

How to Write and Publish a Scientific Paper

Ninth Edition

Barbara Gastel
and Robert A. Day

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Preparation of the current edition of this book began as the COVID-19 pandemic was arriving. The pandemic has highlighted the importance of communicating science and has spurred changes in this regard. It is to the scientists who have helped us understand and control COVID-19, the editors who have helped ensure that the findings are shared expeditiously and soundly, and the many whose lives have been lost in the pandemic that we dedicate this edition.

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Preface

Criticism and testing are of the essence of our work. This means that science is a fundamentally social activity, which implies that it depends on good communication. In the practice of science, we are aware of this, and that is why it is right for our journals to insist on clarity and intelligibility.

—Hermann Bondi

The goal of scientific research is publication. Scientists, starting as graduate students or earlier, are measured primarily not by their adeptness in the laboratory, not by their knowledge of scientific subjects, and certainly not by their wit or charm; they are measured and become known (or remain unknown) on the basis of their publications. On a practical level, a scientist typically needs publications to get a job, obtain funding to keep doing research in that job, and get promoted. At some institutions, publications are needed to obtain a doctorate.

A scientific experiment, no matter how spectacular the results, is not completed until the results are published. In fact, the cornerstone of the philosophy of science is based on the fundamental assumption that original research *must* be published; only thus can new knowledge be authenticated and then added to the existing database that we call scientific knowledge.

Unlike those in many other fields, scientists must provide a document showing what they did, why it was done, how it was done (so others can try to repeat it), and what was learned from it. The key word is *reproducibility*. That is what makes science and scientific writing unique.

Thus, the scientist must not only “do” science but also “write” science. Bad writing can (and often does) prevent or delay the publication of good science.

Unfortunately, the education of scientists is often so overwhelmingly committed to the technical aspects of science that the communication arts are neglected or ignored. In short, many good scientists are poor writers. Certainly, many scientists do not like to write. As Charles Darwin said, “A naturalist’s life would be a happy one if he had only to observe and never to write” (quoted by Trelease 1958).

Most of today’s scientists did not have a chance to take a formal course in scientific writing. As graduate students, they learned to imitate the style and approach of their professors and previous authors. Some scientists became good writers anyway. Many, however, learned only to imitate the writing of the authors before them—with all its defects—thus establishing a system of error in perpetuity.

The main purpose of this book is to help scientists and students of the sciences in all disciplines to prepare manuscripts likely to be accepted for publication and to be completely understood when they are published. Because the requirements of journals vary widely from discipline to discipline, and even within the same discipline, it is not possible to offer recommendations that are universally acceptable. In this book, we present certain basic principles that are accepted in most disciplines.

Let us tell you a bit about the history of this book. The development of *How to Write and Publish a Scientific Paper* began many years ago, when one of us (Robert A. Day) taught a graduate seminar in scientific writing at the Institute of Microbiology at Rutgers University. It quickly became clear that graduate students in the sciences both wanted and needed *practical* information about writing. If a lecture was about the pros and cons of split infinitives, the students became somnolent; if it addressed how to organize data into a table, they were wide awake. Therefore, a straightforward “how to” approach was used for an article (Day 1975) based on the lecture notes. The article turned out to be surprisingly popular, which led to the first edition of this book.

The first edition led naturally to the second edition, and then to succeeding editions. Because this book is now being used in teaching programs in many colleges and universities, it seems especially desirable to keep it up to date. We thank those readers who kindly commented on previous editions, and we invite suggestions that may improve future editions. Please send suggestions and comments to Barbara Gastel at b-gastel@tamu.edu.

This edition, the ninth, is the fourth for which Barbara Gastel joins Robert A. Day. Regrettably, Day did not live to see its publication. He died peacefully at age 97, having lived a vibrant and productive life and having retained his sharp mind despite declining health. Gastel remains grateful to Day for asking her to collaborate, and she feels honored to maintain his legacy. We were delighted that our previous editions together have been translated into at least

five languages, and the hope persists that the current edition will be widely translated too.

In keeping with its title, this book has always focused primarily on writing and publishing scientific papers. It also has long provided broader advice on scientific communication. Beginning with the first edition, it has contained chapters to help readers write review papers, conference reports, and theses. Over time, chapters have been added on other topics, such as how to approach a writing project, how to present a paper orally, how to prepare a poster presentation, how to prepare a grant proposal, how to write about science in English as a foreign language, how to communicate science to the public, how to provide peer review, and how to edit one's own work.

The current edition maintains this overall scope but has been substantially updated and otherwise revised. Newly addressed topics include posting pre-prints, providing visual abstracts, writing personal essays for journal publication, and presenting online. We have expanded the guidance on the writing process, and we have revamped the chapter on the use (and misuse) of English. The list of electronic resources also has been updated. Cartoons have long been a popular feature of the book; we have retained favorites from previous editions and added several new cartoons.

This book remains a “how-to book” or “cookbook,” focusing mainly on points of practical importance. As in past editions, the book also contains some other items, such as examples of humorous errors, intended to lighten the reading. Readers wishing to explore topics further are encouraged to consult works noted in the text or cited as references and to look at websites mentioned in this book.

We hope that, as well as increasing your skill, this book will increase your confidence in communicating science. Yes, writing a scientific paper is a substantial task. But it relies largely on the same attributes—such as intelligence, organization, and perseverance—as doing science does. If you can do research, you can communicate it. After a course using this book, a student said that whereas previously she had likened writing a scientific paper to climbing Mount Everest, she now viewed it more like climbing a high but surmountable peak at a state park. We hope this book will be a faithful guide and good companion during your climb.

Good scientific writing is crucial to scientists’ careers, science, and society. We hope this book will demystify writing and publishing a scientific paper and help you communicate about your work effectively, efficiently, and even enjoyably. Your success will be our greatest reward.

A Word to International Readers

For researchers throughout the world, communicating in English in standard Western formats has become largely the norm for sharing information widely. Thus, over the years, *How to Write and Publish a Scientific Paper* has had many readers for whom English is not their native language. We hope that the current edition will serve an even wider readership.

Aware of the diversity of our readers, we have tried especially hard in the current edition to present the main content in language that nonnative users of English can easily understand. Likewise, in choosing cartoons and other humor, we have increasingly favored items that readers from varied backgrounds can appreciate. We realize, though, that sometimes humor does not translate well. If, as an international reader, you are puzzled by a cartoon or silly-seeming comment, do not worry that something is wrong or that you have missed an important point. Rather, realize that you are seeing some examples of American humor.

We welcome readers from throughout the world and hope that they will find our book helpful in communicating science internationally.

Acknowledgments

Over the years and over the editions, many colleagues and others have contributed directly or indirectly to this book. Those we have worked with in scientific publishing and academia have shared information and ideas. So have fellow members of the Council of Science Editors, the Society for Scholarly Publishing, and other organizations. Students and other users of the book have made suggestions. Many colleagues read and commented on manuscripts for early editions. Sarah Allen, Wura Aribisala, Melissa Espinoza, Tara Gray, George Hale, Duanduan Han, Daniel Limonta Velázquez, Arkady Mak, Corley-Ann Parker, Nancy Day Sakaduski, and Roberto Tuda Rivas read recent editions or parts thereof and offered thoughtful suggestions. Editors and production staff brought the work to publication. We thank all these people. We also thank our families for their support, encouragement, and counsel.

PART I

Some Preliminaries

CHAPTER 1

What Is Scientific Writing?

State your facts as simply as possible, even boldly. No one wants flowers of eloquence or literary ornaments in a research article.

—R. B. McKerrow

THE SCOPE OF SCIENTIFIC WRITING

The term *scientific writing* commonly denotes the reporting of original research in journals through scientific papers that follow a standard format. In its broader sense, scientific writing also includes communication about science through other types of journal articles, such as review papers summarizing and integrating previously published research. And in a still broader sense, it includes other types of professional communication by scientists—for example, grant proposals, oral presentations, and poster presentations. Related endeavors include writing about science for the public, sometimes called *science writing*.

THE NEED FOR CLARITY

The key characteristic of scientific writing is clarity. Successful scientific experimentation is the result of a clear mind attacking a clearly stated problem and producing clearly stated conclusions. Ideally, clarity should be a characteristic of any type of communication; however, when something is being said *for the first time*, clarity is essential. Most scientific papers, those published in our primary research journals, are accepted for publication precisely because they contribute *new knowledge*. Hence, we should demand absolute clarity in scientific writing.

RECEIVING THE SIGNALS

Many people have no doubt heard this question: If a tree falls in the forest and there is no one there to hear it fall, does it make a sound? The correct answer is no. Sound is more than pressure waves, and indeed there can be no sound without someone to hear it.

Similarly, scientific communication is a two-way process. Just as a signal of any kind is useless unless it is perceived, a published scientific paper (signal) is useless unless it is both received *and* understood by its intended audience. Thus we can restate the axiom of science as follows: A scientific experiment is not complete until the results have been published *and understood*. A published paper is no more than pressure waves unless it is understood. Too many scientific papers fall silently in the woods.

UNDERSTANDING THE SIGNALS

Scientific writing is the transmission of a clear signal to a recipient. The words of the signal should be as clear, simple, and well ordered as possible. In scientific writing, there is little need for ornamentation. Flowery literary embellishments—metaphors, similes, idiomatic expressions—are very likely to cause confusion and should seldom be used in research papers.

Science is simply too important to be communicated in anything other than words that have a certain meaning. And the meaning should be clear and certain not just to peers of the authors, but also to students just embarking on their careers, to scientists reading outside their own narrow disciplines, and especially to those readers (most readers today) whose native language is other than English.

Many kinds of writing are designed for entertainment. Scientific writing has a different purpose: to communicate new scientific findings. Scientific writing should be as clear and simple as possible.

UNDERSTANDING THE CONTEXT

What is clear to a recipient depends both on what is transmitted and how the recipient interprets it. Therefore, communicating clearly requires awareness of what the recipient brings. What is the recipient's background? What is the recipient seeking? How does the recipient expect the writing to be organized?

Clarity in scientific writing requires attentiveness to such questions. As communication professionals advise, know your audience. Also know the

conventions, and thus the expectations, for structuring the type of writing that you are doing.

ORGANIZATION AND LANGUAGE IN SCIENTIFIC WRITING

Effective organization is key to communicating clearly and efficiently in science. Such organization includes following the standard format for a scientific paper. It also includes organizing ideas logically within that format.

In addition to organization, the second principal ingredient of a scientific paper should be appropriate language. This book keeps emphasizing proper use of English because many scientists have trouble in this area. All scientists must learn to use the English language with precision. A book (Day and Sakaduski 2011) wholly concerned with English for scientists is available.

If scientifically determined knowledge is at least as important as any other knowledge, it must be communicated effectively, clearly, and in words with a certain meaning. The scientist, to succeed in this endeavor, must therefore be literate. David B. Truman, when he was dean of Columbia College, said it well: “In the complexities of contemporary existence the specialist who is trained but uneducated, technically skilled but culturally incompetent, is a menace.”

Given that the ultimate result of scientific research is publication, it is surprising that many scientists neglect the responsibilities involved with this aspect. Scientists will spend months or years of hard work to secure data and then unconcernedly let much of their findings’ value be lost because of their lack of interest in the communication process. The same scientists who will overcome tremendous obstacles to carry out a measurement to the fourth decimal place will be in deep slumber while a typographical error changes micrograms to milligrams.

English need not be difficult. In scientific writing, we say, “The best English is that which gives the sense in the fewest short words” (a dictum printed for some years in the *Journal of Bacteriology*’s instructions to authors). Literary devices, such as metaphors, divert attention from substance to style. They should be used rarely in scientific writing.

CHAPTER 2

Historical Perspectives

I imagine the early scientists of the Royal Society involved in creating the first journals: If they came forward to 2020, everything in our world would shock and terrify them, but they'd find deep comfort in scientific journals.

—Michael Eisen

THE EARLY HISTORY

Human beings have been able to communicate for thousands of years. Yet scientific communication as we know it today is relatively new. The first journals were published about 350 years ago, and the IMRAD (introduction, methods, results, and discussion) organization of scientific papers has developed within about the past century.

Knowledge, scientific or otherwise, could not be communicated effectively until appropriate mechanisms of communication became available. Prehistoric people could communicate orally, of course, but each new generation started from essentially the same baseline because without written records to refer to, knowledge was lost almost as rapidly as it was found.

Cave paintings and inscriptions carved onto rocks were among the first human attempts to leave records for succeeding generations. In a sense, today we are lucky that our early ancestors chose such media because some of these early “messages” have survived, whereas messages on less-durable materials would have been lost. (Perhaps many have been.) On the other hand, communication via such media was incredibly difficult. Think, for example, of the distributional problems that the U.S. Postal Service would have today if the medium of correspondence were 100-lb (about 45-kg) rocks. It has enough troubles with 1-oz (about 28-g) letters.

The earliest book we know of is a Chaldean account of the Flood. This story was inscribed on a clay tablet in about 4000 BCE, antedating Genesis by some 2,000 years (Tuchman 1980).

A medium of communication that was lightweight and portable was needed. The first successful medium was papyrus (sheets made from the papyrus plant and glued together to form a roll sometimes 20 to 40 ft [6–12 m] long, fastened to a wooden roller), which came into use about 2000 BCE. In 190 BCE, parchment (made from animal skins) came into use. The Greeks assembled large libraries in Ephesus and Pergamum (in what is now Turkey), as well as in Alexandria. According to Plutarch, the library in Pergamum contained 200,000 volumes in 40 BCE (Tuchman 1980).

In 105 CE, the Chinese invented paper, the dominant medium of written communication in modern times—at least until the internet era. However, because there was no effective way of duplicating communications, scholarly knowledge could not be widely disseminated.

Perhaps the greatest single technical invention in the intellectual history of the human race was the printing press. Although movable type was invented in China in about 1100 CE (Tuchman 1980), the Western world gives credit to Johannes Gutenberg, who printed his 42-line-per-page Bible from movable type on a printing press in 1455 CE. Gutenberg's invention was immediately and effectively put to use throughout Europe. By the year 1500, thousands of copies of hundreds of books were printed.

The first scientific journals appeared in 1665, when two journals, the *Journal des Scavans* in France and the *Philosophical Transactions of the Royal Society of London* in England, began publication. Since then, journals have served as the primary means of communication in the sciences. As of late 2021, there were over 48,000 peer-reviewed scholarly journals, of which over 35,000 were in English. The number of articles published per year appeared to exceed 4 million. The number of journals, the number of articles submitted, and the number of articles published all have been increasing from year to year (STM 2021, pp. 15–17).

THE ELECTRONIC ERA

When many older scientists began their careers, they wrote their papers in pen or pencil and then typed them on a typewriter or had a secretary do so. They or a scientific illustrator drew graphs by hand. They or a scientific photographer took photographs on film. They then carefully packaged several copies of the manuscript and sent them via postal service to a journal. The journal then mailed copies to the referees (peer reviewers) for evaluation, and the referees mailed them back with comments. The editor then mailed a decision

letter to the scientists. If the paper was accepted, the scientists made the needed revisions and mailed back a final version of the manuscript. A copy editor edited the paper by hand, and a compositor rekeyboarded the manuscript. Once the paper was typeset, a copy was mailed to the scientists, who checked for typographical errors and mailed back corrections. Before the paper was published, the scientists ordered reprints (freestanding printed copies) of the paper, largely for fellow scientists who lacked access to libraries containing the journal or who lacked access to a photocopier.

Today the process has changed greatly. Word processors, graphics programs, digital photography, and the internet have facilitated the preparation and dissemination of scientific papers. Journals throughout the world have online systems for manuscript submission and peer review. Editors and authors communicate electronically. Manuscript editors edit papers online, and authors receive typeset proofs of their papers electronically for inspection. Journals are available online as well as in print—and sometimes instead of in print; increasingly, accepted papers become available individually online before appearing in journal issues. At some journals, electronic extras, such as appendixes and video clips, supplement online papers. Many journals are openly accessible online, either starting at the time of publication or after a lag period. In addition, readers often can access papers through the authors' websites or through resources at the authors' institutions, or the readers can request electronic reprints. Some of the changes have increased the technical demands on authors, but overall, the changes have hastened and eased the publication process and improved service to readers.

Major trends in recent years have included the increasing use of *preprint servers*—in other words, openly accessible online repositories or archives to which authors post manuscripts before (or sometimes instead of) submitting them to peer-reviewed journals. In physics and related fields, researchers have long posted preprints to the open-access archive now called arXiv, which observed its 30th birthday in 2021 (Celebrating arXiv's 30th Anniversary 2021). More recently, substantial numbers of researchers in biological fields have posted preprints, for example in bioRxiv (Kaiser 2017). The trend accelerated with the advent of COVID-19 and the impetus to share research about it quickly (Kupferschmidt 2020). Related developments have included the advent of *overlay journals*, which are compilations of preprints (and sometimes other online items) that, after peer review, been chosen for inclusion (Alves 2021).

Like circulating drafts to colleagues, posting manuscripts in preprint servers can aid in sharing information, obtaining feedback, and establishing priority. It does not, however, substitute for publication in a peer-reviewed journal or the equivalent. Fellow researchers, members of the public, and the media should be aware that items in preprint servers have not received the scrutiny of formal peer review.

Whereas much regarding the mechanics of publication has changed, much else has stayed the same. Items that persist include the basic structure of a scientific paper, the basic process by which scientific papers are accepted for publication, the basic ethical norms in scientific publication, and the basic features of good scientific prose. In particular, in many fields of science, the IMRAD structure for scientific papers remains dominant.

THE IMRAD STORY

The early journals published papers that we call *descriptive*. Typically, a scientist would report, “First, I saw this, and then I saw that,” or “First, I did this, and then I did that.” Often the observations were in simple chronological order.

This descriptive style was appropriate for the kind of science then being reported. In fact, this straightforward style of reporting still is sometimes used in “letters” journals, case reports in medicine, geological surveys, and other publications.

By the second half of the nineteenth century, science was beginning to move fast and in increasingly sophisticated ways. Microbiology serves as an example. Especially through the work of Louis Pasteur, who confirmed the germ theory of disease and developed pure-culture methods of studying microorganisms, both science and the reporting of science made great advances.

At this time, methodology became all-important. To quiet his critics, many of whom were fanatic believers in the theory of spontaneous generation, Pasteur found it necessary to describe his experiments in exquisite detail. Because reasonably competent peers could reproduce Pasteur’s experiments, the principle of *reproducibility of experiments* became a fundamental tenet of the philosophy of science, and a separate methods section led the way toward the highly structured IMRAD format.

The work of Pasteur was followed, in the early 1900s, by the work of Paul Ehrlich and, in the 1930s, by the work of Gerhard Domagk (sulfa drugs). World War II prompted the development of penicillin (first described by Alexander Fleming in 1929). Streptomycin was reported in 1944, and soon after World War II, the mad but wonderful search for “miracle drugs” produced tetracyclines and dozens of other effective antibiotics.

As these advances were pouring out of medical research laboratories after World War II, it was logical that investment in research would greatly increase. In the United States, this positive inducement to support science was soon (in 1957) joined by a negative factor when the Soviets flew *Sputnik* around the Earth. In the following years, the U.S. government (and others) poured additional billions of dollars into scientific research.

Money produced science, and science produced papers. Mountains of them. The result was powerful pressure on the existing (and the many new) journals. Journal editors, in self-defense if for no other reason, began to demand that manuscripts be concisely written and well organized. Journal space became too precious to be wasted on verbosity or redundancy. The IMRAD format, which had been slowly progressing since the latter part of the nineteenth century, now came into almost universal use in research journals. Some editors espoused IMRAD because they became convinced that it was the simplest and most logical way to communicate research results. Other editors, perhaps not convinced by the simple logic of IMRAD, nonetheless hopped on the bandwagon because the rigidity of IMRAD did indeed save space (and expense) in the journals, and because IMRAD made life easier for editors and referees by indexing the major parts of a manuscript.

The logic of IMRAD can be defined in question form: What question (problem) was studied? The answer is the *introduction*. How was the problem studied? The answer is the *methods*. What were the findings? The answer is the *results*. What do these findings mean? The answer is the *discussion*.

It now seems clear that the simple logic of IMRAD does help the author organize and write the manuscript, and IMRAD provides an easy road map for editors, referees, and ultimately readers to follow in reading the paper.

Although the IMRAD format is widely used, it is not the only format for scientific papers. For example, in some journals, the methods section appears at the end of papers. In some journals, there is a combined results and discussion section. In some, a conclusions section appears at the end. In papers about research in which results of one experiment determine the approach taken in the next, methods sections and results sections can alternate. In some papers, especially in the social sciences, a long literature review section may appear near the beginning of the paper. Thus, although the IMRAD format is often the norm, other possibilities include IRDAM, IMRDRDRD, IMRADC, IMRMRMRD, ILMRAD, and more.

Later in this book, we discuss components of a scientific paper in the order in which they appear in the IMRAD format. However, most of our advice on each component is relevant regardless of the structure used by the journal to which you will submit your paper. Before writing your paper, of course, be sure to determine which structure is appropriate for the journal. To do so, read the journal's instructions to authors and look at papers similar to yours that have appeared in the journal. These actions are parts of approaching a writing project—the subject of the next chapter.

CHAPTER 3

Approaching a Writing Project

Writing is easy. All you do is stare at a blank sheet of paper until drops of blood form on your forehead.

—Gene Fowler

ESTABLISHING THE MINDSET

The thought of preparing a piece of scientific writing can intimidate even the best writers. However, establishing a suitable mindset and taking an appropriate approach can make the task manageable. Perhaps most basic, remember that you are writing to communicate, not to impress. Readers of scientific papers want to know what you did, what you found, and what it means; they are not seeking great literary merit. If you do good research and present it clearly, you will please and satisfy readers. Indeed, in scientific writing, readers should notice mainly the content, not the style.

Realize that those reading your work want you to do well—they are not out to thwart you. Journal editors are delighted to receive good papers; ditto for the scientists they enlist as referees (peer reviewers) to help evaluate your work. Likewise, if you are a student, professors want you to do well. Yes, these people often give constructive criticism. But they are not doing so because they dislike you; rather, they do so because they want your work to succeed. Do not be paralyzed by the prospect of criticism. Rather, feel fortunate that you will receive feedback that can help your writing to be its best.

PREPARING TO WRITE

In the laboratory, careful preparation helps experiments proceed smoothly and efficiently. Much the same is true of scientific writing. By preparing carefully before you start to compose a manuscript, you can make writing relatively easy and painless. Of course, in our unbiased view, preparing to write should include reading this book and keeping it on hand to consult. (Our publisher suggests buying a copy for your office or lab, a copy to use at home, and maybe one to keep in your car or boat.) But using this book is only a start. The following also can help.

Good writing is largely a matter of effective imitation. Therefore, obtain copies of highly regarded scientific papers in your research area, including papers in the journal to which you plan to submit your current work. Notice how these papers are written. For example: What sections do they include, and in what order? How long do the various sections tend to be? How do the sections tend to be structured? What types of subheadings, if any, tend to be included? How many figures and tables, and what types thereof, are typical? Especially if you are a nonnative speaker of English, what seem to be some standard phrases that you could use in presenting your own work? Using published papers as models, and perhaps using detailed outlines of them to help structure your own paper (Gray 2020), can prepare you to craft a manuscript that will be suitable to submit.

Successful writing also entails following instructions. Essentially every scientific journal posts instructions to authors. Following these instructions takes much of the guesswork out of writing and can save you the unpleasant task of rewriting a paper because it did not meet the journal's specifications (or finding that the editor simply rejected your paper without comment). If instructions are long (some journals' instructions run the equivalent of several pages or more), underline or highlight the key points to remember. Alternatively, you may list the points most relevant to the paper you will write. Also, consider bookmarking on your computer the journal's instructions to authors.

For more detailed guidance—for instance, on nomenclature, reference formats, and grammar—instructions for authors often refer readers to standard style manuals. Among style manuals commonly used in the sciences are the following:

The ACS [American Chemical Society] Guide to Scholarly Communication
(Banik et al. 2020—)

AMA [American Medical Association] Manual of Style, 11th edition (Christiansen et al. 2020)

The Chicago Manual of Style, 17th edition (2017)

Publication Manual of the American Psychological Association, 7th edition
(2020)

Scientific Style and Format, 8th edition (Style Manual Subcommittee, Council of Science Editors 2014)

New editions of these manuals come out from time to time. Between editions, updates commonly are posted on the manuals' websites. And increasingly, such manuals are available in continually updated online versions, as well as in print. Indeed, the *ACS Guide to Scholarly Communication*, which succeeds the *ACS Style Guide* (Coghill and Garson 2006), exists only as such a version. Look for the most recent edition of the style manual you will use. Commonly, you can find such style manuals in academic and other libraries. If you lack easy access, consider investing in the style manuals most commonly used in your research field. In any case, be ready to consult such manuals.

If you do not have reference-management software—for example, EndNote, RefWorks, or Zotero—now may be a good time to obtain it. Many universities make such software readily available and provide instruction in its use. Further information about using such software appears in Chapter 15.

While you are gathering scientific content, ideas for your paper may occur to you. For example, you may think of a point to include in the discussion, or you may come up with a good way to structure a table. Write down these ideas; for each section of your paper, consider creating a file in which to place them. Not only will recording your ideas keep them from escaping your memory, but having such ideas readily available can get your writing off to a quick start.

Once you have gathered and analyzed your data, speaking can be a fine transition to writing. If possible, present your work at a departmental seminar or local research day. Perhaps give an oral or poster presentation at a conference. Preparing to speak can help you with formulating your article. Also, questions from listeners can help you to shape what you will write.

Research typically is a team endeavor. So is reporting on research. In the writing, as in the research, different team members commonly take different roles. Sometimes one member drafts the whole paper and the others review and revise it. Other times, different members draft different parts of the paper and then circulate them to the others for review. Whatever the case, clarify beforehand who will do what, and perhaps set a timetable. Maybe consider what software, if any, you will use to facilitate collaboration. Will you share drafts via Dropbox? Will you use Google Docs? Will you use software designed specifically for academic collaboration? Discuss such matters before starting to write.

To facilitate writing, do lots of prewriting. For example, stack copies of published papers in the order in which you plan to cite them. List points you wish to make in a given section, and sort and re-sort them until you are pleased with the order. Perhaps make a formal outline. By doing much of the thinking and organizing beforehand, you can lower the activation energy needed to

write a paper. In fact, such prewriting can catalyze the writing process so well that you find yourself eager to write.

In preparing to write, realize that sometimes ideas must percolate for a while. If, for example, you cannot come up with an effective way to begin your paper or to structure a section, take a break. Exercise for a while, take a nap, or maybe discuss your work with someone. A solution may then occur to you.

The physicist Wolfgang Pauli reportedly stated, “I don’t mind your thinking slowly; I mind your publishing faster than you think” (Mackay and Ebison 1977, p. 117). Take the time to reflect and plan before you write and publish.

DOING THE WRITING

Doing the writing means making time to do it. Most of us in science are busy. If writing must wait until we have extra time, it might never get done. Therefore, block out times to write. Indicate in your calendar or personal organizer the times that you have reserved for specific writing projects. Except in emergencies, do not let other tasks impinge on those times. Also, set deadlines. For example, promise yourself that you will draft a given section by Thursday. Or make clear to yourself that you will not leave for vacation until you have submitted a given item.

One highly published professor advocates the following approach (Zerubavel 1999): On a page showing your weekly schedule hour by hour, cross out the times that you are regularly unavailable—for example, times that you teach, have laboratory meetings, or have personal commitments. Then choose from the remaining times some slots to reserve for writing. In doing so, consider what times of day you tend to write most effectively. For example, if you are a night person, block out some evenings during which to write each week; perhaps save some morning time for more routine writing-related tasks, such as checking references. If you are a morning person, do the reverse.

Also, consider where and how you work best. Do you write most productively in an office, or is the library, a coffee shop, or the couch most conducive to your best writing? Do you need quiet, or does music help you work? Is it most effective for you to write for a brief time every day, or do longer, less frequent stints produce your finest work? Do your ideas flow best when you set fingers to keyboard, or does writing by hand with your favorite pen yield the most favorable work? Contrary to what some may claim, there is no one best set of writing habits. Whatever works for you is fine. To thine own functioning be true.

When writing, you can start with whatever part of a manuscript you find easiest; there is no rule that you must write the introduction first. Many researchers like to begin by drafting the methods section, which tends to be

the most straightforward to write. Many like to begin by drafting the figures and tables. Some like to start by drafting a preliminary reference list—or even the acknowledgments. And many authors leave until last finalizing the title and abstract. Rough-drafting the title and abstract, though, can be an excellent way to gain needed focus when starting to write a paper.

Once you have drafted one section, the momentum that you have established can facilitate writing the others. Feel free to draft the remaining sections in whatever order works best for you. Although the structure of Part II of this book parallels that of a scientific paper—with the first chapter addressing “How to Prepare the Title” and the last “How to Cite the References”—you can draft the parts of a scientific paper (and read these chapters) in whatever order works best for you.

Once you have established momentum, beware of dissipating it by interrupting your writing to search for small details. Rather, make notes to find the missing information later; to identify them easily, type them in boldface, highlight them, or use the “comment” feature in Microsoft Word. Also, if a manuscript will take more than one session to draft, consider how best to maintain your momentum from session to session. Some authors like to stop in the middle of a section while still going strong. Before ending their writing session, they jot down the next few points they wish to make. Thus, at their next writing session, they can start quickly. Consider taking this approach.

Starting with whatever part you find easiest and taking breaks while still going strong can help combat or prevent *writer’s block* at various phases of a writing project. If you nevertheless experience writer’s block, here are some additional remedies to consider:

- Break the writing task into small, manageable pieces—for example, subsections of each part of a scientific paper.
- To bolster your confidence, read something you have successfully written.
- To help get into the proper voice and rhythm, read a well-written example of the type of writing you will do.
- Start by voice-recording your ideas or telling them to someone.
- Write a rough draft in a comfortable, informal format, such as that of an email message.
- Set a timer for 15 or 20 minutes, and throughout that time, write without editing. To prevent editing, try writing with the computer monitor turned off.
- If all else fails, bribe yourself. The promise of a favorite snack, a wanted small purchase, or some preferred recreation can help ensure that you complete the task.



(ScienceCartoonsPlus.com)

Other ways to help ensure that you start—and finish—your writing include taking a writing course and following a schedule designed by a writing expert. As well as supplying instruction, courses where class members write and revise journal articles section by section provide structure and incentive for completing one's paper. Indeed, some researchers have taken such courses more than once in order to obtain that structure. Such structure also can come from externally designed writing plans. For example, the workbook *Writing Your Journal Article in 12 Weeks* (Belcher 2019) presents a detailed, week-by-week plan for producing an article. Although intended primarily for students in the humanities and related areas, the plan can be adapted for writing scientific papers.

Writing groups (also called *writing clubs*) can promote productivity and quality in writing. Simply put, writing groups are groups of people who meet periodically to discuss their writing. They can meet in person, electronically,

or both. And they can focus on the writing process, the written product, or some of each. As well as offering psychological support, writing groups can benefit members in other ways. They can offer accountability by having members regularly report on their progress. They can aid in problem-solving, for example by giving feedback on members' drafts and discussing obstacles members encounter in writing and publication. They can educate members, for instance through readings or speakers. And they can supply professional networking and social interaction. A related option is to have a *writing partner* and regularly check in on each other's progress, brainstorm about difficulties, and review drafts. Many research settings have writing groups, and online options that span settings exist. If you lack access to a writing group and think that you would find such interaction helpful, consider starting one or recruiting a writing partner or partners.

Much like doing a piece of scientific research, crafting a scientific paper typically entails solving a series of problems in order to achieve the overall objective. In writing, as in research, often the problems have more than one reasonable solution, each with advantages and disadvantages. Yet writers sometimes worry that there is "one right way" (Becker 2020). Just how should a given item be worded? In just what format should a given illustration appear? How should a given part of the paper be organized? Often, such questions have more than one good answer. Find one that seems reasonable and go with it. If it seems inadequate, or if a better solution occurs to you, you can make changes when you revise your manuscript.

REVISING YOUR WORK

Good writing tends to be largely a matter of good revising. No one will see your early drafts, and no one cares how rough they are (a comforting thought to those facing writer's block). The important thing is to revise your writing until it works well. First, revise your writing yourself. Then show it to others and, using their feedback, revise your writing some more.

Revision is not just for students or other beginners. Researchers who have long enjoyed great success in publishing revise the papers they write. After a presentation to a scientific-writing class, a well-known scientist and journal editor was asked, "Do you revise your work?" He answered: "If I'm lucky, only about 10 times."

In revising your work, ask yourself questions such as the following:

- Does the manuscript include all the information it should?
- Should any content be deleted?
- Is all the information accurate?
- Is all the reasoning sound?

- Is the content consistent throughout?
- Is everything logically organized?
- Is everything clearly worded?
- Have you stated your points briefly, simply, and directly? In other words, is everything concise?
- Are grammar, spelling, punctuation, and word use correct throughout?
- Are all figures and tables well designed?
- Does the manuscript comply with the instructions?

Information that can aid in answering some of these questions appears in later chapters of the book. For example, Chapters 10 through 13 describe the appropriate content and organization of the main sections of a scientific paper, and Chapters 30 through 34 address word usage and related subjects. In addition to reading these chapters before you write, consider consulting them as you revise your manuscript. Also, for further guidance, please see Chapter 41, which focuses mainly on editing one's own work.

Once your manuscript is nearly the best you can make it, show it to others and request their feedback. Years ago, scientists were advised, “Show your manuscript to a guy in your lab, a guy in a lab down the hall, and your wife.” These days, such advice would rightly be viewed as inaccurate and sexist. Yet the concept remains valid. So, consider following this advice: Show your manuscript to an expert in your research specialty, who can help identify technical problems. Also, show it to someone in your general field, who can note items that may be unclear to readers and other issues. And show it to an intelligent general reader—for instance, a friend in the humanities—who may identify problems that those interested mainly in the content tend to miss. In addition, consider also showing your manuscript to a professional scientific editor, as discussed in Chapter 41.

After receiving feedback from those reviewing your manuscript, consider how to apply it. Of course, follow those suggestions that you find useful. Even if a suggestion seems unsuitable, keep it in mind. Although you may disagree with it, it may alert you to a problem. For example, if a reader misinterpreted a point, you may try to state it more clearly. Comparing the various readers’ comments may aid in this regard. If only one reader had difficulty understanding an item, you might dismiss it as a fluke. If, however, multiple readers did so, improvement probably is needed.

Revise your writing thoroughly. But avoid the temptation to keep revising it forever. No manuscript is perfect. Be satisfied with mere excellence. Journal editors and others will be pleased to receive the fine manuscripts that you will prepare by following the advice in this chapter and the rest of this book.

CHAPTER 4

What Is a Scientific Paper?

Without publication, science is dead.

—Gerard Piel

DEFINITION OF A SCIENTIFIC PAPER

A scientific paper is a written and published report describing original research results. That short definition must be qualified, however, by noting that a scientific paper must be written in a certain way, as defined by tradition, editorial practice, scientific ethics, and the interplay of printing and publishing procedures.

To properly define a “scientific paper,” we must define the mechanism that creates a scientific paper—namely, valid (that is, primary) publication. Abstracts, theses, conference reports, and many other types of literature are published, but such pieces do not normally meet the test of valid publication. Further, even if a scientific paper meets all the other tests, it is not validly published if it is published in the wrong place. That is, a relatively poor research report, but one that meets the tests, is validly published if accepted and published in the right place (a primary journal or other primary publication); a superbly prepared research report is not validly published if published in the wrong place. Most of the government literature and conference literature, as well as institutional bulletins and other ephemeral publications, do not qualify as primary literature.

Many people have struggled with the definition of primary publication (valid publication), from which is derived the definition of a scientific paper. The Council of Biology Editors (CBE), now the Council of Science Editors

(CSE), arrived at the following definition (Council of Biology Editors 1968, p. 2):

An acceptable primary scientific publication must be the first disclosure containing sufficient information to enable peers (1) to assess observations, (2) to repeat experiments, and (3) to evaluate intellectual processes; moreover, it must be susceptible to sensory perception, essentially permanent, available to the scientific community without restriction, and available for regular screening by one or more of the major recognized secondary services (e.g., currently, Biological Abstracts, Chemical Abstracts, Index Medicus, Excerpta Medica, Bibliography of Agriculture, etc., in the United States and similar services in other countries).

At first reading, this definition may seem excessively complex, or at least verbose. But those who had a hand in drafting it weighed each word carefully and doubted that an acceptable definition could be provided in appreciably fewer words. Because it is important that students, authors, editors, and all others concerned understand what a scientific paper is and what it is not, it may be helpful to work through this definition to see what it really means.

“An acceptable primary scientific publication” must be “the first disclosure.” Certainly, first disclosure of new research data often takes place via oral presentation at a scientific meeting. But the thrust of the CBE statement is that disclosure is more than disgorgement by the author; effective first disclosure is accomplished *only* when the disclosure takes a form that allows the peers of the author (either now or in the future) to fully comprehend and use that which is disclosed.

Thus, sufficient information must be presented so that potential users of the data can (1) assess observations, (2) repeat experiments, and (3) evaluate intellectual processes. (Are the author’s conclusions justified by the data?) Then, the disclosure must be “susceptible to sensory perception.” This may seem an awkward phrase because in normal practice, it simply means to be published; however, this definition provides for disclosure not just in terms of printed visual materials (printed journals and the no longer widely used media called microfilm and microfiche), but also in nonprint, nonvisual forms. For example, “publication” in the form of audio recordings, if that publication met the other tests provided in the definition, would constitute effective publication. And electronic journals certainly meet the definition of valid publication. What about material posted on a website (for example, preprints)? Views have varied and can depend on the nature of the material posted. For the most current information, consult materials from professional organizations and journals in your field.

Regardless of the form of publication, that form must be essentially permanent. Therefore, scientific papers receive *digital object identifiers (DOIs)*:



(“Types of Scientific Paper” by xkcd [xkcd.com]. Used by permission.)

internet addresses that persist even if, for example, a journal's URL changes or the journal ceases publication. Primary scientific publications also must be made available to the scientific community without restriction (for example, in a journal that is openly accessible online or to which subscriptions are available), and they must be made available to information-retrieval services (for example, Biological Abstracts, Chemical Abstracts, and MEDLINE). Thus, publications such as newsletters, corporate publications, and controlled-circulation journals, many of which are of value for their news or other features, generally cannot serve as repositories for scientific knowledge.

To restate the CBE definition in simpler but not more accurate terms, primary publication is (1) the first publication of original research results, (2) in a form whereby peers of the author can repeat the experiments and test the conclusions, and (3) in a journal or other source document readily available within the scientific community. To understand this definition, however, we must add an important caveat. The part of the definition that refers to "peers of the author" is accepted as meaning prepublication peer review. Thus, by definition, scientific papers are published in peer-reviewed publications.

This question of definition has been belabored here for two reasons. First, the entire community of science long labored with an inefficient, costly system of scientific communication precisely because it (that is, authors, editors, and publishers) has been unable or unwilling to define primary publication. As a result, much of the literature has been buried in meeting abstracts, obscure conference reports, government documents, or books or journals of minuscule circulation. Other papers, in the same or slightly altered form, have been published more than once; occasionally, this is due to the lack of definition as to which conference reports, books, and compilations are (or should be) primary publications and which are not. Redundancy and confusion result.

Second, a scientific paper is, by definition, a particular kind of document containing specific kinds of information, typically in a prescribed order. If the graduate student or the budding scientist (and even some scientists who have already published many papers) can fully grasp the significance of this definition, the writing task might be a great deal easier. Confusion results from an amorphous task. The easy task is the one in which you know exactly what must be done and in exactly what order it must be done.

ORGANIZATION OF A SCIENTIFIC PAPER

A scientific paper is organized to meet the needs of valid publication. It is, or should be, highly stylized, with distinctive and clearly evident component parts. The most common labeling of the component parts, in the basic sciences, is introduction, methods, results, and discussion (hence the acronym

IMRAD). Actually, the heading “Materials and Methods” may be more common than the simpler “Methods,” but the latter form was used in the acronym.

Some of us have taught and recommended the IMRAD approach for many years. The tendency toward uniformity has increased since the IMRAD system was prescribed as a standard by the American National Standards Institute, first in 1972 and again in 1979 (American National Standards Institute 1979a). Some journals use a variation of IMRAD in which the methods section appears last rather than second. Perhaps we should call this *IRDAM*. In some journals, details regarding methods commonly appear in figure captions.

