# How to Write and Publish a Scientific Paper

Eighth Edition

Barbara Gastel
and Robert A. Day

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# Contents

## PART V: DOING OTHER WRITING FOR PUBLICATION

## PART VI: CONFERENCE COMMUNICATIONS



## PART VII: SCIENTIFIC STYLE

# PART II

## Preparing the Text

# CHAPTER 7

# How to Prepare the Title

*First impressions are strong impressions; a title ought therefore to be well studied, and to give, so far as its limits permit, a definite and concise indication of what is to come.*

—T. Clifford Allbutt

## IMPORTANCE OF THE TITLE

In preparing a title for a paper, you would do well to remember one salient fact: This title will be read by thousands of people. Perhaps few people, if any, will read the entire paper, but many people will read the title, either in the original journal, in one of the secondary (abstracting and indexing) databases, in a search engine's output, or otherwise. Therefore, all words in the title should be chosen with great care, and their association with one another must be carefully managed. Perhaps the most common error in defective titles, and certainly the most damaging one in terms of comprehension, is faulty syntax (word order).

What is a good title? We define it as the fewest possible words that adequately describe the contents of the paper.

Remember that the indexing and abstracting services depend heavily on the accuracy of the title, as do individual computerized literature-retrieval systems. An improperly titled paper may be virtually lost and never reach its intended audience.

Some authors mistakenly sacrifice clarity in an attempt to be witty. The title of a paper need not, and generally should not, be clever. It must, however, be clear. An example (adapted from Halm and Landon 2007): "Association between

Diuretic Use and Cardiovascular Mortality" could be an adequate title. The authors should resist the temptation to use instead "Dying to Pee."

## LENGTH OF THE TITLE

Occasionally, titles are too short. A paper was submitted to the *Journal of Bacteriology* with the title "Studies on *Brucella*." Obviously, such a title was not very helpful to the potential reader. Was the study taxonomic, genetic, biochemical, or medical? We would certainly want to know at least that much.

Much more often, titles are too long. Ironically, long titles are often less meaningful than short ones. A century or so ago, when science was less specialized, titles tended to be long and nonspecific, such as "On the addition to the method of microscopic research by a new way of producing colour-contrast between an object and its background or between definite parts of the object itself" (Rheinberg J. 1896. *J. R. Microsc. Soc.* 373). That certainly sounds like a poor title; perhaps it would make a good abstract.

Not only scientists have written rambling titles. Consider this one from the year 1705: *A Wedding Ring Fit for the Finger, or the Salve of Divinity on the Sore of Humanity with directions to those men that want wives, how to choose them, and to those women that have husbands, how to use them*. Ironically, this title appeared on a miniature book (Bernard A. 1995. Now all we need is a title: famous book titles and how they got that way. New York: Norton, p. 58).

Without question, most excessively long titles contain "waste" words. Often, these waste words appear right at the start of the title, words such as "Studies on," "Investigations on," and "Observations on." An opening *A, An,* or *The* is also a waste word. Certainly, such words are useless for indexing purposes.

## NEED FOR SPECIFIC TITLES

Let us analyze a sample title: "Action of Antibiotics on Bacteria." Is it a good title? In *form* it is; it is short and carries no excess baggage (waste words). Certainly, it would not be improved by changing it to "Preliminary Observations on the Effect of Certain Antibiotics on Various Species of Bacteria." However (and this brings us to the next point), most titles that are too short are too short because they include general rather than specific terms.

We can safely assume that the study introduced by the above title did *not* test the effect of *all* antibiotics on *all* kinds of bacteria. Therefore, the title is essentially meaningless. If only one or a few antibiotics were studied, they should be individually listed in the title. If only one or a few organisms were tested, they should be individually listed in the title. If the number of antibiotics or organisms

was awkwardly large for listing in the title, perhaps a group name could have been substituted. Examples of more acceptable titles are the following:

"Action of Streptomycin on *Mycobacterium tuberculosis*."
"Action of Streptomycin, Neomycin, and Tetracycline on Gram-Positive Bacteria."
"Action of Polyene Antibiotics on Plant-Pathogenic Bacteria."
"Action of Various Antifungal Antibiotics on *Candida albicans* and *Aspergillus fumigatus*."

