the simple style is functional; its virtue stems from the economy with which the purpose is achieved; so it is not enough that the stream of thought be clear, it must also flow from point to point in straight and narrow channels.

The detailed technique and art of simple writing defies analysis. All the usual advice may be considered—prefer the concrete to the abstract, the specific to the general, the definite to the vague, the familiar to the strange, the single word to the circumlocution, the short word to the long, the Saxon word to the Romance; be direct, concise and lucid—yet when all these precepts have been examined, simplicity is not explained. A comment may be borrowed through translation from Anatole France (4):

> The only difficulty is to define what the simple form is,—and it must be allowed to be a great one.
>
> Nature, at any rate as we can know her, and in an environment adapted for organic life, offers us nothing simple, and Art cannot aspire to more simplicity than Nature. Yet we understand well enough what we all mean, when we say such and such a style is simple, and such and such another is not.
>
> I will say this much then, that if properly speaking there is no simple style, there are styles which appear simple, and it is just these that carry youth and power of duration with them. It is only left now to inquire whence they get this lucky appearance. Doubtless we shall conclude they owe it, not to the fact of their being less rich than others in divers elements, but rather because they form a whole in which all the parts are so thoroughly blended that they cannot be distinguished separately. A good style, in fact, is like yonder beam of light that shines in at my window as I write, and which owes its pure brilliancy to the intimate combination of the seven colors of which it is made up. A simple style is like white light. It is complex, but does not seem so. This is only a simile after all, and we know what such parallels are worth when it is not a poet that draws them. What I wanted to make plain is this: in language, true simplicity, the simplicity that is good and desirable, is only apparent, and results solely from the fine co-ordination and sovereign economy of the several parts of the whole.*

* *France, A. The garden of Epicurus, pp. 90–91. Translated by A. R. Allinson. Library ed. John Lane of the Bodley Head, Ltd., London. 1924. Permission to quote these paragraphs is gratefully acknowledged.*

Perhaps simplicity is not so much a prime essential of good style as a concomitant virtue; for surely it is the genius of the English language that simplicity is the almost inevitable offspring of mating absolute clarity with utmost conciseness. And if this be so, perhaps one need strive only for these two qualities.

A good style can hardly be developed without steady practice, but early drafts of any paper can be improved in style by refining and polishing poorer sentences. The process lends itself to the experimental approach—to cut and try methods. There are only two differences between a good sentence and a poor one expressing the same thought: the words selected, and the order in which they occur. Do not glower glumly at a poor sentence. Take a scratch pad and experiment by finding substitutes for key words and by changing the sequence of phrases. Thoughts are usually clarified and made more precise as they are worded and reworded.

Though general advice on writing is helpful, there is no substitute for a thorough knowledge of English grammar and composition. Those who lack this foundation should strive to obtain it. *The King's English*, by Fowler and Fowler (3), is the outstanding text on vocabulary, syntax, punctuation, and related matters; and *Modern English Usage*, by Fowler (2), is a useful reference on the same subjects. Among American texts, *College Handbook of Composition*, by Woolley, Scott, and Berdahl (10), and *Writer's Guide and Index to English*, by Perrin (7), are widely used. Finally, Chapters II, V, VII (last half), and XII of *On the Art of Writing*, by Quiller-Couch (8), are recommended as a delightful treatment of rhetoric and that intangible of good writing called style.

Two recent papers and a book, written specifically for scientists, amplify the foregoing advice. *The Preparation of Manuscripts for Phytopathology*, by Riker (9), covers in more detail much the same ground as the present article. Riker's advice will prove useful not only to phytopathologists but also to other scientists writing for any journal. *Short Cuts to Unity, Clearness, and Brevity*, by Harris (5), and Nelson's (6) book, *Writing the Technical Report*, deal mainly with organization. The book has an excellent treatment of paragraphing, and though it deals primarily with reports, most of the advice is equally applicable to scientific papers.