The basic IMRAD order is so eminently logical that, increasingly, it is used for many other types of expository writing. Whether one is writing an article about chemistry, archaeology, economics, or crime in the streets, the IMRAD format is often the best choice.

This point is generally true for papers reporting laboratory studies and other experiments. There are, of course, exceptions. As examples, reports of field studies in the earth sciences and many clinical case reports in the medical sciences do not readily lend themselves to this kind of organization. However, even in these descriptive papers, the same logical progression from problem to solution is often appropriate.

Occasionally, the organization of laboratory papers must differ. If a number of methods were used to achieve directly related results, it might be desirable to combine the materials and methods and the results into an integrated experimental section. In some fields and for some types of results, a combined results and discussion section is usual or desirable. In addition, many primary journals publish notes or short communications in which the IMRAD organization is modified.

Various types of organization are used in descriptive areas of science. To determine how to organize such papers and which general headings to use, refer to the instructions to authors of your target journal and look at analogous papers that the journal has published. Also, you can obtain general information from appropriate source books. For example, types of medical papers are described by Huth (1999), Peat and others (2002), Taylor (2018), and contributors to a multiauthor guide (Hall 2013); types of engineering papers and reports are outlined by Michaelson (1990) and by Beer and McMurrey (2019). Indeed, even if a paper will appear in the IMRAD format, books on writing in one’s own discipline can be worth consulting. Examples of such books include those in biomedical science by Zeiger (2000); the health sciences by Lang (2010); chemistry by Ebel, Bliefert, and Russey (2004); and psychology by Sternberg and Sternberg (2016).

In short, the preparation of a scientific paper has less to do with literary skill than with *organization*. A scientific paper is not literature. The preparer of

a scientific paper is not an author in the literary sense. As an international colleague noted, this fact can comfort those writing scientific papers in other than their native language.

Some old-fashioned colleagues think that scientific papers should be literature, the style and flair of an author should be clearly evident, and variations in style encourage the interest of the reader. Scientists should indeed be interested in reading literature, and perhaps even in writing literature, but the communication of research results is a more prosaic procedure. As Booth (1981) put it, “Grandiloquence has no place in scientific writing.”

Today, the average scientist, to keep up with a field, must examine the data reported in very many papers. Also, English, the international language of science, is a second language for many scientists. Therefore, scientists (and, of course, editors) must demand a system of reporting data that is uniform, concise, and readily understandable.

SHAPE OF A SCIENTIFIC PAPER

Imagine that a friend visits your laboratory or office. The friend is unfamiliar with your research and wants to know about it. To orient your friend, first you identify your general research area and say why it is important. Then you state the specific focus of your research, summarize how you gathered your data, and say what you found. Finally, you discuss the broader significance of your

Structure of a Scientific Paper



Introduction: starts with broad context; narrows to focus on your work

Methods: focuses narrowly on your work

Results: focuses narrowly on your work

Discussion: starts narrow; broadens to put your work in context

Figure 4.1. (Created with BioRender.com)

findings. The friend now has a new understanding—and, if you are lucky, the friend might buy you lunch.

Although intended for readers who are more knowledgeable, a scientific paper should take much the same approach: first provide a broad orientation, next focus narrowly on the specific research, and then consider the findings in a wider context. Some have likened this shape for a scientific paper to an hour-glass: broad, then narrow, then broad. Keeping this overall structure in mind can aid when writing the individual parts of a paper and integrating them into a coherent whole.

OTHER DEFINITIONS

If *scientific paper* is the term for an original research report, how should this be distinguished from research reports that are not original, are not scientific, or somehow do not qualify as scientific papers? Some specific terms are commonly used: *review paper* (or *review article*), *conference report*, and *meeting abstract*.

A review paper typically reviews the recent work in a defined subject area. Thus, it is designed to summarize, analyze, evaluate, and synthesize information that *has already been published* (research reports in primary journals). Although much or all of the material in a review paper has previously been published, the problem of dual publication (duplicate publication of original data) does not normally arise because the review nature of the work is usually obvious—often from the title of the periodical, such as *Microbiology and Molecular Biology Reviews* or *Annual Review of Astronomy and Astrophysics*. Do not assume, however, that reviews contain nothing new. From the best review papers come new syntheses, new ideas and theories, and even new paradigms.

A conference report is a paper published in a book or journal as part of the proceedings of a symposium, national or international congress, workshop, roundtable, or similar meeting. Such conferences commonly are not designed for the definitive presentation of original data, and the resultant proceedings (in a book or journal) do not qualify as primary publications. Conference presentations often are review papers, presenting reviews of the recent work of particular scientists or recent work in particular laboratories. Material at some conferences (especially the exciting ones) takes the form of preliminary reports in which new, original data are presented, often accompanied by interesting speculation. But usually, these preliminary reports do not qualify, nor are they intended to qualify, as scientific papers. Later, often much later, such work may be validly published in a primary journal; by this time, the loose ends have been tied down, essential experimental details have been described (so that a competent worker could repeat the experiments), and previous speculation has matured into conclusions.

Therefore, the vast conference literature that appears normally is not *primary*. If original data are presented in such contributions, the data can and should be published (or republished) in an archival (primary) journal. Otherwise, the information may essentially be lost. If publication in a primary journal follows publication in a conference report, permission from the original publisher may be needed to reprint figures and other items (see Chapter 19, "Rights and Permissions"); however, the more fundamental problem of dual publication normally does not and should not arise.

Meeting abstracts may be brief or relatively extensive. Although they can and generally do contain original information, they are not primary publications. Therefore, publication of an abstract should not preclude publication of the full report later.

Traditionally, there was little confusion regarding the typical one-paragraph abstracts published as part of the program or distributed along with the program at a national meeting or international congress. It was usually understood that many of the papers presented at these meetings would later be submitted for publication in primary journals. Sometimes conference organizers request extended abstracts (or *synoptics*). The extended abstract can supply almost as much information as a full paper; mainly it lacks the experimental detail. However, precisely because it lacks experimental detail, it cannot qualify as a scientific paper.

Those involved with publishing these materials should see the importance of carefully defining the various types of papers. More and more publishers, conference organizers, and individual scientists have agreed on these basic definitions, and their general acceptance can greatly clarify both primary and secondary communication of scientific information.

CHAPTER 5

Ethics in Scientific Publishing

[A]ll scientists have an unwritten contract with their contemporaries and those whose work will follow to provide observations honestly obtained, recorded, and published.

—CBE Style Manual Committee

ETHICS AS A FOUNDATION

Before writing a scientific paper and submitting it to a journal—and indeed, before embarking on your research—you should know the basic ethical norms for scientific conduct and scientific publishing. Some of these norms may be obvious, others not. Therefore, a basic overview is provided in this chapter. Graduate students and others seeking further information on ethics in scientific publishing, and more broadly in science, may do well to consult *On Being a Scientist: Responsible Conduct in Research* (Committee on Science, Engineering, and Public Policy 2009) and *Doing Global Science: A Guide to Responsible Conduct in the Global Research Enterprise* (Interacademy Partnership 2016), which contain both guidance and case studies. Other resources include ethics chapters in style manuals in the sciences.

AUTHENTICITY AND ACCURACY

The fact that research reported in a journal should actually have been performed may seem too obvious to mention. Yet cases exist in which an author simply made up data in a paper, without ever doing the research. Clearly, such

“dry-labbing,” or *fabrication*, is unethical. Fiction can be a grand pursuit, but it has no place in a scientific paper.

More subtle, and probably more common, are lesser or less definite deviations from accuracy: omitting outlying points from the data reported, preparing figures in ways that accentuate the findings misleadingly, or doing other tweaking. Where to draw the line between editing and distortion may not always be apparent. If in doubt, seek guidance from a more experienced scientist in your field—perhaps one who edits a journal.

The advent of digital imaging has given unethical researchers new ways to falsify findings. (Journal editors, though, have procedures to detect cases in which such *falsification* of images seems probable.) And ethical researchers may rightly wonder what manipulations of digital images are and are not valid. Sources of advice in this regard include sets of guidelines for using and manipulating scientific digital images (Cromey 2010, 2012).

For research that includes statistical analysis, reporting accurately includes using appropriate statistical procedures, not those that may distort the findings. If in doubt, obtain the collaboration of a statistician. Enlist the statistician early, while you are still planning the research, to help ensure that you collect appropriate data. Otherwise, ethical problems may include wasting resources and time. In the words of R.A. Fisher (1938), “To consult the statistician after an experiment is finished is often merely to ask him to conduct a *post mortem* examination.”

ORIGINALITY

As discussed in Chapter 4, the findings in a scientific paper must be new. Except in rare and highly specialized circumstances, they cannot have appeared elsewhere in the primary literature. In the few instances in which republication of data may be acceptable—for example, in a more extensive case series or if a paper is republished in another language—the original article must be clearly cited, lest readers erroneously conclude that the old observations are new. To republish a paper (either in another language or for readers in another field), permission normally must be obtained from the journal that originally published it.

Beginning scientists sometimes wonder whether they may submit the same manuscript to two or more journals simultaneously. After all, a candidate can apply to several graduate programs at once and then choose among those offering acceptance. An analogous situation does not hold for scientific papers, however. Simultaneous submission wastes resources and is considered unethical. Therefore, begin by submitting your paper only to your first-choice journal. If that journal does not accept your paper, you can then proceed to the next journal on your list.

Originality also means avoiding “salami science” (or, for vegetarians, “cucumber science”)—that is, thinly slicing the findings of a research project, as one might slice a sausage or cuke, in order to publish several papers instead of one (or, in the case of a large research project, many papers instead of a few). Good scientists respect the integrity of their research and do not divide it excessively for publication. Likewise, good hiring committees and promotion committees look at the content of publications, rather than only the number, and so are not fooled by salami science.

CREDIT

Good scientists build on each other’s work. They do not, however, take credit for others’ work.

If your paper includes information or ideas that are not your own, be sure to cite the source. Likewise, if you use others’ wording, remember to place it in quotation marks (or to indent it, if the quoted material is long) and to cite a reference. Otherwise, you will be guilty of *plagiarism*, which the U.S. National



Institutes of Health defines as “the appropriation of another person’s ideas, processes, results, or words without giving appropriate credit” (National Institutes of Health 2010). To avoid inadvertent plagiarism, be sure to include information about the source when you copy or download materials that others have written. To avoid the temptation to use others’ wording excessively, consider drafting paragraphs without looking directly at the source materials; then look at the materials to check for accuracy.

In journal articles in most fields of science, it is unusual to include quotations from others’ work. Rather, authors *paraphrase* what others have said. Doing so entails truly presenting the ideas in one’s own way; making minor changes does not constitute paraphrasing. To take an example, imagine that you wish to express the following idea, which appears later in this book:

“Leave your shyness behind when you accompany a poster.” (Gastel and Day, 2022)

The following would *not* constitute adequate paraphrasing:

Be sure to leave your shyness behind you when you present a poster.
(Gastel and Day, 2022)

When you accompany a poster, leave your shyness behind you. (Gastel and Day, 2022)

Examples of sufficient paraphrasing include the following:

Poster presenters should not be shy. (Gastel and Day, 2022)

Gastel and Day (2022) say not to be shy when presenting a poster.

Avoid shyness when presenting a poster. (Gastel and Day, 2022)

If you are presenting a poster, you should not act shy. (Gastel and Day, 2022)

On rare occasions—for example, when an author has expressed a concept extraordinarily well—quoting the author’s own phrasing may be justified. If you are unsure whether to place in quotation marks a series of words from a publication, do so. If the quotation marks are unnecessary, an editor at the journal can easily remove them. If, however, they are missing but should have been included, the editor might not discover that fact (until, perhaps, a reader later does), or the editor might suspect the fact and send you an inquiry that requires a time-consuming search. Be cautious, and thus save yourself from embarrassment or extra work.

Resources to educate oneself about plagiarism, and thus learn better how to avoid it, include a tutorial from Indiana University (Frick et al. 2021), an online guide to ethical writing (Roig 2015), and a variety of materials posted on the websites of university writing centers. Another resource to consider is

plagiarism-checking software. Such software helps identify passages of writing that seem suspiciously similar to text elsewhere; one can then see whether it does indeed appear to be plagiarized. Such software, such as Turnitin, is available at many academic institutions. Free plagiarism checkers, of varied quality, also exist (Warner 2021). Many journal publishers screen submissions with similarity-detection software. Consider prescreening your work yourself to detect and remove inadvertent plagiarism.

Occasionally, substantial similarity between text in different papers can be appropriate. For example, if different studies use some of the same standard methods, parts of their methods sections can rightly include similar wording. Likewise, if a group does a research project so extensive or long-lasting that it yields multiple papers, the methods sections of the different papers might well say some of the same things in the same way. Guidance on when and how authors can appropriately reuse sections of their own text (Hall, Moskovitz, and Pemberton 2021) is available through the Text Recycling Research Project (textrecycling.org).

Also be sure to list as an author of your paper everyone who qualifies for authorship. (See Chapter 8 for more in this regard.) Remember as well to include in the acknowledgments those sources of help or other support that should be listed (see Chapter 14).

ETHICAL TREATMENT OF HUMANS AND ANIMALS

If your research involves human subjects or animals, the journal to which you submit your paper will almost certainly require documentation that they were treated ethically. Before beginning your study, obtain all needed permissions with regard to human or animal research. (In the United States, doing so entails having your research protocol reviewed by a designated committee, generally at your institution.) Then, in your paper, provide the needed statements in this regard. For guidance, see the instructions to authors for the journal to which you are submitting your paper, and use papers similar to yours that have appeared in the journal as models. You may also find it useful to consult relevant sections of style manuals in the sciences. If in doubt, check with the publication office of the journal.

DISCLOSURE OF CONFLICTS OF INTEREST

Authors of scientific papers sometimes have *conflicts of interest*—that is, outside involvements that could, at least in theory, interfere with their objectivity in the research being reported. For example, they may own stock in the company making the product being studied, or they may be consultants to the company.

Journals commonly require authors to report such conflicts of interest. Some have checklists for doing so, and others ask more generally for disclosure. Journals have varied in the degree to which they note conflicts of interest along with published papers (Clark 2005).

Ethics requires honest reporting of conflicts of interest. More important, ethics demands that such involvements not interfere with the objectivity of your research. Some scientists avoid all such involvements to prevent even the appearance of bias.

CHAPTER 6

Where to Submit Your Manuscript

I've always been in the right place and time. Of course, I steered myself there.
—Bob Hope

DECIDE EARLY, DECIDE WELL

Too often, authors write scientific papers and *then* consider where to publish them. The decision, however, is best made early, before the writing begins. That way, the paper can be geared appropriately to the audience (for example, readers of a general scientific journal, a journal in your discipline as a whole, or a journal in your specialized research field). Also, you can initially prepare your manuscript in keeping with the journal's requirements rather than having to revise it accordingly. Of course, if your first-choice journal does not accept your paper, you might need to revise your manuscript to suit another journal. But at least you will have avoided one round of revision.

In addition to deciding early on your first-choice journal, decide well. Choosing a journal carefully helps you to reach the most suitable audience, gain appropriate recognition, and avoid needless difficulties with publication. The decision of where to submit the manuscript is important. Because of poor choices, some papers are delayed in publication, fail to receive sound review and revision, or lie buried in inappropriate journals. If you submit your manuscript to a poor choice of journal, one of three things can happen—all bad.

First, your manuscript may simply be returned to you with the comment that your work “is not suitable for this journal.” Sometimes, however, this judgment is not made until *after* review of the manuscript. A “not suitable” notice after weeks or months of delay is not likely to make you happy.



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Second, if the journal is borderline in relation to your work, your manuscript may receive a poor or unfair review because the reviewers (and editors) of that journal may be only vaguely familiar with your specialty area. You may be subjected to the trauma of rejection even though the manuscript would be acceptable to the right journal. Or you could end up with a hassle over suggested revisions that you do not agree with and that do not improve your manuscript. And if your manuscript really does have deficiencies, you would not be able to benefit from the sound criticism that would come from the editors of the right journal.

Third, even if your paper is accepted and published, your glee will be short-lived if you later find that your work is virtually unknown because it is buried in a publication that few in your intended audience read. Talking with colleagues can help prevent this situation.

Think about the appropriate readership. If, for example, you are reporting a fundamental study in physics, of course you should try to get your paper published in a prestigious international journal. On the other hand, suppose that your study concerns the management of a disease found only in Latin America. In that situation, publication in *Nature* will not reach your audience—the audience that needs and can use your information. You should publish in an appropriate Latin American journal, probably one in Spanish.

To start identifying journals to consider, recall what journals have published work similar to yours. The journals publishing the papers that you will cite are often journals to consider. Perhaps ask colleagues to suggest potential publication sites. Also, consider using online journal selection tools—such as Jane (jane.biosemantics.org), JournalGuide (www.journalguide.com/), and Edanz Journal Selector (www.edanz.com/journal-selector). Based on information that one enters about one's work, these tools generate lists of journals to consider. To help determine whether a journal indeed seems to be a possibility, look at the journal's website for statements describing its purpose and scope. Look at some recent issues of the journal to see whether it publishes research such as yours and whether the papers are of the type you envision writing.

PRESTIGE AND IMPACT

If several journals seem suitable, does it matter which one you choose? Perhaps it shouldn't matter, but it does. There is the matter of *prestige*. Maybe progress in your career (job offers, promotions, grants, etc.) will be determined largely by how many papers you publish. But not necessarily. It may well be that a wise old bird sitting on the faculty committee or the grant review panel will recognize and appreciate quality factors. A paper published in a "garbage" journal simply does not equal a paper published in a prestigious journal. In fact, the wise old bird (and there are quite a few of these in science) may be more impressed by the candidate with one or two solid publications in prestigious journals than by the candidate with 10 or more publications in second- or third-rate journals.

How do you tell the difference? It isn't easy, and of course there are many gradations. In general, however, you can form reasonable judgments by doing just a bit of bibliographic research. You will certainly know the important papers that have recently been published in your field. Make it your business to determine *where* they were published. If most of the real contributions in your field were published in Journal A, Journal B, and Journal C, you should probably limit your choices to those three journals. If Journals D, E, and F, upon inspection, contain only the lightweight papers, each could be eliminated as your first choice, even if the scope is right.

You may then choose among Journals A, B, and C. Suppose that Journal A is an attractive new journal published by a commercial publisher as a commercial venture, with no sponsorship by a society or other organization; Journal B is an old, well-known small journal published by a famous university, hospital, or museum; and Journal C is a large journal published by the principal scientific society in your field. In general (although there are many exceptions), Journal C (the society journal) is probably the most prestigious. It will also have the largest circulation (partly because of quality factors and partly because society journals tend to be less expensive than others, at least to society members). By publication in such a journal, your paper may have its best chance to make an impact on the community of scholars at whom you are aiming. Journal B might have almost equal prestige, but it might have a very limited circulation, which would be a minus; it might also be very difficult to get into if most of its space is reserved for in-house material. Journal A (the commercial journal) might well have the disadvantage of low circulation (because of its comparatively high price, which is the result of both the profit motivation of the publisher and the lack of backing by a society or institution with a built-in subscription list). Publication in such a journal may result in a somewhat restricted distribution of your paper.

Be wary of new journals, especially those not sponsored by a society. (In particular, avoid *predatory journals*, which are discussed later in this chapter.) The circulation may be minuscule, and the journal might fail before it, and your paper, become known to the scientific world. Be wary of publishing in journals that are solely electronic unless you know that those evaluating your work for purposes such as promotion consider those journals sufficiently prestigious. On the other hand, also be wary of publishing in the increasingly few journals that appear only in print, as scientists today expect important scientific literature to be accessible online.

One tool for estimating the relative prestige of journals in a given field is the electronic resource Journal Citation Reports, commonly available through academic libraries. With this resource, you can determine which journals have recently been cited most frequently, both in total and in terms of the average number of citations per article published, or the *impact factor* (Garfield 1999). Although not all good journals have impact factors computed, impact factor can be worth considering in judging the prominence of journals. If, in a given field, the average paper in Journal A is cited twice as frequently as the average paper in Journal B, it is likely that researchers find Journal A the more important journal.

In some countries and institutions, the criteria considered when candidates are evaluated for promotion include the impact factors of journals in which their papers appear. However, limitations of the impact factor also should be noted. The impact factor indicates how much the papers in a journal

are cited *on average*—not how much your paper will be cited if it appears in the journal. It does not indicate how much impact, other than on citation, the papers in a journal have—for example, how much they influence policy or clinical practice. And because different scientific fields have different citation practices, impact factors should not be used to compare the importance of journals in different fields. For instance, in biochemistry and molecular biology, in which papers tend to cite many recent papers, the impact factor of the top-cited journal was 53.4 in the year 2020, but in geology it was 5.4. In short, although knowing a journal's impact-factor ranking in its field can help you assess its scientific importance, the impact factor does not say everything about the journal's quality or its suitability for your work. In journal selection, as in much else in life, a multidimensional concept cannot validly be reduced to a single number.

Increasingly, experts have emphasized the need to include indicators other than impact factor when assessing the importance of a person's research. For example, the San Francisco Declaration on Research Assessment (2012), commonly called DORA, calls for using more varied approaches in evaluating research output. These approaches include—in addition to, most importantly, evaluating the scientific content of the article—using multiple journal-based metrics (rather than only impact factor) and looking at *article-level metrics*.



"..BUT OUR MOST USEFUL PUBLICATION IS THE 'JOURNAL OF DON'T-DO-IT: IT'S-ALREADY-BEEN-DONE'."

Examples of the latter include how many times an article has been viewed, downloaded, or bookmarked; how much attention it has received in social media and mass media; and how many times and where it has been cited (Tananbaum 2013). Noticing which journals' articles in your field tend to receive such attention can aid in identifying suitable journals for your papers.

ACCESS

Other items to consider when choosing journals can include *open access*—that is, the provision of articles online free of charge to all who may be interested. One consideration is whether to choose an *open-access journal*, a journal that immediately provides open access to all its content. At such journals, which do not have subscriptions and thus lack this source of income, the costs typically are defrayed, at least in part, by fees charged to authors. In some countries, these fees commonly are paid from grant funds; it can be wise to consider expected publication costs when preparing the budget for a grant. When authors, such as those in developing countries, cannot afford to pay the fees, the journal may waive or reduce them; if you cannot afford the normal publication fee for an open-access journal in which you hope to publish, contact the journal directly. Some research funders now require that recipients of their grants publish the resulting papers in open-access journals or otherwise make them freely accessible.

Access-related considerations for publishing in traditional journals can include whether to seek a journal for which the electronic version, initially available only to subscribers, becomes openly accessible relatively fast (for example, in a few months). Also, some journals give authors the option of making their articles freely accessible upon publication in return for paying a fee. Another consideration when publishing in a traditional journal is whether the journal allows rapid posting of articles on authors' or their institutions' websites. The website Sherpa Romeo (v2.sherpa.ac.uk/romeo/) provides information about journals' policies on open access and related matters. To ensure that you have the most complete and current information, consulting the journal itself can be advisable as well.

AVOIDING PREDATORY JOURNALS

As noted, open-access journals typically charge authors fees, as these journals lack income from subscriptions. Some dishonest people take advantage of this model by claiming to publish valid journals while instead just trying to get authors' money. For example, these publishers of *predatory journals* may post

all the papers that they receive, without peer review or editing. Or they might take authors' money and publish nothing. Submitting papers to such journals advances neither science nor one's career.

Such journals often market themselves vigorously, filling researchers' email boxes with invitations to submit papers. How can you recognize, and thus avoid, predatory journals? Clues that a journal might be predatory include promises that seem too good to be true (for example, a guarantee to publish all submissions within a week), a website with many typographical and other errors, inclusion of what seem to be fake metrics (such as an "impact index"), and lack of good articles (or any articles at all) on the journal's website.

On the other hand, indications that a journal is likely to be valid include publication of good articles that you already have seen, indexing of the journal by major bibliographic databases, and inclusion of the journal in academic libraries. The website Think.Check.Submit. (thinkchecksubmit.org) features guidance on assessing whether a journal or publisher appears credible. Other resources in this regard include an article (Elmore and Weston 2020) listing tips and resources for identifying predatory journals. Also, if you think that a journal might be predatory, consider checking with a research librarian at your institution, as the library community has taken the lead in identifying fraudulent journals.

Especially if you are inexperienced in publishing, perhaps consult a mentor or senior colleague if you think a journal that you are considering might be predatory or otherwise questionable. In fact, in any case, such consultation can be wise before finalizing one's choice of journal.

OTHER FACTORS TO CONSIDER

In choosing a journal, other factors also can merit consideration. If you might want to post your article on a preprint server before submitting it for publication, it may behoove you to check the relevant policies of the journals that you are considering. Whereas many journals are glad to receive articles that have been posted as preprints, or even require such posting, some journals do not want such articles or have restrictions relating to preprints. It's best to know in advance.

Another factor for possible consideration is the speed of publication. Increasingly, journals have been publishing papers individually online before they appear in print or are compiled into an online issue. You may find it worthwhile to check whether a journal publishes individual articles online first and, if so, how quickly it does so.

The time from acceptance to publication in a journal issue reflects in part the frequency of the journal. For a monthly journal, the time from article submission to publication, including the time for editorial review, commonly

runs several months. Assuming equivalent review times, articles in a quarterly journal tend to take longer to publish. Remember that many journals have backlogs. It sometimes helps to ask colleagues what their experience has been with the journals you are considering. If a journal publishes “received for publication” dates, you can determine for yourself the average lag time. Some journals also post such information on their websites.

Even in this electronic age, quality of printing can be a consideration. In biology, the journals published by the American Society for Microbiology and by the Rockefeller University Press traditionally have been especially noted for their high standards in this respect. Whatever your field, look at the reproduction quality of the journal if it will be important to you.

Finally, consider the likelihood of acceptance. Clearly, not every paper is important enough and of broad enough interest to appear in *Science* or *Nature*. Rather, most papers belong in journals in their disciplines or subdisciplines. Even within specific fields, some papers are of great enough importance for publication in first-line journals, whereas many others can better find homes elsewhere. In initially submitting your paper, aim high, generally for the broadest and most prestigious journal in which your paper seems to have a realistic chance of publication. To decide on that journal, perhaps look again at candidate journals and consult colleagues. Choosing a journal that is appropriate with regard to subject matter, audience, prestige, access, selectivity, and other factors can help ensure that your paper will be published without undue delay—and that it will be read and recognized by those it should reach.

USING INSTRUCTIONS TO AUTHORS

In considering where to submit your paper, you might have looked at some journals’ instructions to authors to learn more about their scopes, audiences, or requirements. If you have not yet obtained the instructions for the journal you chose, do so before starting to write your paper. These instructions should appear on the website of the journal. In addition, instructions from more than 6,000 biomedical journals can be accessed through the website Instructions to Authors in the Health Sciences (mulford.utoledo.edu/instr). This site also includes links to sets of guidelines that many medical journals follow.

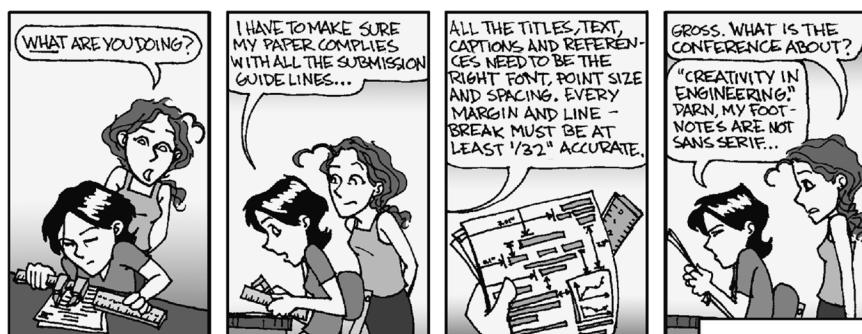
If you do not find instructions to authors immediately on a journal’s website, keep looking. Sometimes their location is not initially apparent. Also, instructions to authors can have a variety of other names, such as “information for authors,” “guide for authors,” and “submission instructions.” If, after careful searching, you still do not find the instructions, perhaps ask a more experienced researcher or a librarian for help or contact the office of the

journal. Also, if there is a true lack of instructions, that can be a clue that a journal is predatory rather than legitimate.

Read the instructions for authors thoroughly before starting to prepare your paper. Among the questions these instructions may answer are the following:

- Does the journal include more than one category of research article? If so, in what category would yours fit?
- What is the maximum length of articles? What is the maximum length of abstracts?
- Does the journal have a template for articles? If so, how can it be accessed?
- Does the journal post supplementary material online? If so, how should this material be provided?
- What sections should the article include? What guidelines should be followed for each?
- What guidelines should be followed regarding writing style?
- How many figures and tables are allowed? What requirements does the journal have for figures and tables?
- In what format should references appear? Is there a maximum number of references?
- In what electronic format should the paper be prepared? Should figures and tables be inserted within the text, or should they appear at the end or be submitted as separate files? Is there an online submission system to use?

Underline, highlight, or otherwise note key points to remember. Then consult the instructions to authors as you prepare the paper. Following the instructions from the outset will save you time overall.



(“Piled Higher and Deeper” by Jorge Cham. www.phdcomics.com)

Also, look at some recent papers in the journal—especially those presenting research analogous to yours. Viewing such examples can clarify points from the instructions to authors. It also can help you see more generally what is suitable for the journal.

Journals vary in their strictness of formatting requirements for submissions. Many journals want all submitted manuscripts to adhere closely to a specified style regarding items such as literature citation, headings and sub-headings, and tables and figures. For initial submissions, however, some other journals are flexible about such items; only if a paper is accepted for publication must the author revise it to comply in detail with the journal's format. Normally, the instructions for authors will either state the format requirements or say that the submission policy is format-neutral.

In any event, authors should know that unless the journal specifies otherwise, they should not submit manuscripts that look like typeset papers in that journal. Rather, the authors submit text and any tables and figures, and the journal does the layout.

Shortly before submitting your manuscript, check the instructions to authors again and ensure that they have been followed. If the instructions include a checklist, use it. By following the instructions carefully, you will facilitate publication of your manuscript from the time you begin to draft it.

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 somewhere else. Therefore, all the 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 of this paper 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. Over 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 1995).

Without question, most excessively long titles contain “waste” words. Often, these waste words—such as “Studies on,” “Investigations on,” and “Observations on”—appear at the start of the title. 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 this 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, Antonie van 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 matters of 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, 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 it to review. 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 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: "Babbling in a Vocal Learning Bat Resembles Human Infant Babbling" (Fernandez et al. 2021). One might object to such a title because presence of a verb (in this case, *resembles*) 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 pages (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 (example: "Studies on Bacteria. IV. Cell Wall of *Staphylococcus aureus*") was common decades ago. Today, editors generally believe that it is important, especially for the reader, that each published paper be sufficient by itself. Thus, series titles now are rare.

The hanging title (similar to a series title but with a colon instead of a roman numeral) is considerably better. Some journals, especially in the social sciences (Hartley 2007), seem to favor hanging titles, perhaps to get the most important words of the title up to the front. (Example: "Debunking Misinformation About Genetically Modified Food Safety on Social Media: Can Heuristic Cues Mitigate Biased Assimilation?" *Science Communication* 43:460, 2021). Hanging titles may sometimes aid the reader, but they may appear pedantic, emphasize the general term rather than a more significant term, require punctuation, and scramble indexes. Views also vary as to whether questions

are appropriate to include in titles, as in the example just given. Looking at titles in the journal to which you will submit your paper can help in discerning what forms of titles are acceptable to it.

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, the title “New Color Standard for Biologists” (*Bioscience* 27:762, 1977) makes us wonder whether the new standard might help in distinguishing the green biologists from the blue ones.

CHAPTER 8

How to List the Authors and Addresses

The list of authors establishes accountability as well as credit.

—National Academies Committee
on Science, Engineering,
and Public Policy

DEFINITION OF AUTHORSHIP

The list of authors should include all those, and only those, who substantially contributed to the overall conceptualization, design, execution, and interpretation of the research. It should not include those without considerable contributions—whether to please them, help advance their careers, or try to impress editors, referees, or readers. Nor should it omit those whose contributions merit authorship. In other words, as described by the Council of Science Editors (2020), there should be no *gift authors*, *guest authors*, or *ghost authors*.

Colleagues and supervisors should not ask to have their names on manuscripts reporting research with which they themselves have not been intimately involved. Nor should they allow their names to appear on such manuscripts. Some individuals listed without valid reason have come to regret their inclusion when the reported research was found deficient or even fraudulent.

Each listed author should have made an important contribution to the study being reported, with the word *important* referring to those aspects of the study that produced new information, the concept that defines an original scientific paper. Qualification for authorship should be based on contribution, not on rank or stage of education.

An author of a paper should take intellectual responsibility for the research results being reported. However, this point must be tempered by realizing that

modern science in many fields is collaborative and multidisciplinary. It may be unrealistic to assume that all authors can defend all aspects of a paper written by contributors from a variety of disciplines. Even so, authors should be held fully responsible for their choice of colleagues. In general, all those listed as authors should have been involved enough to defend the paper or a substantial aspect thereof.

Admittedly, deciding on authorship is not always easy. It is often incredibly difficult to analyze the intellectual input into a paper. Certainly, those who have worked together intensively for months or years on a research problem might have difficulty in remembering who had the original research concept or whose brilliant idea was the key to the success of the experiments. And what do these colleagues do when everything suddenly falls into place as a result of a searching question by the traditional "guy (or gal) in the next lab" who had nothing whatever to do with the research?

With the increase in collaborative research, the number of authors per paper has tended to rise. In some fields, it is not rare to see 10 or more authors listed at the head of a paper. For example, a paper by F. Bulos and others (*Phys. Rev. Letters* 13:486, 1964) had 27 authors and only 12 paragraphs. Such papers sometimes come from laboratories that are so small that 10 people couldn't fit into the lab, let alone make a meaningful contribution to the experiment.



"I DIDN'T EXACTLY WRITE THE ARTICLE, BUT...WELL, I DIDN'T EXACTLY DO THE RESEARCH, EITHER."

Occasionally, huge collaborations yield papers with hundreds of authors. A paper on fruit-fly genomics listed more than 1,000 authors (Woolston 2015), and a physics paper listed more than 5,000 (Castelvecchi 2015). (A confession: We did not count the listed authors ourselves. Nor were we cruel enough to inflict the task on a graduate student. Rather, we relied on counts reported as news items in *Nature*.)

To repeat, the scientific paper should list as authors only those who contributed substantially to the work. Unjustified listing of multiple authors adversely affects the *real* investigators and can lead to bibliographic nightmares. For more on issues relating to the definition of authorship, see Davidoff (2000), Claxton (2005), International Committee of Medical Journal Editors (2019), and Council of Science Editors (2020).

THE ORDER OF THE NAMES

"If you have co-authors, problems about authorship can range from the trivial to the catastrophic" (O'Connor 1991, p. 10).

The easiest part of preparing a scientific paper is simply entering the bylines: the authors and addresses. Sometimes.

We haven't yet heard of a duel being fought over the order of listing of authors. But there have been instances in which otherwise reasonable, rational colleagues have become bitter enemies solely because they could not agree on whose names should be listed, and in what order.

What is the right order? Unfortunately, there are no agreed-upon rules or generally accepted conventions. Some authors, perhaps to avoid arguments among themselves, agree to list their names alphabetically. In the field of mathematics, this practice appears to be common. Some pairs of researchers who repeatedly collaborate take turns being listed first. If allowed by the journal, sometimes papers include a note indicating that the first two authors contributed equally to the research.

In the past, there was a general tendency to list the head of the laboratory (or head of the research group) as an author, whether or not that person actively participated in the research. Often, the "head" was placed last (second of two authors, third of three, etc.). Therefore, the terminal spot seemed to acquire prestige. Thus, two authors, neither of whom was head of a laboratory or even necessarily a senior professor, would vie for the second spot. If there were three or more authors, the prestige-seeking author would want the first or last position, but not one in between.

Commonly, the first author is the person who played the lead role in the research. Qualification to be listed first does not depend on rank. A graduate student, or even an undergraduate, may be listed first if they led the research

project. And even Nobel laureates are not to be listed first unless their contributions predominate. Multiple authors may then be listed approximately in order of decreasing contribution to the work. In some fields, the head of the laboratory is still often listed last, in which case this position may continue to command particular respect. However, the head should be included only if they indeed at least provided guidance.

The sequence of authors on a published paper tends to be best decided unanimously before the research begins. Accordingly, upon receiving a grant, some research groups prepare a spreadsheet specifying what presentations and publications are expected to result and stating the anticipated author list for each. Changes may be required later, depending on which turn the research takes, but it is foolish to leave this important question of authorship to the end of the research process.

DEFINING THE ORDER: AN EXAMPLE

Perhaps the following example will help clarify the level of conceptual or technical involvement that should define authorship.

Suppose that Scientist A designs a series of experiments that might result in important new knowledge, and then Scientist A tells Technician B exactly how to perform the experiments. If the experiments work out and a manuscript results, Scientist A should be the sole author, even though Technician B did all the physical work. (Of course, the assistance of Technician B should be recognized in the acknowledgments.)

Now let us suppose that the experiments just described do not work out. Technician B takes the negative results to Scientist A and says something like, "I think we might get this damned strain to grow if we change the incubation temperature from 24°C to 37°C and if we add serum albumin to the medium." Scientist A agrees to a trial, and the experiments this time yield the desired outcome. Technician B also provides some important insights that contribute to the interpretation of the results. In the ensuing paper, Scientist A and Technician B, in that order, should both be listed as authors.

Let us take this example one step further. Suppose that the experiments at 37°C and with serum albumin work, but that Scientist A perceives that there is now an obvious loose end; that is, growth under these conditions suggests that the test organism is a pathogen, whereas the previously published literature had indicated that this organism was nonpathogenic. Scientist A now asks Scientist C, an expert in pathogenic microbiology, to test this organism for pathogenicity. Scientist C runs a quick test by injecting the test substance into laboratory mice, in a standard procedure that any medical microbiologist would use, and confirms pathogenicity. A few important sentences are then added to

the manuscript, and the paper is published. Scientist A and Technician B are listed as authors; the assistance of Scientist C is noted in the acknowledgments.

Suppose, however, that Scientist C gets interested in this peculiar strain and proceeds to conduct a series of well-planned experiments that lead to the conclusion that this particular strain is not just mouse-pathogenic, but is the long-sought culprit in certain rare human infections. Thus, two new tables of data are added to the manuscript, and parts of the manuscript are rewritten. The paper is then published listing Scientist A, Technician B, and Scientist C as authors. (A case could be made for listing Scientist C as the second author.)

SPECIFYING CONTRIBUTIONS

Some journals require a list of which author or authors did what—for example, who designed the research, who gathered the data, who analyzed the data, and who wrote the paper. Some journals publish this list of contributors with the paper. Others just keep it for their own information. Sometimes there are contributors who are not authors—for example, people who obtained some of the data but did not participate more broadly in the research or who provided technical or other guidance.

Listing contributions can have at least three advantages. First, it helps ensure that everyone listed as an author deserves to be listed—and that no one who ought to be listed has been left out. Second, it can help identify people to thank in the acknowledgments. And third, if the list is published, it can help readers determine which author to contact for which type of information.

Which contributions, though, should be identified? And how should those contributions be designated? A system called CRediT (for Contributor Roles

THE AUTHOR LIST: GIVING CREDIT WHERE CREDIT IS DUE

The first author
Senior grad student on the project. Made the figures.

The third author
First year student who actually did the experiments, performed the analysis and wrote the whole paper. Thinks being third author is “fair”.

The second-to-last author
Ambitious assistant professor or post-doc who instigated the paper.

Michaels, C., Lee, E. F., Sap, P. S., Nichols, S. T., Oliveira, L., Smith, B. S.

The second author
Grad student in the lab that has nothing to do with this project, but was included because he/she hung around the group meetings (usually for the food).

The middle authors
Author names nobody really reads. Reserved for undergrads and technical staff.

The last author
The head honcho. Hasn’t even read the paper but, hey, he got the funding, and his famous name will get the paper accepted.

(“Piled Higher and Deeper” by Jorge Cham. www.phdcomics.com)

Taxonomy) now exists. The CRediT website, at credit.niso.org, lists and defines 14 roles that authors and other contributors may have. Many publishers now require the use of these categories. Whether or not your paper is for a journal that uses CRediT, the list can be a useful resource.

PROPER AND CONSISTENT FORM

As to names of authors, the preferred designation for English-language names normally is given name, middle initial, surname (if an author indeed has a middle initial). If an author uses only initials, which has been a regrettable tendency in science, the scientific literature may become confused.