Although these titles are more acceptable than the sample, they are not especially good because they are still too general. If the "Action of" can be defined easily, the meaning might be clearer. For example, the first title might have been phrased "Inhibition of Growth of *Mycobacterium tuberculosis* by Streptomycin."

Long ago, Leeuwenhoek used the word "animalcules," a descriptive but not very specific word. In the 1930s, Howard Raistrick published an important series of papers under the title "Studies on Bacteria." A similar paper today would have a much more specific title. If the study featured an organism, the title would give the genus and species and possibly even the strain. If the study featured an enzyme in an organism, the title would not be anything like "Enzymes in Bacteria." It would be something like "Dihydrofolate Reductase Produced by *Bacillus subtilis*."

## IMPORTANCE OF SYNTAX

In titles, be especially careful of syntax. Most of the grammatical errors in titles are due to faulty word order.

A paper was submitted to the *Journal of Bacteriology* with the title "Mechanism of Suppression of Nontransmissible Pneumonia in Mice Induced by Newcastle Disease Virus." Unless this author had somehow managed to demonstrate spontaneous generation, it must have been the pneumonia that was induced and not the mice. (The title should have read: "Mechanism of Suppression of Nontransmissible Pneumonia Induced in Mice by Newcastle Disease Virus.")

If you no longer believe that babies result from a visit by the stork, we offer this title (*Am. J. Clin. Pathol.* 52:42, 1969): "Multiple Infections among Newborns Resulting from Implantation with *Staphylococcus aureus* 502A." (Is this the "Staph of Life"?)

Another example (*Clin. Res.* 8:134, 1960): "Preliminary Canine and Clinical Evaluation of a New Antitumor Agent, Streptovitacin." When that dog gets

through evaluating streptovitacin, we've got some work we'd like that dog to look over. A grammatical aside: Please be careful when you use "using." The word "using" might well be the most common dangling participle in scientific writing. Either there are some more smart dogs, or "using" is misused in this sentence from a manuscript: "Using a fiberoptic bronchoscope, dogs were immunized with sheep red blood cells."

Dogs aren't the only smart animals. A manuscript was submitted to the *Journal of Bacteriology* under the title "Isolation of Antigens from Monkeys Using Complement-Fixation Techniques."

Even bacteria are smart. A manuscript was submitted to the *Journal of Clinical Microbiology* under the title "Characterization of Bacteria Causing Mastitis by Gas-Liquid Chromatography." Isn't it wonderful that bacteria can use GLC?

## THE TITLE AS A LABEL

The title of a paper is a label. It normally is not a sentence. Because it is not a sentence, with the usual subject-verb-object arrangement, it is simpler than a sentence (or, at least, shorter), but the order of the words becomes even more important.

Actually, a few journals do permit a title to be a sentence. An example of such a title: "Fruit Flies Diversify Their Offspring in Response to Parasite Infection" (*Science* 349:747, 2015). One might object to such a title because presence of a verb (in this case, *diversify*) makes the title seem like a loud assertion. Such a title may sound dogmatic because we are not accustomed to seeing authors present their results in the present tense, for reasons that are discussed in Chapter 30. Rosner (1990, p. 108) gave the name "assertive sentence title" (AST) to this kind of title and presented a number of reasons why such titles should not be used. In particular, ASTs are "improper and imprudent" because "in some cases the AST boldly states a conclusion that is then stated more tentatively in the summary or elsewhere" and "ASTs trivialize a scientific report by reducing it to a one-liner."

The meaning and order of the words in the title are important to the potential reader who sees the title in the journal table of contents. But these considerations are equally important to *all* potential users of the literature, including those (probably a majority) who become aware of the paper via secondary sources. Thus, the title should be useful as a label accompanying the paper itself, and it also should be in a form suitable for the machine-indexing systems used by *Chemical Abstracts,* MEDLINE, and others. In short, the terms in the title should be those that highlight the significant content of the paper.

As an aid to readers, journals commonly print *running titles* or *running heads* at the top of each page. Often the title of the journal or book is given at the top

of left-facing pages and the article or chapter title is given at the top of right-facing ages (as in this book). Usually, a short version of the title is needed because of space limitations. (The maximum character count is likely to be stated in the journal's instructions to authors.) It can be wise to suggest an appropriate running title on the title page of the manuscript.