Only the apprenticeship of continuous practice, the hard work of putting pen to paper, the discipline of repeated revising and polishing, can make an expert writer. But reading helps. Textbooks and articles serve mainly to guide the student by precept, but it is also profitable to learn by example. Like the chameleon's skin in a physical environment, a man's style takes on the color of his mental environment; and reading good books thus helps to improve writing habits. An example that any author might well ponder has been chosen from the greatest classic in the English language. The passage illustrates the beautiful interplay of vowel sounds and the varied rhythms

and cadences of the best prose. Yet it is written with active verbs, concrete nouns, and few adjectives, in a style that is lucid, direct, and simple. Read it aloud.

> Behold, a sower went forth to sow;
> And when he sowed, some seeds fell by the way side, and the fowls came and devoured them up:
> Some fell upon stony places, where they had not much earth: and forthwith they sprung up, because they had no deepness of earth:
> And when the sun was up, they were scorched; and because they had no root, they withered away.
> And some fell among thorns; and the thorns sprung up, and choked them:
> But other fell into good ground, and brought forth fruit, some an hundredfold, some sixtyfold, some thirtyfold.
> Who hath ears to hear, let him hear.

Preparation of Copy

Prior sections deal mainly with broad principles. This one advises on some essential details. Information required for instructing the stenographer on typing text and tables is given first. Detailed advice on preparing figures follows; this is important because figures cannot be edited, and even the miracles of modern photography cannot make good reproductions from faulty copy. Lastly, the appendix contains those rules which the *Journal* follows in dealing with minutiae of style. These are recorded so that authors (and stenographers) may read them occasionally and thus avoid correspondence with the editors on minor details.

Typing the Manuscript

Manuscripts should be typewritten, double spaced, on $8\frac{1}{2}$ by 11 in. white paper. The ribbon copy and one carbon should be submitted; the extra copy is sent out for review, and the *Journal* retains the original to ensure the author against loss. All pages, whether text, figures, or tables, should be numbered.

Titles are typed wholly in capitals. Authors' names follow, with initials preceding the surname. One Christian name is written in full for a woman author, and this is sometimes done by men with common surnames. There are no periods after the title or authors' names. A superscript number follows the title, and the footnote thus indicated starts with "Manuscript received . . ." and a blank space for the editor to fill in. This is followed by the source of the contribution and, if required, by an acknowledgment of financial aid. If the author's institution numbers its publications, the serial number of the paper may also be added. Author footnotes are not always required. They may be used to show position, and address if this differs from that given in the title footnote. They should certainly be used to show a change of position and address since the research was done, or to record that the author holds a scholarship or bursary.

To help the editor select the appropriate weight of type, the relative importance of each heading in the manuscript should be shown by its position

on the page and by proper use of capitals and lower case letters. The following sequence is suggested:

First order center heading—all capitals;
Second order center heading—capitals and lower case;
Side heading—capitals and lower case, underlined, not indented;
Run-in heading—capitals and lower case, underlined, indented.

The *Journal's* policy is to use run-in headings only for those subsections of the text that consist of one paragraph. No punctuation is used after center or side headings; run-in headings are followed by a period and a dash.

Particular pains should be taken in dealing with the following matters. Names of all simple chemical compounds rather than their formulae should be used in the text. Greek letters or unusual signs should be written plainly. When letters are written by hand in equations or elsewhere, editors often have difficulty in differentiating between upper case "K" and lower case "k", lower case kappa (κ) and "k", lower case omega (ω) and "w", lower case mu (μ) and "u", and between lower case nu (ν) and "v". Underlining all Greek letters in red helps the editorial staff and the typesetter. Superscripts and subscripts should be legible and carefully placed. Complex mathematical equations should be laid out just as carefully as graphs; and this can seldom be done adequately with a typewriter.

Before they are submitted, manuscripts should be thoroughly checked to reduce the need for changes after the type is set.

Typing Tables

Tables are best typed on separate sheets, their place in the text being indicated by a parenthetic insertion (Table I here). If the table is large, single spacing may be used in typing it.