If there are two people named Janet B. Jones, the literature services can probably keep them straight (by their addresses). But if dozens of people published under the name J. B. Jones (especially if, on occasion, some of them use Janet B. Jones), the retrieval services have a hopeless task in keeping things neat and tidy. Many scientists decide not to change their names (for example, after marriage), at least in part to avoid confusion in the literature.

Instead of given name, middle initial, and surname, wouldn't it be better to spell out the middle name? No. Again, we must realize that literature retrieval is a computerized process, and computers can be easily confused. An author with a common name (for example, Robert Jones) might be tempted to spell out his or her middle name, thinking that Robert Smith Jones is more distinctive than Robert S. Jones. However, the resulting double name is a problem. Should the computer index the author as "Jones" or "Smith Jones"? Because double names, with or without hyphens, are common, especially in England and in Latin America, this problem is not an easy one for computers (or for their programmers).

Knowing how to list one's name on an English-language scientific paper can be difficult for international authors, as different languages have different formats for names and more than one form of transliteration can exist. For authors with Chinese names, an article by Sun and Zhou (2002) offers recommendations. And for authors of a variety of national origins, style manuals can provide guidance, as can editors at journals. Whatever format a scientist chooses, they should use it consistently in English-language scientific papers—rather than, for example, using Shou-Chu Qian on some papers, Shouchu Qian on others, and S. Chien on still others.

In general, scientific journals do not print degrees after authors' names and do not include titles such as Dr. (You may know what "B.S." means. "M.S." is "More of the Same." "Ph.D." is "Piled Higher and Deeper." "M.D." is "Much Deeper.") However, most medical journals do list degrees after the names. Even in medical journals, however, degrees are not given in the references. Contributors should consult the journal's instructions to authors or a recent issue regarding preferred usage.

SOLUTIONS: ORCID AND MORE

Even when best practices for listing names are followed, authors can be difficult to distinguish from one another—for example, if two or more in the same field have the same name. Listing authors’ institutions can help in distinguishing scientists with the same name. But sometimes scientists with the same name work at the same institution. Also, some scientists move from one institution to another or do not state their names the same way on all their papers over the years, and so their work is hard to track. Fortunately, a mechanism now exists to unambiguously identify each author.

This mechanism is ORCID, which stands for “Open Researcher and Contributor ID.” An ORCID identifier is a persistent identification number that you can obtain and include with your research communications. When you apply at the ORCID website, you receive a unique identification number and establish an ORCID record online. You can then associate this number with your journal articles, grant proposals, and other writings, both in the future and retroactively. Many journals and funding sources now ask authors to supply their ORCID identifiers. Information about the ORCID initiative and a link through which to obtain an ORCID identifier appear at orcid.org.

Granted, ORCID doesn’t solve the “yes, that’s the same author” dilemma in all regards. For example, if you saw the name Barbara J. Vogel and the ORCID ID 0000-0003-0804-2953, would you realize that the person is Barbara Gastel unless you knew that she is married to Tom Vogel? ORCID can, however, greatly assist those taking the initiative to check authors’ identities.

Sometimes scientists who change their names want their new names to replace their old ones on previously published work. Accordingly, journal publishers have increasingly been adopting policies that allow retroactive name changes on digital editions of papers and other publications. The impetus for this option came from a group of transgender scientists. Sometimes the option also exists for other authors, such as those who change their names for marital or religious reasons and wish all their work to appear under their new names (DePaul 2021). Policies and procedures regarding name changes in the literature have been evolving. Authors considering seeking such changes should consult resources such as publishers’ websites for the latest information.

LISTING AFFILIATIONS AND ADDRESSES

Listing authors’ affiliations and addresses serves two purposes. It helps to identify the authors. It also indicates how to contact them. Because scientists now communicate largely by email, an email address generally should be included at least for the author to whom inquiries about the paper should be conveyed. Some journals use asterisks, footnotes, or the acknowledgments to

identify this person. Authors should be aware of journal policy in this regard, and they should decide *in advance* which author will serve in this role.

Scientific papers often have multiple authors, from multiple institutions or departments. For example, there may be seven authors, from a total of three institutions. In such instances, each author's name and address should include an appropriate designation, such as a superscript *a*, *b*, or *c* after the author's name and alongside the appropriate affiliation. (Sometimes a journal may just request the affiliation of each author and then do the formatting itself. In this regard, as in others regarding affiliations and addresses, follow the instructions to authors from that particular journal.)

Sometimes graduate students, postdoctoral fellows, or others do research at one institution and then move to another. In such situations, researchers may wonder: Which one should I list? You should list the institution where the research was done. Your new information should then appear in a "present address" footnote.

The author who should receive inquiries about the paper is called the *corresponding author*. Journals ask that a corresponding author be designated for each paper. The corresponding author typically submits the paper, receives the editor's decision whether to publish it, submits revisions, works with the editorial office after acceptance (for example, by answering questions from the manuscript editor and checking page proofs), and responds to inquiries from readers. The corresponding author should be someone who expects to be readily reachable during and after publication. Opinions vary as to whether being a corresponding author is an honor or just a task.

Unless scientists wish to publish anonymously (or as close to it as possible), they should devote appropriate care to presenting their names, affiliations, and contact information.

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 it goes with. The abstract should provide a *brief* summary of each of the main sections of the paper: introduction, 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 in a 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

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 2015 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.

(4) state the principal conclusions. Most or all of the abstract should be written in the past tense because it refers to work already done.

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

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 2015 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 then often appear without change in the secondary services (Chemical Abstracts, etc.). This type of abstract is called an *informative abstract*, and it is designed to condense the paper. It should briefly state the problem, the method used to study the problem, and the principal data and conclusions.

Often, scientists skim multiple abstracts to help keep up with 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 type of abstract 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. 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 can be 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 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.”

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.

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

CLARITY AND CONCISENESS

Occasionally, a scientist omits something important from the abstract. By far, the more common faults, though, are ambiguous wording and inclusion of extraneous detail.

An abstract normally appears before the main text of the paper. Thus, during the review process, it generally is the first part that editors and reviewers encounter. (Indeed, editors often rely on it to identify main content and thus choose suitable reviewers.) Therefore, it is crucial that the abstract be written clearly and simply. If you cannot make a good and accurate impression in your abstract, your cause may be lost. Usually, a good abstract is followed by a good paper; a poor abstract is a harbinger of woes to come.

Most journals require abstracts. Likewise, conferences commonly require an abstract to accompany each presentation; often, the choice of presentations to include in a conference is based on abstracts of the proposed presentations. Therefore, scientists should master the basics 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.

In rough-drafting an abstract, though, do not be paralyzed by the need to be brief. Initially, just try to express your ideas. Then, if the abstract is too long and wordy, go back and condense it. For example, in the fictional abstract in Figure 9.1, the first sentence might initially have read "Individuals in the sciences must do a considerable amount of writing in order to be successful in their careers, but a relatively small proportion have received any formal education in how to write about science" (35 words). After condensation, it reads, "Scientists must write to succeed, but few receive training in scientific writing" (12 words).

Here's an example of an especially brief abstract, which accompanied a paper by M. V. Berry and colleagues published in 2011 (*J. Phys. A: Math. Theor.* 44:492001). 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.

KEYWORDS

Some journals require authors to provide *keywords* (terms indicating the content of the article, much as those in an index would). Keywords can help readers find articles on desired topics. Generally, several keywords are provided. Some journals specify lists of terms from which keywords should be taken. Also, some journals say that keywords should be terms other than those in the title, which already would be available to indexers and search engines. In a published article, the keywords normally appear below the abstract. Looking at keywords of articles on work similar to one's own, and identifying major terms in the abstract of your own article, can aid you in providing suitable keywords.

VISUAL VARIETIES

Traditionally, abstracts of journal articles have consisted only of text. Increasingly, though, journals have been letting authors include a graphic in or with an abstract or have been publishing or posting visual versions of abstracts. For example, American Chemical Society journals require those publishing each paper to submit a graphic that will appear in the abstract and table of contents (ACS Publications 2020). Some other journals in various fields now include visual summaries, commonly called *visual abstracts* or *graphical abstracts*, for at least some articles. Sometimes the journal prepares this visual summary;

commonly, the authors provide it. Visual abstracts often have a one-panel format (see, for example, www.cell.com/pb/assets/raw/shared/figureguidelines/GA_guide.pdf) or a three-panel format (see, for example, www.cdc.gov/pcd/for_authors/visual_abstracts.htm).

Various resources (such as Aoki n.d.; Elsevier 2021; Ibrahim 2018) offer guidance on preparing visual abstracts. Points to remember include the following:

- Obtain (and follow) any instructions from the specific journal regarding items such as dimensions, typeface, image resolution, and file type. Also, look at examples in the journal. See whether the journal has a template to use for visual abstracts.
- Consider enlisting assistance from a scientific illustrator or other visual-communication expert. Many universities and research institutions have such individuals available.
- Think about your audience. Define, and focus on, your main message to that audience.
- Plan before you draft. Try to tell a story. Structure the visual abstract in an easy-to-follow way—for example, to be read from left to right or from top to bottom. Maybe break the visual abstract into sections or use arrows to guide readers.
- Be concise, with uncluttered images and minimal words (far fewer than in a regular abstract). Perhaps use icons or the like. Incorporate enough white space.
- Use color effectively. For example, show related items in the same color or use color to draw attention to key items.
- Revise, revise, revise. Get feedback, and revise some more.

In short, whether you are preparing a textual abstract or a visual one, be focused, well organized, clear, and concise. You will then represent your work effectively and serve readers well.

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 the 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 can best determine 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 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. Starting to write early also helps ensure that your coauthors still will be readily available to consult.

The first section of the text proper should, of course, be the introduction. The main 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 the 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 direct readers toward 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 beginners. 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 readers labor through your paper, which is unlikely if you haven’t presented the problem in a meaningful way, they will be unimpressed with the brilliance of your solution. In a sense, a scientific paper is like journalism: In the introduction, you should have a “hook” (a lead) to gain the reader’s attention. Why did you choose *that* subject, and why is it *important*?

Structure of the Introduction

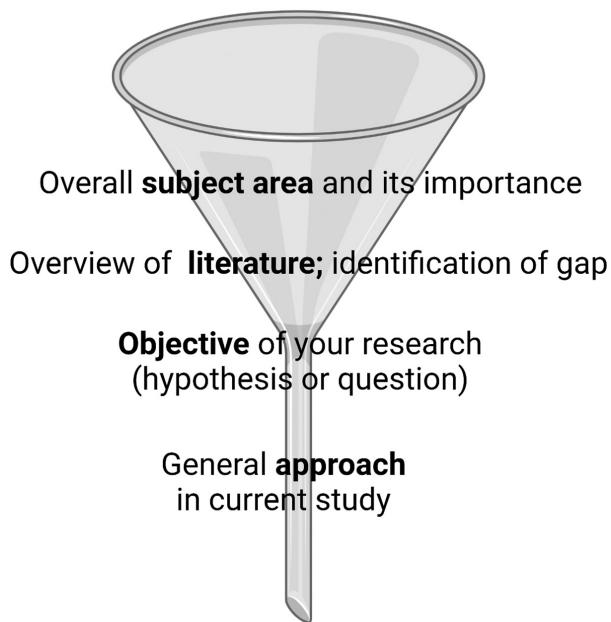


Figure 10.1. (Created with BioRender.com)

The second, third, and fourth guidelines relate to the first. The literature review, specification of objectives, and identification of method should be presented in such a way that the readers 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 readers in suspense; let them follow the development of the evidence. A surprise ending like that in an O. Henry short story 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 sometimes have 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 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 (see Figure 10.2). This map is so important that a bit of redundancy with the abstract is often desirable.

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 conferences³⁻⁵ have taken a course in scientific writing. Even when briefer forms of instruction, such as workshops, are included, only about 25 percent of US scientists have received formal instruction in scientific writing¹. Discussions at a recent roundtable⁶ suggest that the figure tends to be lower in other countries.

Further, relatively little information exists regarding the effectiveness of such instruction. One study⁷ 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 study⁸ 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 study⁹ 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 10.2. 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.

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.

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 what 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.”

CHAPTER 11

How to Write the Materials and Methods Section

The greatest invention of the nineteenth century was the invention of the method of invention.

—A. N. Whitehead

PURPOSE OF THE SECTION

In the first section of the paper, the introduction, you should have stated the methodology employed in the study. If necessary, you also defended the reasons for your choice of a particular method over competing methods.

Now, in “Materials and Methods” (also designated in some cases by other names, such as “Experimental Procedures” or just “Methods”), you must give the full details. Most of this section should be written in the past tense because it reports actions already completed. Do not fall prey to the graduate student error of cutting and pasting from a thesis proposal without changing the tense.

The main purpose of the materials and methods section is to describe (and if necessary, defend) the experimental design, and then provide enough detail so that a competent worker can repeat the experiments. Other purposes include providing information that will let readers judge the appropriateness of the experimental methods (and thus the probable validity of the findings) and assess the extent to which the results can be generalized. Many (perhaps most) readers of your paper will skip or just skim this section because they already know from the introduction the general methods you used, and they probably have no interest in the experimental details. However, careful writing of this section is critical because the cornerstone of the scientific method requires that, to be of scientific merit, your results are reproducible—and, for



(www.CartoonStock.com)

the results to be adjudged reproducible, you must provide the basis for repetition of the experiments by others. That experiments are unlikely to be reproduced is beside the point; the potential for reproducing the same or similar results must exist, or else your paper does not represent good science.

When your paper is subjected to peer review, a good reviewer will read the materials and methods section carefully. If there is any serious doubt that your experiments could be repeated, the reviewer will recommend rejection of your manuscript or provision of more detail, no matter how awe-inspiring your results.

MATERIALS

For materials, include the exact technical specifications, quantities, and source or method of preparation. Sometimes it is even necessary to list pertinent chemical and physical properties of the reagents used. In general, avoid the use of trade names; the use of generic or chemical names is usually preferred. This approach avoids the advertising inherent in the trade name. Besides, the nonproprietary name is likely to be known throughout the world, whereas the

proprietary name may be known only in the country of origin. However, if there are known differences among proprietary products, and if these differences might be critical, then using the trade name, plus the name of the manufacturer, is essential. When using trade names, which are usually registered trademarks, capitalize them (*Teflon*, for example) to distinguish them from generic names. Normally, the generic description should immediately follow the trademark; for example, one would refer to *Kleenex* facial tissues. In general, it is not necessary to include trademark symbols (such as ® and ™). However, some journals ask authors to do so.

Experimental animals, plants, and microorganisms should be identified accurately, usually by genus, species, and strain designations. Sources should be listed and special characteristics (age, sex, and genetic and physiological status) described. If human subjects were used, the criteria for selection should be described, and an “informed consent” statement should be included in the manuscript. Likewise, if human or animal subjects were used, approval by the appropriate committee (such as an institutional review board in the former case or an institutional animal care and use committee in the latter) should be noted.

Because the value of your paper (and your reputation) can be damaged if your results are not reproducible, you must describe research materials with great care. Examine the instructions to authors of the journal to which you plan to submit the manuscript because important specifics are often detailed there. Also, look at examples of methods sections in the journal, as journals differ among themselves in the amount of detail provided about materials and methods and in the structuring of the section.

METHODS

For methods, the usual order of presentation is chronological. However, related methods should be described together, and straight chronological order cannot always be followed. For example, even if a particular assay was not done until late in the research, the assay method should be described along with the other assay methods, not by itself in a later part of the materials and methods section. Also, sometimes it is helpful to begin the methods section with a general overview of the experimental design.

HEADINGS

The materials and methods section often has subheadings. To see whether subheadings would indeed be suitable—and, if so, what types are likely to be appropriate—look at analogous papers in your target journal. When possible, construct subheadings that match those to be used in the results section. The

writing of both sections will be easier if you strive for internal consistency, and the reader will be able to grasp quickly the relationship of a particular method to the related results.

MEASUREMENTS AND ANALYSIS

Be precise. Methods are similar to cookbook recipes. If a reaction mixture was heated, give the temperature. Questions such as "How?" and "How much?" should be precisely answered by the author and not left for the reviewer or the reader to puzzle over.

Statistical analyses are often necessary, but your paper should emphasize the data, not the statistics. Generally, a lengthy description of statistical methods indicates that the writer has recently acquired this information and believes that the readers need similar enlightenment. Ordinary statistical methods generally should be used without comment; advanced or unusual methods may require a literature citation. In some fields, statistical methods and statistical software customarily are identified at the end of the materials and methods section.

And again, be careful of your syntax. A manuscript described what could be called a disappearing method. The author stated, "The radioactivity in the tRNA region was determined by the trichloroacetic acid-soluble method of Britten et al." And then there is the painful method: "After standing in boiling water for an hour, examine the flask."

NEED FOR REFERENCES

In describing the methods of the investigations, you should give (or direct readers to) sufficient details so that a competent worker could repeat the experiments. If your method is new (unpublished), you must provide *all* of the needed detail. (Indeed, if the method is a substantial advance, you may find it worthwhile to publish and cite a separate paper about it.) If the method has been published in a journal, however, the literature reference should be given. For a method well known to readers, only the literature reference is needed. For a method with which readers might not be familiar, a few words of description tend to be worth adding, especially if the paper in which the method was described might not be readily accessible.

If several alternative methods are commonly employed, it is useful to identify your method briefly, as well as to cite the reference. For example, it is better to state, "Cells were broken by ultrasonic treatment as previously described (9)" rather than "Cells were broken as previously described (9)."

TABLES AND FIGURES

Tables and figures can aid in presenting materials and methods clearly and concisely.

For example, if many microbial strains or mutants have been used in a study, prepare strain tables identifying the source and properties of mutants, bacteriophages, plasmids, and other materials. Likewise, the properties of multiple chemical compounds or the experimental conditions for different groups in a study can be presented in tabular form, often benefiting both the author and the reader.

Figures also can aid in presenting methods. Examples include flowcharts of experimental protocols, diagrams of experimental apparatus, and maps of study locations. Such items can help readers understand your methods at a glance.

CORRECT FORM AND GRAMMAR

Do *not* make the common error of including some of the results in this section. There is only one rule for a properly written materials and methods section: Enough information must be given so that the experiments could be reproduced by a competent colleague.

A good test (and a good way to avoid rejection of your paper), is to give a copy of your finished manuscript to a colleague and ask whether they can follow the methodology. In reading about your materials and methods, your colleague might well notice an error that you missed simply because you were too close to the work. For example, you might have described your distillation apparatus, procedure, and products with infinite care—but then neglected to define the starting material or to state the distillation temperature.

Mistakes in grammar and punctuation are not always serious; the meaning of general concepts, as expressed in the introduction and discussion, can often survive a bit of linguistic mayhem. In materials and methods, however, exact and specific items are being dealt with, and precise use of English is a must. Even a missing comma can cause havoc, as in this sentence: “Employing a straight platinum wire rabbit, sheep, and human blood agar plates were inoculated. . . .” That sentence was in trouble right from the start because the first word is a dangling participle. Comprehension was not totally lost, however, until the author neglected to put a comma after “wire.”

Authors often are advised, quite rightly, to minimize the use of passive voice. However, in the materials and methods section—as in the current paragraph—passive voice often can validly be used, for although what was done must be specified, who did it is often irrelevant. Thus, you may write, for

example, “Mice were injected with . . .” rather than “I injected the mice with . . .,” “A technician injected the mice with . . .,” or “A student injected the mice with. . . .” Alternatively, you may say, “We injected . . .,” even if a single member of the team did that part of the work. (Although the belief persists that journals prohibit use of first person, many journals permit and even encourage use of “I” and “we.”)

Because the materials and methods section usually gives short, discrete bits of information, the writing sometimes becomes too condensed, with details essential to the meaning omitted. The most common error is to state the action without, when necessary, stating the agent of the action. In the sentence “To determine its respiratory quotient, the organism was . . .” the only stated agent of the action is “the organism,” and we doubt that the organism was capable of making such a determination. Here is a similar sentence: “Having completed the study, the bacteria were of no further interest.” Again, we doubt that the bacteria “completed the study”; if they did, their lack of “further interest” was certainly an act of ingratitude.

“Blood samples were taken from 48 informed and consenting patients . . . the subjects ranged in age from 6 months to 22 years” (*Pediatr. Res.* 6:26, 1972). There is no grammatical problem with that sentence, but the lack of detail leaves the reader wondering just how the 6-month-old infants gave informed consent.

And, of course, always watch for spelling errors, both in the manuscript and in the proofs. We are not astronomers, but we suspect that a word is misspelled in the following sentence: “We rely on theatrical calculations to give the lifetime of a star on the main sequence” (*Annu. Rev. Astron. Astrophys.* 1:100, 1963). Although they might have been done with a flourish, presumably the calculations were theoretical, not theatrical.

Be aware that a spell-checker can introduce such errors and therefore cannot substitute for careful proofreading. One recent example: A spell-checker converted “pacemakers in dogs” to “peacemakers in dogs.” We have known some dogs that could benefit from peacemakers, but we rightly suspected that this wording was not intended in writing about canine cardiology.

CHAPTER 12

How to Write the Results

Results! Why, man, I have gotten a lot of results. I know several thousand things that won't work.

—Thomas A. Edison

CONTENT OF THE RESULTS

So now we come to the core of a paper—the data. This part of the paper is called the *results section*.

Contrary to popular belief, you shouldn't start the results section by describing methods that you inadvertently omitted from the materials and methods section. The results section usually has two ingredients. First, you should give some kind of overall description of the experiments, providing the big picture without repeating the experimental details previously provided in materials and methods. Second, you should present the data. Your results should be presented in the past tense. (See the section “Tense in Scientific Writing” in Chapter 30.)

Of course, it isn't quite that easy. How do you present the data? A simple transfer of data from laboratory notebook to manuscript will hardly do.

As elsewhere in a scientific paper, good organization is crucial. Chronological organization often works well. So does topic-by-topic organization, with headings parallel to those in the methods section (if any). Another option is to present the most important results first, followed by results of decreasing importance. In some fields, and for some types of studies, conventions exist as to which types of results to present in which order. Consult any guidelines from the journal or elsewhere, perhaps see how results were reported in articles on research similar to yours, and consider in what order you could most logically present your results.

Importantly, in the manuscript you should present representative data rather than endlessly repetitive data. The fact that you could perform the same experiment 100 times without significant divergence in results might be of considerable interest to your professor, but editors, not to mention readers, prefer a little bit of predigestion. Aaronson (1977, p. 10) said it another way: "The compulsion to include everything, leaving nothing out, does not prove that one has unlimited information; it proves that one lacks discrimination." Exactly the same concept, and it is an important one, was stated almost a century earlier by John Wesley Powell, a geologist who served as president of the American Association for the Advancement of Science in 1888. In Powell's words: "The fool collects facts; the wise man selects them."

HOW TO HANDLE NUMBERS

If one determination or only a few determinations are to be presented, the determination(s) should be reported in the text. Repetitive determinations should be given in tables or graphs.

Any determinations, repetitive or otherwise, should be meaningful. Suppose that in a particular group of experiments, a number of variables were tested (one at a time, of course). Those variables that affect the reaction become determinations or data, and if extensive, they are tabulated or graphed. Those variables that do not seem to affect the reaction need not be tabulated or presented; however, it is often important to note even the negative aspects of your experiments. Knowing what did *not* occur can be as important as knowing what did.

If statistics are used to describe the results, they should be meaningful. A prominent journal editor told of a paper that reputedly read: "33 1/3% of the mice used in this experiment were cured by the test drug; 33 1/3% of the test population were unaffected by the drug and remained in a moribund condition; the third mouse got away."

Beware of including overly many decimal places when reporting percentages. If 17 of 59 squirrels showed a given response, it is not meaningful to say that 28.8136% percent of squirrels did so; saying 29% would be more appropriate. Just because your calculator can show it doesn't mean you should say it.

STRIVE FOR CLARITY

The results should be short and sweet, without verbiage. Mitchell (1968) quoted Einstein as having said, "If you are out to describe the truth, leave elegance to the tailor." Although the results section is the most important part of the paper,

it is often the shortest, particularly if it is preceded by a well-written materials and methods section and followed by a well-written discussion.

The results need to be clearly and simply stated because it is the results that constitute the new knowledge that you are contributing to the world. The earlier parts of the paper (introduction and materials and methods) are designed to tell why and how you got the results; the later part of the paper (discussion) is designed to tell what they mean. Obviously, therefore, the whole paper must stand or fall on the basis of the results. Thus, the results must be presented with crystal clarity.

AVOID REDUNDANCY

Do not be guilty of redundancy in the results. The most common fault is the repetition in words of what is already apparent to the reader from examining the figures and tables. Even worse is the actual presentation, in the text, of all or many of the data shown in the tables or figures. This grave sin is committed so frequently that it is commented on at length, with examples, in the chapters on how to prepare tables and illustrations (Chapters 16 and 17).

Do not be verbose in citing figures and tables. Do not say, "It is clearly shown in Table 1 that nocillin inhibited the growth of *N. gonorrhoeae*." Say, "Nocillin inhibited the growth of *N. gonorrhoeae* (Table 1)." The latter format has multiple benefits. Because it is briefer, it helps authors comply with journals' word limits. It also is more readable. Further, it directs attention to what is most important: the findings, not the table or figure.

Some writers go too far in avoiding verbiage, however. In particular, they often fail to provide clear antecedents for the pronoun "it." Here is an item from a medical manuscript: "The left leg became numb at times and she walked it off. . . . On her second day, the knee was better, and on the third day it had completely disappeared." In both instances, the antecedent of "it" is presumably "the numbness," but the wording seems a result of dumbness.

A SUPPLEMENT ON SUPPLEMENTARY MATERIAL ONLINE

Increasingly, journals are electronically posting material that is supplementary to papers being published. Although sometimes this material is about methods, most commonly it provides information about the results. For example, additional data may be posted, or additional tables and figures may be provided online. Whether authors may submit such supplementary material, and if so how, varies among journals. Also, norms regarding what

supplementary materials to provide online vary among research fields. If you think that providing supplementary material for online posting would be desirable, consult the instructions to authors given by your target journal. If possible, also see what papers analogous to yours have done in this regard. Keep in mind, too, that the journal editor may ask you to place some of your material in an online supplement.

CHAPTER 13

How to Write the Discussion

Free and fair discussion will ever be found the firmest friend to truth.

—George Campbell

DISCUSSION AND VERBIAGE

The discussion is harder to define than the other sections. Thus, it is usually the hardest section to write. And, whether you know it or not, *many* papers are rejected by journal editors because of a faulty discussion, even though the data of the paper might be both valid and interesting. Even more likely, the true meaning of the data may be obscured by the interpretation presented in the discussion, again resulting in rejection.

Many, if not most, discussion sections are too long and verbose. As Doug Savile said, “Occasionally, I recognize what I call the squid technique: the author is doubtful about his facts or his reasoning and retreats behind a protective cloud of ink” (*Tableau*, September 1972). Another reason some discussions are long and hard to follow is that many authors think they must avoid using the first person. If you mean “I found that . . .” or “We conclude that . . .,” say so. Try to avoid wordier, and sometimes more ambiguous, constructions such as “It was found in the present investigation that . . .” and “It is concluded that . . .”

Some discussion sections remind one of the diplomat, described by Allen Drury in *Advise and Consent* (Garden City, NY: Doubleday, 1959, p. 47), who characteristically gave “answers which go winding and winding off through the interstices of the English language until they finally go shimmering away altogether and there is nothing left but utter confusion and a polite smile.”

COMPONENTS OF THE DISCUSSION

What are the essential features of a good discussion? The following advice will help ensure that all main components are present:

- Try to present the principles, relationships, and generalizations shown by the results. And bear in mind that in a good discussion, you *discuss*—you do not *recapitulate*—the results.
- Point out, and reflect on, any exceptions or any lack of correlation and define unsettled points. Never take the high-risk alternative of trying to cover up or fudge data that do not quite fit into your paper.
- Show how your results and interpretations agree (or contrast) with previously published work. Consider reasons for discrepancies.
- Don’t be shy; discuss the theoretical implications of your work, as well as possible practical applications.
- State your conclusions as clearly as possible.
- Summarize your evidence for each conclusion. Or, as the wise old scientist will tell you, “Never assume anything except a low-interest mortgage.”

Much as the methods and the results should correspond to each other, the introduction and the discussion should function as a pair. At least implicitly, the introduction should have posed one or more questions. The discussion should indicate what the findings say about the answers. The failure to address the initial questions commonly afflicts discussions. Be sure that the discussion answers what the introduction asked.

Whereas the content of the introduction commonly moves from the general topic to your specific research, in sort of a funnel format, the discussion tends to do largely the reverse, much like an inverted funnel (Figure 13.1). For example, a well-structured discussion may first restate the main findings, then discuss how they relate to findings of previous research, then note the implications and applications, then identify limitations of the current study, and perhaps finally identify unanswered questions well suited for future research. In the introduction, you invited readers into your research venue; in the discussion, you usher them out, now well informed about your research and its meaning.

NOTING STRENGTHS AND LIMITATIONS

The discussion is a place to note substantial strengths and limitations of the research being reported. Some authors feel awkward about including such content. However, doing so can aid readers, and it can make the case to editors and referees (peer reviewers) that your work is publishable.

Structure of the Discussion



Figure 13.1. (Created with BioRender.com)

Some authors consider it immodest to note the strengths of their work—for example, superior experimental techniques, a large sample size, or long follow-up. However, such information can aid readers in determining how definitive the findings are.

What if the research has significant limitations—such as difficulties with a technique, a relatively small sample size, or relatively short follow-up? Some authors might try to hide such limitations. However, doing so runs counter to the openness that should characterize science. And astute reviewers, editors, or readers might well notice the limitations anyway—and assume, either to themselves or in writing, that you were too naive to notice them. It is better, therefore, to identify limitations yourself. In doing so, you may be able to discuss what impact, if any, the limitations are likely to have on the conclusions that can be drawn.

Not every discussion needs to discuss strengths or limitations of the research. However, if a study has strengths or limitations major enough to be worthy of note, consider addressing them in the discussion.

SIGNIFICANCE OF THE PAPER

Too often, the *significance* of the results is not discussed or not discussed adequately. If readers of the paper finds themselves asking “So what?” after reading the discussion, the chances are that the authors became so engrossed with

the trees (the data) that they didn't really notice how much sunshine had appeared in the forest.

The discussion should end with a short summary or conclusion regarding the significance of the work. We like the way Anderson and Thistle (1947) said it: "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." Or, in the words of T. S. Eliot, many scientific papers end "Not with a bang but a whimper."

CONCLUSIONS

Some journals require or allow papers to end with a conclusions section rather than providing conclusions at the end of the discussion. Such a section (or the conclusion of a discussion) commonly consists of a single paragraph recapping what was done, then what was found, and finally what the findings imply. Although a conclusions paragraph appears last, some readers read it first. Whenever they read it, they should easily come away with the paper's take-home message.

Speaking of reading the conclusions first: In writing or revising your scientific paper, be aware that, quite likely, the sections will be read in different orders by different people or in different circumstances. (Have you ever jumped straight to the methods section? Begun by looking at the tables and figures? Or maybe started by skimming the discussion?) Each part should therefore be clear in and of itself. Such clarity can require some redundancy from part to part. But it can help greatly in communicating your research to readers—which, after all, is why you are writing and publishing a scientific paper.

DEFINING SCIENTIFIC TRUTH

In showing the relationships among observed facts, you do not need to reach cosmic conclusions. Seldom will you be able to illuminate the whole truth; more often, the best you can do is shine a spotlight on one area of the truth. Your one area of truth can be illuminated by your data; if you extrapolate to a bigger picture than that shown by your data, you may appear foolish to the point that even your data-supported conclusions are cast into doubt.

One of the more meaningful thoughts in poetry was expressed by Sir Richard Burton in *The Kasidah*:

All Faith is false, all Faith is true;
Truth is the shattered mirror strown
In myriad bits; while each believes
His little bit the whole to own.

So exhibit your little piece of the mirror, or shine a spotlight on one area of the truth. The “whole truth” is a subject best left to the ignoramuses, who loudly proclaim its discovery every day.

When you describe the meaning of your little bit of truth, do it simply. The simplest statements evoke the most wisdom; verbose language and fancy technical words are used to convey shallow thought.

CHAPTER 14

How to State the Acknowledgments

Life is not so short but that there is always time enough for courtesy.

—Ralph Waldo Emerson

INGREDIENTS OF THE ACKNOWLEDGMENTS

The main text of a scientific paper is usually followed by two additional sections—namely, the acknowledgments and the references.

As to the acknowledgments, two possible ingredients require consideration.

First, you should acknowledge any significant technical help you received from individuals in your research group or elsewhere. These individuals may include both fellow scientists (and scientists-in-training) and others who helped with your research and its reporting—for example, librarians, statisticians, and any editors who refined your paper before submission. (The listed individuals, however, should be only those providing professional assistance. Unlike in a thesis or book, you should not acknowledge the support of your family, friends, or pets.) You should also acknowledge the source of special equipment, cultures, or other materials.

Second, it is commonly in the acknowledgments that you should note any outside financial assistance, such as grants, contracts, or fellowships. (In this time of scarce funding, we can be especially appreciative of such support.)

An acknowledgments section might include, for example, a statement such as “We thank J. Gomez for assistance with the experiments and R. Liao for valuable discussion.” (Of course, most of us who have been around for a while recognize that this is simply a thinly veiled way of admitting that Gomez did the work and Liao explained what it meant.)

Acknowledgments

What you write:

“Thanks to the editor and the referees for their exceptionally helpful comments during the review process.”

“Thanks to the person in our research group with whom we had long conversations regarding the subject of this paper.”

“Thanks to the Grant Funding Agency for supporting this work. This work was supported under grant N00014-98-7994.”

“Thanks to certain Professors in other Institutions for their insight and helpful feedback provided at Conference discussions.”

“Thanks to our collaborators who provided the data used in this work.”

What you actually want to say:

“Thank you for your endless requests and revisions that sucked the life out of a poor Ph.D. student.”

“Thank you for helping us come up with the critical idea that helped solve our problem but you don’t get authorship credit.”

“None of the money was actually used for this paper but we needed to say this in order to get more \$\$ from them.”

“Your comments were not helpful, but I’m writing this in case any of you happen to be reviewing this paper.”

“Actually, we really do want to thank them. They saved us a TON of work! (But they still don’t get authorship credit).”

(“Piled Higher and Deeper” by Jorge Cham. www.phdcomics.com)

BEING COURTEOUS

As well as providing transparency, acknowledgments show courtesy. There isn’t anything really scientific about this section of a scientific paper. The same rules that would apply in any other area of civilized life should apply here. If you borrowed a neighbor’s lawn mower, you would (we hope) remember to express thanks for it. If your neighbor gave you a really good idea for landscaping your property and you then put that idea into effect, you would (we hope) remember to say thank you. It is the same in science; if your neighbor (your colleague) provided important ideas, important supplies, or important equipment, you should thank him or her. And you must say thanks *in print*, because that is how scientific landscaping is presented to its public.

A word of caution is in order. Before mentioning someone in an acknowledgment, obtain permission to do so. Often, it is wise to show the proposed wording to the person whose help you are acknowledging. State specifically what is being acknowledged, lest the person seem to be endorsing the entire paper.

We wish that the word *wish* would disappear from acknowledgments. *Wish* is a perfectly good word when you mean *wish*, as in “I wish you success.” However, if you say, “I wish to thank John Jones,” you are wasting words. You may also be introducing the implication that “I wish that I could thank John Jones for his help, but it wasn’t all that helpful.” “I thank John Jones” is sufficient.

CHAPTER 15

How to Cite the References

Manuscripts containing innumerable references are more likely a sign of insecurity than a mark of scholarship.

—William C. Roberts

RULES TO FOLLOW

There are two rules to follow in the references section, just as in the acknowledgments section.

First, list only, or almost only, significant published references. References to unpublished data, abstracts, theses, and other secondary materials should not clutter up the references or literature-cited section. If such a reference seems essential, you may add it parenthetically or, in some journals, as a footnote in the text. A paper that has been accepted for publication can be listed in the literature cited, citing the name of the journal, followed by “in press” or “forthcoming.” Increasingly, journals have been allowing preprints to be cited. If, however, a published version of the paper exists, it should be cited instead.

Second, ensure that all parts of every reference are accurate. Doing so may entail checking every reference against the original publication before the manuscript is submitted, and perhaps again at the proof stage. Take it from an erstwhile librarian: There are far more mistakes in the references section of a paper than anywhere else.

Authors sometimes ask whether they can cite their own work. The answer: Yes, *when relevant*. Do not cite your own work, or that of friends and colleagues, to inflate your or others’ citation counts or egos. However, if the work is

relevant, it should indeed be cited. A good guideline is as follows: If you would cite the paper if it had other authors, cite it; otherwise, don't. Whether to cite a paper should be based on what the paper said, not who said it.

Don't forget, as a final check, to ensure that all references cited in the text are indeed listed in the literature cited, and that all references listed in the literature cited are indeed cited somewhere in the text.

CHECKING AGAINST THE ORIGINAL

Some authors (certainly not you) may be tempted to state a fact referenced in another paper and copy the bibliographic reference without looking at the source originally cited. Beware of doing so. Sometimes authors have inaccurately stated what the original source said. And sometimes references contain errors. Thus, such copying has perpetuated errors in the literature. Obtain the original source, check its content, and note the correct bibliographic information.

What if the paper you want isn't immediately accessible online? If you have access to an academic or other library, it may well have the journal of interest. Even if the library lacks the journal, quite likely it can obtain the wanted paper through interlibrary loan. Some authors' websites contain some of their papers; ditto for online repositories at their institutions. Papers normally list corresponding authors (remember those?); you generally can request from the corresponding author a copy of the paper for personal scholarly use. Thus, with a little perseverance, you can obtain almost any paper. If, despite your best efforts, you still cannot obtain a paper you need, the safest tack is to identify the fact as "as cited in" and list in your references the source where you found it.

ELECTRONIC AIDS TO CITATION

Checking that every reference is accurate and that all cited items appear in the reference list has become much easier in the electronic era. Common word-processing programs include features for tasks such as creating, numbering, and formatting footnotes and endnotes. These features can aid in citing references and developing reference lists. Some journals, however, say not to use these features, which can interfere with their publishing process. Check the journal's instructions to authors in this regard.

Perhaps more notably, citation-management software programs such as EndNote, RefWorks, and Zotero let a researcher develop a database of references and use it to create reference lists in the formats of many journals.

Rather than keying in the information for each reference, you may be able to import it from bibliographic databases. Once the information is accurately entered, it should remain correct whenever it appears in a reference. Do, however, still check references. Electronic gremlins sometimes lurk. So does human error; if somehow you indicated the wrong reference, the wrong reference will appear.

If you are not using reference-management software, consider looking into doing so. Using such software can save you time, especially if you will cite some of the same references in multiple publications or if journals in your field have a variety of reference styles. If you study or work at a university or other research institution, you might easily be able to obtain such software through it. Also, some reference-management software, such as Zotero, is available for free. Conveniently, some university libraries provide instruction in using reference-management software. Consider checking whether you have access to such instruction.

CITATIONS IN THE TEXT

Many authors use slipshod methods in citing literature. A common offender is the “handwaving reference,” in which the reader is glibly referred to “Smith’s elegant contribution” without any hint of what Smith reported or how Smith’s results relate to the present author’s results. If a reference is worth citing, the reader should be told why.

Even worse is the nasty habit some authors have of insulting the authors of previous studies. It is probably all right to say, “Smith (2015) did not study. . . .” But it is not all right to say, “Smith (2015) totally overlooked, . . . ,” “Smith (2015) ignored, . . . ,” or “Smith (2015) failed to. . . .”

Some authors get into the habit of putting all citations at the end of sentences. This is wrong. The reference should be placed at that point in the sentence to which it applies. Michaelson (1990, p. 92) gave this example:

We have examined a digital method of spread-spectrum modulation for multiple-access satellite communication and for digital mobile radiotelephony.^{1,2}

Note how much clearer the citations become when the sentence is recast as follows:

We have examined a digital method of spread-spectrum modulation for use with Smith’s development of multiple-access communication¹ and with Brown’s technique of digital mobile radiotelephony.²

REFERENCE STYLES

Journals vary considerably in their style of handling references. O'Connor (1978) looked at 52 scientific journals and found 33 different styles for listing references. Some journals include article titles within references, and some do not. Some insist on inclusive pagination (listing of the full page range), whereas others print the numbers of first pages only.

If you use an electronic reference management system, and if that system includes the styles of all the journals in which you might like to publish, you might not need to concern yourself in detail with differences among reference styles. In that case, perhaps just skim—or even skip—the sections of this chapter that discuss formats for citing and listing references. If, however, you might at least occasionally be preparing and citing references by traditional means, we advise you to read these sections.