## ABBREVIATIONS AND JARGON

Titles should almost never contain abbreviations, chemical formulas, proprietary (rather than generic) names, jargon, and the like. In designing the title, the author should ask: "How would I look for this kind of information in an index?" If the paper concerns an effect of hydrochloric acid, should the title include the words "hydrochloric acid," or should it contain the much shorter and readily recognizable "HCl"? The answer seems obvious. Most of us would look under "hy" in an index, not under "hc." Furthermore, if some authors used (and journal editors permitted) HCl and others used hydrochloric acid, the user of the bibliographic services might locate only part of the published literature, not noting that additional references are listed under another, abbreviated entry. Actually, the larger secondary services have computer programs that can bring together entries such as deoxyribonucleic acid, DNA, and even ADN (*acide deoxyribonucleique*). However, by far the best rule for authors (and editors) is to avoid abbreviations in titles. And the same rule should apply to proprietary names, jargon, and unusual or outdated terminology.

## MORE ABOUT TITLE FORMAT

Many editors are opposed to main title-subtitle arrangements and to hanging titles. The main title-subtitle (series) arrangement was quite common some years ago. (Example: "Studies on Bacteria. IV. Cell Wall of *Staphylococcus aureus*.") Today, many editors believe that it is important, especially for the reader, that each published paper "present the results of an independent, cohesive study; thus, numbered series titles are not allowed" (instructions to authors, *Journal of Bacteriology*). Series papers, in the past, have tended to relate to each other too closely, giving only bits and pieces with each contribution; thus, the reader was severely handicapped unless the whole series could be read consecutively. Furthermore, the series system is annoying to editors because of scheduling problems and delays. (What happens when IV is accepted but III is rejected or delayed in review?) Additional objections are that a series title almost always provides considerable redundancy; the first part (before the roman numeral) is usually so general as to be useless, and the results when the secondary services

spin out an index are often unintelligible. (Article titles phrased as questions also can become unintelligible, and so they probably should not be used.)

The hanging title (similar to a series title but with a colon instead of a roman numeral) is considerably better, avoiding some of the problems mentioned. Some journals, especially in the social sciences (Hartley 2007), seem to favor hanging titles, presumably on the grounds that it is helpful to get the most important words of the title up to the front. (Example: "Environmental Science in the Media: Effects of Opposing Viewpoints on Risk and Uncertainty Perceptions" *Science Communication* 37:287, 2015). Occasionally, hanging titles may aid the reader, but they may appear pedantic, emphasize the general term rather than a more significant term, necessitate punctuation, and scramble indexes.

Use of a straightforward title does not lessen the need for proper syntax, however, or for the proper form of each word in the title. For example, a title reading "New Color Standard for Biology" would seem to indicate the development of color specifications for use in describing plant and animal specimens. However, in the title "New Color Standard for Biologists" (*Bioscience* 27:762, 1977), the new standard might be useful for study of the taxonomy of biologists, permitting us to separate the green biologists from the blue ones.

# CHAPTER 9

# How to Prepare the Abstract

*I have the strong impression that scientific communication is being seriously hindered by poor quality abstracts written in jargon-ridden mumbo-jumbo.*
—Sheila M. McNab

## DEFINITION

An abstract should be viewed as a miniature version of the paper. The abstract should provide a *brief* summary of each of the main sections of the paper: introduction, materials and methods, results, and discussion. As Houghton (1975) put it, "An abstract can be defined as a summary of the information in a document."

"A well-prepared abstract enables readers to identify the basic content of a document quickly and accurately, to determine its relevance to their interests, and thus to decide whether they need to read the document in its entirety" (American National Standards Institute 1979b). The abstract should not exceed the length specified by the journal (commonly, 250 words), and it should be designed to define clearly what is dealt with in the paper. Typically, the abstract should be typed as a single paragraph, as in Figure 9.1. Some journals, however, run "structured" abstracts consisting of a few brief paragraphs, each preceded by a standardized subheading, as in Figure 9.2. Many people will read the abstract, either in the original journal or as retrieved by computer search.

The abstract should (1) state the principal objectives and scope of the investigation, (2) describe the methods employed, (3) summarize the results, and (4) state the principal conclusions. The importance of the conclusions is indicated by the fact that they are often given three times: once in the abstract, again in the introduction, and again (in more detail, probably) in the discussion.