TABLE I

THE MAIN HEADING MUST BE ADEQUATELY DESCRIPTIVE BUT SHOULD NOT REPEAT BOX AND SIDE HEADINGS

(The headnote* comments on all contents of the table)

These	Are the**	Box headings
These Are the** Side Headings		

* *Headnotes are centered and footnotes are indented.*
** *Capitalize only the first word in box and side headings.*

Table I illustrates most of the other details of style. Vertical lines should be inserted to prevent misplacement of column headings by printer or misinterpretation by readers. Horizontal lines should be used sparingly; a space is generally better than a line for horizontal separation of parts of a table.

Column heads should be brief, and textual matter in tables should be minimized. In all headings, main, box, and side, only the first word and proper names have capital initial letters. If necessary, punctuate the title and box headings, but do not use a period at the end. Unit or other abbreviations should follow the box or side headings, separated only by a comma, and should not be placed below the line at the top of vertical columns. Abbreviations are followed by a period.

Preparing Copy for Illustrations

The original drawings and one set of small photographic copies should be submitted; photographs are sent to the reviewers, and the original drawings are retained to prevent possible loss or damage that might occur if they were mailed to reviewers. Illustrations are treated separately by the printer and if they are not fully identified, loss or confusion may occur. Write author's name, figure number, and title of the paper—in that order—on the lower left-hand side of the front of the sheet, well apart from the illustration. Photographs should carry the same information written lightly on the back of the print. Editors strongly condemn lettering done on separate strips pasted onto an illustration because frequent handling may detach these patches. Even the author who avoids redrawing his graph completely by using a small strip and rubber cement to correct an error in lettering still risks the editorial ire. Captions should not be written on the illustrations but typed together on a separate page of the manuscript. All figures, including line drawings and photographs, should be numbered consecutively in order of their appearance and in Arabic numerals.

Drawings should be made with India ink on white paper or tracing linen. For graphs, use *blue-lined* co-ordinate paper only, and over-rule in black all lines that must be reproduced. Use of co-ordinate paper in any other color is unsatisfactory because the background of fine grid lines cannot be screened out in photographing. Nothing but trouble is caused by drawing charts with ordinary ink on the first piece of paper that comes to hand.

Illustrations should not be drawn more than two or three times the desired size of the reproduction, and the ratio of height to width should conform to that of the printed page, 7 by $4\frac{3}{4}$ in., when this is feasible. Modern photographic technique will usually make some kind of reproduction of a chart the size of a window blind, but such copy seldom yields a well balanced reproduction.

All lines on the drawing should be of sufficient thickness to reproduce well. Lettering and numerals should be plain and neat, preferably done with a guide and never with a typewriter, and should be of such size that they will be legible and not less than 1 mm. in height when the drawing is reduced to a width of 3 or 4 in. Guide and pen numbers for graphs of various sizes are given in Table II. All experimental points on graphs should be carefully drawn with instruments. Use large clear-cut symbols to indicate points on the graphs, i.e., open or filled circles, squares, or triangles (○ □ △ ● ■ ▲),

not half-filled circles or squares (◒ ▬), as these are likely to close up on reduction. Small points and small spaces disappear on reduction, so decimal points and spaces between letters must also be of adequate size.

TABLE II

LEROY GUIDE AND PEN NUMBERS FOR GRAPHS DRAWN 1½, 2, 3, AND 4 TIMES THE SIZE OF THE PRINTED GRAPH

(The over-all width of the printed graph is assumed to be 4 in.)