Whether electronically or otherwise, smart authors retain full information about every item that might be cited. Then, in preparing a manuscript, they have all the needed information. It is easy to edit out information; it is indeed laborious to track down 20 or so references to add article titles or ending pages when a journal editor requires you to do so. Even if you know that the journal to which you plan to submit your manuscript uses a short form (no article titles, for example), you would still be wise to establish your reference list in the complete form. This is good practice because (1) the journal you selected may reject your manuscript, and you may then decide to submit the manuscript to another journal, perhaps one with more demanding requirements; and (2) it is likely that you will use some of the same references again in later research papers, review papers (and most review journals demand *full* references), or books. When you submit a manuscript for publication, make sure that the references are presented according to the instructions for authors. If the references are radically different, the editor and referees may assume that this is a sign of previous rejection or, at best, carelessness.

Although there is an almost infinite variety of reference styles, most journals cite references in one of three general ways: name and year, alphabet-number, and citation order.

Name and Year System

The name and year system (sometimes called the *Harvard system*) has been very popular for many years and is used by many journals and books, including this book. Disciplines in which it is popular include the social sciences. Its big advantage is convenience to the author. Because the references are unnumbered, references can be added or deleted easily. No matter how many times

the reference list is modified, “Smith and Jones (2015)” remains exactly that. If there are two or more “Smith and Jones (2015)” references, the problem is easily handled by listing the first as “Smith and Jones (2015a),” the second as “Smith and Jones (2015b),” and so on. The disadvantages of name and year relate to readers and publishers. The disadvantage to readers occurs when (often in the introduction) many references must be cited within one sentence or paragraph. Sometimes readers must jump over several lines of parenthetical references before being able to again pick up the text. Even two or three references, cited together, can distract readers. The disadvantage to publishers is increased cost. When “Higginbotham, Hernandez, and Chowdhary (2022)” can be converted to “(7),” printing costs can be reduced.

Because some papers are written by an unwieldy number of authors, most journals that use name and year have an “et al.” (meaning “and others”) rule. Commonly, it works as follows: Names are always used in citing papers with either one or two authors, such as “Smith (2015)” and “Smith and Jones (2015).” If the paper has three authors, list all three the first time that the paper is cited, such as “Smith, Jones, and Nguyen (2015).” If the same paper is cited again, it can be shortened to “Smith et al. (2015).” When a cited paper has four or more authors, it should be cited as “Smith et al. (2015)” even in the first citation. In the references section itself, some journals prefer that all authors be listed (no matter how many); other journals cite only the first three authors and follow with “et al.”

Alphabet-Number System

This system, citation by number from an alphabetized list of references, is a modification of the name and year system. Citation by numbers keeps printing expenses within bounds; the alphabetized list is relatively easy for authors to prepare and readers (including librarians) to use.

Some authors who have habitually used name and year tend to dislike the alphabet-number system, claiming the citation of numbers cheats the reader. The reader should be told, the argument goes, the name of the person associated with the phenomenon; sometimes, the reader should also be told the date, on the grounds that a 1921 reference might be viewed differently than a 2021 reference.

Fortunately, these limitations can be overcome. As you cite references in the text, decide whether names or dates are important. If they are not (as is usually the case), use only the reference number: “Ptyrosine is quantitatively converted to phenylalanine under these conditions (13).” If you want to feature the name of the author, do it within the context of the sentence: “The role of the carotid sinus in the regulation of respiration was discovered by Heymans (13).”

If you want to feature the date, you can also do that within the sentence: “Streptomycin was first used in the treatment of tuberculosis in 1945 (13).”

Citation Order System

The citation order system simply involves citing the references (by number) in the order in which they appear in the paper. This system avoids the substantial printing expense of the name and year system, and readers often like it because they can quickly refer to the references in one-two-three order as they come to them in the text. It is a useful system for a journal that is basically a “note” journal, each paper containing only a few references. For long papers, with many references, the citation order system can have disadvantages. It can be burdensome for authors who do not use reference-management software, as adding or deleting references may entail a substantial renumbering chore. It might not be ideal for the reader either because the nonalphabetical presentation of the reference list may result in the separation of various references to works by the same author.

Regardless of which citation system is used, readers of papers online can often link from a citation to the full reference on the list, or even the full paper cited. And authors using reference-management software can use various citation systems with approximately equal ease. In this regard, the electronic age has decreased the burden on authors and readers of scientific papers. And it has diminished arguments in favor of one citation system or another.

TITLES AND INCLUSIVE PAGES

Should article titles be given in references? Normally, you must follow the style of the journal; if the journal allows a choice (and some do), we recommend that you give *complete* references. By denoting the overall subjects, the article titles make it simple for interested readers (and librarians) to decide whether they need to consult none, some, or all of the cited references.

The use of inclusive pagination (first and last page numbers) makes it easy for potential users to distinguish between 1-page notes and 50-page review articles. Users may wish to proceed differently depending on the number of pages involved.

Even if a journal does not require titles and inclusive pages, note them. If the journal decides not to publish your paper, a journal to which you later submit your paper may require them. Also, you might later wish to cite the item again when writing for a publication that does require titles, inclusive pages, or both.

JOURNAL ABBREVIATIONS

Although journal styles vary widely, one aspect of reference citation has been standardized: abbreviations of journal names. As the result of widespread adoption of a standard (American National Standards Institute 1969), almost all major journals and secondary services now use the same system of abbreviation. Previously, most journals abbreviated journal names (significant printing expense can be avoided by abbreviation), but there was no uniformity. The *Journal of the American Chemical Society* was variously abbreviated to “J. Amer. Chem. Soc.”, “Jour. Am. Chem. Soc.”, “J.A.C.S.”, and so forth. These differing systems posed problems for authors and publishers alike. Now there is essentially only one system, and it is uniform. The word “Journal” is now always abbreviated “J.” (Some journals omit the periods after the abbreviations.) By noting a few of these standard rules, authors can abbreviate many journal titles, even unfamiliar ones, without referring to a source list. It is helpful to know, for example, that all “ology” words are abbreviated at the “l.” (“Bacteriology” is abbreviated “Bacteriol.”, “Physiology” is abbreviated “Physiol.”, etc.) Thus, if one memorizes the abbreviations of words commonly used in titles, most journal titles can be abbreviated with ease. An exception to remember is that one-word titles (such as *Science* and *Biochemistry*) are never abbreviated.

Appendix 1 lists the abbreviations for commonly used words in periodical titles. If you are unsure how to abbreviate a journal title, you can often discern the correct abbreviation from a listing in a bibliographic database, from information in the journal, or from a previous citation of the journal. Abbreviations for the titles of many journals in the biomedical sciences and related fields can be obtained from the *PubMed* journals database (www.ncbi.nlm.nih.gov/nlmcatalog/journals).

SOME TRENDS IN REFERENCE FORMAT

Not all journals abbreviate journal titles in references. For example, American Psychological Association (APA) style (*Publication Manual of the American Psychological Association* 2020, p. 294) calls for stating periodical titles in full. More generally, journals may increasingly be including full journal titles in references. Earlier, when journals appeared only in print, publishers favored abbreviating journal titles because it saved valuable space, thus saving paper costs or allowing more papers to be published. Today, with many journals appearing mainly or solely online, the space saved may be less of a consideration than are convenience to authors and clarity to readers. Writing out journal titles in full may serve especially well in journals that publish interdisciplinary papers, and

thus have readers who might not understand the abbreviations of some words in the titles of cited journals.

If a journal article has been published online, either exclusively or as well as in print, the publisher quite likely has assigned it a digital object identifier (DOI), which specifies a persistent link to its location on the internet. If an article has a DOI, it commonly appears on the first page. Some reference formats include providing the DOI, if one exists, at the end of the reference. Additional information about DOIs is available at www.doi.org.

EXAMPLES OF DIFFERENT REFERENCE STYLES

So that you can see at a glance the differences among the three main systems of referencing, here are three sample references as they might appear in the references section of a journal. (In some journals, references in these systems will look somewhat different from those here because journals differ among themselves in such aspects as how, if at all, they use italics and boldface in references.)

Name and Year System

- Bonetti P, Leuz C, and Michelon G. 2021. Large-sample evidence on the impact of unconventional oil and gas development on surface waters. *Science* 373:896–902.
- Ingelfinger JR. 2021. Hematuria in adults. *N. Engl. J. Med.* 385:153–163.
- Steen DA. 2019. Secrets of snakes: the science beyond the myths. Texas A&M University Press.

Alphabet-Number System

1. Bonetti, P., Leuz, C., and Michelon, G. 2021. Large-sample evidence on the impact of unconventional oil and gas development on surface waters. *Science* 373:896–902.
2. Ingelfinger, J.R. 2021. Hematuria in adults. *N. Engl. J. Med.* 385: 153–163.
3. Steen, D.A. 2019. Secrets of snakes: the science beyond the myths. Texas A&M University Press.

Citation Order System

1. Bonetti P, Leuz C, Michelon G. Large-sample evidence on the impact of unconventional oil and gas development on surface waters. *Science*. 2021;373:896–902.

2. Steen DA. Secrets of snakes: the science beyond the myths. Texas A&M University Press, 2019.
3. Ingelfinger JR. Hematuria in adults. *N Engl J Med.* 2021;385:153–163.

In addition to its nonalphabetical arrangement of references, the citation order system tends to differ from the others in its advocacy of eliminating periods after abbreviations (of journal titles, for example) and commas after authors' surnames.

CITING ELECTRONIC MATERIAL

The internet contains more and more material appropriate for citation. In particular, scientific papers commonly are appearing in electronic journals or being posted online as well as appearing in print. The number of papers posted on preprint servers has been burgeoning. In addition, some reports, databases, and other items accessed online can be valid to cite.

Accordingly, formats have been developed, and are continuing to be developed, for citing electronic materials. These formats appear in recent editions of style manuals and in the instructions to authors of some journals. If you wish to cite electronic material, begin by consulting the instructions to authors of your target journal. These instructions may show the formats to use or direct you to a source of guidance in print or online. Also, you may find it useful to look in the journal for examples of reference entries that list electronic materials.

ONE MORE REASON TO CITE CAREFULLY

Accurate citation is part of being a rigorous researcher. Whether you use reference-management software or prepare references by other means, ensure that the right reference is cited in the right place, all information in every citation is accurate, and content from the cited sources is accurately reported. Such accuracy is important in ensuring that your paper is useful to readers.

And, on a very practical note, careful citation helps keep you from alienating those evaluating your paper. Commonly, some of the referees (peer reviewers) chosen by editors are researchers whose work your paper cites. If your reference section lists their writings inaccurately, or if your text misrepresents their findings or conclusions, they might well question whether you are a careful researcher.

So, take the same care with your references that you do with other aspects of your work. The effort is likely to serve you well.

PART III

Preparing the Tables and Figures

CHAPTER 16

How to Design Effective Tables

A tabular presentation of data is often the heart or, better, the brain, of a scientific paper.

—Peter Morgan

WHEN TO USE TABLES

Before proceeding to the “how to” of tables, let us first examine the question of “whether to.”

As a rule, do not construct a table unless repetitive data *must* be presented. There are two reasons for this general rule. First, it is simply not good science to regurgitate reams of data just because you have them in your laboratory notebooks; only samples and breakpoints need be given. Second, the cost of publishing tables can be high compared with that of text, and all of us involved with the generation and publication of scientific literature should worry about costs.

If you made (or need to present) only a few determinations, give the data in the text. Tables 16.1 and 16.2 are useless, and yet they are typical of many tables that are submitted to journals.

Table 16.1 is faulty because two of the columns give standard conditions, not variables and not data. If temperature is a variable in the experiments, it can have its own column. If all experiments were done at the same temperature, however, this single bit of information should be noted in the materials and methods section and perhaps as a footnote to the table, but not in a column in the table. The data presented in the table can be given in the text itself in a form that is readily comprehensible to the reader without taking up space with a table. Very simply, these results would read: “Aeration of the growth

Table 16.1. Effect of Aeration on Growth of *Streptomyces coelicolor*

Temp (°C)	No. of Expts.	Aeration of Growth Medium	Growth ^a
24	5	+	78
24	5	-	0

^aAs determined by optical density (Klett unit).

^bSymbols: +, 500-ml Erlenmeyer flasks were aerated by having a graduate students blow into the bottles for 15 min out of each hour; -, identical test conditions, except that the aeration was provided by an elderly professor.

Table 16.2. Effect of Temperature on Growth of Oak (*Quercus*) Seedlings^a

Temp (°C)	Growth in 48 h (mm)
-50	0
-40	0
-30	0
-20	0
-10	0
0	0
10	0
20	7
30	8
40	1
50	0
60	0
70	0
80	0
90	0
100	0

^aEach individual seedling was maintained in an individual round pot, 10 cm in diameter and 100 cm high, in a rich growth medium containing 50 percent Michigan peat and 50 percent dried horse manure. Actually, it wasn't "50 percent Michigan"; the peat was 100 percent "Michigan," all of it coming from that state. And the manure wasn't half-dried (50 percent), it was all dried. And, come to think about it, I should have said "50 percent dried manure (horse)"; I didn't dry the horse at all.

medium was essential for the growth of *Streptomyces coelicolor*. At room temperature (24°C), no growth was evident in stationary (unaerated) cultures, whereas substantial growth (OD, 78 Klett units) occurred in shaken cultures.”

Table 16.2 has no columns of identical readings, and it looks like a good table. But is it? The independent variable column (temperature) looks reasonable enough, but the dependent variable column (growth) has a suspicious number of zeros. You should question any table with a large number of zeros (whatever the unit of measurement) or a large number of 100s when percentages are used. Table 16.2 is a useless table because all it tells us is that “The oak seedlings grew at temperatures between 20°C and 40°C; no measurable growth occurred at temperatures below 20°C or above 40°C.”

In addition to zeros and 100s, be suspicious of plus and minus signs. Table 16.3 is of a type that often appears in print, although it is obviously not very informative. All this table tells us is that “*S. griseus*, *S. coelicolor*, *S. everycolor*, and *S. rainbowensky* grew under aerobic conditions, whereas *S. nicolor* and *S. greenicus* required anaerobic conditions.” Whenever a table, or columns within a table, can be readily put into words, do it.

Some authors believe that all numerical data must be put in a table. Table 16.4 is a sad example of this phenomenon. It gets sadder when we learn (at the end of the footnote) that the results were not statistically significant

Table 16.3. Oxygen Requirement of Various Species of *Streptomyces*

Organism	Growth Under Aerobic Conditions ^a	Growth Under anaerobic Conditions
<i>Streptomyces griseus</i>	+	-
<i>Streptomyces coelicolor</i>	+	-
<i>Streptomyces nicolor</i>	-	+
<i>Streptomyces everycolor</i>	+	-
<i>Streptomyces greenicus</i>	-	+
<i>Streptomyces rainbowensky</i>	+	-

^aSee Table 16.1 for explanation of symbols. In this experiment, the cultures were aerated by a shaking machine (New Brunswick Shaking Co., Scientific, NJ).

Table 16.4. Bacteriological Failure Rates

Nocillin	K Penicillin
5/35 (14) ^a	9/34 (26)

^aResults expressed as number of failures/total, which is then converted to a percentage (within parentheses). $P=0.21$.

anyway ($P = 0.21$). If these data were worth publishing (which seems doubtful), one sentence in the results would have done the job: “The difference between the failure rates—14 percent (5 of 35) for nocillin and 26 percent (9 of 34) for potassium penicillin V—was not significant ($P = 0.21$).”

In presenting numbers, give only significant figures. Nonsignificant figures may mislead the reader by creating a false sense of precision; they also make comparison of the data more difficult. Unessential data, such as laboratory numbers, results of simple calculations, and columns that show no significant variations, should be omitted.

Another very common but often useless table is the word list. Such a list might be suitable for a slide in a presentation, but it does not belong in a scientific paper. Table 16.5 is an example. This information could easily be presented in the text. A good copy editor will kill this kind of table and incorporate the data into the text. Yet, when copy editors do so (and this leads to the next rule about tables), they often find that much or all of the information was already in the text. Thus, the rule: Present the data in the text, or in a table, or in a figure. *Never* present the same data in more than one way. Of course, selected data from a table can be singled out for discussion in the text.

Tables 16.1 to 16.5 provide typical examples of the kinds of material that should not be tabulated. Now let us look at material that *should* be tabulated.

HOW TO ARRANGE TABULAR MATERIAL

Having decided to tabulate, you ask yourself the question: “How do I arrange the data?” Since a table has both left-right and up-down dimensions, you have two choices: The data can be presented either horizontally or vertically. But *can*

Table 16.5. Adverse Effects of Nickleclillin in 24 Adult Patients

No. of Patients	Side Effect
14	Diarrhea
5	Eosinophilia (≥ 5 eos/mm 3)
2	Metallic taste ^a
1	Yeast vaginitis ^b
1	Mild rise in urea nitrogen
1	Hematuria (8–10 rbc/hpf)

^aBoth of the patients who tasted metallic worked in a zinc mine.

^bThe infecting organism was a rare strain of *Candida albicans* that causes vaginitis in yeasts, but not in humans.

does not mean *should*; the data should be organized so that the like elements read *down*, not across.

Examine Tables 16.6 and 16.7. They are equivalent, except that Table 16.6 reads across, whereas Table 16.7 reads down. Table 16.7 is the preferred format because it allows the reader to grasp the information more easily, and it is more compact and thus less expensive to print. The point about ease for the reader would seem to be obvious. (Did you ever try to add numbers that were listed horizontally rather than vertically?) The point about reduced printing costs refers to the fact that all columns must be wide or deep in the across arrangement because of the diversity of elements, whereas some columns (especially those with numbers) can be narrow without runovers in the down arrangement. Thus, Table 16.7 appears to be smaller than Table 16.6, although it contains the same information.

Words in a column are lined up on the left. Numbers are lined up on the right (or on the decimal point). Table 16.7, for example, illustrates this point.

Table 16.6. Characteristics of Antibiotic-Producing *Streptomyces*

Determination	<i>S. fluoricolor</i>	<i>S. griseus</i>	<i>S. coelicolor</i>	<i>S. nicolor</i>
Optimal growth temperature (°C)	-10	24	28	92
Color of mycelium	Tan	Gray	Red	Purple
Antibiotic produced	Fluoricillinmycin	Streptomycin	Rholmondelay ^a	Nomycin
Yield of antibiotic (mg/ml)	4,108	78	2	0

^aPronounced “Rumley” by the British.

Table 16.7. Characteristics of Antibiotic-Producing *Streptomyces*

Organism	Optimal Growth Temperature (°C)	Color of Mycelium	Antibiotic Produced	Yield of Antibiotic (mg/ml)
<i>S. fluoricolor</i>	-10	Tan	Fluoricillinmycin	4,108
<i>S. griseus</i>	24	Gray	Streptomycin	78
<i>S. coelicolor</i>	28	Red	Rholmondelay ^a	2
<i>S. nicolor</i>	92	Purple	Nomycin	0

^aWhere the flying fishes play.

Table 16.8 is an example of a well-constructed table. It reads down, not across. Its title and headings are clear enough for readers to understand the data without referring to the text. Items in the body of the table appear in a logical order. The footnote provides supplementary information on how the data were obtained rather than repeating excessive methodological detail.

Table 16.8. Hospitalizations and Total Charges for Neglected Tropical Diseases and Malaria, United States, 2003–2012*

Disease	Hospitalizations		Total Charges	
	No. (SE)	95% CI	(SE)	US\$, millions 95% CI
Cysticercosis	23,266 (778)	21,741–24,792	1,149 (56)	1,039–1,259
Malaria	14,319 (434)	13,469–15,169	387 (18)	351–423
Echinococcosis	3,919 (170)	3,586–4,252	206 (16)	174–237
Soil-transmitted helminth-associated infections	3,256 (151)	2,959–3,552	201 (19)	162–239
Dengue	2,644 (135)	2,379–2,909	89 (9)	70–107
Leprosy	2,055 (135)	1,791–2,319	94 (9)	76–111
Lymphatic filariasis	1,836 (106)	1,629–2,044	86 (9)	68–103
Schistosomiasis	1,811 (120)	1,576–2,046	101 (12)	78–125
Chagas disease	1,686 (151)	1,389–1,982	118 (17)	84–152
Leishmaniasis	1,022 (92)	841–1,203	52 (7)	38–66
Trachoma	649 (69)	514–784	20 (4)	13–28
Foodborne trematode-associated infections	610 (60)	492–729	41 (7)	28–54
Onchocerciasis	380 (47)	287–473	29 (12)	5–53
Yaws	161 (28)	106–216	7 (2)	3–11

*National estimates were determined from the Nationwide Inpatient Sample by using diagnostic codes from the *International Classification of Diseases*, 9th Revision, Clinical Modification. A complete list of ICD-9-CM codes used in this study is provided in the online Technical Appendix (<http://wwwnc.cdc.gov/EID/article/21/6/14-1324-Techapp1.pdf>).

Source: O’Neal SE, Flecker RH. Hospitalization frequency and charges for neurocysticercosis, United States, 2003–2012. *Emerg. Infect. Dis.* 21:969–976, 2015. Available at wwwnc.cdc.gov/eid/article/21/6/14-1324_article.pdf. Accessed August 27, 2015.

Note that these tables have three horizontal rules (lines) but no vertical rules. Virtually all tables are constructed this way. Occasionally, straddle rules (as below “Hospitalizations” and “Total charges” in Table 16.8) are used. Vertical rules normally are not used in tables at all.

EXPONENTS IN TABLE HEADINGS

If possible, avoid using exponents in table headings. Confusion has resulted because some journals use positive exponents and some use negative exponents to mean the same thing. For example, some have used “cpm $\times 10^3$ ” to refer to thousands of counts per minute, whereas others have used “cpm $\times 10^{-3}$ ” for the same thousands of counts. If it is not possible to avoid such labels in table headings (or in figures), it may be worthwhile to state in a footnote (or in the figure legend), in words that eliminate the ambiguity, what convention is being used.

FOLLOWING THE JOURNAL'S INSTRUCTIONS

Instructions to authors commonly include a section about tables. Before preparing your tables, check the instructions to authors of your target journal. These instructions may indicate such items as the dimensions of the space available, the symbols or form of lettering for indicating footnotes to tables, and the electronic tools to use in preparing tables. Looking at tables in the journal as examples also can aid in preparing suitable tables.

Style manuals in the sciences provide guidance in preparing not only text, but also tables and figures. If your target journal specifies a style manual that it follows, consult it in this regard. Even if the journal does not specify a style manual, looking at one relevant to your field can aid considerably in preparing effective tables and figures.

Traditionally, journals have asked authors to submit each table on a separate page at the end of the text. In addition, some journals have said to identify in the margin of the text the first mention of each table, for example, by writing “Table 3” and circling it. This procedure helps ensure that the author has indeed cited each table in the text, in numerical order. It also indicates to the compositor, at the page makeup stage, where to break the text to insert the tables. Today, some journals ask authors to embed tables in the text near their first mention. And some journals ask authors to submit tables as separate files. To determine whether tables should be placed within the text, placed at the end, or provided in separate files (and to determine how, if requested, to indicate their placement), consult the instructions to authors.

TITLES, FOOTNOTES, AND ABBREVIATIONS

The title of the table (or the legend of a figure) is like the title of the paper itself. That is, the title or legend should be concise and generally not divided into two or more clauses or sentences. Unnecessary words should be omitted.

Give careful thought to the footnotes to your tables. If abbreviations must be defined, you often can give all or most of the definitions in the first table. Then, later tables can carry the simple footnote: "Abbreviations as in Table 1."

Note that "temp" (Tables 16.1, 16.2, 16.6, and 16.7) is used as an abbreviation for "temperature." Because of space limitations in tables, almost all journals encourage abbreviating certain words in tables that would not be abbreviated in the text. Capitalize any such abbreviations used as the first word in a column heading; do not use periods (except after "No.," which might be misread without the period). To identify abbreviations that your target journal considers acceptable in tables, you can look at tables published in the journal. Also, some journals list in their instructions to authors the abbreviations that can be used without definition in tables that they publish.

ADDITIONAL TIPS ON TABLES

The following are some further tips to help ensure that you design and use tables effectively.

Use wording that will be clear without reference to the text. For example, a table should not just refer to "Group 1" and "Group 2." Rather, it should identify each group by a more meaningful designation (examples: "High-Dose Group" and "Low-Dose Group," "REM Sleep Group" and "NREM Sleep Group," and "Graduate Students" and "Professors").

If a paper includes a series of tables presenting analogous data, use an analogous format for each. For example, if several tables compare the same four groups from different standpoints, list the four groups in the same order in each table. Or if different tables present data on the same variables at different times, keep listing the variables in the same order. Such consistency saves readers effort. (And it is easier for you, too.)

Finally, remember to mention every table in the text. Do so as soon as readers are likely to want to see the table. You have gone to the effort of preparing good tables. Be sure that readers can benefit fully from them.

CHAPTER 17

How to Prepare Effective Graphs

A good illustration can help the scientist to be heard when speaking, to be read when writing. It can help in the sharing of information with other scientists. It can help to convince granting agencies to fund the research. It can help in the teaching of students. It can help to inform the public of the value of the work.

—Mary Helen Briscoe

WHEN NOT TO USE GRAPHS

In chapter 16, we discussed certain types of data that should not be tabulated. They should not be turned into graphs either. Basically, graphs are pictorial tables.

The point is this: Certain types of data, particularly the sparse type or the type that is monotonously repetitive, do not need to be brought together in either a table or a graph. The facts are still the same: Preparing and printing an illustration can be time-consuming and expensive, and you should consider illustrating your data only if the result is a real service to the reader.

This point bears repeating because many authors, especially those who are beginners, think that a table, graph, or chart somehow adds importance to the data. Thus, in the search for credibility, they tend to convert a few data elements into what they think is an impressive-looking graph or table. Don't do it. Your more experienced peers and most journal editors will not be fooled; they will soon deduce that (for example) three of the four curves in your graph are simply the standard conditions and the meaning of the fourth curve could have been stated in just a few words. Attempts to dress up scientific data are usually doomed to failure.

If a proposed graph will contain only one curve, can you describe it in words? Possibly only one value is really meaningful, either a maximum or a minimum; the rest is window dressing. If you determined, for example, that the optimum pH value for a particular reaction was 8.1, it would probably be sufficient to state something like "Maximum yield was obtained at pH 8.1." If you determined that the maximum growth of an organism occurred at 37°C, a simple statement to that effect is better economics (and better science) than a graph showing the same thing.

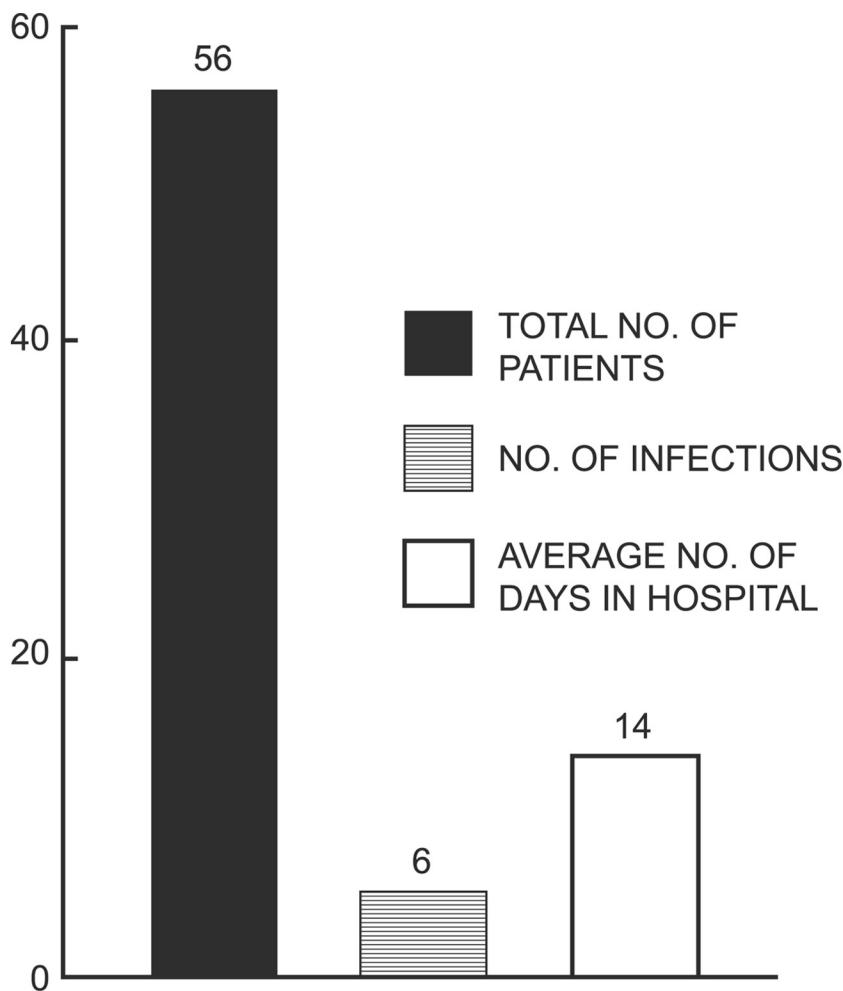


Figure 17.1. Incidence of hospital-acquired infections.

If the choice is not graph versus text but graph versus table, your choice might relate to whether you want to impart to readers exact numerical values or a picture of the trend or shape of the data. Rarely, there might be a reason to present the same data in both a table and a graph, the first presenting the exact values and the second showing a trend not otherwise apparent. Most editors would resist this obvious redundancy, however, unless the reason for it was compelling.

An example of an unneeded bar graph is shown in Figure 17.1. This figure could be replaced by one sentence in the text: "Among the test group of 56 patients who were hospitalized for an average of 14 days, 6 acquired infections."

When is a graph justified? There are no clear rules, but let us examine some indications for their effective use.

WHEN TO USE GRAPHS

Graphs resemble tables in that they are a means of presenting data in an organized way. In fact, the results of many experiments can be presented either as tables or as graphs. How do we decide which is preferable? This is often a difficult decision. A good rule might be this: If the data show pronounced trends, making an interesting picture, use a graph. If the numbers just sit there, with no exciting trend in evidence, a table should be satisfactory (and perhaps easier and cheaper for you to prepare). Tables are also preferred for presenting *exact* numbers.

Examine Table 17.1 and Figure 17.2, both of which record exactly the same data. Either format would be acceptable for publication, but Figure 17.2 clearly seems superior to Table 17.1. In the figure, the synergistic action of the two-drug combination is immediately apparent. Thus, the reader can quickly grasp the significance of the data. It also appears from the graph that streptomycin is more effective than is isoniazid, although its action is somewhat slower; this aspect of the results is not readily apparent from the table.

Table 17.1. Effect of Streptomycin, Isoniazid, and Streptomycin Plus Isoniazid on *Mycobacterium tuberculosis*^a

Treatment ^b	Percentage of Negative Cultures at			
	2 weeks	4 weeks	6 weeks	8 weeks
Streptomycin	5	10	15	20
Isoniazid	8	12	15	15
Streptomycin + Isoniazid	30	60	80	100

^aThe patient population, now somewhat less so, was described in a preceding paper (61).

^bHighest quality available from our supplier (Town Pharmacy, Podunk, IA).

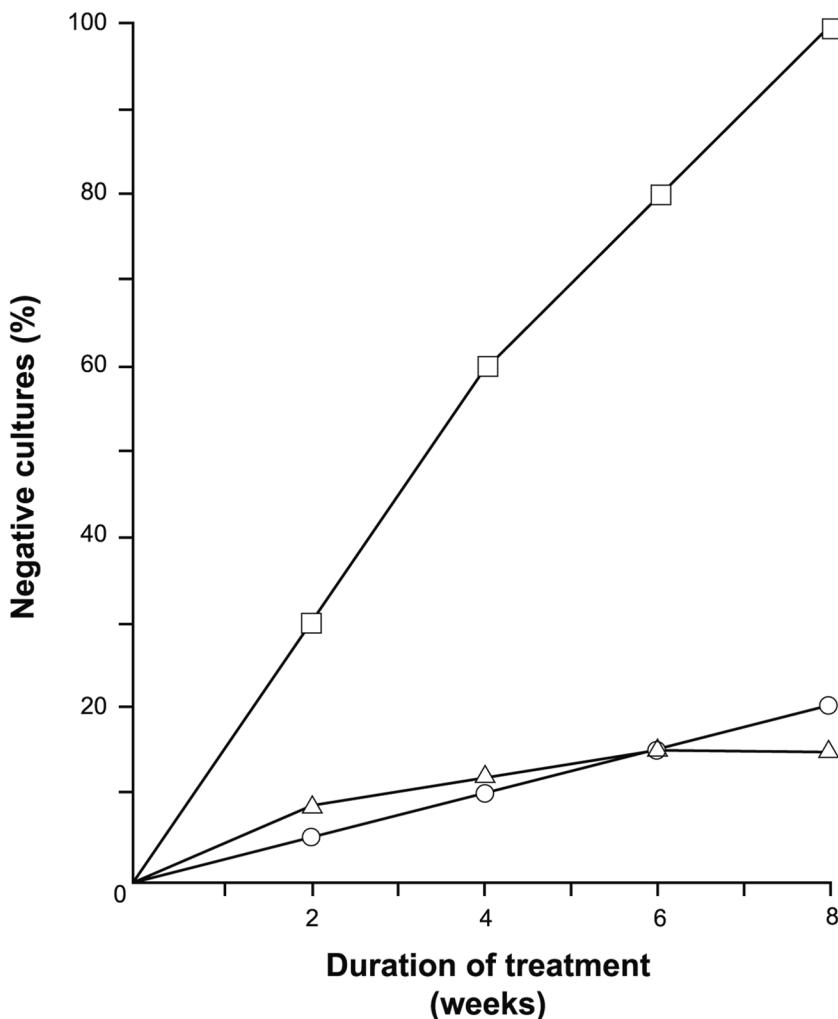


Figure 17.2. Effect of streptomycin (○), isoniazid (△), and streptomycin plus isoniazid (□) on *Mycobacterium tuberculosis*.

HOW TO PREPARE GRAPHS

Early editions of this book included rather precise directions for using graph paper, India ink, lettering sets, and the like. Graphs had been prepared with these materials and using these techniques for generations.

Today, though, we prepare graphs by computer. However, the *principles* of producing good graphs have not changed. The sizes of the letters and

symbols, for example, must be chosen so that the final published graph in the journal is clear and readable.

The size of the lettering must be based on the anticipated reduction that will occur in the publishing process. This factor can be especially important if you are combining two or more graphs into a single illustration. Remember: Text that is easy to read on a large computer screen may become illegible when reduced to the width of a journal column. If you are preparing a graph on a computer, reduce it to the size at which you would expect it to appear in the journal (or the size at which you would expect readers to read it on a small screen), and make sure that it still is legible.

Each graph should be as simple as possible. “The most common disaster in illustrating is to include too much information in one figure. Too much information in an illustration confuses and discourages the viewer” (Briscoe 1996, p. 6).

Figure 17.3 is a nice graph. The lettering is large enough to read easily. It is boxed, rather than two-sided (compare with Figure 17.2), making it a bit easier to estimate the values on the right side of the graph. The scribe marks point inward rather than outward.

If your paper contains two or more graphs that are most meaningful when viewed together, consider grouping them in a single illustration. To maximize readability, place the graphs above and below each other rather than side by side. For example, in a two-column journal, placing three graphs in an “above and below” arrangement allows each graph to be one or two columns in width. If the graphs appear side by side, each can average only one third of a page wide.

Whether or not you group graphs in such a composite arrangement, be consistent from graph to graph. For example, if you are comparing interventions, keep using the same symbol for the same intervention. Also, be consistent in other aspects of design. Both conceptually and aesthetically, the graphs in your paper should function as a set.

Do not extend the axes (or the explanatory wording) beyond what the graph demands. For example, if your data points range between 0 and 78, your top-most index number should be 80. You might feel a tendency to extend the graph to 100, a nice round number; this urge is especially difficult to resist if the data points are percentages, for which the natural range is 0 to 100. Resist this urge, however. If you do not, parts of your graph will be empty; worse, the live part of your graph will then be restricted in dimension because you have wasted perhaps 20 percent or more of the width (or height) with white space.

In the preceding example (data points ranging from 0 to 78), your reference numbers should be 0, 20, 40, 60, and 80. You should use short index lines at each of these numbers, and also at the intermediate 10s (10, 30, 50, 70). Obviously, a reference stub line halfway between 0 and 20 could only be 10. Thus, you need not label the 10s, and you can then use larger lettering for the 20s,

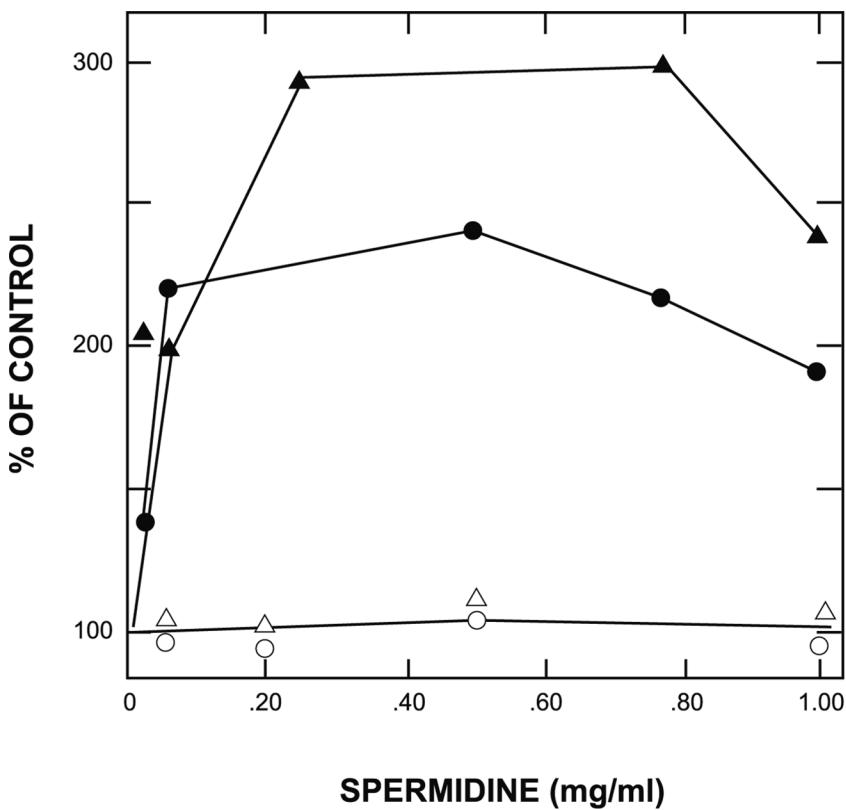


Figure 17.3. Effect of spermidine on the transformation of *B. subtilis* BR 151. Competent cells were incubated for 40 min with spermidine prior to the addition of 5 μg of donor DNA per ml (●) or 0.5 μg of donor DNA per ml (▲). DNA samples of 5 μg (○) or 0.5 μg per ml (△) were incubated for 20 min prior to the addition of cells. (Redrawn from Fig. 1 in Clark PO and Leach FR. Stimulation of *Bacillus subtilis* transformation by spermidine. Mol. Gen. Genet. 178:21–25, 1980. © by Springer-Verlag 1980. With permission of Springer.)

without squeezing. By using such techniques, you can make graphs simple and effective instead of cluttered and confusing.

SYMBOLS AND LEGENDS

If there is space in the graph itself, use it to present the key to the symbols. In the bar graph in Figure 17.1, the shadings of the bars would have been a bit difficult to define in the legend; given as a key, they need no further definition (and any additional typesetting, proofreading, and expense are avoided).

If you must define the symbols in the figure legend, you should use only symbols that are considered standard and are widely available. Perhaps the

most standard symbols are open and closed circles, triangles, and squares (\circ , \triangle , \square , \bullet , \blacktriangle , \blacksquare). If you have just one curve, use open circles for the reference points; use open triangles for the second, open squares for the third, closed circles for the fourth, and so on. If you need more symbols, you probably have too many curves for one graph, and you should consider putting some of the curves in one graph and the rest in another. Different types of connecting lines (solid, dashed, etc.) can also be used. But do *not* use different types of connecting lines *and* different symbols.

As to the legends, they should normally be provided on a separate page, not at the bottom or top of the illustrations themselves. The main reason is that the two portions commonly are processed separately during journal production. Consult the instructions to authors of your target journal regarding this matter and other requirements for graphs.