## Effects of Scientific-Writing Training on Knowledge and Publication Output

*(An Imaginary Study)*

Scientists must write to succeed, but few receive training in scientific writing. We studied the effects of a scientific-communication lecture series, alone and combined with feedback on writing, on scientific-communication knowledge and publication performance. During the spring 2010 semester, 50 science PhD students in their last year at Northeast Southwest University were randomly assigned to receive no instruction in scientific writing, attend eight 1-hour lectures on the topic, or attend these lectures and receive feedback from classmates and an instructor on successive parts of a scientific paper they drafted. Members of each group then took a test of scientific-communication knowledge, and the publication output of each group was monitored for 5 years. Members of the groups receiving instruction scored between 80 and 98 percent on the test of scientific-communication knowledge, whereas all but two members of the control group scored below 65 percent. Although on average the group receiving lectures and feedback scored higher than the lecture-only group, the difference was not significant. During the 5-year follow-up, on average the control-group members submitted 6.1 papers to journals and had 4.1 accepted. The corresponding figures for the lecture group were 6.5 and 4.8, and those for the lecture-plus-feedback group were 8.3 and 6.7. Higher proportions of the latter two groups had papers accepted by the first journal to which they were submitted. These findings suggest that instruction in scientific writing, especially if it includes practice and feedback, can increase knowledge of scientific communication and promote publication success.


**Figure 9.1.** Abstract (in conventional format) of a fictional scientific paper. This abstract runs slightly less than 250 words and so would comply with typical word limits. Were a real study being reported, the statistical information probably would be more sophisticated. Note that the order of information parallels that in a typical scientific paper.

Most or all of the abstract should be written in the past tense because it refers to work done.

The abstract should never give any information or conclusion that is not stated in the paper. Literature must not be cited in the abstract (except in rare instances, such as modification of a previously published method). Likewise, normally the abstract should not include or refer to tables and figures. (Some journals, however, allow or even require the abstract to include a graphic.)

EFFECTS OF SCIENTIFIC-WRITING TRAINING ON KNOWLEDGE AND PUBLICATION OUTPUT

*(An Imaginary Study)*

**Background.** Scientists must write to succeed, but few receive training in scientific writing. We studied the effects of a scientific-communication lecture series, alone and combined with feedback on writing, on scientific-communication knowledge and publication performance.

**Method.** During the spring 2010 semester, 50 science PhD students in their last year at Northeast Southwest University were randomly assigned to receive no instruction in scientific writing, attend eight 1-hour lectures on the topic, or attend these lectures and receive feedback from classmates and an instructor on successive parts of a scientific paper they drafted. Members of each group then took a test of scientific-communication knowledge, and the publication output of each group was monitored for 5 years.

**Results.** Members of the groups receiving instruction scored between 80 and 98 percent on the test of scientific-communication knowledge, whereas all but two members of the control group scored below 65 percent. Although on average the group receiving lectures and feedback scored higher than the lecture-only group, the difference was not significant. During the 5-year follow-up, on average the control-group members submitted 6.1 papers to journals and had 4.1 accepted. The corresponding figures for the lecture group were 6.5 and 4.8, and those for the lecture-plus-feedback group were 8.3 and 6.7. Higher proportions of the latter two groups had papers accepted by the first journal to which they were submitted.

**Conclusion.** These findings suggest that instruction in scientific writing, especially if it includes practice and feedback, can increase knowledge of scientific communication and promote publication success.

**Figure 9.2.** Structured version of the abstract shown in Figure 9.1. The two abstracts are the same except for division into paragraphs and inclusion of headings. As noted, the content is fictional.

## TYPES OF ABSTRACTS

The preceding rules apply to the abstracts that are used in primary journals and often without change in the secondary services (*Chemical Abstracts,* etc.). This type of abstract is often called an *informative* abstract, and it is designed to condense the paper. It can and should briefly state the problem, the method used to study the problem, and the principal data and conclusions. Often, the

abstract supplants the need for reading the full paper; without such abstracts, scientists would not be able to keep up in active areas of research. (However, before citing a paper, you should read it in its entirety because some abstracts—surely not yours, though!—do not convey an entirely accurate picture of the research.) This is the type of abstract that precedes the body of the paper (thus serving as a "heading") in most journals.