Size of drawing	Guide (and pen) for lettering			Pen for lines		
	Headings	Scale and scale captions	Labels or keys	Curves	Frame	Grid lines
1½ × printed size	140 (1)	120 (0)	120 (0)	(3)	(1)	(00)
2 × printed size	175 (2)	140 (1)	120 (0)	(4)	(2)	(0)
3 × printed size	240 (3)	200 (3)	175 (2)	(5)	(3)	(0)
4 × printed size	350 (4)	290 (4)	240 (3)	(6)	(4)	(1)

Minutiae of Style

There are many details—such as spelling, abbreviations, and layout for equations—which the *Journal* must treat uniformly in all papers; exceptions cannot be made to meet the wishes and idiosyncrasies of individual authors. A surprising amount of time is wasted by correspondence dealing with authors' objections to some of these minor points. This could be avoided if each author realized that most authors will side with the editor in these arguments. A set form for all details has been achieved by the majority opinion of many authors and editors throughout the years. The door is not closed against further improvements, and the editors welcome suggestions based on full and careful consideration of the advantages and disadvantages of existing policies. But even when a change is agreed on, it cannot be adopted at short notice for any given paper; it must await the beginning of a new volume, and will then apply to all new manuscripts. By setting policies on style, the editors hope to avoid arguments about details without hindering suggestions for improvements.

A dictionary is an indispensable book for both authors and editors, and the *Canadian Journal of Research* has adopted *Webster's Dictionary* as its standard. The *Canadian Government Editorial Style Manual*, published by the Department of Public Printing and Stationery, Ottawa, is also a useful reference. Unfortunately, it does not cover all matters that must be considered in editing scientific papers, so the *Journal* has had to develop its own practices. Some of these are illustrated in the appendix, which deals with abbreviations, hyphened modifiers, use of numbers in the text, layout for equations, names of genera and species, and reference lists. It is on these points that authors most frequently go astray, so an occasional glance through the list may be

helpful. The author who submits a paper for the first time to the *Journal* may also benefit from study of a few papers on his subject in recent volumes.

Authors can hardly familiarize themselves with all the details of editorial style in each of the periodicals for which they write. But editors can reasonably expect that the same faults will not be repeated time and again. Occasional errors in dealing with minor points of style cause little trouble, but, when an author pays no attention to the practices of the journal for which he is writing, hours of hard editorial work may be required. Thus some emphasis must be placed on details though these are of little importance in comparison with the broad principles described in prior sections on sound organization and good style.

No scientist starts an investigation without studying what is already known, nor does he expect to become proficient in new techniques without practice. Yet some laboriously grind out papers for half a century without referring to a single book on writing, and without attempting to become proficient in this technique to which they must resort so often. Is that scientific? Those who learn by study and practice to write well and easily in their youth save endless time at the height of their careers when a spate of papers must flow from their pens.

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Appendix

The following lists illustrate the editorial practices of the *Canadian Journal of Research*. They include some minor changes in policy recently approved by the Editorial Board for adoption in January, 1948.

Abbreviations

Words should be abbreviated only when the shortened forms are generally recognized, and then care should be taken to follow good usage. Abbreviations should not be used in manuscript unless it is the intention to have them appear in the printed text.

The following abbreviations and symbols are applicable to either the singular or the plural form of the word:

absolute	abs.
acre	ac.
alternating current (adj.)	a-c.
ampere	amp.
ampere-hour	amp.-hr.
angstrom unit	Å
annual (botany)	⊙
antilogarithm	antilog.
atomic weight	at. wt.
atmosphere	atm.
average	av.
avoirdupois	avdp.
aqueous	aq.
barrel	bbl.
Baumé	Bé.
biennial (botany)	⊙
board foot	bd. ft.
board measure	B.M.
boiling point	b.p.
brake horsepower	b.hp.
brake horsepower-hour	b.hp.hr.
Brinell hardness number	B.h.n.
British thermal unit	B.t.u.
bushel	bu.
calculated	calc.
calorie	cal.
candlepower	cp.
centigram	cgm.
centigrade	C.
centiliter	cl.
centimeter	cm.
centimeter-gram-second	c.g.s.
chain	ch.
chemically pure	c.p.
coefficient	coef.
compare	cf.
cubic centimeter	cc.
cubic foot	cu.ft.
cubic foot per minute	c.f.m.
cubic inch	cu. in.
cubic meter	cu.m.
cubic millimeter	cu.mm.
cubic yard	cu.yd.
cycles per second	c.p.s.
decibel	db.
degree	°
degree Centigrade	°C.
degree Fahrenheit	°F.
degree Kelvin	°K.
degree Réaumur	°R.
density	d.
diameter	diam.
diameter at breastheight	D.B.H.
or	d.b.h.
direct current (adj.)	d-c.
dozen	doz.
efficiency	eff.
electromotive force	e.m.f.
electron volt	ev.
equivalent	equiv.
et alii, -ae (and others)	*et al.*
et cetera (and the rest)	etc.
et sequentes (and the following)	*et seq.*
experiment	expt.
exempli gratia (for example)	e.g.
Fahrenheit	F.
feet per minute	f.p.m.
feet per second	f.p.s.
female (biology)	♀
figure	Fig.
following	f., ff.
foot	ft.
foot-candle	ft-c.
foot-Lambert	ft-L.
foot board measure	ft.b.m.
foot-pound	ft-lb.
foot-pound-second	fps.
free on board	f.o.b.
freezing point	f.p.
gallon	gal.
grain	(spell out)
gram	gm.
gram-calorie	gm-cal.
henry	h.
horsepower	h.p. *or* hp.
horsepower-hour	hp-hr.
hour	hr.
hundred	C
hundredweight	cwt.

hybrid..... ×

ibidem (in the same place). ibid.
id est (that is)..... i.e.
inch..... in.
inch-pound..... in-lb.
indicated horsepower..... i.hp.
inside diameter..... I.D.

joule..... j.

kilocycle..... kc.
kilogram..... kg.
kilogram-meter..... kgm.
kilograms per cubic meter. kgm./cu.m.
kiloliter..... kl.
kilometer..... km.
kilovolt..... kv.
kilovolt-ampere..... kva.
kilowatt..... kw.
kilowatt-hour..... kwh.

lambert..... L
latitude..... lat.
linear foot..... lin.ft.
liter..... (spell out)
loco citato (in the place cited)..... loc. cit.
longitude..... long.
lumen..... l.
lumen-hour..... l-hr.
lumens per watt..... l.p.w.

magnetomotive force..... m.m.f.
male (biology)..... ♂
manuscript, manuscripts.. MS., MSS.
maximum..... max.
mean horizontal candle-power..... m.h.cp.
melting point..... m.p.
meter..... m.
microfarad..... μf.
microgram..... μgm.
micromicron..... $\mu\mu$
micron..... μ
microvolt..... μv.
microwatt..... μw.
miles per hour..... m.p.h.
milliampere..... ma.
milliequivalent..... m.e.
millifarad..... mf.
milligram..... mgm.
millihenry..... mh.
millilambert..... mL
milliliter..... ml.
millimeter..... mm.
millimicron..... mμ
millivolt..... mv.
minimum..... min.
minute..... min.
minute (angular measure). ′ (symbol)
molecular weight..... mol.wt.

name unknown..... n.u.
name changed..... n.m.
new..... n.
new genus..... n.g.
new name..... n.n.
new series..... n.s.
new species..... n.sp.
or..... sp.nov.
normal (as applied to concn.)..... *N*
nota bene (note well)..... N.B.
numero (number)..... No.

ohm..... (spell out)
ounce..... oz.
outside diameter..... O.D.

page, pages..... p., pp.
parts per million..... p.p.m.
peck..... pk.
penny (pence)..... d.
pennyweight..... dwt.
pint..... pt.
pound..... lb.
pound-foot..... lb-ft.
pound-inch..... lb-in.
pounds per square foot.... lb. per sq. ft.
or..... p.s.f.
pounds per square in..... lb. per sq. in.
or..... p.s.i.

quart..... qt.

revolutions per minute.... r.p.m.
revolutions per second.... r.p.s.
root mean square..... r.m.s.