A FEW MORE TIPS ON GRAPHS

Design graphs, like tables, to be understandable without the text. For example, use meaningful designations (not just numbers) to identify groups. And refer to each graph as soon as readers are likely to want to see it. Do not leave readers trying to visualize your findings by sketching them on a napkin—only to find that a graph is displaying them three pages later.

Use graphs that depict your findings fairly and accurately. For example, do not adapt the scales on the axes to make your findings seem more striking than they are. With rare exceptions, avoid beginning a scale at anything other than zero. And if you interrupt a scale line to condense a graph, make the interruption obvious. Also, if the standard deviation is the appropriate way to show the variability in your data, do not substitute the standard error of the mean, which might make the data seem more consistent than they are. In general, avoid using pie charts, which can be confusing and are not considered very suitable for scientific papers. Also, unless you are presenting three-dimensional data, do not use three-dimensional graphs.

Note that some journals (mainly the larger and wealthier ones) redraw graphs and some other types of figures to suit their own format. Whether or not a journal will do so, prepare your graphs well. Doing so will help make your findings and their value clear and show the care with which you do your work.

BEYOND GRAPHS

Many journal articles include illustrations other than graphs. For example, they may have diagrams, flowcharts, or maps. In some fields (for example, descriptive biology), line drawings are superior to photographs in showing important details. Such illustrations are also common in medicine, especially

in presenting anatomic views, and indeed these have become virtually an art form. Some scientists prepare such graphics themselves, while others enlist professionals such as scientific illustrators, medical illustrators, or cartographers.

The specifics of preparing such graphics exceed the scope of this chapter. However, the principles of preparing good scientific graphics are much the same as those of preparing good scientific text: Know your audience and the conventions in your field. Obtain and follow your target journal's instructions. Follow good models. Organize the item well. Define the point that you want to make, and focus on communicating it. Minimize clutter. Revise your work. Get feedback and revise some more. And always keep learning.

SOURCES OFFERING FURTHER ASSISTANCE

Various resources can aid in learning to prepare—and in preparing—graphs and other scientific graphics. Some style manuals, such as the *AMA Manual of Style* (Christiansen et al. 2020) and the *Publication Manual of the American Psychological Association* (2020), have extensive sections on tables and figures, including examples of well-designed figures of various types. The *Clinical Chemistry Guide to Scientific Writing* (www.aacc.org/science-and-research/clinical-chemistry/clinical-chemistry%C2%A0guide-to-scientific-writing) contains excellent articles (Annesley 2010a, Annesley 2010b) on the basics of preparing good graphs. Other articles (for example, Rougier, Droettboom, and Bourne 2014) also provide helpful guidance in this regard.

Some style manuals (such as American Psychological Association 2020 and Banik et al. 2020) include advice on creating color visuals that colorblind individuals can follow. A piece by Collinge (2017) on this topic includes a list of color combinations to avoid. It also includes the following advice: In addition to colors, use symbols to distinguish items. For example, if different lines on a graph are different colors, also make the data points on them different shapes. Similarly, use not only colors but also patterns to distinguish bars on a bar graph. Also, to minimize confusion, use only a few colors.

Professional designers commonly keep “swipe files,” which are collections of examples to consider emulating. Likewise, if you encounter a well-designed table or figure presenting work akin to yours, consider keeping a copy to consult. Also consider, where permitted for free or affordably, literally swiping elements to use. Sources of free-to-use images include the Noun Project (thenounproject.com) and the Servier Medical Art collection (smart.servier.com). For biological scientists wanting to create scientific illustrations, the commercial resource BioRender contains icons and templates and includes tutorials

on how to use them. Somewhat similarly, ScienceDraw includes images and templates to use in creating illustrations in a variety of sciences.

For scientists seeking professional illustrations (or consultation in preparing their own illustrations), many universities and other research-oriented institutions have scientific illustrators or other professionals specializing in visual communication of science. In addition, such illustrators can be identified through degree programs in scientific or medical illustration and through organizations such as the Guild of Natural Science Illustrators and the Association of Medical Illustrators.

With the resources available and your own resourcefulness, you can prepare graphs and other illustrations that effectively communicate your science.

CHAPTER 18

How to Prepare Effective Photographs

Life is not about significant details, fixed in a flash, fixed forever. Photographs are.
—Susan Sontag

PHOTOGRAPHS AND MICROGRAPHS

If your paper is to be illustrated with one or more photographs, there are several factors to keep in mind.

The most important factor to worry about is the *value* of the photographs for the story you are presenting. The value can range from essentially zero (in which case, like useless tables and graphs, they should not be submitted) to a value that transcends that of the text itself. In many studies of cell ultrastructure, for example, the significance of the paper lies in the photographs. If photographs (such as electron micrographs) are of prime importance to your story and you are publishing in a journal with a print version, ensure that the journal you choose has high-quality reproduction standards, as discussed in Chapter 6.

As with graphs, the size (especially the width) of the photograph in relation to the column and page width of the journal can be important. Try to avoid dimensions that will require excessive reduction of the photograph to suit the journal page.

SUBMISSION FORMATS

Today, journals normally request photographs in electronic format. To ascertain requirements for photographs, see the instructions to authors for your target journal. For example, check what formats (such as EPS, JPEG, or TIFF)

are acceptable and what resolution is required. As indicated in Chapter 5, care must be taken to avoid making unwarranted changes to digital images, including photographs. Sources of guidance on using digital images ethically include Cromeley (2010, 2012). Authors should be aware that journals watch for inappropriately manipulated images and sometimes use software to detect them.

CROPPING AND COMBINING

Whatever the quality of your photographs, you want to have them published legibly. To some degree, you can control this process yourself.

If you are concerned that detail might be lost by excessive reduction, there are several ways you might avoid this. Seldom do you need the whole photograph, right out to all four edges. Therefore, crop the photograph to include only the important part. Figures 18.1 and 18.2 show photographs with and without cropping.

Composite images consisting of two or more photographs, or of photographs and other elements such as graphs, also can aid in conveying one's message. If, for example, readers should compare photographs, consider this option. Do not, however, prepare composites merely to evade a journal's limit on number of figures. Images should be combined only if substantive reason exists to do so. Advice on designing composite figures, as well as on many other aspects of using photographs and related images, appears in the extensively illustrated article "Creating Clear and Informative Image-Based Figures for Scientific Publications" (Jambor et al. 2021).

NECESSARY KEYS AND GUIDES

If you can't crop down to the features of special interest, consider superimposing arrows or letters on the photographs, as shown in Figure 18.3. In this way, you can draw the reader's attention to the significant features. Having arrows or letters to refer to can aid in writing clear, concise legends.

Unless your journal requests that photographs and other illustrations be embedded in the text, it is a good idea to indicate the preferred location for each illustration. In this way, you will be sure that all illustrations have been referred to in the text, in one-two-three order, and the designer will know how to weave the illustrations into the text so that each one is close to the text related to it.

With electron micrographs, put a micrometer marker directly on the micrograph. In this way, regardless of any reduction (or even enlargement) in the printing process, the magnification factor is clearly evident. The practice of

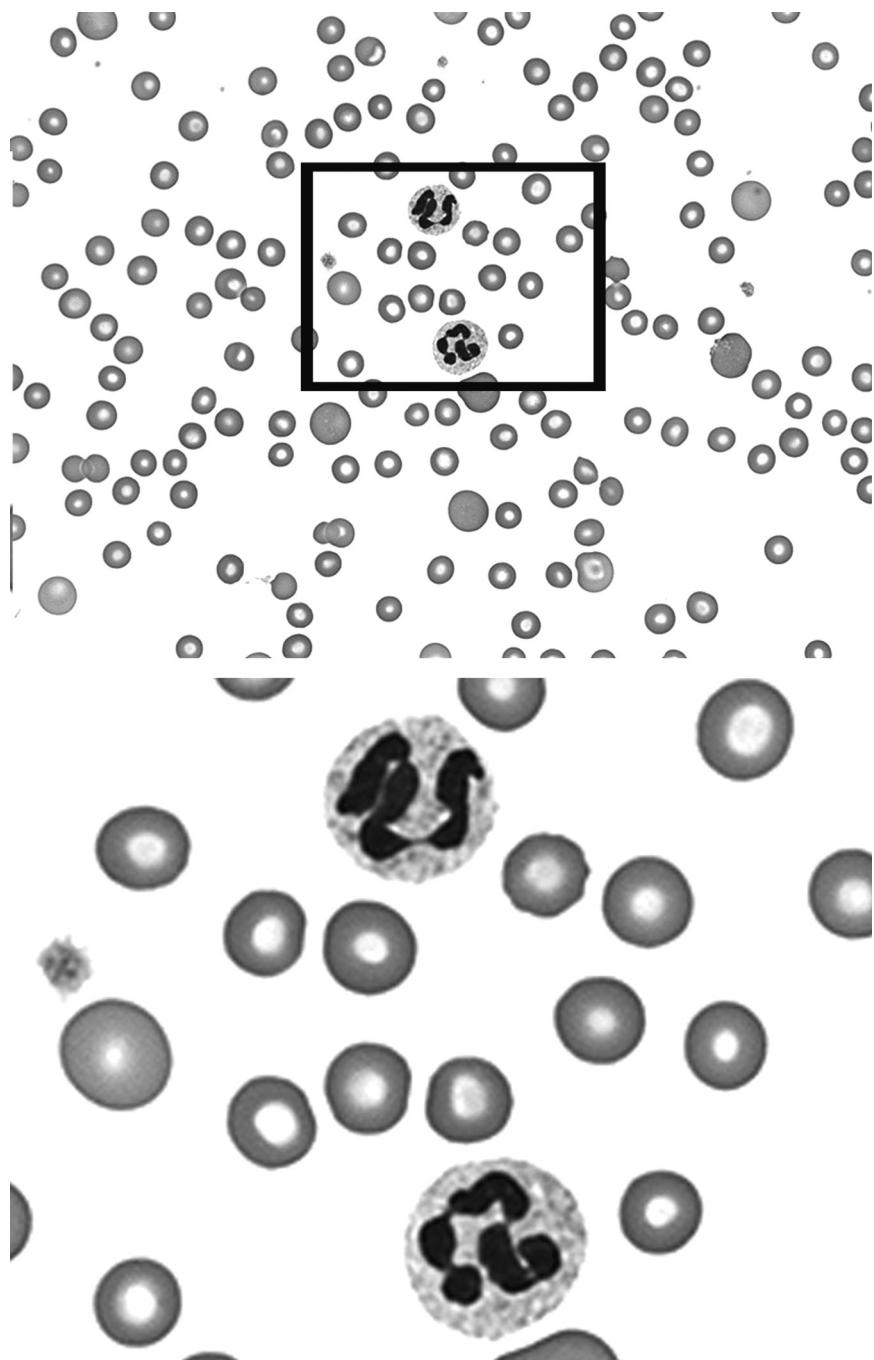


Figure 18.1. Uncropped (top) and cropped versions of a photograph. (Courtesy of Media Resources, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University)

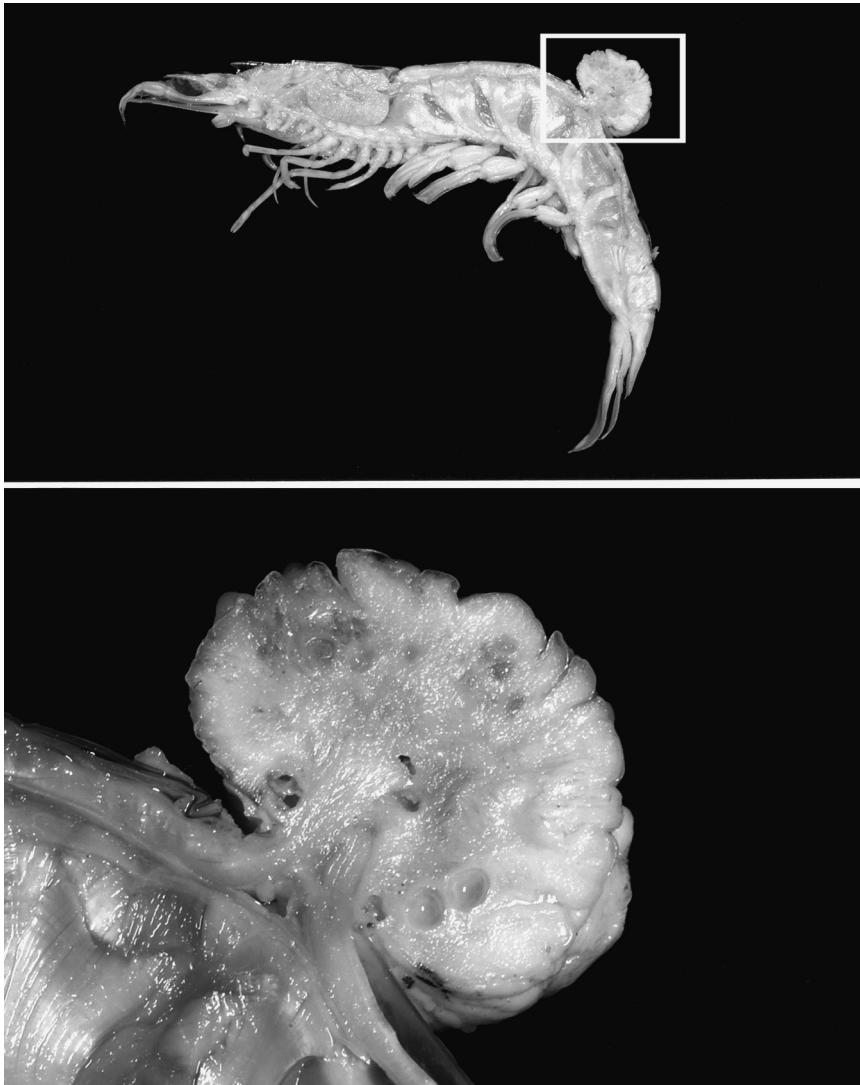


Figure 18.2. Uncropped (top) and cropped versions of a photograph. In this case, publication of both versions may be warranted, to both show the tumor in context and display detail. (Courtesy of Media Resources, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University)

putting the magnification in the legend (for example, $\times 50,000$) is not advisable, and some journals no longer allow it, precisely because the size (and thus magnification) is likely to change in printing. And, usually, the author forgets to change the magnification at the proof stage.

In other photographs where the size of the object is important, likewise include a scale bar. Sometimes showing a familiar object, such as a paper clip,

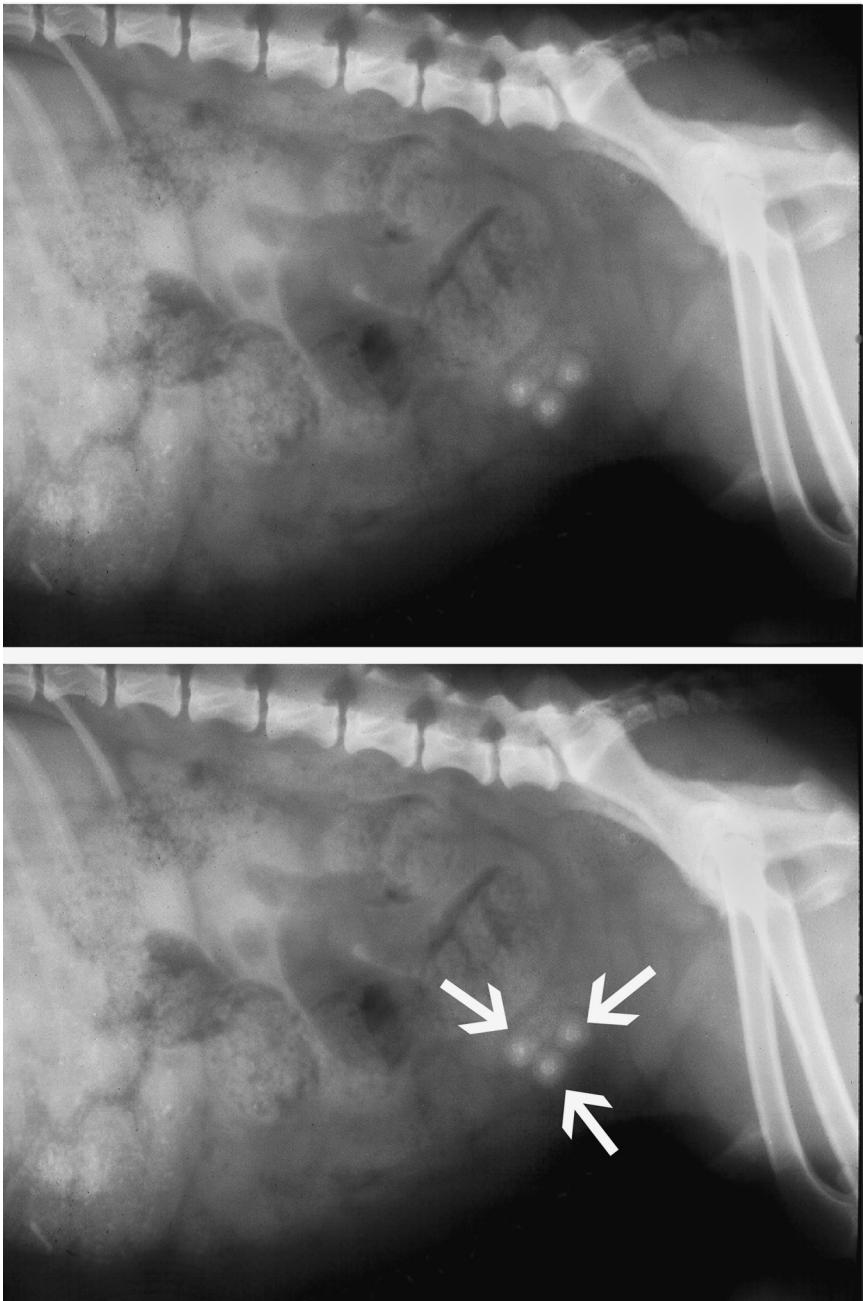


Figure 18.3. An example of adding arrows to direct readers' attention to structures of interest. (Courtesy of Media Resources, College of Veterinary Medicine and Biomedical Sciences, Texas A&M University)

near the object can help readers discern an object's size. Remember, though, that some objects (such as coins of given denominations) that are familiar to readers in one country might be unfamiliar to readers elsewhere.

COLOR

Until fairly recently, journals seldom published color photographs and other color illustrations, because of the high cost of printing them. Today, however, color printing has become more affordable. And for articles online, color does not increase cost at all. Thus, more color illustrations are appearing, and the use of color has become relatively common in some fields and journals. If you have the option of including color, consider whether doing so will improve your scientific paper. Would color help to tell your story? Or would it be merely decorative, or even distracting? Have you made sure, as discussed near the end of chapter 17, that readers who are colorblind would be able to understand the images?

If you are considering using color, see the instructions to authors of your target journal for specifications regarding color illustrations and for information on any charges for color. If color illustrations are to appear in print, authors commonly must pay a fee. Some journals, however, do not charge for color. For example, the author guidelines for American Chemical Society journals state: "Color may be used to enhance the clarity of complex structures, figures, spectra, and schemes, etc., and color reproduction of graphics is provided at no cost to the author."

PART IV

Publishing the Paper

CHAPTER 19

Rights and Permissions

Take away from English authors their copyrights, and you would very soon take away from England her authors.

—Anthony Trollope

WHAT IS COPYRIGHT?

Before you submit your paper to a journal, you should be aware of two items regarding copyright. First, if your paper includes illustrations or other materials that have been published elsewhere, you will need permission to republish them unless you hold the copyright or they are in the public domain. Second, you may need to transfer the copyright for your paper to the journal (or, for some journals, transfer limited rights while retaining copyright). The copyright information in this chapter focuses mainly on U.S. copyright laws. However, international agreements have provided considerable consistency among countries in this regard. Information on such agreements can be accessed online (for example, U.S. Copyright Office n.d.). Likewise, information on copyright policies of individual countries can be accessed online.

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Accordingly, if you post your materials on your website or share them in your institutional repository, they are already copyrighted. Ditto if you post your unpublished article in a preprint server. Journals vary as to whether they want materials that already have been posted. But the issue is separate from copyright.

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OBTAINING PERMISSIONS

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Obtaining permissions is often straightforward. Websites of many journal publishers include sections for seeking permissions. Also, permissions for materials from many journals and other sources can be obtained online through the Copyright Clearance Center (www.copyright.com). When neither option exists, contact the publisher or the creator of the item to identify the copyright holder and find out how to proceed.

If you republish an image or other material from elsewhere, you generally must include a credit line, such as "Reprinted with permission from (journal or book reference); copyright (year) by (owner of copyright)." Commonly, the copyright holder will specify the wording of the credit line. If not, the venue in which you are republishing the item may provide guidance in this regard. Some style manuals also provide such guidance, and looking at examples of credit lines in your target journal can clarify expectations as well.

CHAPTER 20

How to Submit the Manuscript

Great journals are born in the hands of the editors; they die in the hands of businessmen.

—Bernard DeVoto

CHECKING YOUR MANUSCRIPT

Before submitting your manuscript, review the instructions to authors from the journal. If the journal provides a manuscript-submission checklist, remember to use it. Make sure that you have followed all the instructions. If a manuscript deviates substantially from what is required, it may be returned for correction of the problems before it even undergoes review on its merits.

Unless the journal (or the style manual that it says to use) instructs otherwise, follow these guidelines:

- Double-space.
- Use margins of at least 1 inch (at least about 25 mm).
- Left-justify the text; leave a “ragged” right margin.
- Start each section of the manuscript on a new page. The title and authors’ names and addresses are usually on the first page, which should be numbered 1. The abstract is on the second page. The introduction starts on the third page, and each succeeding section (materials and methods, results, etc.) then starts on a fresh page. Figure legends are grouped on a separate page. Traditionally, the tables, figures, and figure legends have been assembled at the back of the manuscript. Currently, though, some journals ask authors to insert them in the text or to provide them as separate files.

Grammar-checking and spell-checking software can help, but you should not rely on them too heavily. Grammar checkers can alert you to possible problems in grammar and style. But given their limitations, you should accept their suggestions only if you confirm that they are correct. Almost all spell-checkers provide for the creation of custom dictionaries—for example, for scientific terms and unusual words; also, some specialized spell-checkers are commercially available. Spell-checkers recognize definite misspellings, but not those typographical errors that result in a word that exists but is wrong (for example, as occurs embarrassingly often, *pubic* instead of *public*). Thus, proofreading is still necessary to make sure that the correct word has been used and to detect errors such as missing words. In addition to proofreading the manuscript yourself, try to have someone do so who has not seen the manuscript before and therefore may notice problems that you miss. Consider also reading the manuscript aloud, as doing so can aid in noticing difficulties.

SUBMITTING YOUR MANUSCRIPT

For most of the history of scientific publication, researchers submitted their papers by mail. Yes, physical mail. Yes, the postal service, not email. In fact, early editions of this book advised readers on how to package a manuscript for mailing and what class of mail to use. Today, if a journal asks you to submit a hard copy of your manuscript by post, take a clue: The journal probably still is still stuck in the last century—which presumably is not where you want the output of your new research to be.

Today, journals commonly have online submission systems through which authors must submit their manuscripts. Journals that are small or are not associated with major publishers sometimes request manuscripts simply as email attachments. Over the years, online systems for electronic submission have become relatively easy to use. And conveniently, they can allow authors to track the progress of their papers as they head toward publication. For guidance on how to submit your manuscript, consult the journal's instructions to authors and look at the journal's website.

THE COVER LETTER

Finally, you should submit a cover letter with the manuscript (or provide equivalent information if an online submission system prompts you to do so). This letter, which is from the corresponding author, provides context for considering your paper. Most basically, it identifies the title of the article, the



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authors, and the journal to which the paper is being submitted. It may also identify the type of submission (for example, scientific paper or review article) and, if applicable, indicate the intended subject-matter section of the journal. Commonly, the letter must attest that the work is original and that the manuscript is not being considered by other journals. (Whereas one may apply to multiple graduate schools for admission and accept the best offer, standard practice is to submit a paper to one journal at a time. If the paper is not accepted, it can then be submitted to another journal.)

The letter also may attest that all the listed authors qualify to be listed and that no one meeting the criteria for authors was excluded. In addition, it may indicate whether the authors have conflicts of interest and, if so, what these

conflicts are. If some content of the paper has appeared previously (for example, in a conference abstract), the cover letter typically should state that. The letter also may do other things, such as mention a photograph or other image in the paper that may be well suited to appear on the cover of the journal.

Sometimes cover letters also suggest potential peer reviewers of the paper—or identify individuals whom the authors do *not* want as peer reviewers. Suggested reviewers should be scientists who can review the paper knowledgeably and without bias. They should not be people with conflicts of interest (for example, colleagues at the authors' institution or mentors, close friends, or family members of the authors). They can, however—as may be inevitable in small fields—be people whom the authors have met at conferences or otherwise know casually. Only if serious reason exists to believe that someone will be biased or otherwise unsuitable should a request be made to exclude a potential reviewer. Such a request may be made if, for example, someone in the authors' research area has had a major professional conflict with an author, is suspected of unscrupulous behavior, or is a spouse—or former spouse—of an author. Suggestions regarding reviewers are simply that: suggestions. The journal may follow them or not; commonly, they may use some reviewers suggested by authors plus some other reviewers. Journals often appreciate, and sometimes request or require, names and contact information of potential reviewers.

Explaining why the paper is believed to merit publication in the journal can also be useful in the cover letter. Doing so may be especially helpful if the relevance of the subject matter to the journal or the novelty or value of the research may not be immediately apparent. It also may be especially valuable if the journal is of broad scope, in which case the editor who first sees the paper might not be very familiar with the research topic and so might not readily recognize the importance of the contribution.

Some journals' instructions to authors include guidance on what to include in the cover letter. If so, of course proceed accordingly.

SAMPLE COVER LETTER

This is a model of a brief, simple cover letter:

Dear Dr. _____:

Accompanying this letter is a manuscript by Mary Q. Smith and Adam B. Appiah titled "Fatty Acid Metabolism in *Cedecia neteri*," which is being submitted for possible publication in the "Physiology and Metabolism" section of the *Journal of Bacteriology*.

This manuscript is new, is not being considered elsewhere, and reports new findings that extend results we reported earlier in the *Journal of Biological Chemistry* (284:112–117, 2020). An abstract of this manuscript was presented earlier (Abstr. Annu. Meet. Am. Soc. Microbiol., p. 406, 2021).

Sincerely,
Mary Q. Smith

A more extensive example appears at journals.lww.com/greenjournal/Documents/SampleCoverLetter.pdf. You may find this letter, which introduces the (fictional) paper “Primary Cesarean Delivery Among Pandas,” both instructive and amusing.

ELECTRONIC COVER LETTERS

If you are submitting your manuscript electronically, the manuscript-submission website may supply a mechanism for providing your cover letter. Alternatively, it may prompt you for the information the journal wants to receive, thus automatically generating a cover letter or the equivalent. This electronic option saves you the trouble of composing a letter and helps ensure that the journal receives the information it requires.

CONFIRMATION OF RECEIPT

Most journals send out an acknowledgment of receipt by email or other means when the manuscript is received, or they have a mechanism by which authors check the journal website to see whether submission is complete. Indeed, many journals now have online means by which authors can track the progress of their manuscripts from receipt, through review, to publication. If you do not receive acknowledgment within 2 weeks (or less for electronically submitted manuscripts), call or write to the editorial office to verify that your manuscript was indeed received. We know of one author whose manuscript was lost in transit, and not until 9 months later was the problem brought to light by his meek inquiry as to whether the reviewers had reached a decision about his manuscript. Do be sure that your manuscript was received.

CHAPTER 21

The Review Process (How to Deal with Editors)

Many editors see themselves as gifted sculptors, attempting to turn a block of marble into a lovely statue, and writers as crude chisels. In actual fact, the writers are the statues, and the editors are pigeons.

—Doug Robarchek

FUNCTIONS OF EDITORS, MANAGING EDITORS, AND MANUSCRIPT EDITORS

Editors and managing editors have impossible jobs. What makes their work impossible is the attitude of some authors. This attitude was well expressed by Earl H. Wood of the Mayo Clinic in his contribution to a panel on the subject “What the Author Expects from the Editor.” Dr. Wood said, “I expect the editor to accept all my papers, accept them as they are submitted, and publish them promptly. I also expect him to scrutinize all other papers with utmost care, especially those of my competitors.”

Somebody once said, “Editors are, in my opinion, a low form of life—inferior to the viruses and only slightly above academic deans.”

Returning to the first sentence in this chapter, let us distinguish between editors and managing editors. Authors should know the difference, if for no other reason than knowing to whom to complain when things go wrong.

An *editor* (some journals have several) decides whether to accept or reject manuscripts. Thus, the editor of a scientific journal is a scientist, often of pre-eminent standing. Editors not only make the final “accept” and “reject” decisions, but they also designate the peer reviewers upon whom they rely for advice. When you have reason to object to the quality of the reviews of your paper (or the decision reached), your complaint should be directed to the



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editor. (Adlai Stevenson joked that the role of the editor is to separate the wheat from the chaff and then make sure that the chaff gets printed.)

Especially at larger journals, there may be several such editors. For example, there may be an *editor-in-chief* (the top editor, in charge of overall journal content), a second in command known as a *deputy editor*, and a few associate or assistant editors. Sometimes different associate or assistant editors oversee the review of papers in different subject areas covered by the journal. Collectively, the editor-in-chief and other editors involved in evaluating and choosing papers sometimes are called *scientific editors*.

The *managing editor* is normally a full-time paid professional, whereas editors commonly are unpaid volunteer scientists. (A few large scientific and medical journals do have full-time paid editors. Some other journals, especially those that are in medical fields or are published commercially, pay salaries to their part-time editors.) Normally, managing editors are not directly involved with the accept-or-reject decisions. Instead, they attempt to relieve the editor of all the clerical and administrative details of the review process,

and they are responsible for the later events that convert accepted manuscripts into published papers. Thus, when problems occur at the proof and publication stages, you should communicate with the managing editor.

In short, preacceptance problems are normally within the province of the editor, whereas postacceptance problems are within the bailiwick of the managing editor. However, managing editors have observed that there seems to be one fundamental law that everybody subscribes to: "Whenever anything goes wrong, blame the managing editor."

Another editor you may encounter once your paper is accepted is a *manuscript editor*, also known as a *copy editor*. This individual may be a staff member working at the journal office or publishing company or a freelance contractor working at home in pajamas. A manuscript editor edits your paper for consistency with the journal's style and format. In addition, manuscript editors correct errors in grammar, spelling, punctuation, and usage. At some journals, they also work to improve expression in other ways, such as by making the wording clearer and more concise. If manuscript editors have questions (for instance, about inconsistencies between numbers in a table and in the text), they will ask the author for clarification by submitting what are called *queries*. View the manuscript editor as an ally in communicating your research to your readers and presenting yourself well to your professional community. Or, as one author told a manuscript editor, "Until I saw your edited version of my paper, I didn't realize how brilliant I was."

THE REVIEW PROCESS

You, as an author, should have some idea of the whys and wherefores of the review process. Therefore, we will describe the policies and procedures that are typical in most editorial offices. If you understand (and perhaps even appreciate) some of the reasons for the editorial decisions that are made, perhaps you can facilitate publication of your papers simply by knowing how to deal with editors.

When your manuscript arrives at the journal's editorial office, the editor (or the managing editor, if the journal has one) makes several preliminary decisions. First, is the manuscript concerned with a subject area within the scope of the journal? If it clearly is not, the manuscript is immediately returned to the submitting author, along with a short statement of the reason for the action. Seldom would an author be able to challenge such a decision successfully, and it is usually pointless to try. It is an important part of the editor's job to define the scope of the journal, and editors seldom take kindly to suggestions by authors, no matter how politely the comments are phrased, that the editor is somehow incapable of defining the basic character of their journal.

Remember, however, that such a decision does not constitute rejection of your data or conclusions. Your course of action is obvious: Try another journal.

Second, if the subject of the manuscript is appropriate for the journal, is the manuscript itself in suitable form for consideration? Is the manuscript complete, with no sections, tables, or figures missing? Is the manuscript in the editorial style of the journal, at least as to the basics? If the answer to either of the preceding questions is no, the manuscript may be immediately returned to the author, or at least the review will be delayed while the deficiencies are rectified. Most journal editors will not waste the time of their valued peer reviewers by sending poorly prepared manuscripts to them for review.

Only after these two preconditions (a proper manuscript on a proper subject) have been met is the editor ready to consider the manuscript for publication.

At this point, the editor must perform two very important functions. First, the basic housekeeping must be done. That is, careful records should be established so that the manuscript can be followed throughout the review process and (if the manuscript is accepted) the publication process. If the journal has a managing editor, as most large ones do, this activity is normally a part of their assignment. It is important that this work be done accurately, so that the whereabouts of manuscripts are known at all times. It is also important that the system include a number of built-in signaling devices so the inevitable delays in reviewing and other problems can promptly be brought to the attention of the editor or managing editor. The electronic systems that many journals use for manuscript submission and tracking facilitate this work.

Second, the editor must decide whether the paper will be peer reviewed (evaluated by other experts in the same research field) and, if so, choose peer reviewers. At many journals, all manuscripts reaching this stage are sent for peer review. At some journals—especially the larger and more competitive ones, which receive very many papers—the editors decide which manuscripts will be peer reviewed. If the editors know they would not publish the paper, for example because the research is too weak or the topic is too narrow, they return the paper to the author without peer review. Such return generally happens quickly; thus, the author does not waste weeks or more awaiting the unfavorable decision, as could well occur if the paper went for peer review. If you receive a rapid rejection—sometimes known as a “desk rejection” or “desk reject”—realize that you are not alone, and submit your paper to another, perhaps more specialized journal. Of course, carefully consult the new journal’s instructions to authors, and revise your manuscript accordingly before submitting it.

If the paper will be sent for peer review, the editor or editors must choose the peer reviewers (also known as *referees*). Commonly, two or three reviewers are selected for each manuscript; in some fields, however, more reviewers

sometimes are used, especially for interdisciplinary papers, and in some fields, the use of a single reviewer is the norm. The reviewers must be peers of the author—that is, fellow experts—or their recommendations will be of little value.

Frequently, the editor starts with the editorial board of the journal. Who on the board has the appropriate subject expertise to evaluate a particular manuscript? Often, because of the highly specialized character of modern science, only one member (or no member) of the board has the requisite familiarity with the subject of a particular manuscript. The editor must then obtain one or more reviews from nonboard members, often called *ad hoc reviewers* or *editorial consultants*. (Also, some journals depend entirely on ad hoc reviewers.) Sometimes the editor must make many inquiries before appropriate reviewers for a given manuscript are identified.

How do journals choose ad hoc reviewers? Often, the editors or editorial board members know suitable candidates. Some journals keep databases of researchers who have served as reviewers or could do so; as well as noting areas of expertise, such databases sometimes include information on the promptness and quality of reviews received from each person. Editors often invite authors of works cited in the manuscript to serve as reviewers. They also search the literature on the topic to identify appropriate candidates. As discussed in chapter 20, some journals allow authors to suggest potential reviewers—and let them list people they consider unsuited to serve as peer reviewers for such reasons as conflicts of interest. (Editors get suspicious, though, when authors include in the latter list most of the researchers in their fields!) Also, when researchers who are invited to review a paper are not available, they typically are asked to identify others who are qualified to do so. (And if you have a paper accepted by a journal, you may be added to its pool of potential reviewers.)

Does the peer review system work? According to Bishop (1984, p. 45), “The answer to this question is a resounding, Yes! All editors, and most authors, will affirm that there is hardly a paper published that has not been improved, often substantially, by the revisions suggested by referees.” Research (for example, Goodman et al. 1994) supports the conclusion that peer review and editing improve manuscripts.

Most journals in the sciences use anonymous reviewers. Some, however, disclose the names of reviewers or give reviewers the option of revealing their identities. A few journals make the authors anonymous by deleting their names from the copies of manuscripts sent to reviewers.

If the reviewers have been chosen wisely, their reviews will soundly identify strengths and limitations of the paper and will contain substantial constructive feedback. Thus, the editor will be in a good position to arrive at a decision regarding publication of the paper. Also, whether the paper is accepted or not,

the author will receive the reviewers' suggestions and thus can use them to improve the paper.

Peer review has been a subject of considerable research and reflection, and a number of international congresses have focused on the topic. Resources for those interested in peer review include books on the subject (Godlee and Jefferson 2003; Lock 1985) and the website of the International Congress on Peer Review and Biomedical Publication (peerreviewcongress.org).

THE EDITOR'S DECISION

Sometimes the editor's decision is easy. If all reviewers advise "accept" with no or only slight revision, and they all state solid reasons for their recommendation, the editor has no problem. Ditto if there's a unanimous and persuasive recommendation to reject the paper. Unfortunately, there are many instances in which the opinions of the reviewers are contradictory or unaccompanied by strong evidence. In such cases, the editor must either make the final decision or send the manuscript to one or more additional reviewers. Editors are likely to take the first approach if they are reasonably expert in the subject area of the manuscript and can thus serve as additional reviewers. At journals with many more submissions than they can publish, even papers receiving all "accepts" may be rejected if strong arguments cannot be mustered for their inclusion (much like when a grant application is "approved but not funded").

The review process being completed, and the editor having made a decision, the author is now notified of the editor's decision. And it is the editor's decision. Editorial board members and ad hoc reviewers can only recommend; the final decision is and must be the editor's. This is especially true for those journals (the majority) that use anonymous reviewers. The decisions will be presented to the authors as though they were the editor's own, and indeed they are.

The editor's decision will be one of three general types, commonly expressed in one word: accept, reject, or modify. Commonly, one of these three decisions will be reached within 4 to 6 weeks after submission of the manuscript. If you are not advised of the editor's decision within 8 weeks, or provided with an explanation for the delay, do not be afraid to contact the journal. You have the right to expect a decision, or at least a report, within a reasonable length of time; also, your inquiry might bring to light a problem. Perhaps the editor's decision was made, but notification did not reach you. If the delay was caused within the editor's office (usually by lack of response from one of the reviewers), your inquiry is likely to trigger an effort to resolve the problem, whatever it is.

Besides, you should never be afraid to contact editors. With rare exceptions, editors are very nice people. Never consider them adversaries. They are on

your side. Their only goal is to publish good science in understandable language. If that is not also your goal, you will indeed be dealing with a deadly adversary; however, if you share the same goal, you will find the editor to be a resolute ally. You are likely to receive advice and guidance that you could not possibly buy at any price.

THE ACCEPT LETTER

Finally, you get the word. Suppose that the editor's letter announces that your manuscript has been accepted for publication. When you receive such a letter, you have every right to treat yourself to a glass of champagne, a hot fudge sundae, or whatever you choose to indulge in when you have cause both to celebrate and to admire yourself. The reason that such a celebration is appropriate is the relative rarity of the event. In the good journals (in biology, at least), only a tiny percentage of the papers are accepted as submitted.

THE MODIFY LETTER—AND HOW TO RESPOND TO IT

More likely, you will receive from the editor a cover letter and two or more lists labeled "reviewers' comments." The letter may say something like, "Your manuscript has been reviewed, and it is being returned to you with the attached comments and suggestions. We believe these comments will help you improve your manuscript." If the editor feels confident that the research is publishable in the journal but believes that the paper's content, presentation, or both should be improved, the letter may go on to say that the paper will be published if modified as requested. Alternatively, if the author thinks the research might be publishable in the journal but cannot validly decide until the paper is revised (for example, by describing the methods in more detail or clarifying some points), the letter may say only that the paper will be reconsidered if the modifications are made. Especially if different reviewers made contradictory requests, the editor might say which requests to follow. Editors also may list requests of their own.

By no means should you feel disconsolate when you receive a "modify letter." Realistically, you should not expect that rarest of all species—the accept letter without a request for modification. The vast majority of submitting authors will receive either a modify letter or a reject letter, so you should be pleased to receive the former rather than the latter.

Nevertheless, you might not feel very pleased at first. You worked so hard on the paper. To you, maybe it seemed perfect, or nearly so. The revisions



"Thank you for your detailed and lengthy criticism of my manuscript. I will be sure to incorporate your suggestions in my next draft."

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would require even more work. And maybe they look unreasonable. If this is your reaction—as it commonly is—take some time to cool down. On rereading the requests after a day or two, you may realize that they are not really so burdensome. You may also find that items with you disagreed contain at least some truth.