Another type of abstract is the *indicative* abstract (sometimes called a descriptive abstract). This type of abstract (see Figure 9.3) is designed to indicate the subjects dealt with in a paper, much like a table of contents, making it easy for potential readers to decide whether to read the paper. However, because of the descriptive rather than substantive nature, it can seldom serve as a substitute for the full paper. Thus, indicative abstracts should not be used as "heading" abstracts in research papers, but they may be used in other types of publications, such as review papers, conference reports, and government reports. Such indicative abstracts are often of great value to reference librarians.

An effective discussion of the various uses and types of abstracts was provided by McGirr (1973, p. 4), whose conclusions are well worth repeating: "When writing the abstract, remember that it will be published by itself, and should be self-contained. That is, it should contain no bibliographic, figure, or

TEACHING OF SCIENTIFIC WRITING

*(An Imaginary Review Article)*

In this article we summarize and discuss the literature on teaching scientific writing. Although we focus mainly on articles in peer-reviewed journals, we also draw on material in professionally oriented magazines and newsletters and in books. First we describe methods used for the literature review, including databases searched, keywords used, and languages and dates included. Then we present information on the history of teaching scientific writing and on instructional designs reported, including single sessions, intensive short courses, and semester-long courses; examples of instruction at specific institutions and under other auspices are noted. Also addressed are the teaching of English-language scientific writing to non-native users of English, the use of distance instruction in teaching scientific writing, issues in scientific-writing instruction, and current trends in the field. Finally, we identify topics on which further research appears advisable. Supplementary materials include annotated lists of textbooks and websites useful in teaching scientific writing.

**Figure 9.3.** Indicative (descriptive) abstract of a fictional review article. This abstract runs about 150 words. Like a table of contents, it lists topics but does not state what is said about them.

table references. . . . The language should be familiar to the potential reader. Omit obscure abbreviations and acronyms. Write the paper before you write the abstract, if at all possible."

Unless a long term is used several times within an abstract, do not abbreviate the term. Wait and introduce the appropriate abbreviation at first use in the text (probably in the introduction).

## ECONOMY OF WORDS

Occasionally, a scientist omits something important from the abstract. By far the most common fault, however, is the inclusion of extraneous detail.

A scientist once had some terribly involved theory about the relation of matter to energy. He then wrote a terribly involved paper. However, the scientist, knowing the limitations of editors, realized that the abstract of his paper would have to be short and simple if the paper was to be judged acceptable. So, he spent hours and hours honing his abstract. He eliminated word after word until, finally, all of the verbiage had been removed. What he was left with was the shortest abstract ever written: "$E = mc^2$."

Today, most scientific journals print an abstract before the main text of each paper. Because the abstract precedes the paper itself, and because the editors and reviewers like a bit of orientation, the abstract is almost always the first part of the manuscript read during the review process. Therefore, it is of fundamental importance that the abstract be written clearly and simply. If you cannot make a good impression in your abstract, your cause may be lost. Very often, the reviewer may be perilously close to a final judgment of your manuscript after reading the abstract alone. This could be because the reviewer has a short attention span (often the case). However, if by definition the abstract is simply a very short version of the whole paper, it is only logical that the reviewer will often reach a preliminary conclusion, and that conclusion is likely to be the correct one. Usually, a good abstract is followed by a good paper; a poor abstract is a harbinger of woes to come.

Because an abstract is required by most journals and because a meeting abstract is a requirement for participation in a great many national and international meetings (participation sometimes being determined on the basis of submitted abstracts), scientists should master the fundamentals of abstract preparation.

When writing the abstract, examine every word carefully. If you can tell your story in 100 words, do not use 200. Economically and scientifically, it doesn't make sense to waste words. The total communication system can afford only so much verbal abuse. Of more importance to you, the use of clear, significant words will impress the editors and reviewers (not to mention readers), whereas

the use of abstruse, verbose constructions might well contribute to a check in the "reject" box on the review form.