second (angular measure). ″ (symbol)
second..... sec.
specific gravity..... sp.gr.
specific heat..... sp. ht.
species..... sp., spp.
spherical candlepower..... s. cp.
square..... sq.
square centimeter..... sq. cm.
square foot..... sq. ft.
square inch..... sq. in.
square kilometer..... sq. km.
square meter..... sq. m.
square millimeter..... sq. mm.
square root of mean square..... r.m.s.
subgenus..... s.g.

temperature..... temp.
thousand..... M
thousand feet board measure..... M ft.b.m.

versus (against)..... vs.
videlicet (namely)..... viz.
volt..... v.
volt-ampere..... va.
volume..... vol.

watt..... w.
watt-hour..... w-hr.
watts per candle..... w.p.c.
weight..... wt.

yard..... yd.
year..... yr.

Hyphened Modifiers

When an adjective and a noun are used together to qualify another noun, hyphen the adjective and qualifying noun whenever there is any danger of ambiguity. Adverbs with adjectives need never be hyphened. Long and awkward adjectival phrases may often be avoided by rearranging the sentence. Examples follow:

Write	*Instead of*
Hydrogen ion concentration	Hydrogen-ion concentration
25-gm. samples	25 gm. samples
Small-scale drawing	Small scale drawing
The first determination of water soluble sulphates.	The first water-soluble sulphate determination.

Numbers in Text

Numbers used at the beginning of sentences should be written out in full (exception: names of chemical compounds, for example, 2-Bromobutane), and if followed by units, the units should also be written out in full. Numbers of one digit should also be written out, even when used in the body of a sentence, except before abbreviations of units. Abbreviations are not pluralized except when they precede more than one numeral (e.g. Figs. 1 and 2). Numbers of two to six digits should ordinarily be given in figures. Examples follow:

Write	*Instead of*
A few seconds	A few sec.
100° C. (*or* F. *or* K.)	100° *or* 100 deg.
Fig. 4	Figure 4 *or* Figure IV.
10 gm.	10 grams *or* 10 g. *or* 10 gr.
10 in.	10″
90%	90 per cent
Several hours	Several hr.
Six seconds	Six sec. *or* 6 secs. *or* 6 seconds *or* 6 sec.
Six tests were made	6 tests were made
Table IV	Table 4 *or* The following *or* The above table
This required six tests	This required 6 tests
This required 100 tests	This required one hundred tests
This would require one hundred million volts *or* 10^8 v.	This would require 100,000,000 v.

Equations

Check these carefully in the manuscript and galley. Complex mathematical formulae should be prepared with just as much care as a graph.

This can seldom be done adequately with a typewriter. Distinguish between the following: capital and lower case letters, the lower case letter "l" and the figure "one", "zero" and the letter "O", "X" and "χ" (Chi).

Names of Genera and Species

When first mentioned in the body of the paper, scientific names are given in full and are followed by the authority. Examples: *Agropyron Smithii* Rydb.; *Calamagrostis canadensis* (Michx.) Beauv.; *Lepidium draba* L. Thereafter the genus is to be designated by the first letter only: *A. Smithii*, *C. canadensis*, *L. draba*. However, should ambiguity arise, the name should again be written out in full. Scientific names should be underlined to indicate italics.

References and Reference Lists

For the abbreviated names of periodicals, the *Canadian Journal of Research* uses the abbreviations in the "List of Periodicals Abstracted by *Chemical Abstracts*". All references must be listed alphabetically according to the authors' names, then numbered consecutively, and placed at the end of the article.