Your first decision, then, is whether to proceed with the revisions or instead submit the paper elsewhere. In the case of a “publish if revised” letter, the better choice almost always is to proceed with the revisions. After all, publication of your paper is now almost guaranteed. In the case of a “reconsider if revised” letter, perhaps weigh your choices more thoroughly. If you can readily make the changes (for example, by describing or discussing your study in more detail), resubmission tends to be wise. If, however, the suggested revisions would entail much more work (such as conducting extensive experiments that you do not consider warranted) or would greatly change the nature of your paper, perhaps consider whether to proceed as advised or to try submitting the paper elsewhere.

In proceeding with revisions, remember that the reviewers and journal editor are your allies. Their goal, like yours, is for the paper to achieve its full potential. Rather than resenting the request to revise, realize that the reviewers and editor are helping you to excel. In fact, remembering their comments when writing future papers can minimize the need for such revision then.

Also, remember that, like writing a paper, revising a paper is likely to be a team effort. The corresponding author will receive the request to revise. However, different members of the author list may be best suited to help address requests about different parts or aspects of the paper.

As you read the requests, you might find that some are unsuitable because the editor or reviewer misunderstood what you were trying to say. Do not disregard such requests. Instead, take them as evidence that clarification is needed. After all, the editors and reviewers probably read your paper more carefully than almost anyone else would; if they misunderstood a point, others might be especially likely to do so. So, revise the writing in question to make it unambiguous.

In some other cases, the editors or reviewers might understand what you were saying but make a request with which you disagree. For example, they might ask for a change that you believe would introduce an inaccuracy. Or they might suggest an addition that you consider unwarranted. Do not just ignore these requests either; such behavior might well prevent publication of your paper. Rather, respectfully address such requests. For example, if a request was intended to solve a problem with the paper, propose another way to solve it. Or if an addition seems unwarranted, calmly explain why you consider it so. Editors want to publish papers with which both they and the authors are satisfied. Sometimes they will even arrange a phone or video call to work out a mutually acceptable solution.

Journals commonly state a deadline for submitting revisions. If at all possible, meet this deadline. If you cannot do so, inform the editor as soon as possible, so schedules can be revised accordingly.

Sometimes only the editor reviews the revisions and determines whether they are acceptable. In other instances, one or more of the reviewers also

evaluate the revisions. Accordingly, papers sometimes undergo more than one round of revision. If additional revisions are needed, persevere. Quite likely, you are almost there.

When you submit a revised manuscript, make it easy for the editor to identify the changes. For example, if the editor supplied a numbered list of revisions to make, state, by number, how each was addressed. Perhaps use the Track Changes feature of Microsoft Word to show your revisions. Or if the editor asked you to indicate your revisions in another way, such as by highlighting, carefully follow the instructions. Clearly identifying the changes made can speed the final decision about your paper. It also can help earn you a reputation as a good author to work with—a fact that can facilitate further interactions with the editorial office.

THE REJECT LETTER

Now let us suppose that you get a reject letter. (Almost all editors say “unacceptable” or “unacceptable in its present form”; seldom is the harsh word “reject” used.) Before you begin to weep, do two things. First, remind yourself that you have a lot of company; good journals commonly have rejection rates of 50 percent or considerably more. If your paper receives peer review but is not accepted, you will still receive the reviewers’ comments. These comments can guide you in how to proceed. For example, upon reading the comments, you might conclude that additional research is needed to yield a paper acceptable to a journal of the current type. Or you may realize that if you make some of the suggested revisions, the paper might be well suited for a more specialized journal. Learn from the feedback, and proceed accordingly.

Most of all, do not be discouraged. Papers often are rejected by the first journal to which they were sent; always having one’s papers accepted on the first try probably means that one is not aiming high enough. If you do good research, work hard on presenting it well, are responsive to feedback from editors and reviewers, and persevere, almost certainly your paper will appear in a journal.

EDITORS AS GATEKEEPERS

An important point to remember is that the editor is a mediator between you and the reviewers. If you deal with editors respectfully and can defend your work scientifically, you can facilitate your paper’s acceptance. The editor and the reviewers are usually on your side. Their primary function is to help you express yourself effectively and provide you with an assessment of the science involved. It is to your advantage to cooperate with them in all ways possible.

Academic Rejection Letter

We don't know if you have a Ph.D. but it's better to stroke your ego just in case.
Dear Dr. _____,

Thank you for submitting your manuscript titled "Cut and paste title here".

(not really)

We regret to inform you that your manuscript will not be included for publication in our journal at this time.

* awesome *

Actually, it was just me. After careful consideration and extensive discussion among the editorial staff, we feel this paper would be more appropriate for publication in another journal.

a lesser

They were pretty bad, though.

Although the reviews are not entirely negative, it is evident that the manuscript does not meet our criteria for novelty and impact.

(i.e. your topic isn't trendy enough)

After you pick up the pieces of your shattered soul.

Although you could address these issues in a revised manuscript, we must decline without further review so that you may submit it elsewhere without delay.

We don't want to read it again.

See how considerate we are?

I am sorry our response could not be more positive. (or negative)

Not really. Paper is cheap and websites don't have a size limit.

Our decision in no way reflects any criticism or doubt about the quality of the work submitted or your work in general.

Ok, maybe just a little.

Due to the high volume of submissions we receive and the constraints of space, we must limit the number of articles we select for publication.

Just rubbing that in your face.

We hope that you will continue to consider our journal for future manuscript submissions.

i.e. We are not desperate enough to publish you now, but we might be in the future.

Sincerely,

The Journal's Editor's Assistant

("Piled Higher and Deeper" by Jorge Cham. www.phdcomics.com)

The possible outcomes of the editorial process were neatly described by Morgan (1986, p. vii): “A modern metaphor for editing would be a car wash . . . through which all cars headed for a goal must pass,” he wrote. “Very dirty cars are turned away; dirty cars emerge much cleaner; clean cars are little changed.” Work with editors and reviewers to ensure that your vehicle passes expeditiously through the car wash and emerges as shiny as it can be.

CHAPTER 22

The Publishing Process (How to Deal with Proofs)—and After Publication

If life had a second edition, how I would correct the proofs.

—John Clare

THE COPYEDITING AND PROOFING PROCESSES

The following is a brief description of the process that your manuscript follows after it has been accepted for publication.

The manuscript usually goes through a copyediting procedure, during which errors in spelling and grammar are corrected. In addition, the copyeditor will standardize all abbreviations, units of measure, punctuation, and spelling in accord with the style of the journal in which your manuscript is to be published. At some journals, copyeditors also revise writing to increase readability, such as by improving sentence structure and making wording more concise. Many English-language journals with sufficient staff to do so devote extra effort to copyediting papers by nonnative speakers of English in order to promote clear international communication. The copyeditor may direct questions to you if any of your wording is not clear or if any additional information is needed. These questions may appear as *author queries* written on or accompanying the *proofs* (typeset pages) sent to the author. Alternatively, the queries may appear on or with the copyedited manuscript if the journal sends it to the author for approval before preparing the proofs.

Typically, the edited version of the electronic file that you provided is loaded into a computer system that can communicate with a typesetting system, which will produce the proofs of your article. The copyeditor or compositor enters codes that indicate the typefaces and page layout of the various elements.

The output of this effort is your set of proofs, which is then returned to you so that you may check the editorial work that has been done on your article, look for typographical errors, and answer any further questions by the copy-editor. Commonly, you will receive the proofs of your article as a PDF file.

Finally, someone at the journal will enter the corrections that you make on your proofs. The final version will be what you see when your paper is published in the pages of the journal.

WHY PROOFS ARE SENT TO AUTHORS

Some authors seem to forget their manuscripts as soon as they are accepted for publication, paying little attention to the proofs when they arrive and assuming that their papers will magically appear in the journals without error.

Why are proofs sent to authors? Authors are provided with proofs of their papers for one main reason: to check the accuracy of the type composition. In other words, you should examine the proofs carefully for typographical errors. Even if you carefully proofread and spell-checked your paper before submitting it, errors can remain or can be introduced when editorial changes are input. And sometimes the typesetting process mysteriously converts Greek letters into squiggles or corrupt characters, cuts off lines of text, or causes other mischief. No matter how perfect your manuscript might be, it is only the printed version in the journal that counts. If the printed article contains serious errors, all kinds of later problems can develop, not the least of which may be serious damage to your reputation.

The damage can be real, in that many errors can destroy comprehension. Something as minor as a misplaced decimal point can make a published paper almost useless. In this world, we can be sure of only three things: death, taxes, and typos.

MISSPELLED WORDS

Even if an error does not greatly affect comprehension, it won't do your reputation much good if it turns out to be funny. Readers will know what you mean if your paper refers to a "nosocomical infection," and they will get a laugh out of it, but *you* won't think it is funny.

A major laboratory-supply corporation submitted an ad with a huge, bold-face headline: "Quality is consistant because we care." We certainly hope that they cared more about the quality of their products than about the quality of their spelling.

Although all of us in publishing occasionally lose sleep worrying about typographical errors, we can take comfort in the realization that whatever slips past our eye is probably less grievous than some of the monumental errors committed by our publishing predecessors.

The best way to read proofs is first, *read* them, and second, *study* them. Reading will miss 90 percent of the errors, but it will catch errors of *omission*. If the printer has dropped a line, reading for comprehension is the only likely way to catch it. Alternatively, or *additionally*, it can be helpful for two people to read the proofs, one reading aloud while the other follows the manuscript.

To catch most errors, however, you must slowly examine each word. If you let your eye jump from one group of words to the next, as it does in normal reading, you will not catch very many misspellings. In particular, you should study the technical terms. A good keyboarder might be able to type the word *cherry* 100 times without error; however, there was a proof in which the word *Escherichia* was misspelled 21 consecutive times (in four different ways). One might also wonder about the possible uses for a chemical whose formula was printed as C₁₂H₆Q₃. One way to look at each word without distraction is to read the proof backward, from last word to first.

As a safeguard, consider having someone else review the proofs in addition to doing so yourself. But do not delegate the proofreading solely to others, lest you suffer the plight of a colleague of ours who, tired of the publication process, had an office worker review the proofs. Only after the journal was published did the colleague find that the article title contained a misspelling.

We mentioned the havoc that could occur from a misplaced decimal point. This observation leads to a general rule in proofreading. Examine each and every number carefully. Be especially careful when proofing the tables. This rule is important for two reasons. First, errors frequently occur when typing numbers, especially in tabular material. Second, you are the *only* person who can catch such errors. Most spelling errors are caught in the printer's proof room or in the journal's editorial office. However, professional proofreaders catch errors by "eyeballing" the proofs. The proofreader has no way of knowing that "16" should be "61."

MARKING THE CORRECTIONS

Like much else in scientific publishing, correction of proofs has been changing in the electronic era. No longer do authors receive galley proofs (long strips of type) to correct before page proofs are prepared. And rather than being sent proofs by mail, authors receive them electronically or access them through websites. Accordingly, procedures for indicating corrections have

been evolving. Be sure to follow the current instructions that the journal provides with the proof.

The long-established procedure is to mark each error *twice* on a hard copy of a proof, once at the point where it occurs and once in the margin opposite where it occurs. The compositor uses the margin marks to find the errors, as a correction indicated only in the body of the text can easily go unnoticed. Standard proofreading marks, the most common of which are listed in Table 22.1, should be used to indicate corrections. Normally, if you are to print out a hard copy and indicate corrections on it, the publisher provides a list of such marks along with the proofs. Learning the main proofreading marks can

Table 22.1. Frequently Used Proofreaders' Marks

Instruction	Mark in Text	Mark in Margin
Capitalize	He a la cells	cap
Make lowercase	the P enicillin reaction	l.c.
Delete	a very good reaction	e
Close up	Mac D onald reaction	—
Insert space	lymph n node cells	#
Start new paragraph	in the cells. T he next	#
Insert comma	in the cells, after which	↑
Insert semicolon	in the cells; however	;
Insert hyphen	well k nown event	=
Insert period	in the cells. T hen	①
Insert word	in c ells	#the#
Transpose	proofre d der	tr
Subscript	CO ₂	<u>2</u>
Superscript	³² P	<u>32</u>
Set in roman type	The <u>bacterium</u> was	rom
Set in italic type	<u>P. aeruginosa</u> cells	ital
Set in boldface type	Results	b.f.
Let it stand	a very good reaction	stet

facilitate reviewing the proofs of your papers and proofing typeset versions of other items you write.

Other options have been developing as well. Some journals, for example, ask authors to use tools in Adobe Acrobat to indicate corrections on PDF versions of the proofs. Some have their own online proofreading systems for authors to use.

Whatever approach is used, return the proofs quickly, by the deadline given you by the journal. Failure to do so disrupts the publication schedule of the journal and can result in delay or even withdrawal of your paper. If you think that you might be unreachable when the proofs become available, inform the journal so the timetable can be revised or the proofs can be sent to a coauthor or other colleague to review.

ADDITIONS TO THE PROOFS

Earlier in this chapter, we stated that authors are sent proofs so that they can check the accuracy of the typesetting. Stated negatively, the proof stage is *not* the time for revising, rewriting, rephrasing, adding more recent material, or making any other significant changes to the final edited manuscript. There are three good reasons why you should not make substantial changes in the proofs.

First, an ethical consideration: Since neither proofs nor changes in the proofs are seen by the editor unless the journal is a small, one-person operation, it simply is not proper to make substantive changes. The paper approved by the editor, after peer review, is the one that should be printed, not some new version containing material not seen by the editor or the reviewers.

Second, it is not wise to disturb typeset material, unless it is really necessary, because new typographical errors may be introduced.

Third, corrections can be expensive. Therefore, you should not abuse the publisher (possibly a scientific society of which you are an otherwise loyal member) by requesting unessential changes; in addition, you just might receive a substantial bill for author's alterations. Most journals absorb the cost of a reasonable number of author's alterations, but sooner or later, many, especially those with managing editors or business managers, will crack down on you if you are patently guilty of excessive alteration of proofs.

One type of addition to the proofs is sometimes allowed. The occasion arises when a paper on the same or a related subject is published while yours is undergoing the publication process. In light of the new study, you might be tempted to rewrite several portions of your paper. You must resist this temptation, for the reasons stated previously. What you may do, though, is prepare a short addendum to the proofs (at most a few sentences), describing the general

nature of the new work and giving the literature reference. If the editor approves including it, the addendum can then be printed at the end, without disturbing the body of the paper.

ADDITION OF REFERENCES

Sometimes a new paper appears that you would like to add to your references; in doing so, you would not need to make any appreciable change to the text other than adding a few words, perhaps, and the number of the new reference. If you are unsure how the journal would like you to proceed, consult its editorial office.

If the journal employs the numbered, alphabetized reference system, you may be asked to add the new reference with an “a” number. For example, if the new reference would alphabetically fall between references 16 and 17, the new reference would be listed as “16a.” In that way, the numbering of the rest of the list can remain the same, thus avoiding the cost and the potential for error of renumbering the references in the reference list and the text. An analogous procedure may be requested for references in the citation order system. Conveniently, if the new reference is cited in an addendum, it would appear last in the citation order system, thus not disrupting the rest of the reference list.

PROOFING THE ILLUSTRATIONS

It is important to examine the proofs of the illustrations carefully. In the era when authors submitted photographic prints and other hard-copy illustrations, one needed to check carefully for quality of reproduction. Now that illustrations are being submitted electronically, such a need has diminished. Nevertheless, checking illustrations remains important. Make sure that all illustrations are present, complete, and appropriately placed. Also, make sure that electronic gremlins have not somehow disturbed or distorted the illustrations. If you perceive problems with the illustrations, report them as instructed by the journal.

WHEN TO COMPLAIN

If you have learned nothing else from this chapter, we trust that you now know that *you* must provide quality control. Too many authors have complained after the fact (after publication) without ever realizing that only they could have prevented whatever it is they are complaining about. For example, many

authors have complained that their pictures were printed upside down or sideways. When such complaints have been checked, it has commonly been found that the authors failed to note that the photos were oriented incorrectly in their proofs.

So, if you are going to complain, do it at the proof stage. And, believe it or not, your complaint is likely to be received graciously. Publishers have invested heavily in setting the specifications that can provide quality reproduction. They need your quality control, however, to ensure that their money is not wasted.

Good journals with hard-copy versions are printed by good printers, hired by good publishers. The published paper will have your name on it, but the reputations of both the publisher and the printer are also at stake. They expect you to work with them in creating a superior product. Likewise, if a journal is solely electronic, the publisher wants to ensure that the product is of high quality, and depends on your collaboration in that regard. (If, however, the published version of your paper contains an error despite your best efforts, inform the journal. Depending on the situation, they may be able to correct the paper online, publish a correction, or both.)

Because managing editors of such journals must protect the integrity of the product, those we have known would *never* hire a printer exclusively because it was the lowest bidder. John Ruskin was no doubt right when he said, “There is hardly anything in the world that somebody cannot make a little worse and sell a little cheaper, and the people who consider price only are this person’s lawful prey.”

A sign in a printing shop made the same point:

PRICE
QUALITY
SERVICE

Pick any two of the above

REPRINTS

Historically, authors received with their proofs a form for ordering hard-copy reprints of their articles. Older scientists remember the days—before widespread electronic access to journal articles, and indeed before widespread access to photocopying—when obtaining reprints from authors served as an important way to keep up with the literature. As well as giving researchers access to articles, reprint requests helped authors learn who was interested in their work (Wiley 2009). Today, however, reprints are much less a part of scientific culture.

Some journals make available “electronic reprints,” which allow authors to grant one-time electronic access to their articles. Someday, scientists may ask why articles that authors share are called *reprints* at all.

PUBLICIZING AND ARCHIVING YOUR PAPER

In the era when paper reprints prevailed, scientists commonly sent them to colleagues worldwide soon after publishing a paper. Today, many scientists alert others to their new articles largely through social media. Depending on their preferences and the scientific cultures where they work, they may, for instance, tweet news of the publication on Twitter or post it on Facebook. They also may add listings (and links) to their ORCID (Open Researcher and Contributor ID) records, LinkedIn profiles, and profiles on science-related networking sites such as ResearchGate. Sometimes they may appear on podcasts produced by their journal, their institution, or others. When you publish an article, such steps—and the follow-up by those who thus notice the article and inform others in their networks—can inform those potentially interested in your paper.

General media too can aid in publicizing your newly published research, both to the public and to fellow researchers. Many universities and other



"I haven't been in any academic journals but I
do get my Tweets re-Tweeted a lot."

research institutions have public information officers (PIOs), whose role is largely to publicize the research done there. When you have a paper accepted, alert a PIO at your institution. The PIO can then consider whether to publicize the research to journalists and others (for instance, through news releases, institutional websites and publications, and the use of social media networks). PIOs know that some journals place articles under *embargoes*; in other words, research reported in them is not to appear in the media until the release date for the issue in which they are published. A PIO can aid in obtaining timely coverage without violating embargoes. Advice on working with PIOs appears in an article by Tracy Vence (2015) in *The Scientist*.

Publicizing a newly published paper—through social media, mass media, or other means—can benefit a scientist in multiple ways, notes PIO Matt Shipman (2015a). For example, it can lead to citations, please funding agencies, engender collaborations, and more generally expand one’s professional network. It also may attract potential graduate students—or perhaps, earlier in one’s career, attract the attention of employers or postdoctoral-fellowship sites. And if your findings have applications outside the research sector, publicity may bring them to the attention of those who can use them. Indeed, if research is supported with public funds, scientists may be morally obligated to get the word out. In fact, some public and other sources of research funds require that grant recipients make their work openly available.

Whether required or not, making your journal articles (and reports based on them) widely available can benefit science, society, and your career. Follow, of course, the policies of relevant funding agencies regarding public access to papers resulting from your research. (An example is the U.S. National Institutes of Health public access policy, publicaccess.nih.gov/policy.htm.) If your university or other institution has an institutional archive, explore depositing electronic copies of your publication there. Also, consider linking publications to your own website or your curriculum vitae. The Sherpa Romeo website (v2.sherpa.ac.uk/romeo) includes information on journal publishers’ policies on self-archiving.

In short, publishing a journal article, though a major accomplishment, is not the last step in getting word out about your research. In a way, it is just the beginning. You have invested great effort in doing a study, writing a paper about it, and publishing the paper. Now take the additional steps to help ensure that, in the broadest sense, your paper has maximum impact.

CELEBRATING PUBLICATION

As noted, publishing a scientific paper is a major accomplishment. By the time a paper comes out, you may well be working on the next one—or even the one after that. But take some time to celebrate your success. Some scientists or research groups have traditions for doing so. For example, some gather

for a celebration dinner and post a photo taken there. Some treat themselves to a good bottle of wine and collect the labels as reminders of their successes. Some may attend a concert, play, or athletic event and keep the ticket or the program as a memento. Perhaps best of all is to spend some time—perhaps at a favorite park—with the family members or friends who tolerated our absences, insecurities, and complaints as we struggled to write about and publish the work. Whatever you choose, you deserve to celebrate. Congratulations on publishing your paper!

PART V

Doing Other Writing for Publication

CHAPTER 23

How to Write a Review Paper

Review articles constitute a form of original research, albeit done in the library rather than in the laboratory or at the bedside.

—Bruce P. Squires

CHARACTERISTICS OF A REVIEW PAPER

A review paper (also known as a *review article*) is *not* an original publication in the usual sense, though it can be valuable scholarship. On rare occasions, a review may contain new data (from the author's own laboratory) that have not yet appeared in a primary journal. However, the purpose of a review paper is to review previously published literature and to put it into perspective.

A review paper tends to be long, often ranging between 10 and 50 published pages. (Some journals, however, now print short “mini-reviews.”) The subject usually is fairly general compared with that of research papers, and the literature review is, of course, the principal product. However, the really good review papers are much more than just annotated bibliographies. They offer critical evaluation of the published literature and often provide important original conclusions based on that literature.

The organization of a review paper usually differs from that of a research paper. The IMRAD (introduction, materials and methods, results, and discussion) arrangement traditionally has not been used for the review paper. However, some review papers are prepared more or less in the IMRAD format; for example, they may contain a methods section describing how the literature review was done. In particular, systematic review articles, which methodically identify and integrate literature on a focused question, commonly follow the IMRAD format or a variant thereof. Indeed, multiple

varieties of review articles, each with certain conventions, have now arisen. A review article on the types of review articles (Grant and Booth 2009) analyzes 14 such types.

If you have previously written research papers and are now about to write your first conventional review paper (sometimes known as a *narrative review*), it might help you conceptually if you visualize the review paper as a research paper, as follows: Greatly expand the introduction; delete the materials and methods (unless original data are being presented or you will say how you identified and chose the literature to include); delete the results; and expand the discussion.

Actually, you may have already written the equivalent of many review papers. In format, a review paper is not very different from a well-organized term paper or the literature review section of a thesis.

As in a research paper, however, it is the *organization* of the review paper that is important. The writing will almost take care of itself once you get the thing organized.

PREPARING AN OUTLINE

Unlike research papers, there is no prescribed organization for conventional review papers. Therefore, you will have to develop your own. A cardinal rule for writing a review paper is to *prepare an outline*.

The outline must be prepared carefully. It will assist you in organizing your paper, which is all-important. If your review is organized properly, its overall scope will be well defined and the integral parts will fit together in a logical order.

Obviously, you must prepare the outline *before* you start writing (although you may end up revising it as you write). Moreover, before you start writing, it is wise to determine whether a journal (either a review journal or a primary journal that includes review articles) would be interested in considering a review article that you submit on the topic. Possibly, the editor will want to limit or expand the scope of your proposed review or add or delete specific subtopics. Or perhaps the journal is already publishing a review on the subject, in which case you should direct your efforts elsewhere.

Not only is the outline essential for the preparer of the review, it is also very useful to potential readers of the review. Therefore, many review journals print the outline at the beginning of the article, where it serves as a convenient table of contents for prospective readers.

Also to guide readers, review papers make considerable use of subheadings (which, if an outline is published, correspond to the subjects that it lists). For

example, the review paper “Mechanics of Cytokinesis in Eukaryotes,” by Thomas D. Pollard (2010), contains the following subheadings:

Introduction
Origins of cytokinesis genes
Mechanisms specifying the position of the division plane
 Fission yeast
 Budding yeast
 Animal cells
Mechanism of contractile ring assembly
 Fission yeast
 Animal cells
Architecture of the ring
Mechanism of constriction and disassembly of the contractile ring
 Actin filaments
 Myosin-II
 Mechanism of constriction
 Sources of drag
 Modeling
Conclusions

In 2015, Pollard, the author of this review paper, received the National Academy of Sciences Award for Scientific Reviewing “for his many review articles describing the molecular mechanisms of the protein actin in cell motility and cell division”; it was noted that these articles “have been cited hundreds and even thousands of times.” This award, given in different years to authors in different fields, was presented from 1979 through 2020. Information on its recipients appears on the U.S. National Academy of Sciences website (nasonline.org/programs/awards/scientific-reviewing.html). To see some review papers by masters, look on this site to identify recipients in your field, and then search the literature to find their reviews.

TYPES OF REVIEWS

Before actually writing a review, you also need to determine the requirements of the journal to which you plan to submit it. Some journals demand critical evaluation of the literature, whereas others are more concerned with bibliographic completeness. There are also matters of organization, style, and emphasis that you should consider before you proceed anyfurther.

By and large, the old-line review journals prefer (and some demand) authoritative and critical evaluations of the published literature on a subject.

Many of the “book” series (*Annual Review of Recent Advances in, Yearbook of, etc.*), however, publish reviews designed to compile and annotate, but not necessarily evaluate, the papers published on a particular subject during a defined time period. Some active areas of research are reviewed yearly. Both of these types of review papers serve a purpose, but the different purposes need to be recognized.

At one time, review papers tended to present historical analyses. In fact, the reviews were often organized chronologically. Although this type of review is now less common, one should not deduce that the history of science has become less important. There is still a place for history.

Today, however, most review media prefer either “state of the art” reviews or reviews that provide a new understanding of a rapidly moving field. Mainly, the recent literature on the subject is catalogued or evaluated. If you are reviewing a subject that has not previously been reviewed or one in which misunderstandings or polemics have developed, a bit more coverage of the historical foundations would be appropriate. If the subject has been effectively reviewed before, the starting point for your review might well be the date of the previous review (not the publication date, but the date up to which the literature was reviewed). And, of course, your review should begin by citing the previous review.

Another type of review paper, known as a *systematic review article*, has become common in some fields. A systematic review addresses “a clearly formulated question using systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review” (epoc.cochrane.org/sites/epoc.cochrane.org/files/public/uploads/SURE-Guides-v2.1/Collectedfiles/source/glossary.html). Commonly, systematic review articles follow a variant of the IMRAD format; for example, they include a methods section specifying such items as databases searched, search terms used, dates and languages included, and criteria for including and excluding studies. Academic librarians, some of whom specialize in literature searching for systematic reviews, can be well worth consulting when preparing such a review. Written sources of guidance for preparing systematic review articles include the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al. 2021).

WRITING FOR THE AUDIENCE

Another basic difference between review papers and primary scientific papers is the *audience*. The primary scientific paper is highly specialized, and so is its audience (mainly peers of the author). The review paper will probably encompass a number of specialized subjects in your field, so it will be read by many

peers. The review paper will also be read by many people in related fields because reading good review papers is the best way to keep up in one's broad areas of interest—or to start preparing to enter related areas of research. Finally, review papers are valuable in teaching, so student use is likely to be high.

Because the review paper is likely to have a wide and varied audience, your style of writing should be much less technical than for a research paper. Jargon and specialized abbreviations must be eliminated or carefully explained. Your writing style should be expansive rather than telegraphic (condensed).

IMPORTANCE OF INTRODUCTORY PARAGRAPHS

Readers are much influenced by the introduction of a review paper. They are likely to decide whether to read further on the basis of what they find in the first few paragraphs (if they haven't already been repelled by the title).

Readers are also influenced by the first paragraph of each major section of a review, deciding whether to read, skim, or skip the rest of the section depending on what they find in the first paragraph. If the first paragraphs are well written, all readers, including skimmers and skipper, will be able to achieve some comprehension of the subject.

IMPORTANCE OF CONCLUSIONS

Because the review paper typically covers a wide subject for a wide audience, some form of conclusion is worth taking the trouble to write. Doing so is especially important for a highly technical, advanced, or obscure subject. Painful compromises must be made sometimes if one really tries to summarize a difficult subject to the satisfaction of both expert and amateur. Yet in time, good summaries and simplifications will find their way into textbooks and mean a great deal to students yet to come.

ADDITIONAL TIPS FOR WRITING REVIEW ARTICLES

Other pointers for writing review articles include the following:

- Consider using a spreadsheet to keep track of articles for potential inclusion. The spreadsheet can include columns for bibliographic information and for elements such as methods, main findings, and comments.

- Do not feel compelled to cite *everything* written on a topic. If a paper is obscure for good reason, let it remain so. If, however, a prominent paper has substantial limitations, include it, but tactfully note the limitations.
- Integrate rather than catalog. For example, include paragraphs that combine different studies' findings on a given topic and reflect on the similarities and differences. Do not just summarize each study in a separate paragraph; a review article is not a string of abstracts.
- If appropriate, include figures or tables. Systematic reviews often contain flowcharts showing the literature selection process and tables summarizing the studies included. Depending on their content, conventional (narrative) reviews also can benefit from figures and tables; possibilities include drawings of structures and diagrams of processes. At some major journals, scientific illustrators prepare final versions of such graphics.
- Indicate not only what the literature contains, but also what it doesn't; an important function of review articles can be to identify gaps in knowledge. Such identification can lead to new research, producing new scientific papers and ultimately more complete reviews.

A review article is both scholarship and service. By giving its preparation the attention it deserves, you can produce an informative, insightful, accessible article that increases your prominence as a scholar and serves your readers well.

CHAPTER 24

How to Write Opinion (Letters to the Editor, Editorials, Book Reviews, and Essays)

It is hard enough to remember my opinions, without also remembering my reasons for them!

—Friedrich Nietzsche

WRITING INFORMED OPINION

As you become known in your field, editors of journals and other publications may invite you to write pieces expressing your professional judgment. In particular, you may be asked to write editorials and book reviews. Chances to write the latter also may arise earlier in your career. And whatever your seniority (or lack thereof), you may submit letters to the editor for potential publication or posting. Some journals also publish personal essays.

All these pieces express opinion. But not just any opinion: your scientifically informed opinion. Although sometimes allowing more creativity in writing style, they should display the same rigor as a scientific paper. Evidence should support the views expressed, and logic should be tight. In short, scientific opinion pieces should clearly evidence the mind of a researcher.

LETTERS TO THE EDITOR

Many journals print or post letters to the editor. Usually, not all letters received are published.

Often, letters comment on papers recently published in the journal, thus serving as postpublication peer review. Sometimes they deal independently with issues of professional interest to readers. In some journals, brief research

reports or case reports can appear as letters; an editor who decides not to publish a paper may offer to publish a condensed version as a letter to the editor. When a letter comments on a paper, the authors of the paper may have the opportunity to prepare a reply for publication.

Before drafting a letter, check the journal's instructions, which commonly appear in the letters section of the journal and on the journal website. Among items that the instructions may specify are maximum length, number of figures and tables allowed, number of references allowed, and acceptable means of submission. Increasingly, journals have been requesting or requiring that letters be submitted electronically. Some journals' websites include a section through which letters can be submitted.

If you are writing a letter to the editor about a published article, submit it shortly after the article appeared. Some journals consider for publication only those letters received within a stated interval. If you criticize an article, do so in a constructive and respectful tone. (Remember: The author might peer-review your next scientific paper or grant proposal.) Similarly, if you are responding to a letter noting a possible shortcoming of your work, word your reply calmly—no matter what your initial reaction might have been.

Especially because of length limitations, word your letter concisely, in keeping with principles presented later in this book in Part VII, "Scientific Style." Focus on a single point (or a group of closely related points) and relate the other content to that central focus. Whatever your message, support it clearly. Your letter may then be a fine addition to the literature.

EDITORIALS

Some journals include invited editorials and other opinion pieces by scientists. In addition, scientists sometimes write opinion pieces for professional venues such as *The Scientist*, for op-ed pages of newspapers read by the general public, or for other popular venues.

Invited editorials in journals can include both "perspective editorials" and "persuasive editorials." A perspective editorial provides context for and comments on a scientific paper in the same issue of the journal. Often, a scientist who peer-reviewed the paper is invited to write it. The beginning of such an editorial commonly resembles a miniature review paper on the subject. The end can then serve somewhat as an independently written discussion section—noting, for example, strengths and limitations of the research reported in the paper and discussing the implications. For a perspective editorial to appear in the same issue as the paper it comments on, it may need to be submitted quickly. Therefore, along with the honor of being invited to write such a piece, you might receive a stringent deadline.

A persuasive editorial, in a journal or elsewhere, argues for a specific point of view (for example, on science policy). How to structure your argument can depend on your audience. If your audience seems largely to agree with your main point, presenting it early and then supporting it can be most effective. If, however, many readers are likely to be opposed initially, you might gain the most agreement by starting with mutually supported ideas and relatively unexceptionable data and then showing how they lead to your conclusions. Whatever your approach, include arguments for and against your point of view and competing points of view. Acknowledging other viewpoints and showing that yours is superior is scientifically sounder, and thus more credible, than acting as if other viewpoints do not exist.

Some journals publish unsolicited opinion pieces, sometimes called *sound-ing boards*. The principles of writing them tend to be much the same as for writing persuasive editorials. For guidelines on writing such items, consult the journal's instructions to authors. Similarly, if you wish to submit an opinion piece to a newspaper op-ed page or other popular venue, check that publication's requirements by looking at its website or contacting its editorial office.

BOOK (AND OTHER MEDIA) REVIEWS

Textbooks. Reference books. Specialized monographs for scientists. Trade books for the public. Science abounds with books. And many journals, magazines, and other publications include reviews of books on science. As well as helping readers choose books to obtain or consult, book reviews can inform readers by sharing content from the books. They also can provide useful feedback to authors and publishers and help guide future authors. Reviews of other media—such as journals, electronic resources, and museum exhibits—can serve similar functions. Regardless of whether a book or other item is reviewed, the principles are much the same. Thus, guidelines for writing book reviews generally apply to other types of reviews.

At journals, book review editors typically take the initiative in recruiting reviewers. However, they usually are glad to have potential reviewers volunteer, either to be approached as needed or to review specific books. Of course, if you have a conflict of interest (for example, because a book is by a close colleague), you should not offer to review the book or accept an invitation to do so.

A good review should both describe and evaluate the book. Among questions it may address are the following (Gastel 1991): What is the goal of the book, and how well does the book accomplish it? From what context did the book emerge? What is the background of the authors or editors? What is the scope of the book, and how is the content organized? What main points

does the book make? If the book has special features, what are they? What are the strengths and weaknesses of the book? How does the book compare with other books on the same topic or with previous editions of the book? Who would find the book valuable?

Normally, answering these questions entails reading the book thoroughly. For a reference work, however, sampling the content is more feasible and better reflects the intended use. If you take such an approach, consider drawing on your skills in research design in determining how to proceed. For instance, when reviewing a multivolume encyclopedia, you might evaluate randomly selected entries, evaluate entries on topics you know best, or both. You might also have potential users, such as students, read some entries and share their reactions.

To facilitate writing, take notes as you read or mark passages of interest in the book; tagging with self-adhesive notes can help you easily locate relevant pages later. Write down ideas for points to make as they occur to you. To help formulate your ideas, perhaps talk to someone about the book.

Although some journals have featured structured book reviews, with standardized headings for specified types of content, the reviewer generally can choose how to organize the book review. One format that can work well is a variant of the IMRAD (introduction, methods, results, and discussion) structure commonly used for scientific papers. In this format, the “introduction” presents an opening comment on the book, the “results” section describes the book, and the “discussion” evaluates it. No “methods” section may be needed if you read the book from cover to cover and did not otherwise test it. But if, for example, you systematically sampled content in a reference book, you would summarize your procedure in the “methods.”

A review is not an advertisement; it should not gush with praise. Neither should it nitpick or ridicule the writing (or the author). Rather, it should take a reasoned tone. By presenting information about the book and drawing careful conclusions, you will serve the readers of your review well.

ESSAYS

Some journals and other media include personal essays by scientists or others in science-related fields. These essays commonly focus on professionally related personal experiences and the insights gained from them. Venues containing such essays include “Working Life” in *Science* magazine, “A Piece of My Mind” in the medical journal *JAMA*, and the cleverly titled “Narrative Matters” in *Health Affairs*.

If you have an experience to share, consider submitting an essay. Some pointers: Just as for other submissions, read the instructions from the journal. Also, read essays published in the journal to get a sense of the norm. Write



"Congratulations! Your manuscript was the one-millionth personal memoir submitted to us this year."

(www.CartoonStock.com)

about an experience to which the journal's readers can relate. For example, your essay may show how you addressed an issue that many readers contend with, depict how your experience transformed your understanding of a professionally related situation, or maybe share an especially heartwarming experience from your career. Do not use such an essay only to complain. Save rants for your significant other, your dog, or maybe your therapist.

Regarding the writing itself: Begin the essay strongly. One way is to start with an especially engaging part of the tale. You can then provide background and tell the rest of the story. Give the story a beginning, middle, and end. Include both narrative and reflection. As writers often are told, show rather than tell. For example, rather than saying that stress was affecting you physically, describe (briefly) your sleeplessness, headaches, and lack of appetite. Consider thinking cinematically. Write simply, concisely, and vividly (though in general not melodramatically). Use lively verbs and minimize the use of adjectives and adverbs. Be clear, clear, clear. And revise, revise, revise. Perhaps get feedback from colleagues or others.

Realize that acceptance of essays, like that of other journal submissions, can be very competitive. Therefore, do not be discouraged if your essay is not accepted. If your essay is indeed accepted, realize that even if you have strong writing skills, the journal might request considerable revision, and you may have extensive back-and-forth with an editor.

Over the years, personal essays in journals have addressed a wide range of subjects—including communication of science. “Working Life” essays about such communication include the following:

- “Paper Writing Gone Hollywood” (DOI: 10.1126/science.355.6320.102)
- “How I Became Easy Prey to a Predatory Publisher” (DOI:10.1126/science.caredit.aax9725)
- “Reviewers, Don’t Be Rude to Nonnative English Speakers” (DOI: 10.1126/science.caredit.aaz7179)
- “How I Conquered My Fear of Public Speaking and Learned to Give Effective Presentations” (DOI:10.1126/science.caredit.aaz2161)
- “Poster Presentations Are a Great Way to Showcase Your Science” (DOI: 10.1126/science.caredit.aba1279)
- “How I Learned to Speak Up for Myself about Authorship” (DOI: 10.1126/science.caredit.abd2832)
- “Don’t Erase Undergrad Researchers and Technicians from Author Lists” (DOI: 10.1126/science.caredit.abf8865)
- “Two Surnames, No Hyphen: Claiming My Identity as a Latin American Scientist” (DOI: 10.1126/science.caredit.abj4464)
- “How I Transformed Myself into a Confident Presenter—Thanks to Lady Gaga” (DOI:10.1126/science.caredit.abh2491)

Blogs and podcasts designed for one’s professional community or more general audiences also can be fine forums for personal essays relating to science. In particular, scientists’ tales in such venues can engagingly convey science to members of the general public. For advice in this regard, and more generally on writing science-related personal essays, see “Science and the Art of Personal Storytelling” by Ben Lillie (2016).

Especially if you have an enlightening science-related experience to share, consider venturing beyond the usual formats in which scientists write. You may find yourself with your largest readership.

CHAPTER 25

How to Write a Book Chapter or a Book

I'm writing a book. I've got the page numbers done.

—Steven Wright

HOW TO WRITE A BOOK CHAPTER

Congratulations! You have been invited to write a chapter in a multiauthored book. Here is one more sign that you have attained visibility in your field. Enjoy the compliment, and accept the invitation if you have the time to prepare the chapter well and submit it promptly. If you cannot write the chapter, recommend a peer if possible.

If you agree to write a chapter, be sure that the editor provides thorough instructions. Follow the instructions carefully; only if chapters are of the proper scope, length, and format, and only if they are submitted on time, can the book be published without undue difficulty and delay. If events arise that may slow submission of your chapter, tell the editor immediately so plans can be revised if needed.

In many cases, writing a book chapter is much like writing a review paper. If you are writing a chapter that summarizes knowledge on a topic, follow relevant advice from Chapter 23, “How to Write a Review Paper.” In particular, plan the chapter carefully. Time invested in organizing the chapter can save much time in writing later.

After submitting the chapter, you may receive queries from the copy editor (for example, requests for clarification of points). You also may receive an edited manuscript, and then page proofs to review. So as not to disrupt the production schedule, take care to respond by the deadlines you are given. If

you will be unreachable for a substantial time while a chapter is in press, tell the editor so alternative plans can be made.