Here's an example of an especially brief abstract, which accompanied a paper by M. V. Berry and colleagues (*J. Phys. A: Math. Theor.* 44:492001, 2011). The title of the paper: "Can apparent superluminal neutrino speeds be explained as a quantum weak measurement?" The abstract: "Probably not." Should you write abstracts this short? Well, probably not. Normally an abstract should be more informative than this one. But at least, unlike some meandering abstracts, this one answers the question that the research addressed.

## AKIN TO ABSTRACTS

Some journals include, in addition to abstracts, other components briefly conveying key points to readers, skimmers, or browsers. For example, some journals ask authors to provide a bulleted list of key messages of their articles, either for posting only online or for publication as part of the article as well. Others, for instance, request a nontechnical summary or a brief statement of implications. Some journals require such items to accompany all papers submitted; others request them only for some or all of the papers accepted for publication. Be aware that you may be asked to provide, in essence, an abstract of your abstract.

# CHAPTER 10

# How to Write the Introduction

*A bad beginning makes a bad ending.*

—Euripides

## GUIDELINES

Now that we have the preliminaries out of the way, we come to the paper itself. Some experienced writers prepare their title and abstract after the paper is written, even though by placement these elements come first. You should, however, have in mind (if not on paper or in the computer) a provisional title and an outline of the paper you propose to write. You should also consider the background of the audience you are writing for so that you will have a basis for determining which terms and procedures need definition or description and which do not. If you do not have a clear purpose in mind, you might go writing off in six directions at once.

It is wise to begin writing the paper while the work is still in progress. This makes the writing easier because everything is fresh in your mind. Furthermore, the writing process itself is likely to point to inconsistencies in the results or perhaps to suggest interesting sidelines that might be followed. Thus, start the writing while the experimental apparatus and materials are still available. If you have coauthors, it is wise to write up the work while they are still available to consult.

The first section of the text proper should, of course, be the introduction. The purpose of the introduction is to supply sufficient background information to allow the reader to understand and evaluate the results of the present study without needing to refer to previous publications on the topic. The introduction

should also provide the rationale for the present study. Above all, you should state briefly and clearly your purpose in writing the paper. Choose references carefully to provide the most important background information. Much of the introduction should be written in present tense because you are referring primarily to your problem and the established knowledge relating to it at the start of your work.

Guidelines for a good introduction are as follows: (1) The introduction should present first, with all possible clarity, the nature and scope of the problem investigated. For example, it should indicate why the overall subject area of the research is important. (2) It should briefly review the pertinent literature to orient the reader. It also should identify the gap in the literature that the current research was intended to address. (3) It should then make clear the objective of the research. In some disciplines or journals, it is customary to state here the hypotheses or research questions that the study addressed. In others, the objective may be signaled by wording such as "in order to determine." (4) It should state the method of the investigation. If deemed necessary, the reasons for the choice of a particular method should be briefly stated. (5) Finally, in some disciplines and journals, the standard practice is to end the introduction by stating the principal results of the investigation and the principal conclusions suggested by the results.

An introduction that is structured in this way (see, for example, Figure 10.1) has a "funnel" shape, moving from broad and general to narrow and specific. Such an introduction can comfortably funnel readers into reading about the details of your research.

## REASONS FOR THE GUIDELINES

The first four guidelines for a good introduction need little discussion, being reasonably well accepted by most scientist-writers, even beginning ones. It is important to keep in mind, however, that the purpose of the introduction is to introduce the paper. Thus, the first rule (definition of the problem) is the cardinal one. If the problem is not stated in a reasonable, understandable way, readers will have no interest in your solution. Even if the reader labors through your paper, which is unlikely if you haven't presented the problem in a meaningful way, he or she will be unimpressed with the brilliance of your solution. In a sense, a scientific paper is like other types of journalism. In the introduction, you should have a "hook" to gain the reader's attention. Why did you choose *that* subject, and why is it *important?*

The second, third, and fourth guidelines relate to the first. The literature review, specification of objective(s), and identification of method should be

presented in such a way that the reader will understand what the problem was and how you tried to resolve it.

Although the conventions of the discipline and the journal should be followed, persuasive arguments can be made for following the fifth guideline and thus ending the abstract by stating the main results and conclusions. Do not keep the reader in suspense; let the reader follow the development of the evidence. An O. Henry surprise ending might make good literature, but it hardly fits the mold of the scientific method.