Papers intended for publication in the *Technology Section* of the *Canadian Journal of Research* should give references in the following form:

References

1. Anonymous. Ann. Applied Biol. 18 : 313-333. 1931.
2. Blakeslee, A. F. Proc. Natl. Acad. Sci. U.S. 18 : 120-130. 1932.
3. Bliss, C. I. Ann. Applied Biol. 24 : 815-852. 1937.
4. Crist, J. W. and Seaton, H. L. Food Research, 6 : 529-536. 1941.
5. Crocker, E. G. Flavor. McGraw-Hill Book Co., Inc., New York. 1945.
6. Fisher, R. A. Statistical methods for research workers. 8th ed. Oliver & Boyd, Ltd., London. 1941.
7. Fisher, R. A. and Yates, F. Statistical tables for biological, agricultural and medical research. Oliver & Boyd, Ltd., London. 1938.
8. Knowles, D. and Johnson, P. E. Food Research, 6 : 207-216. 1941.
9. Platt, W. Food Research, 2 : 237-249. 1937.
10. Smith, W. H. M.A. Thesis. University of Toronto. 1938.
11. Werkman, C. H. *In* Enzymes and their role in wheat technology, ed. by J. A. Anderson. Interscience Publishers, Inc., New York. 1946.

Papers intended for publication in the *Medical*, *Physical*, and *Chemical Sections* follow the above form except that the number for the last page is omitted.

Papers intended for publication in the *Botanical* and *Zoological Sections* should give references in the following form:

References

1. AVERY, G. S., JR. and POTTORF, L. Polyploidy, auxin and nitrogen in green plant tissue. Am. J. Botany, 32 : 669-671. 1945.
2. BANNAN, M. W. Tetraploid *Taraxacum kok-saghyz*. I. Characters of the leaves and inflorescences in the parental colchicine-induced generation. Can. J. Research, C, 23 : 131-143. 1945.
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4. GUSTAFSON, F. G. Growth hormone studies of some diploid and autotetraploid plants. J. Heredity, 35 : 269-272. 1944.
5. HECHT, A. Induced tetraploids of a self sterile *Oenothera*. Genetics, 29 : 69-74. 1944.
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7. KROTKOV, G. A review of literature on *Taraxacum kok-saghyz* Rod. Botan. Rev. 11 : 417-461. 1945.
8. LEWIS, D. and MODLIBOWSKA, I. Genetical studies in pears. IV. Pollen-tube growth and incompatibility. J. Genetics, 43 : 211-222. 1942.
9. NICHIPOROVICH, A. A. and IVANITZKAJA, E. F. On the relation between leaf development and formation of laticiferous vessels in roots of kok-saghyz and krym-saghyz. Compt. rend. acad. sci. U.S.S.R. 44 : 33-36. 1944.
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12. STOUT, A. B. Inactivation of incompatibilities in tetraploid progenies of *Petunia axillaris*. Torreya, 44 : 45-51. 1944.
13. WARMKE, H. E. Experimental polyploidy and rubber content in *Taraxacum kok-saghyz*. Botan. Gaz. 105 : 315-324. 1945.

The punctuation and capitalization used in the *Canadian Journal of Research* references are illustrated in the foregoing lists.

The majority of references deal with articles published in periodicals but there are several other types of references. Note that even in reference lists in which the titles of journal articles are omitted, the titles of books must be given. When it is desirable to cite a portion of a book consisting of papers by several authors, the author's name is given first, then the word *In* (in italics), the title of the book, the name of the editor, the name and address of the publisher, and the year of publication. If it is desirable to refer to specific pages, tables, or figures in any reference, the citation in the text should include the numbers of these after the reference number, as follows: (6, p. 345), (6, Table VII), (6, Fig. 4). If reference is made to a patent, state: name of patentee, country in which patented, number of patent, and year granted, as follows:

I.G. Farbenindustrie, A.-G. Fr. Pat., No. 631,995. July 18, 1929.

Confidential reports must not be cited in the references: the author must obtain permission to use a statement and insert it as a personal communication to be indicated in a footnote.

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Turn letter
Delete
Delete letter and close up
Left out; insert
Insert space
Equal space between words
Less space
Close up entirely
Period
Comma
Apostrophe
Quotation
Colon
Semicolon
Hyphen

Move over to right
Move over to left
One-em dash
Paragraph
No paragraph
Wrong font
Let it stand
Transpose
Capital letter
Lower case (small) letter
Italics
Roman
Superscript, i.e., A^2
Subscript, i.e., A_2.
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