WHY (OR WHY NOT) TO WRITE A BOOK

There can be many good reasons to write a book. A monograph focusing on a specialized technical topic can aid fellow scientists. A handbook can assist scientists and those applying science. A textbook can greatly help students of science. A work of popular scientific nonfiction can interest and enlighten general readers, including scientists in fields other than your own.

There also can be good reasons *not* to write a book—or not to do so at present. In most fields of science, scientific papers (not books) are the currency of advancement. Thus, it can be unwise to spend time writing a book early in one's career. Of course, writing a book takes much effort, so it should not be pursued without careful reflection first.

As for the monetary aspect: A widely used textbook or bestselling work of scientific nonfiction can net the author a nice sum. Most books in the sciences, however, earn the author relatively little—sometimes less than the author spent preparing the book. Thus, only if the psychological rewards would suffice should one embark on writing a book.

HOW TO FIND A PUBLISHER

Sometimes the publisher finds you. At companies publishing books in the sciences, editors keep track of science, for instance by attending scientific conferences. Thus, an editor may approach you about the possibility of writing a book. Make sure, though, that the publisher is legitimate, for example by ascertaining that it has published high-quality books in your field. Unfortunately, just as predatory journal publishers exist, so do predatory book publishers. They take authors' money and do not produce a valid product—or any product at all.

If you are the one with the idea, see which publishers have published good books on topics related to yours. These publishers are most likely to accept your book. They also can best edit and produce your book and market it to the right audience. For scholarly or technical books in the sciences, university presses and commercial scientific publishers often prove most appropriate. Popular books in the sciences often are served well by commercial publishers that include such books among their specialties. Some university presses also excel at publishing science books for general readerships.

Whether the idea for the book is yours or a publisher's, you generally must submit a proposal before receiving approval to prepare and submit the

manuscript. Typically, the proposal includes an annotated table of contents, a description of the intended market for the book, a sample chapter, and your curriculum vitae or résumé. To help decide whether to accept the proposal, the publisher may send it for peer review. The publisher also will do a financial analysis; if the expected profits do not seem to justify the cost of producing the book, the publisher may decline the project even if it seems otherwise promising. However, sometimes another, perhaps more specialized publisher will accept the project. For example, sometimes a university press, not a commercial publisher, agrees to publish a book that is of scientific importance, but for which sales are expected to be low.

Book proposals, unlike scientific papers, may be submitted to more than one publisher at once. If, however, a proposal is being submitted simultaneously, the author should inform each publisher. For specialized scientific books, the author typically submits a proposal directly to the publisher. If, however, a book seems likely to sell very well, using an agent can be advisable.

If a proposal is accepted, the publisher is likely to offer the author an advance contract to sign. (Some publishers, however, do not generally offer a contract until the book manuscript is completed and accepted.) An advance contract, which typically runs several pages, usually specifies such items as length, the maximum number of figures and tables, the deadline, royalties paid to the author, electronic rights, and even film rights (not a likely concern, though, for most book authors in the sciences). Review the contract carefully. If modifications seem called for, work with the publisher to come to an agreement.

An advance contract is not a guarantee that the book will be published. It does indicate, however, that if you satisfactorily complete the manuscript, publication should proceed. In the sciences, unlike in fiction writing, you generally should have a contract before doing most of the work on a book.

Another option is to publish the book yourself—in print, online, or both. This option can have both pluses and minuses. On the plus side, you will retain full control of the project, including the schedule, content, editing, design, production, marketing, and price (if any). Also on the plus side, you will reap all of any profits made. The minuses are much the flip side of the pluses. You will not have the publisher's services, such as editing, page design, cover design, and marketing (though you yourself can contract for these services, for example from companies that specialize in helping authors self-publish books). And you will bear all the expenses of producing, publicizing, and distributing the book. Academic and other libraries may be less likely to buy a self-published book than one from an established publisher, from which they may routinely purchase. Also, publication by a highly regarded publisher, especially after peer review, provides validation that self-publication lacks and so can aid more in career advancement.

A book is a major investment of time and effort. Take the time to reflect carefully on where and how you wish to publish.

HOW TO PREPARE A BOOK MANUSCRIPT

Joy at signing a book contract can readily become terror as the prospect looms of writing several hundred manuscript pages. Breaking the project into manageable chunks, however, can keep it from becoming overwhelming. While still remembering the scope of the book, focus on one chapter, or part of a chapter, at a time. Soon you might be amazed at how much you have written. Unless chapters build directly on each other, you may be able to write them in whatever order you find easiest. Similarly, a chapter, like a scientific paper, often need not be written from start to finish.

Much as journals have instructions for authors, book publishers have author guidelines. These guidelines, which sometimes can be accessed from a publisher's website, present the publisher's requirements or preferences regarding manuscript format, preparation of tables and figures, and other items, such as obtaining permission to reprint copyrighted materials. The guidelines also may specify the style manual to follow. Before starting to write, look carefully at the guidelines. For convenience, perhaps prepare a sheet listing the main points to remember about the manuscript format, print it on colored paper for easy identification, and post it where you readily can consult it. Following the instructions can save you, and the publisher, effort later.

Immediate demands on your time can easily rob you of opportunities to work on a book. If possible, set aside specific times for writing. For example, include in your regular weekly calendar some blocks of time to work on the book, as if they were appointments. Or have certain times of the year to focus on writing. If you have the opportunity, perhaps arrange beforehand to get a sabbatical leave to work on the book, or negotiate to have reduced duties while doing so.

For a busy scientist-author, the writing of a book can extend over months or years, sometimes with interruptions of weeks or more. Therefore, a consistent style and voice can be difficult to maintain. One tactic that can help address this problem: Before resuming your writing, reread, or spend a little time editing, a section you have already drafted. Also, once you have drafted the entire book manuscript and are revising it, look for consistency.

And yes, be prepared to revise the manuscript. In books, as in scientific papers, good writing tends to be much-revised writing. Some book authors do much of the revising as they go, a paragraph or subchapter at a time, and then have little more than final polishing left. Others do a rough draft of the entire manuscript and then go back and refine it. Take whatever approach works for you. But one way or another, do revise.

If the book will include material for which you do not hold copyright—for example, illustrations published elsewhere—you will need permission unless

the material is in the public domain. You also may need to pay permission fees. Usually, obtaining the needed permissions is your responsibility, not your publisher's. However, your publisher may be able to provide advice in this regard, and publishers' guidelines for authors often include sample letters for seeking permission. Start the permissions process early; identifying copyright holders, receiving permissions, and (if needed) obtaining images suitable for reproduction sometimes takes weeks. (For more on rights and permissions, see Chapter 19.)

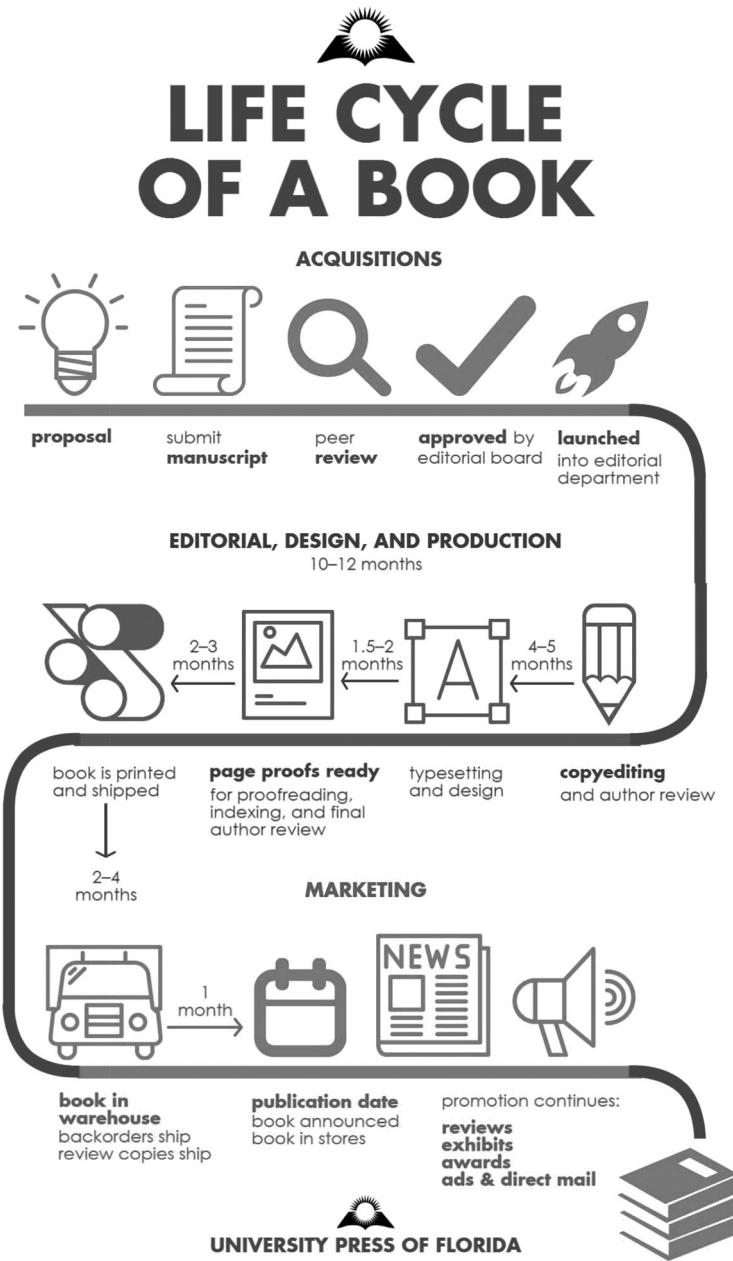
Once you submit your book manuscript, the publisher may send it for peer review. Beforehand or simultaneously, consider obtaining some peer reviews of your own. Show the manuscript to people whose views you regard highly, including experts on your subject and individuals representative of the intended readers of your book. Solicit and consider their frank feedback. If appropriate, thank your reviewers in the acknowledgments (with their permission) and give them copies of the book when it appears.

HOW TO PARTICIPATE IN THE PUBLICATION PROCESS

At the publishing company, the proposal for a new book typically goes to an editor in charge of obtaining new manuscripts in your field. This editor, often called an *acquisitions editor*, oversees the review of your proposal, answers questions you may have while preparing the manuscript, and supervises the review of your manuscript. Once your manuscript is accepted, responsibility commonly moves to another editor, sometimes called a *production editor*, who coordinates the editing of the manuscript and other aspects of the conversion of your manuscript into a book.

Open communication with the editors facilitates publication. If, as you prepare the manuscript, you have questions about format, permissions, potential changes in content, or other matters, ask the acquisitions editor. Getting the answer now may save much time later. If you fall behind and might not be able to meet any of your deadlines, inform the acquisitions editor promptly so that, if necessary, plans can be revised. Similarly, if at times during the editing and production phase you will not be available to review materials or answer questions, inform the production editor so that schedules can be designed or adjusted accordingly.

Book manuscripts in the sciences, like scientific papers, commonly undergo peer review. Your editor may do a preliminary assessment to determine whether the manuscript is ready for peer review or whether revisions are needed first. Once the manuscript is ready for peer review, you may be able to help the editor by suggesting experts in your field to consider including among the reviewers. After peer review is complete, the publisher will decide how to



(Rachel Doll, University Press of Florida)

proceed. At a university press, a committee of faculty members is likely to advise the publisher in this regard.

For a book manuscript, as for a scientific paper, any of four decisions may be reached. Commonly, the manuscript will be accepted, but some revisions will be required. Occasionally, the manuscript will be accepted without revisions. Sometimes, if the manuscript needs major revision, the author will be asked to revise it and submit it for reevaluation. And sometimes, if a manuscript has fallen far short of its seeming potential, it will not be accepted.

In the likely instance that some revisions are required, the editor will indicate how to proceed. Commonly, you will receive peer reviewers' suggestions. You also should receive guidance from the editor—for example, regarding which suggestions are important to follow and which are optional, or what to do about contradictory advice from different reviewers. The editor will also work with you to determine a timetable for completing the revisions.

Once your manuscript is successfully revised, the book will enter production. In this phase, a copy editor will edit the manuscript, a designer will design the book, and ultimately, the book will go to the printer. Your manuscript probably will go to a freelance copy editor who specializes in editing book manuscripts in your field. Because such individuals know your field and the conventions in it, they can edit your manuscript more appropriately than general copy editors could.

Your communication with the copy editor is likely to go through the production editor coordinating publication of your book. You will receive the edited manuscript for review, as well as any *queries* (questions) the copy editor might have, such as about points that seem inconsistent or otherwise in need of clarification. Check the edited manuscript in the time allotted; if inaccuracies or other problems have been introduced, correct them. Answer any queries so that necessary changes can be made.

In addition to receiving the edited manuscript to check, you will later receive page proofs—that is, copies of the draft pages of the book. Review the page proofs promptly but thoroughly. Make sure that nothing has been omitted, all corrections of the edited manuscript were entered accurately, and all photographs and other illustrations are included and correctly oriented. Limit your changes, however, to those that are necessary. Now is not the time for rewriting.

For many books in the sciences, a good index is crucial. Once the page proofs are ready, and thus one can see what information will appear on what page, an index can be prepared. Some authors prepare the indexes for their books themselves. Others, however, use professional indexers. Indexing is a highly skilled craft, and often a professional indexer can prepare a more useful index than the author could. A professional indexer also is likely to prepare the index more efficiently. If your book will be professionally indexed, your

publisher should be able to identify and hire a suitably qualified indexer. In some cases, the contract for your book may indicate that the publisher will pay for indexing. If you are to pay, the publisher may deduct the sum from your book royalties rather than ask you to pay directly. In any case, the money is likely to be well spent.

HOW TO HELP MARKET YOUR BOOK

If you have chosen well, your publisher will have experience and expertise marketing books to the audiences for your book. To do its best job, though, the publisher needs information from you. Thus, you are likely to receive an *author questionnaire*. The questionnaire may, for example, ask you to identify scientific organizations that have members interested in your topic, conferences at which your book might appropriately be sold, journals for which your book is suitable for review, and people well suited to provide endorsements or blurbs. The questionnaire also is likely to request information about you, as well as other information that can aid in promoting your book. Take the time to complete the questionnaire thoroughly. This information can help the marketing department ensure that the appropriate audience knows of your book, and thus that your book receives the sales it deserves.

Increasingly, authors are expected to take active roles in marketing, especially if their books are for general audiences. “Today, I do not offer a contract or invest in a project if the author isn’t willing to promote his or her book,” states an acquisition editor at a university press. “In today’s world of Facebook, YouTube, Twitter, blogs, and so on, we ask authors to actively seek venues in which to speak, lecture, present—anything to get the book into the right hands. Markets are increasingly specialized and targeted, and a reader is more likely to purchase a book on astronomy at, say, a star party where the author is a featured guest than by walking into a Barnes and Noble and reaching for that book among the other 150,000 or so titles available each year.”

You may also be asked to participate in the marketing of a book in other ways. For example, you may be interviewed for radio or television, or for a podcast or webinar. Book signings may be arranged. Arrangements may be made for excerpts of the book to appear in magazines. Be open to such possibilities, and suggest any that occur to you. If you have questions, consult the marketing department.

For scholarly or technical books, marketing remains more restrained than for books aimed at the general public. Although pushing one’s book in

inappropriate venues, such as scientific presentations, can be counterproductive, do mention your book when suitable occasions arise. For example, if a posting in an email discussion list requests information that your book happens to contain, mention your book. Likewise, consider mentioning your book in science blogs and on professionally oriented social networking sites. Doing so can at least prompt prospective users to seek out the book in the library. And given the ideals of science, the success of a book should be measured not only in its sales, but also in the service it provides to those who can benefit.

CHAPTER 26

How to Write for the Public

Regard readers not as being ignorant but, more likely, innocent of your topic and its jargon. Write for them, not at them.

—Alton Blakeslee

WHY WRITE FOR GENERAL READERSHIPS?

Preparing papers and proposals for peers to read can entail plenty of writing. Why might you write for nonscientists as well?

Sometimes your academic program or job includes doing some writing for lay readerships. For example, requirements for a graduate degree can include writing a nontechnical summary of your thesis. Your funding agency may require public outreach. Or, if you teach introductory courses in your discipline, you may prepare teaching materials that are essentially for the public.

Some of us write for the public on our own initiative as well. Some of us enjoy doing such writing and appreciate the chance to reach audiences broader than those in our own fields. Other motivations can include giving members of the public useful information on technical topics, attracting people to scientific careers, and helping to engender public support for science. Some of us also welcome the bit of extra income that popular writing can bring.

FINDING PUBLICATION VENUES

If you wish to write for the public, how might you find a home for your work? Good places to start can be publications, both online and in print, that you like to read. Do not limit yourself to those devoted solely to science. Other

publications, including magazines focusing on specific interests or geared to specific population groups, often contain articles on science-related topics. If you have not published articles for the public before, suitable starting points can include local, regional, or specialized publications, including those at your own institution. Another good starting point can be a blog that you establish or an existing blog for which you arrange to write guest posts. Then, once you have proved your ability to write for the public, publications of greater scope are more likely to welcome your requests to write.

If a venue seems suitable, try to determine whether it accepts freelance work. One way is to see who writes for it. If all the authors are staff members listed in its masthead, a magazine is unlikely to accept your work. But if some articles have blurbs saying that they are by scientists not on the staff, the venue might be appropriate for you.

Many popular publications that accept freelance work have writer's guidelines, which are analogous to journals' instructions to authors. Look for these guidelines, which appear on the publications' websites or can be obtained from their editorial offices. Items often addressed include subject areas in which articles are wanted (and not wanted), standard article lengths, requested writing style, rates of payment, and email addresses or websites to which article proposals should be submitted.

Typically, magazines want prospective authors to submit article proposals, known as *query letters* or *pitches*, rather than submitting completed articles at the outset. Doing so is more efficient for the author, who can thus avoid wasting time writing articles that the magazine would not want. It also is more efficient for the editor: By reading a query, the editor can quickly evaluate the story idea and the writer's skill. And if the query is accepted, the editor can work with the writer from the outset to suit the story to the magazine's needs.

A query letter or pitch generally should be limited to one page (or the equivalent amount of text in an email message or on a proposal portal). Begin by describing the article you propose. Among questions you might address are the following: What is the main topic of the article, and what major subtopics do you plan to address? Why is the topic likely to interest readers? What information sources do you expect to use? How might the article be organized? What types of photographs or other graphics might be appropriate? Near the end of the letter, include a paragraph summarizing your qualifications to write the article. If you have not written for the magazine before, provide or link to examples, if available, of articles you have written for the public, or direct the editor to your website if you have articles for general readers posted there. Further information on writing queries or pitches, and more generally on writing for magazines, can be found in books such as *You Can Write for Magazines* (Daugherty 1999) and *The Complete Guide to Article Writing* (Saleh 2013), in magazines such as *Writer's Digest*, and on the science writers' website The

Open Notebook (www.theopennotebook.com), which includes guidance on pitching and a database of pitches.

In addition to magazines, a venue to consider querying is The Conversation (theconversation.com), whose content consists of articles that academic experts write for it in order to inform the general public. The Conversation posts the articles on its website and makes them available free of charge for use in newspapers and elsewhere. Articles well suited for The Conversation include those providing scientific context for items in the news. To publish in The Conversation, one must be “a researcher or academic with a university or research institution” or a PhD candidate supervised by an academic. Authors whose pitches are accepted work with editors at The Conversation to develop and refine their articles.

Before writing for a magazine, website, or other venue, analyze writing that it has published or posted so that yours can fit in. Notice, for example, how long the paragraphs tend to be, how formal or informal the wording is, whether headings divide the articles into sections, and whether articles tend to include bulleted lists. In writing for a popular venue, as in writing a scientific paper, suiting the writing to the site will increase the likelihood of publication.

ENGAGING THE AUDIENCE

Readers of journals where your papers appear are likely to be already interested in your topic. Or at least they are deeply interested in science. Thus, beyond perhaps noting the importance of the topic, you generally need to do little to attract readers.

When writing for the public, however, you typically must do more to engage the audience. One key to engaging the audience is analyzing it. The public is not uniform. Rather, readers of different publications have different interests. Ditto for users of different websites and audiences of different broadcast programs. Consider what the audience members are likely to care about, and relate what you say to those interests.

Regardless of other interests, most people care about people. Thus, use human interest to help engage the audience. For example, tell about the people who did the research. If there are technology users or patients, tell about them as well. When appropriate, also include almost-human interest, for much of the public likes animals.

Include quotes from the people in your piece. Doing so contributes to human interest and can keep readers’ attention through varied voices and lively wording. To obtain quotes, of course, you generally must do interviews, even if you are well versed on the topic about which you are writing.

People generally like stories, which often combine human interest and suspense. So consider including some narrative. For example, show how a line of research developed—and do not omit the difficulties encountered. Or include some anecdotes illustrating your points.

Especially with regard to technologies, costs may interest and be important to the public; consider including economic context. Likewise, if relevant to your subject, provide social and ethical context.

Science is full of wonder as well. Use it to help engage the audience. Draw on the audience's curiosity. Too much gee-whiz can cheapen science, but a little can enliven a piece.

In a popular article, unlike in a scientific paper, you may be able to engage in wordplay and other humor. If, for example, puns are your passion, now may be your chance. Be sure, however, that any humor would be understandable to the audience; avoid scientific in-jokes.

Think visually as well as verbally. Editors of popular pieces for print, the web, and television generally want to use photos or other graphics. Even radio stories benefit from description of visual aspects. If a piece is to include visuals, the editor can tell you whether to provide them yourself or merely provide ideas.

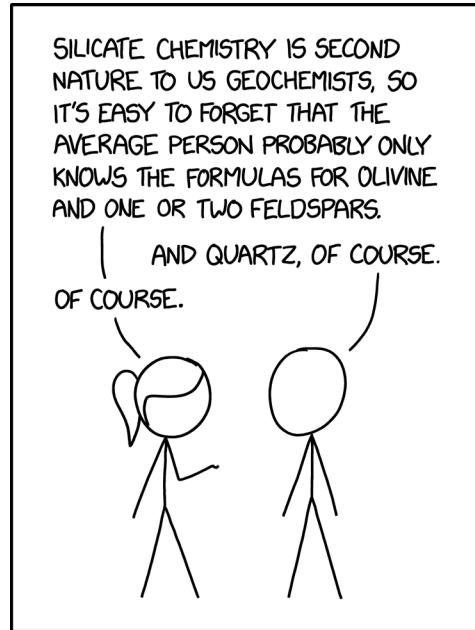
To maintain interest, pace the article carefully. Think of a popular article as a chocolate chip cookie. Just as each bite of the cookie should contain at least one chocolate chip, each few paragraphs of the article should contain something tasty—for example, a good quote, a lively anecdote, or a deft analogy. Keep your readers wanting one more bite.

CONVEYING CONTENT CLEARLY

Much of what you do to engage the audience also can aid in conveying content clearly. For example, gearing your piece to the audience, using lucid analogies, and providing visuals can serve both roles. So can supporting what you say with examples.

Members of the public probably will not know technical terms in your field. Where feasible, avoid such jargon. If technical terms are important to the story you are telling, or if readers should learn them for future use, remember to define them. One way to avoid intimidating readers is to state an item in familiar words before providing the technical term (example: “bone-forming cells called *osteoblasts*”). Also, remember to define abbreviations. “PCR” may be everyday language for you, but it may be meaningless to your readers.

Structure what you say to promote clarity. For instance, provide overviews before details. Explicitly state the relationships between concepts. Repeat important points.



(“Average Familiarity” by xkcd [xkcd.com].
Used by permission.)

Include numbers; members of the public often expect and enjoy them. However, present them in easily understood ways. If the audience is unfamiliar with metric units, use English units (or whatever units your audience generally uses). And relate sizes to familiar ones (“about the size of . . .”). Do not overwhelm readers with many numbers clustered together. Separate pieces of “hard stuff” with softer material, such as anecdotes and examples.

Sometimes readers have misconceptions about scientific items. To counter misconceptions without seeming condescending, consider taking the following approach (Rowan 1990): First, state the commonly held view and note its seeming plausibility. Then show the inadequacy of that view. Finally, present the scientifically supported view and explain its greater adequacy.

Of course, follow the principles of readable writing presented elsewhere in this book. For example, use concise, straightforward language when possible. Structure sentences simply. Avoid lengthy paragraphs.

Finally, consider checking with potential readers. Show a draft to nonscientist friends, neighbors, or family members. See what they find interesting or what doesn't work for them. See what they find clear or unclear. Then consider revising your piece based on this feedback before submitting it.

EMULATING THE BEST

Further guidance in writing for the public about science appears in *The Open Notebook* (www.theopennotebook.com), the book *The Craft of Science Writing: Selections from The Open Notebook* (Carpenter 2020), and *Science Blogging: The Essential Guide* (Wilcox, Brookshire, and Goldman 2016). A variety of other books and articles (for example, Blakeslee 1994; Blum, Knudson, and Henig 2006; Gastel 1983, 2005; Hancock 2003; Stocking et al. 2011; Writers of Science 2013) also provide such advice.

In addition, good popular science writing, like good writing for scientific audiences, benefits from following good examples. Where can you find such examples? Major newspapers and magazines contain much good science writing. So do the bestseller lists. Fine pieces of popular science communication in various media have won AAAS Kavli Science Journalism Awards, National Association of Science Writers (NASW) Science in Society Journalism Awards, NASW Excellence in Institutional Writing Awards, Pulitzer Prizes, and awards for communicating about specific fields of science; the websites for such awards list recipients and often include links to the winning pieces. Other sources of excellent examples include the annual anthology titled *The Best American Science and Nature Writing*. Consume good works of popular science communication. Whether or not you explicitly analyze them, you are likely to assimilate much about writing skillfully for the public.

PART VI

Conference Communications

CHAPTER 27

How to Present a Paper Orally

Talk low, talk slow, and don't say too much.

—John Wayne

HOW TO GET TO PRESENT A PAPER

The first step in presenting a paper is to obtain a chance to do so. Sometimes, you might receive an unsolicited invitation. For major conferences, however, you normally must take the initiative by submitting an abstract of the paper that you hope to present.

Those organizing the conference typically provide abstract submission forms; these usually can be accessed and submitted via the websites of those holding the conferences. The submitted abstracts undergo peer review, and the submitters whose abstracts seem to describe the strongest research are asked to give oral presentations. For some conferences, those whose abstracts represent good work of lower priority are asked to give poster presentations. For other conferences, separate application processes exist for oral presentations and for posters.

Those who decide whether you should present a paper are likely to have only your abstract on which to base their decision. Therefore, prepare the abstract carefully, following all instructions. Word the abstract concisely, so it can be highly informative even if brief. (The word limit sometimes is higher than that for abstracts accompanying published papers, but be sure to stay within the required count.) If figures or tables are allowed, follow all instructions, and do not exceed the number permitted. Organize the abstract well—typically following the same sequence as a scientific paper. Also, write clearly and readably, as those reviewing the abstracts probably will be busy scientists

with many abstracts to review and little patience with those that are unclear on first reading. Of course, be sure to submit the abstract by the deadline. Present your research well in your abstract, and you may soon be presenting a paper.

For many conferences, the peer reviewers might not be the only ones seeing your abstract. Often, presentation abstracts are printed in the conference program, posted on the conference website, or both. Those reading them can include conference registrants trying to decide which sessions to attend, fellow scientists unable to attend the conference but interested in the content, and science reporters trying to determine which sessions to cover. All the more reason to provide an informative and readable abstract.

A WORD OF CAUTION

If you receive an unsolicited invitation to speak at a conference that you have not heard of, check into the matter carefully rather than automatically accepting. In recent years, what are known as *predatory conferences* have arisen. These are not valid scientific conferences, but rather scams to take people's money. The organizers invite prospective attendees, obtain their advance registration fees, and then either hold a conference with little scientific substance or hold no conference at all.

One clue that a conference might be predatory is if you are invited to speak at a conference that is outside your field. Other possible clues include an invitation that emphasizes the beautiful location rather than the conference content, lists fees that are much higher than usual, or has many grammatical errors and misspellings. If you are early in your career, perhaps consult a mentor or senior colleague to help determine whether a conference is valid. Also, online searching can help identify conference organizers that credible sources, such as academic librarians, have deemed questionable.

ORGANIZATION OF THE PAPER

The best way to organize a paper for oral presentation generally is to proceed in the same logical pathway that one usually does in writing a paper, starting with "What was the problem?" and ending with "What is the solution?" However, it is important to remember that oral presentation of a paper does *not* constitute publication, and therefore different rules apply. The greatest distinction is that the published paper must contain the full experimental protocol so that the experiments can be repeated. The oral presentation, however, need not (and should not) contain all of the experimental detail, unless by chance you have been called on to administer a soporific at a meeting of

insomniacs. Extensive citation of the literature is also undesirable in an oral presentation.

PRESENTATION OF THE PAPER

Most oral presentations are short (with a limit of 10 minutes at many meetings). Thus, even the theoretical content must be trimmed down relative to that of a written paper. No matter how well organized, too many ideas presented too quickly will be confusing. Stick to your most important point or result and stress that. There will not be time to present all your other neat ideas.

There are, of course, other, longer types of oral presentations. A typical time allotted for symposium presentations is 20 minutes. A few are longer. A seminar is normally 1 hour. Obviously, you can present more material if you have more time. Even so, you should go slowly, carefully presenting a few main points or themes. If you proceed too fast, especially at the beginning, your audience will lose the thread; the daydreams will begin, and your message will be lost.

Time limits for conference presentations tend to be strictly enforced. Therefore, carefully plan your presentation to fit the allotted time—lest you be whisked from the podium before you can report your major result. If possible, make your presentation a bit shorter than the limit (say, 9 or 9.5 minutes if 10 minutes are allotted) to accommodate unexpected slowdowns. Rehearse your presentation beforehand, both to make sure that it is the right length and to help ensure a smooth delivery. During your presentation, stay aware of the time. Perhaps indicate in your notes what point in the presentation you should have reached by what time so that you can adjust your pace if necessary.

A few more pointers on delivery: Speak very clearly and avoid speaking quickly, especially if the language in which you are presenting is not the native language of all the audience members. Remember to look at the audience. Show interest in your subject. Avoid habits that might be distracting—such as repeatedly saying “um” or “you know” or the equivalent from your native language. To polish your delivery, consider videoing rehearsals of one or more of your presentations.

Does stage fright plague you? Consider the following suggestions: Prepare well so you can feel confident, but do not prepare so much that you feel obsessed. To dissipate nervous energy, take a walk or take advantage of the exercise facilities in the conference hotel. Beware of taking in too much caffeine, food, or water before your talk. Hide physical signs of anxiety; for example, if your hands tremble under stress, do not hold papers. Realize that a presentation need not be flawless to be excellent. Perhaps most important,

DATA: BY THE NUMBERS



(“Piled Higher and Deeper” by Jorge Cham. www.phdcomics.com)

realize that the audience members are there not because they wish to judge your speaking style, but because they are interested in your research.

SLIDES

At small, informal scientific meetings, various types of visual aids—including flip charts, whiteboards, and blackboards—may be used. At most scientific conferences, however, Microsoft PowerPoint presentations or the equivalent are the norm. Every scientist *should* know how to prepare effective slides and use them well, and yet almost any session at a conference quickly demonstrates that many do not.

Here are a few important considerations. First, slides should be designed specifically for use with oral presentations, with large-enough lettering to be seen from the back of the room. In general, use lettering that is at least 28 points in size. Choose a sans serif typeface, such as Arial or Calibri. Slides prepared from graphs that were drawn for journal publication are seldom effective and often are not even legible. Slides prepared from a printed journal or book are almost never effective. So, if necessary, re-create the content. Also, remember that, quite likely, some audience members will be colorblind. Therefore, avoid using solely color to distinguish items such as lines on a graph, beware of combinations of colors (such as red and green) that are hard for many people with colorblindness to distinguish, and follow other guidelines (for example, Collinge 2017) for accessibility to people who are colorblind.

Slides should be uncrowded. Each slide should illustrate a particular point or perhaps summarize a few. To permit rapid reading, use bullet points, not paragraphs. For text slides, try not to exceed about seven lines of about seven words each—or, stated another way, about 50 words in total. It has been said that if a slide cannot be understood in 4 seconds, it is not good.

Beware of showing too many slides. A moderate number of well-chosen slides will enhance your presentation; too many will be distracting. One general guideline is not to exceed an average of about one slide per minute. If you show a slide of an illustration or table, indicate its main message. As one long-suffering audience member said, “Don’t just point at it.”

Speaking of illustrations and tables: If there are findings that you can present in either a graph or a table, use a graph in an oral presentation. Doing so will help the audience grasp the point more quickly. And speaking of pointing: If you use a laser pointer, take care with it. In your enthusiasm or in distraction, do not wildly gesture at the slide—or the audience—with a lighted pointer. Rather, turn on the laser pointer only when you want to call attention to a specific item on a slide. Direct the laser pointer specifically at the item. And if, for example, you are showing a pathway, trace it with the pointer. If you shake during presentations, hold the laser pointer in one hand and use the other hand to steady that hand.

If the conference is in person and has a speaker ready room (a room in which speakers can test their audiovisuals), check that your slides are functioning properly. Also, if possible, get to the hall before the audience does. Make sure that the projector is working, ascertain that your slides will indeed project, and check the lights. If you will use a microphone, ensure that it is functioning.

Normally, each slide should make one simple, easily understood visual statement. The slide should supplement what you are saying when it is on the screen; it should *not* simply repeat what you are saying, or vice versa. Except when doing so could help overcome a language barrier, do not read the slide text to the audience.

A nice touch, and a tradition in some research areas, is to include a closing slide acknowledging your collaborators and perhaps showing a photo of the research group. If the research being reported was a team effort, consider including such a slide if appropriate in your field.

Slides that are thoughtfully designed, well prepared, and skillfully used can greatly enhance the value of a scientific presentation. Poor slides would have ruined Cicero.

PRESENTING ONLINE

Traditionally, conferences have taken place in person. Now, however, many conferences are held either online or in a hybrid format, with some components face to face and others online. Therefore, a scientist’s set of presentation skills should include those for presenting remotely, for example via Zoom. The basics—such as preparing thoroughly, designing slides for easy understanding, speaking slowly and clearly, and carefully complying with the time limit—remain much the same as for presenting in person. However, some of the details differ.

Specific tips for preparing to present online include the following:

- If unacquainted with the software for the conference, familiarize yourself with it. Know, for example, how to share your screen. Conference organizers commonly provide briefing materials or instruction sessions for online presenters.
- Arrange to have a light source in front of you so that your face will be lit. Otherwise, you may just appear in silhouette.
- Position the camera at an appropriate level. Audience members do not want to look at the top of your head or, worse yet, peer up your nose.
- If you will use a virtual background, choose one that is simple and professional. If your actual surroundings will be shown, avoid distracting—or potentially embarrassing—clutter.
- Dress suitably (in general, with the same formality as for a presentation in person). Avoid wearing patterns such as stripes and checks, which can seem to writhe on camera.
- Minimize intrusions. If you will speak from home and you have pets or small children, make arrangements accordingly, so they won't be barking up a storm, meandering across your keyboard, or wandering in to ask for a cookie.
- Rehearse and refine. Take advantage of the software's capacity to record your presentation and review the video.

Also, have backup plans. For example, consider sending the moderator your slides in case a glitch keeps you from projecting them yourself. Perhaps be ready to connect to the meeting by phone in case of an internet outage.

As for the presentation itself: Arrive early, so that any final arrangements can be made and technical matters resolved. To help ensure energetic delivery, consider standing during your presentation. (Make sure that the camera is positioned accordingly.) Remember to look at the camera. If the chat function will be used, consider having someone monitor the chat while you are speaking, so you are not distracted. Also, if the technology permits, consider obtaining a video of the presentation, a transcript of the presentation, and a transcript of the chat for future reference.

MAKING A MINI-PRESENTATION

Chances sometimes arise to speak very briefly about one's work. One instance is when, at a conference or elsewhere, one is asked, "Well, what kind of research do you do?" Another instance is when one can talk at an event such as a Three Minute Thesis competition.

The response to the “What do you do?” question is sometimes called an *elevator speech* because it should be brief enough to give in an elevator ride with someone. Like other communications, it should be geared to the audience, be it a newly met colleague at a conference or your long-lost nonscientist cousin at a family reunion. Regardless of the audience, the following flow can be helpful. If your identity might not be clear, introduce (or reintroduce) yourself. (“I’m _____, a graduate student in _____’s lab at the University of _____,” or “As you may recall, I’m your cousin _____ from _____.”) Briefly provide some context at the appropriate technical level. (“Our laboratory focuses on basic mechanisms of _____, especially as _____,” or “My work relates to _____, which has become an increasingly serious problem in this country.”) Then say more specifically—again, at a suitable technical level—what you are working on. And finally, look ahead. (“I’m currently seeking postdoc opportunities in this field,” or “I hope my research will contribute to addressing this problem.”) The ideal is to leave the listener wanting, and requesting, more.

In a Three Minute Thesis competition, participants briefly present their research in a suitable way for a nonspecialist audience (University of Queensland n.d.). Such competitions began at the University of Queensland in Australia and have now been held at hundreds of universities worldwide. Tips to consider when preparing and presenting a Three Minute Thesis include to start with a relevant statement that engages the audience, move from broad context to your specific research, structure the presentation as a story, emphasize the “why” or “so-what,” speak slowly enough, rehearse extensively, and share your enthusiasm for your work. Other advice from this chapter and chapter 26 (on writing for the public) can apply. Whether or not you win, a Three Minute Thesis competition can be a fine chance to share your research and enhance your communication skills.

THE AUDIENCE

The presentation of a paper at a scientific meeting is a two-way process. Because the material being communicated at a scientific conference is likely to be the newest available information in that field, both the speakers and the audience should accept certain obligations. As indicated earlier in this chapter, speakers should present their material clearly and effectively so that the audience can understand and learn from the information being communicated.

Almost certainly, the audience for an oral presentation will be more diverse than the readership of a scientific paper. Therefore, the oral presentation should be pitched at a more general level than a written paper would be. Avoid technical detail. Define terms. Beware of using acronyms that the audience does not already know. Explain difficult concepts. Repeat important points. Rehearsing

a paper before the members of one's own department or group (even just a few of them) can make the difference between success and disaster.

For communication to be effective, the audience also has a number of responsibilities. These start with simple courtesy. The audience should be quiet and attentive, no matter how compellingly a mobile device may beckon. Speakers respond well to an interested, attentive audience, whereas the communication process can be virtually destroyed when the audience is noisy, distracted, or, worse, asleep.

The best part of an oral presentation is often the question-and-answer period. During this time, members of the audience have the option, if not the obligation, of raising questions not covered by the speaker and of briefly presenting ideas or data that confirm or contrast with those presented by the speaker. Such questions and comments should be stated courteously and professionally. This is not the time (although we have all seen it) for windbags to vent their spleens or to describe their own erudition in infinite detail. It is all right to disagree, but do not be disagreeable. In short, the speaker has an obligation to be considerate to the audience, and the audience has an obligation to be considerate to the speaker.

A FEW ANSWERS ON QUESTIONS

What should you do if an audience member is indeed abrasive? If someone asks an irrelevant question? If a question is relevant but you lack the answer?

If someone is rude, stay calm and courteous. Thank them for the question or comment, and if you have a substantive reply, provide it. If the person keeps pursuing the point, offer to talk after the session.

If a question is irrelevant, take a cue from politicians and try to deflect the discussion to something related that you wish to address—perhaps a point that you had hoped to include in your presentation but didn't have time to add. ("That's an interesting question, but a more immediate concern to us was. . . .") Alternatively, again offer to talk with the person later.

If you lack the answer to a question, do not panic—and definitely do not bluff. Admit that you do not know. If you can provide the answer later, offer to do so; if you know how to find the answer, say how. To help prepare for questions that might arise, have colleagues quiz you after you rehearse.

Especially if you have not yet submitted for publication the work you are presenting, consider making note of the questions and comments (or having a colleague do so). Audience members can function as some of your earliest peer reviewers. Keeping their questions in mind when you write may strengthen your paper and hasten its acceptance.

CHAPTER 28

How to Prepare a Poster

It takes intelligence, even brilliance, to condense and focus information into a clear, simple presentation that will be read and remembered. Ignorance and arrogance are shown in a crowded, complicated, hard-to-read poster.