To expand on that last point: Many authors, especially beginning authors, make the mistake of holding back their more important findings until late in the paper. In extreme cases, authors have sometimes omitted important findings from the abstract, presumably in the hope of building suspense while proceeding to a well-concealed, dramatic climax. However, this is a silly gambit that, among knowledgeable scientists, goes over like a double negative at a grammarians' picnic. Basically, the problem with the surprise ending is that the readers become bored and stop reading long before they get to the punch line. "Reading a scientific article isn't the same as reading a detective story. We want to know from the start that the butler did it." (Ratnoff 1981, p. 96).

In short, the introduction provides a road map from problem to solution. This map is so important that a bit of redundancy with the abstract is often desirable.

## EXCEPTIONS

Introductions to scientific papers generally should follow the guidelines that we have noted. However, exceptions exist. For example, whereas the literature review in the introduction typically should be brief and selective, journals in some disciplines favor an extensive literature review, almost resembling a review article within the paper. Some journals even make this literature review a separate section after the introduction—yielding what might be considered an ILMRAD structure.

A colleague of ours tells of reviewing an introduction drafted by a friend in another field. The introduction contained a lengthy literature review, and our colleague advised the friend to condense it. The friend followed the advice—but after she submitted the paper to a journal, the peer reviewers and editor asked her to expand the literature review. It turned out that, unknown to our colleague, her field and her friend's had different conventions in this regard. I hope that the friend kept earlier drafts (as is a good habit to follow), so she could easily restore some of what had been deleted.

In short, the conventions in your field and the requirements of your target journal take precedence. See what, if anything, the journal's instructions to

authors say about the content and structure of the introduction. Also look at some papers in the journal that report research analogous to yours, and see what the introductions are like.

### Introduction to an Imaginary Paper

Scientists must write to succeed, but few receive training in scientific writing. According to recent surveys, only 9 percent of scientists in the United States,[1] 5 percent of scientists in China,[2] and 3 to 12 percent of scientists attending recent international conferences[3–5] have taken a course in scientific writing. Even when briefer forms of instruction, such as workshops, are included, only about 25 percent of U.S. scientists have received formal instruction in scientific writing.[1] Discussions at a recent roundtable[6] suggest that the figure tends to be lower in other countries.

Further, relatively little information exists regarding the effectiveness of such instruction. One study[7] indicated that compared with peers without such instruction, postdoctoral fellows who had taken a scientific-writing course as graduate students felt more confident of their scientific-writing abilities and received more comments of "well written" from peer reviewers. Another study[8] suggested that the time from submission to final acceptance tended to be shorter for papers by authors who had taken a course in scientific writing. However, a third study[9] found no difference in quality of scientific papers written by early-career scientists who had completed a week-long workshop on scientific writing and those who had spent the time vacationing at a national park. The literature appears to contain little, if anything, on effects of scientific-writing instruction on knowledge or on number of publications. Likewise, it contains little or nothing on the relative effects of different forms of scientific-writing instruction.

To help address these gaps, we compared outcomes in advanced graduate students randomly assigned to receive no instruction in scientific writing, to attend a lecture series on the topic, and to attend the lecture series and receive feedback on a draft of a scientific paper. We then tested scientific-communication knowledge and monitored publication output for 5 years. Outcome measures included number of papers submitted, number of papers accepted for publication, and time from initial acceptance to publication.

**Figure 10.1.** Introduction to an imaginary paper on effects of scientific-writing training. This introduction, which runs about 300 words, follows the "funnel format," moving from general to specific. All content in this introduction is fictional.

## CITATIONS AND ABBREVIATIONS

If you have previously published a preliminary note or abstract of the work, you should mention this (with the citation) in the introduction. If closely related papers have been or are about to be published elsewhere, you should say so in the introduction, customarily at or near the end. Such references help to keep the literature neat and tidy for those who must search it.

In addition to the preceding rules, keep in mind that your paper may well be read by people outside your narrow specialty. Therefore, in general you should define in the introduction any specialized terms or abbreviations that you will use. By doing so, you can prevent confusion such as one of us experienced in the following situation: An acquaintance who was a law judge kept referring to someone as a GC. Calling a lawyer a gonococcus (gonorrhea-causing bacterium) seemed highly unprofessional. It turned out, however, that in law, unlike in medicine, GC stands for "general counsel."