—Mary Helen Briscoe

POPULARITY OF POSTERS

Whether a conference is local, regional, national, or international, it is likely to include posters presenting research. Sessions featuring such posters originated—apparently in the late 1960s through the mid-1970s (Waquet 2008)—as follows: As attendance at meetings increased, and as pressure mounted on program committees to schedule more and more papers for oral presentation, something had to change. The large annual meetings, such as those of the Federation of American Societies for Experimental Biology, reached the point where the number of available meeting rooms no longer sufficed. And, even when enough rooms were available, the resulting large numbers of concurrent sessions made it difficult or impossible for attending scientists to keep up with the work being presented.

At first, program committees simply rejected however many abstracts were deemed beyond the capabilities of meeting room space. Then, as poster sessions were developed, program committees could take the sting out of rejection by telling the rejectees that they could present their work as posters. In the early days, posters were relegated to the hallways of the hotels or conference centers where meetings took place; nevertheless, many authors, especially graduate students trying to present their first paper, were happy to have their work accepted for a poster session rather than being knocked off the

program altogether. Also, younger scientists had come of age during the era of science fairs, and they liked posters.

Nowadays, poster sessions have become an accepted and meaningful part of many meetings. Large societies set aside substantial space for poster presentations; at some meetings, thousands of posters are presented. Even small societies often encourage poster presentations because some types of material may be presented more effectively in poster graphics and the accompanying discussion than in the confines of the traditional 10-minute oral presentation.

Meanwhile, posters and poster sessions continue to evolve. Recent developments include electronic posters, also known as *e-posters* or *digital posters*. More and more conferences are featuring e-poster sessions, for which posters are provided digitally and displayed electronically. Some such sessions are limited to e-posters that have only static images, and so are largely digital equivalents of conventional posters. Others display e-posters that incorporate dynamic elements, such as videos, animations, and opportunities for interaction. Also, some conferences include related sessions such as 3-minute spoken “flash poster presentations,” intended to interest attendees in visiting the speakers’ posters. Since the advent of virtual and part-virtual conferences, many posters have been presented remotely.

Before starting to prepare a poster, be sure to know the requirements specified by the meeting organizers. If the poster will be a physical one, you of course must know the height and width of the space available for it. The minimum sizes of type may be specified, as may other aspects, such as requirements for e-posters. As well as being given directly to the presenters, this information is likely to be available on the conference website.

ORGANIZATION

The organization of a poster normally should follow the IMRAD format (introduction, methods, results, and discussion). There is very little text in a well-designed poster; most of the space is used for illustrations. In general, a poster should contain no more than 500 to 1,000 words (approximately the number of words in two to four double-spaced pages of manuscript or in two to four typical article abstracts). If a poster is in landscape format, with the width exceeding the height, placing the content in three to five vertical columns generally works well. For posters in portrait format, using two or three columns is usually the best choice. Unless the conference organizers require an abstract on your poster, do not include one; the poster as a whole is not much more extensive than an abstract, so an abstract tends to be redundant and waste valuable space. Where feasible, use bulleted or numbered lists rather than paragraphs. If paragraphs are used, keep them short for readability.

The introduction should present the problem succinctly; the poster will fail unless it has a clear statement of purpose at the beginning. The methods section will be very brief; sometimes a sentence or two will suffice to describe the type of approach used. The results section, which is often the shortest part of a written paper, is usually the major part of a well-designed poster. Most of the available space should be used to illustrate the results. The discussion should be brief. Some of the best posters do not even use the heading “Discussion”; instead, the heading “Conclusions” appears over the far-right panel, with the individual conclusions perhaps being in the form of numbered or bulleted short sentences. Literature citations should be kept to a minimum.

PREPARING THE POSTER

Preparing a poster often begins with writing an abstract for the selection committee. As with an oral presentation, this abstract should be carefully written. It should conform to all stated requirements, and it should be readably worded for easy peer review. Before writing the abstract, think ahead to what the poster will look like. Choose as your topic a part of your research that is focused enough to present effectively as a poster (Mitrany 2005) rather than trying to cover so much that a bafflingly cluttered poster would result.

The title of your poster should be short and (if feasible) attention-grabbing; if it is too long, it might not fit in the space. The title should be readable to a distance of 10 feet (about 3 m). The typeface should be bold and dark, and the type should be at least about 1 inch (about 25 mm) high—in other words, at least about 72 points. Unless the conference organizers require titles to be in all capital letters, use mainly lowercase letters; in addition to taking up less space, they make the title easier to read, as lowercase letters vary more in shape than capital letters do. (Compare “PRESENTING POSTERS” and “Presenting Posters.”) The names of the authors should be somewhat smaller. The text type should be large enough to be readily readable (normally at least 18 points). Large blocks of type should be avoided; where feasible, use bulleted or numbered lists.

A poster should be self-explanatory, allowing viewers to proceed at their own pace. If the author must spend most of their time merely explaining the poster rather than responding to scientific questions, the poster is largely a failure.

Having ample white space throughout the poster is important. Distracting clutter will drive people away. Try to make it *very* clear what is meant to be looked at first, second, and so forth (although many people will still read the poster backward). Visual impact is particularly critical in a poster session. If

you lack graphic talent, consider getting the help of a graphic artist, such as from the media resources department at your institution.

A poster should contain *highlights*, so that passersby can easily discern whether the poster is of interest to them. If they are interested, there will be plenty of time for them to ask questions about the details. Also, consider preparing handouts containing more detailed information; they will be appreciated by colleagues with similar specialties. Another option is to include a QR code for accessing further information.

A poster may actually be better than an oral presentation for showing the results of a complex experiment. In a poster, you can organize the highlights of several threads well enough to give informed viewers the chance to recognize what is going on and then get further details if they so desire. The oral presentation, as stated in chapter 27, is better for getting across a single result or point.

The really nice thing about posters is the variety of illustrations that can be used. There is no barrier (as there sometimes is in journal publication) to the use of color. All kinds of photographs, graphs, drawings, paintings, radiographs, maps, and even cartoons can be presented. Try to use images that both attract and inform. Make the images large enough to see easily, and keep them simple enough to understand quickly.

Once the poster is drafted, check it carefully. Be sure, for example, that all the illustrations are clearly labeled and the poster includes your contact information. Proofread the poster, and have others do so too—lest you discover too late that your coinvestigator's name was misspelled. If you will present a physical poster, consider what material to print it on. Traditionally, posters have been printed on heavy paper. Some presenters have their posters printed on cloth for easier transport.

If you are traveling by airplane to a conference, carry your poster with you. Do not check it in your luggage—it might be delayed until after the poster session if, as happened to a colleague of ours, you are flying to San Jose but your luggage gets routed to San Juan. Regardless of whether your poster is conventional or electronic, have a backup copy in case the original is lost, destroyed, or damaged. For example, carry a copy on a USB drive, email a copy to yourself, save a copy in the cloud—or do more than one of these.

There are many excellent posters. Some scientists indeed have considerable creative ability. It is obvious that these people are proud of the science they are doing, and they are pleased to put it all into a pretty picture.

There are also many terrible posters. A few are simply badly designed. The great majority of bad posters are bad because the author is trying to present too much in them. Huge blocks of typed material will not be read, especially if the type is small. Crowds will gather around the simple, well-illustrated posters; the cluttered, wordy posters will be ignored.

PRESENTING THE POSTER

A poster presentation is, as its name says, both poster and presentation. Typically, for some of the time the poster is on display, one or more of the authors accompany and discuss it. Thus, creating a well-designed poster constitutes only part of a successful poster presentation.

Leave your shyness behind when you accompany a poster. Now is not the time to hide behind the poster or stare at your shoes. Think ahead about questions you might be asked and, verbally and otherwise, show a readiness to answer them. If the occasion arises, ask questions as well. Take advantage of the chance for feedback. Also, take advantage of the chance to network. Those talking with you might well include potential collaborators or employers.

What should you wear when presenting a poster? At some conferences, poster presenters typically wear suits. At others, they usually dress more casually. If in doubt, ask a mentor or colleague who knows the norms. A light-hearted report of a very small study (Keegan and Bannister 2003) suggests that wearing colors that coordinate with those of a poster might increase the number of visitors to the poster. A photo of a presenter wearing clothes color-coordinated with his poster appears on the web page *Designing Conference Posters* (colinpurrington.com/tips/poster-design), which presents extensive advice on preparing and presenting posters; scroll down patiently to find this photo, for this web page is extensive, even containing templates for poster design. Another source of extensive advice on posters is the book *Better Posters* (Faulkes 2021), which includes many visuals and has an informal, sometimes irreverent style.

As noted, consider having handouts available that present your work in more detail; remember to include your contact information. Also consider having, or providing access to, printouts of your poster and copies of papers describing related research you have done. If you run out of handout materials or wish to share materials that you did not bring, obtain email addresses and send the materials as attachments. Perhaps have business cards available too. And if, for example, you are seeking a postdoctoral fellowship or a job, perhaps have copies of your curriculum vitae or résumé on hand.

In short, take advantage of the interactive opportunities of the poster session. As your professional community comes to you, present your work—and yourself—at their best.

CHAPTER 29

How to Write a Conference Report

Conference: a gathering of important people who singly can do nothing, but together decide that nothing can be done.

—Fred Allen

DEFINITION

A conference report can be of many kinds. However, let us make a few assumptions and, from these, try to devise a picture of what a more-or-less typical conference report should look like.

It all starts, of course, when you are invited to participate in a conference (congress, symposium, workshop, panel discussion, seminar, or colloquium), the proceedings of which will be published. At that early time, you should stop to ask yourself, and the conference convener or editor, exactly what is involved in the publication.

The biggest question, yet one that is often left cloudy, is whether the proceedings volume will be defined as a primary publication. If you or other participants present previously unpublished data, the question arises (or at least it should) as to whether data published in the proceedings are validly published, thus precluding later republication in a primary journal.

The clear trend, it seems, is to define conference reports as not validly published primary data. This is seemingly in recognition of three important considerations: (1) Most conference proceedings are one-shot, ephemeral publications, not purchased widely by science libraries around the world; thus, because of their limited circulation and availability, they fail one of the fundamental tests of valid publication. Or if the proceedings are posted online,

they might not be permanently accessible. (2) Most conference reports either are essentially review papers, which do not qualify as primary publication, or are preliminary reports presenting data and concepts that may still be tentative or inconclusive and that the scientist would not yet dare to contribute to a primary publication. (3) Conference reports are normally not subjected to peer review or to more than minimal editing; therefore, because of the lack of any real quality control, many reputable publishers now define proceedings volumes as nonprimary. (There are, of course, exceptions. Some conference proceedings are peer-reviewed and rigorously edited, and their prestige is the equal of primary journals. Indeed, some conference proceedings appear as issues of journals.)

This is important to you because you can determine whether your data will be buried in an obscure proceedings volume. It also answers in large measure how you should write the report. If the proceedings volume is adjudged as primary, you should (and the editor will no doubt so indicate) prepare your manuscript in journal style. You should give full experimental detail, and you should present both your data and your discussion of the data as circumspectly as you would in a prestigious journal.

If, on the other hand, you are contributing to a proceedings volume that is not a primary publication, your style of writing may (and should) be quite different. The fundamental requirement of reproducibility, inherent in a primary publication, may now be ignored. You need not, and probably should not, have a materials and methods section. Certainly, you need not provide the intricate detail that might be required for a peer to reproduce the experiments.

Nor is it necessary to provide the usual literature review. Your later journal article will carefully fit your results into the preexisting fabric of science; your conference report should be designed to give the news and the speculation on the data for today's audiences. Only the primary journal need serve as the official repository.

FORMAT

If your conference report is not a primary scientific paper, just how should it differ from the usual scientific paper?

A conference report is often limited to one or two printed pages, or 1,000 to 2,000 words. Commonly, authors are provided with a simple formula, such as "up to five manuscript pages, double-spaced, and not more than three illustrations (any combination of tables, graphs, or photographs)."

Today, conference reports often appear in electronic formats, either instead of or in addition to print. However, the principles remain the same.

PRESENTING NEW IDEAS

As stated, the conference report can be relatively short because most of the experimental detail and much of the literature review can be eliminated. In addition, the results can usually be presented in brief form. Because the full results will be presumably published later in a primary journal, only the highlights need be presented in the conference report.

On the other hand, the conference report might give greater space to speculation. Editors of primary journals can get quite nervous about discussion of theories and possibilities that are not thoroughly buttressed by the data. The conference report, however, should serve the purpose of the true preliminary report; it should present and encourage speculation, alternative theories, and suggestions for future research.

Conferences themselves can be exciting precisely because they do serve as the forum for presentation of the very newest ideas. If the ideas are truly new, they are not yet fully tested. They may not hold water. Therefore, the typical scientific conference should be designed as a sounding board, and the published proceedings should reflect that ambience. The strict controls of stern editors and peer review are fine for the primary journal but are out of place for the conference literature.

Because conference reports may interest readers largely because of the newness of the ideas, submit your report promptly. Sometimes the reports are due before the conference. Other times, they are due shortly afterward, allowing you to add ideas that emerged at the conference. In either case, submit your report by the deadline so as not to delay publication or posting. If your paper is due shortly after the conference, a good approach can be to draft it before the conference and start revising it during the conference, while any discussion of your presentation is fresh in your mind.

The typical conference report, therefore, need not follow the usual introduction, materials and methods, results, discussion progression that is standard for the primary research paper. Instead, an abbreviated approach may be used. The problem is stated; the methodology used is stated (but not described in detail); and the results are presented briefly, with one, two, or three tables or figures. Then, the meaning of the results is speculated about, often at considerable length. There is likely to be description of related or planned experiments in the author's own laboratory or in the laboratories of colleagues who are currently working on related problems.

EDITING AND PUBLISHING

Finally, it is only necessary to remind you that the editor of the proceedings, usually the convener of the conference, is the sole arbiter of questions relating to manuscript preparation. If the editor has distributed instructions to authors,

you should follow them (assuming that you want to be invited to other conferences). You might not have to worry about rejection, since conference reports are seldom rejected; however, if you have agreed to participate in a conference, you should follow whatever rules are established. If all contributors follow the rules, whatever they are, the resultant volume is likely to exhibit reasonable internal consistency and be a credit to everyone involved.

PART VII

Scientific Style

CHAPTER 30

Use and Misuse of English

Long words name little things. All big things have little names, such as life and death, peace and war, or dawn, day, night, love, home. Learn to use little words in a big way—It is hard to do. But they say what you mean. When you don't know what you mean, use big words: They often fool little people.

—SSC BOOKNEWS, July 1981

SOME BASICS

Keep It Simple

Earlier chapters of this book outlined the various components that could (and perhaps should) go into a scientific paper. Perhaps, with this outline, the paper won't quite write itself. But if this outline, this table of organization, is followed, the writing might be much easier than otherwise.

Of course, you still must use the English language if you want your work to have the greatest visibility. For some, this may be difficult. If your native language is not English, you may face particular challenges in English-language writing; some suggestions for overcoming those challenges appear in chapter 34. Even if your native language is English, you may have a problem because the native language of many of your readers is not English.

Learn to appreciate, as most manuscript editors have done, the sheer beauty of the simple declarative sentence (subject, then verb, then object). You will thereby avoid most serious grammatical problems and make it easier for people whose native language is not English. You also will make it easier for readers who are busy—as almost all readers of scientific papers are.

Tense in Scientific Writing

One special convention of writing scientific papers is very tricky. It has to do with tense, and it is important because proper usage derives from scientific ethics.

When a scientific paper has been validly published in a primary journal, it thereby becomes knowledge. Whenever you state previously published findings, ethics requires you to treat the work with respect. You do this by using the *present* tense. It is correct to say, “*Streptomycin inhibits the growth of *Mycobacterium tuberculosis* (13).*” Whenever you state previously published findings, you should use the present tense, as you are referring to established knowledge. You would do this just as you would say, “The Earth is round.” (If previously published results have been proven false in later experiments, the use of past rather than present tense would be appropriate.)

Your own present work must be referred to in the *past* tense. Your work is not presumed to be established knowledge until *after* it has been published. If you determined in your study that the optimal growth temperature for *Streptomyces everycolor* was 37°C, you should say, “*S. everycolor* grew best at 37°C.” If you are citing previous published work (even possibly your own), it is then correct to say, “*S. everycolor* grows best at 37°C.”

In the typical paper, you will normally go back and forth between the past and present tenses. Most of the abstract should be in the past tense because you are referring to your own present results. Likewise, the materials and methods and the results sections should be in the past tense, as you describe what you did and what you found. On the other hand, much of the introduction and much of the discussion should be in the present tense because these sections often emphasize previously established knowledge.

Suppose that your research concerned the effect of streptomycin on *S. everycolor*. The tense would vary somewhat as follows.

In the abstract, you would write, “The effect of streptomycin on *S. everycolor* grown in various media *was* tested. Growth of *S. everycolor*, measured in terms of optical density, *was* inhibited in all media tested. Inhibition *was* most pronounced at high pH levels.”

In the introduction, typical sentences might be, “*Streptomycin is an antibiotic produced by *Streptomyces griseus* (13).* This antibiotic *inhibits* the growth of certain other strains of *Streptomyces* (7, 14, 17). The effect of streptomycin on *S. everycolor* *is reported* in this paper.”

In the materials and methods section, you would write, “The effect of streptomycin *was* tested against *S. everycolor* grown on Trypticase soy agar (BBL) and several other media (Table 1). Various growth temperatures and pH levels *were* employed. Growth *was* measured in terms of optical density (Klett units).”

In the results, you would write, “Growth of *S. everycolor* was inhibited by streptomycin at all concentrations tested (Table 2) and at all pH levels (Table 3). Maximum inhibition occurred at pH 8.2; inhibition was slight below pH 7.”

In the discussion, you would write, “*S. everycolor* was most susceptible to streptomycin at pH 8.2, whereas *S. nicolor* is most susceptible at pH 7.6 (13). Various other *Streptomyces* species are most susceptible to streptomycin at even lower pH levels (6, 9, 17).”

In short, you should normally use the present tense when you refer to previously published work, and you should use the past tense when referring to your present results.

The main exceptions to this rule are in the areas of attribution and presentation. It is correct to say, “Smith (9) showed that streptomycin inhibits *S. nicolor*.” It is also correct to say, “Table 4 shows that streptomycin inhibited *S. everycolor* at all pH levels.” Another exception is that the results of calculations and statistical analysis should be in the present tense, even though statements about the objects to which they refer are in the past tense; for example, “These values are significantly greater than those of the females of the same age, indicating that the males grew more rapidly.” Still another exception is a general statement or known truth. Simply put, you could say, “Water was added and the towels became damp, which proves again that water is wet.” More commonly, you will need to use this kind of tense variation: “Significant amounts of type IV procollagen were isolated. These results indicate that type IV procollagen is a major constituent of the Schwann cell ECM.”

Active Versus Passive Voice

Let us now talk about *voice*. In any type of writing, the active voice tends to be more powerful, more precise, and less wordy than the passive voice.

Some exceptions do exist, though. As noted in Chapter 11, passive voice (for example, “the tubes were centrifuged” rather than “we centrifuged the tubes”) sometimes works well in the methods section. Elsewhere in a scientific paper, however, it rarely should be employed.

Why, then, do scientists use so much passive voice? Perhaps this bad habit results from the erroneous idea that it is somehow impolite to use first-person pronouns. Because of this idea, the scientist commonly uses verbose (and imprecise) statements such as, “It was found that” in preference to the short, unambiguous “We found.”

Young scientists should renounce the false modesty of their predecessors. Do not be afraid to name the agent of the action in a sentence, even when it is “I” or “we.” Once you get into the habit of saying “I found,” you will also find that you tend to write “*S. aureus* produced lactate” rather than “Lactate was

produced by *S. aureus*." (Note that the "active" statement is in three words; the passive requires more.)

You can avoid the passive voice by saying "The authors found" instead of "it was found." But compared with the simple "we found," "the authors found" is pretentious and imprecise (which authors?).

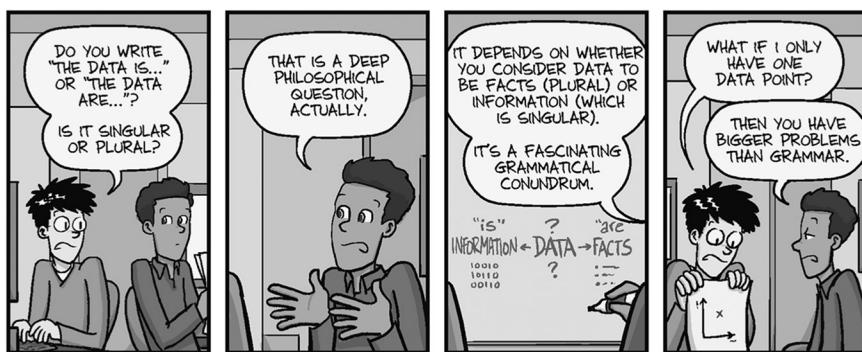
Singulare and Plurale

When you use first-person pronouns, use both the singular and the plural forms as needed. Do not use the "editorial we" in place of "I." The use of "we" by a single author is outrageously pedantic.

A frequent error in scientific papers is the use of plural forms of verbs when the singular forms would be correct. For example, you should say, "10 g *was* added," not "10 g *were* added." This is because a *single* quantity was added. Only if the 10 g were added 1 g at a time would it be correct to say, "10 g *were* added."

The singular-plural problem also applies to nouns. The problem is severe in scientific writing, especially in biology, because so many of the words are, or are derived from, Latin or Greek. Commonly, these words retain their Latin or Greek plurals; at least they do when used by careful writers.

Many of these words (for example, *data*, *media*) have entered popular speech, where the Latin *a* plural ending is rarely recognized as plural. Most people habitually use "data *is*" constructions and probably have never used the real singular, *datum*. In *The Careful Writer*, Bernstein (1965) objected to this usage, terming it "a common solecism." Today, although debate on the subject persists, both the plural and the singular usages are commonly acceptable, at least in informal contexts. For instance, *Merriam-Webster's Collegiate Dictionary*



("Piled Higher and Deeper" by Jorge Cham. www.phdcomics.com)

(11th edition) gives “the data is plentiful” as an example of accepted usage. Whether to use *data* as a plural or a singular word can depend on whether you are referring to a group of individual pieces of data or the data as a single mass. Often, in deciding whether to use *data* with a plural verb or a singular one, the best approach is to follow your discipline’s conventions in this regard and the predominant usage in your target journal.

This “plural” problem was commented upon by Sir Ashley Miles, the eminent microbiologist and scholar, in a letter to the editor of *ASM News* (44:600, 1978):

“A Memoranda on Bacterial Motility.” The motility of a bacteria is a phenomena receiving much attention, especially in relation to the structure of a flagella and the effect on it of an antisera. No single explanatory data is available; no one criteria of proof is recognized; even the best media to use is unknown; and no survey of the various levels of scientific approach indicates any one strata, or the several stratae, from which answers may emerge. Flagellae are just as puzzling as the bacteriae carry them.

Numbers

The preferred usage regarding numbers varies among style manuals and among journals. The *Chicago Manual of Style* (2017) favors “spelling out whole numbers from zero through one hundred” and using numerals for other numbers. However, it notes that many publications, for example in science, spell out only single-digit numbers. In the “revised or modern scientific number style” (Style Manual Subcommittee, Council of Science Editors 2014), single-digit whole numbers, with few exceptions, appear as numerals too.

If the style for numbers is not specified otherwise, here are some widely acceptable guidelines to follow: One-digit numbers should be spelled out; numbers of two or more digits should be expressed as numerals. You would write “three experiments” or “13 experiments.” Now the exception: With standard units of measure, always use numerals. You would write “3 ml” or “13 ml.” The only exception to the exception is that you should not start a sentence with a numeral. You should either reword the sentence or spell out both the number and the unit of measurement. For example, your sentence could start “Reagent A (3 ml) was added” or it could start “Three milliliters of reagent A was added” or “In total, 3 ml of reagent A was added.” Actually, there is still another exception. In a sentence containing a series of numbers, at least one of which is of more than one digit, all of the numbers generally should be expressed as numerals. (Example: “I gave water to 3 scientists, milk to 6 scientists, and beer to 11 scientists.”)

English as an Evolving Language

“But my fourth-grade English teacher said never to. . . .” “But I know I read somewhere that this was right. . . .” “But for my first paper, the journal changed it to be the opposite way. . . .”

Although the basics of good English remain the same, English keeps evolving as a language—and thus, so do the norms that style manuals recommend and journals follow. Some relatively recent examples: The word “internet” no longer normally is capitalized. The term “underway” no longer tends to be two separate words. And it is now considered acceptable to use the word “they” as a singular pronoun for an individual whose gender is not specified.

So, what’s an author to do? Don’t worry if you can’t keep up with such matters. A journal won’t reject your paper because you still wrote “e-mail” rather than “email.” Luckily, journals have experts—manuscript editors—whose remit includes keeping up with such changes. In editing your paper, these experts help ensure that the English complies with current norms. Appreciate their services. Don’t argue with them that “My fourth-grade English teacher said. . . .”

SOME FINER POINTS

Misuse of Words

Avoid self-canceling, contradictory, or redundant words. Recently, someone was described as being a “well-seasoned novice.” A newspaper article referred to “young juveniles.” A sign in a stamp and coin dealer’s shop read “authentic replicas.” If there is any expression that is dumber than “7 a.m. in the morning,” it is “viable alternative.” (If an alternative is not viable, it is not an alternative.)

Certain words are wrongly used thousands of times in scientific writing. Some of the worst offenders are the following:

affect/effect. Almost always, *affect* is a verb, and *effect* is a noun. Example: “The barometric pressure *affects* this process. However, the *effect* is small.” A mnemonic to help remember the distinction is RAVEN, for “Remember: Affect Verb, Effect Noun” (www.mnemonic-device.com/languages/affect-and-effect). (Exceptions are the noun *affect*, meaning external expression of emotion, and the verb *effect*, meaning “produce,” as in the expression “*effect change*.”)

amount/number. Use *amount* when you refer to a mass or aggregate. Use *number* when individual entities are involved. “An amount of cash” is all right. “An amount of coins” is wrong.

fewer/less. Use *fewer* for countable items and *less* for uncountable ones.

Example: “fewer coins,” but “less money.”

it. This common, useful pronoun can cause a problem if an antecedent is not clear, as in the sign that read: “Free information about VD. To get it, call 555-7000.”

like. Often used incorrectly as a conjunction; it should be used only as a preposition. When a conjunction is needed, substitute *as.* Like I just said, this sentence should have started with *As.*

only. Many sentences are only partially comprehensible because the word *only* is positioned correctly in the sentence only some of the time. Consider this sentence: “I hit him in the eye yesterday.” The word *only* can be added at the start of the sentence, at the end of the sentence, or between any two words within the sentence, but look at the differences in meaning that result.

quite. Next time you notice this word in one of your manuscripts, delete it and read the sentence again. You will notice that *quite* is quite unnecessary.

varying. The word *varying* means *changing.* Often used erroneously when *various* is meant. “Various concentrations” are multiple defined concentrations that do not vary.

which. The word *which* is properly used in a nonrestrictive sense, to introduce a clause that adds information but does not make the preceding term more specific; *that* introduces a clause that adds specificity. Examine these two sentences: “CetB mutants, *which* are tolerant to colicin E2, also have an altered. . . .” “CetB mutants *that* are tolerant to colicin E2 also have an altered. . . .” Note the substantial difference in meaning. The first sentence indicates that *all* CetB mutants are tolerant to colicin; the second sentence indicates that only some of the CetB mutants are tolerant to it.

Style manuals in the sciences commonly include sections on words that tend to be misused; browsing through such a section can be time well spent. Also, such style manuals often provide guidance on using language that is inclusive and otherwise unbiased. Because guidelines on this topic keep evolving, we recommend looking at a continually updated online version of such a manual or checking the manual’s website for updates.

Noun Problems

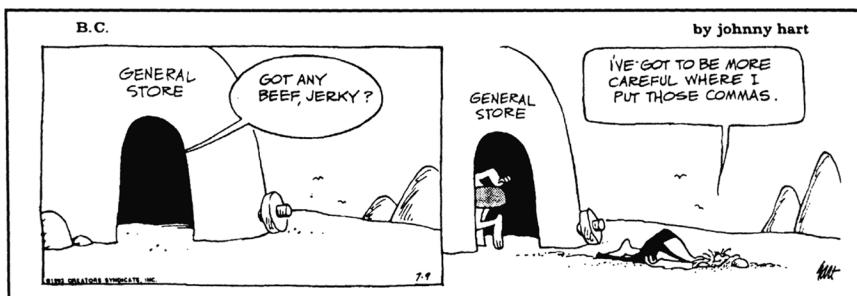
Another frequent problem in scientific writing is the wordiness that results from using abstract nouns. This malady often can be corrected by turning the nouns into verbs. “Examination of the patients was carried out” should be changed to the more direct “We examined the patients”; “separation of the

compounds was accomplished" can be changed to "the compounds were separated"; "transformation of the equations was achieved" can be changed to "the equations were transformed."

An additional problem with nouns results from using them as adjectives. Normally, there is no problem with such usage, but you should watch for special difficulties. For example, there is no problem in understanding "liver disease" (even though the adjective *hepatic* could be substituted for the noun *liver*). The problem with such usage is illustrated by the following sentences from an autobiography: "When I was 10 years old, my parents sent me to a child psychiatrist. I went for a year and a half. The kid didn't help me at all." There once was an ad (in the *New York Times*, of all places) with the headline "Good News for Home Sewers." It could have been an ad for a drain-cleaning compound or for needle and thread.

The problem gets still worse when clusters of nouns are used as adjectives, especially when a real adjective gets into the brew. "Tissue culture response" is awkward; "infected tissue culture response" may be baffling. (Just what is infected?) Baffling too are these gems from job ads: "newborn hospital photographer" and "portable toilet route driver." Sometimes you can resolve the confusion by inserting a hyphen to show which words function together as an adjective. Consider, for example, the headline "Technology Can Help Drought Hit Farmers." (How odd to use technology to aid drought in hitting farmers!) Inserting a well-placed hyphen yields a much more reasonable headline: "Technology Can Help Drought-Hit Farmers." (Similarly, we think the author who wrote of the "animal owning public" actually meant the "animal-owning public.")

Like hyphens, commas can change the meaning of phrases. An author wrote that all samples in a study had been evaluated by "a single, board-certified pathologist." Presumably, the comma should have been deleted. With the comma included, the phrase means not "the same board-certified



(By permission of Johnny Hart and Creators Syndicate, Inc.)

pathologist” but rather “a pathologist who is single and board certified”—a description less suited for a scientific journal than for an online dating site.

Euphemisms

In scientific writing, euphemistic words and phrases normally should be avoided. The harsh reality of dying is not improved by substituting “passed away.” Laboratory animals are not “sacrificed,” as though scientists engaged in arcane religious exercises. They are killed, and that’s that. The *CBE Style Manual* (CBE Style Manual Committee 1983) cited a beautiful example of this type of euphemism: “Some in the population suffered mortal consequences from the lead in the flour.” It then corrects this sentence, adding considerable clarity as well as eliminating the euphemism: “Some people died as a result of eating bread made from the lead-contaminated flour.” An instructor gave graduate students the “mortal consequences” sentence as a test question in scientific writing. Most were simply unable to say “died.” On the other hand, there were some inventive answers. They included “Get the lead out” and “Some were dead from the lead in the bread.”

Dangling Modifiers and Other Syntactical Sins

It is not always easy to recognize a dangling participle or related error, but you can avoid many problems by paying proper attention to syntax. The word *syntax* refers to that part of grammar dealing with the way in which words are put together to form phrases, clauses, and sentences.

That is not to say that a well-dangled participle or other misplaced modifier isn’t a joy to behold, after you have developed a taste for such things. Those of you who use chromatographic procedures may be interested in a new technique reported in a manuscript submitted to the *Journal of Bacteriology*: “By filtering through Whatman no. 1 filter paper, Smith separated the components.” Those wishing that lab animals could do research themselves might be pleased to read about the endeavor “to evaluate the fecal microbiome in cats using PCR.” Along similar lines, a headline stated, “Researchers Detect Land Animals Using DNA in Nearby Water Bodies.” But some animals might indeed be this smart: A draft of an essay by a veterinary school applicant read, “While in high school, my cat began to develop kidney disease.”

In Hampshire, England, the fire department received a government memorandum seeking statistical information. One of the questions was, “How

many people do you employ, broken down by sex?" The fire chief took that question right in stride, answering "None. Our problem here is booze."

Here's another headline, from the *Washington Post*: "Antibiotic-Combination Drugs Used to Treat Colds Banned by FDA." Perhaps the next FDA (Food and Drug Administration) regulation will ban all colds, and virologists will have to find a different line of work.

A manuscript contained this sentence: "A large mass of literature has accumulated on the cell walls of staphylococci." After the librarians have catalogued the literature in the staphylococci, they will have to start on the fish, according to this sentence from a manuscript: "The resulting disease has been described in detail in salmon."

The first paragraph of a news release issued by the American Lung Association said, "Women seem to be smoking more but breathing less," says Colin R. Woolf, M.D., Professor, Department of Medicine, University of Toronto. He presented evidence that women who smoke are likely to have pulmonary abnormalities and impaired lung function at the annual meeting of the American Lung Association." Even though the annual meeting was in the lovely city of Montreal, we hope that women who smoke stayed home.

And finally, some favorites from an email discussion list: A student wrote that she was seeking housing "for me, my two dogs, and my rabbit that has a washer-dryer." (We hadn't realized that rabbits do laundry.) A technician said that she was looking for a "large or medium dog kennel for a researcher." (Hmmm, is office space that scarce?) And another list member wrote that "due to moving, internship salary, and a lack of need for it," she was highly motivated to sell the item that she was advertising. (Gee, if you don't need your internship salary, we know someone who would like it.)

Metaphorically Speaking

We suggest that you largely avoid similes and metaphors. Use them rarely in scientific writing. If you use them, use them carefully. We have seen mixed metaphors and noted how comprehension gets mixed along with the metaphor. (Figure this one out: A virgin forest is a place where the hand of man has never set foot.) A rarity along this line is the "self-canceling metaphor." A favorite was ingeniously concocted by the eminent microbiologist L. Joe Berry. After one of his suggestions had been quickly negated by a committee vote, Joe said, "Boy, I got shot down in flames before I ever got off the ground."

Watch for hackneyed expressions too. These are usually similes or metaphors that have grown tired from overuse (for example, "timid as a mouse"). Interesting and picturesque writing results from the use of fresh similes and metaphors; dull writing results from the use of stale ones.

ON A LIGHTER NOTE

The Ten Commandments of Good Writing

From the “do as I say, not as I do” school of thought, here are a few longtime favorites:

1. Each pronoun should agree with their antecedent.
2. Just between you and I, case is important.
3. A preposition is a poor word to end a sentence with.
4. Verbs has to agree with their subject.
5. Don’t use no double negatives.
6. Remember to never split an infinitive.
7. Avoid clichés like the plague.
8. Join clauses good, like a conjunction should.
9. Do not use hyperbole; not one writer in a million can use it effectively.
10. About sentence fragments.

Please, Please Proofread

Whether because of autocomplete, autocorrect, autotranscribe, or an author on automatic pilot, manuscripts often include typographical errors. Some recent examples: “catchers” instead of “catheters,” “lumber puncture” instead of “lumbar puncture,” “Chihuahua terror mix” instead of “Chihuahua-terrier mix,” and “wiener” instead “webinar.” Sometimes the typos seem to have a grain of truth: “play it by hear” instead of “play it by ear,” “author argument” instead of “author agreement” (although we would never argue with our publisher), “eternal applicants” instead of “external applicants” (alas, we’ve known some of the former), and “remail” instead of “email” (in a message from a colleague who has sent far too many).

A newspaper headline told of an “amphibious” baseball pitcher instead of an “ambidextrous” one. The following also crossed our desks: “humane immunodeficiency virus” for “human immunodeficiency virus,” “craps” for “crabs,” “laundry mat” for “laundromat,” and “keyboards” for “keywords.” And we have encountered “captions” instead of “cations,” “edible file” for “editable file,” “venerable populations” for “vulnerable populations,” “heard immunity” for “herd immunity,” “concurring heroes” for “conquering heroes,” “plural” for “pleural,” “knit-picking” for “nitpicking,” and “nerve-wrecking” for “nerve-wracking.”

Although it may seem nitpicking and nerve-wracking, always take the time to proofread.

Odds and Ends

Let us end by again emphasizing the importance of syntax. When comprehension goes out the window, faulty syntax is usually responsible. Sometimes faulty syntax is simply funny and comprehension is not lost, as in these two items, culled from want ads:

“For sale, fine German Shepherd dog, obedient, well trained, will eat anything, very fond of children.”

“For sale, fine grand piano, by a lady, with three legs.”

But look at this sentence, which is similar to thousands that have appeared in the scientific literature: “Thymic humoral factor (THF) is a single heat-stable polypeptide isolated from calf thymus composed of 31 amino acids with molecular weight of 3,200.” The prepositional phrase “with molecular weight of 3,200” would logically modify the preceding noun “acids,” meaning that the amino acids had a molecular weight of 3,200. Less logically, perhaps the calf thymus had a molecular weight of 3,200. Least logical of all (because of their distance apart in the sentence) would be for the THF to have a molecular weight of 3,200—but, indeed, that was what the author was trying to tell us.

If you wish to use English more effectively, consider reading Strunk and White’s (2000) *The Elements of Style* if you have not yet done so. The “elements” are given briefly (in fewer than 100 pages!) and clearly. Anyone writing anything should read and use this famous little book. (You can read an early edition, by Strunk alone, at www.bartleby.com/141.) After you have mastered Strunk and White, proceed immediately to Fowler (Butterfield 2015). Do not pass go; do not collect \$200. Of course, if you really do want to get a Monopoly on good scientific English, buy that superbly quintessential book *Scientific English* (Day and Sakaduski 2011).

CHAPTER 31

Avoiding Jargon

Clutter is the disease of American writing. We are a society strangling in unnecessary words, circular constructions, pompous frills and meaningless jargon.

—William Zinsser

DEFINITION OF JARGON

According to *Merriam-Webster's Collegiate Dictionary* (11th edition), definitions of *jargon* include the following: (1) “confused, unintelligible language”; (2) “the technical terminology or characteristic idiom of a special activity or group”; and (3) “obscure and often pretentious language marked by circumlocutions and long words.”

The first and third types of jargon should be avoided. The second type (“technical terminology”) is much more difficult to avoid in scientific writing, and it may be used if readers already are familiar with it or if you have defined or explained it. If you are writing for a technically trained audience, only the unusual technical terms need explanation.

MUMBLESPEAK AND OTHER SINS

The most common type of verbosity that afflicts authors is jargon. This syndrome is characterized, in extreme cases, by the total omission of one-syllable words. Writers with this affliction never *use* anything—they *utilize*. They never *do*—they *perform*. They never *start*—they *initiate*. They never *end*—they *finalize*.

(or *terminate*). They never *make*—they *fabricate*. They use *initial* for *first*, *ultimate* for *last*, *prior to* for *before*, *subsequent to* for *after*, *militate against* for *prohibit*, *sufficient* for *enough*, and *a plethora* for *too much*. An occasional author will slip and use the word *drug*, but most will salivate like Pavlov's dogs in anticipation of using *chemotherapeutic agent*. (We do hope that the name Pavlov rings a bell.) Who would use the three-letter word *now* instead of the elegant expression *at this point in time*?

Stuart Chase (1954) told the story of the plumber who wrote to the Bureau of Standards saying he had found that hydrochloric acid is good for cleaning out clogged drains. The bureau wrote back, "The efficacy of hydrochloric acid is indisputable, but the chlorine residue is incompatible with metallic permanence." The plumber replied that he was glad the bureau agreed. The bureau tried again, writing, "We cannot assume responsibility for the production of toxic and noxious residues with hydrochloric acid, and suggest that you use an alternate procedure." The plumber again said that he was glad that the bureau agreed with him. Finally, the bureau wrote to the plumber, "Don't use hydrochloric acid; it eats hell out of the pipes."

Should we liken the scientist to a plumber, or is the scientist perhaps more exalted? With that doctor of philosophy degree, should the scientist know some philosophy? We agree with John W. Gardner, who said, "The society which scorns excellence in plumbing because plumbing is a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water" (*Science News*, p. 137, March 2, 1974).

We like the way that Aaronson (1977) put it: "But too often the jargon of scientific specialists is like political rhetoric and bureaucratic mumble-speak: ugly-sounding, difficult to understand, and clumsy. Those who use it often do so because they prefer pretentious, abstract words to simple, concrete ones."

The trouble with jargon is that it is a special language, the meaning of which is known only to a specialized "in" group. Science should be universal, and therefore every scientific paper should be written in a universal language.

Of course, you will have to use specialized terminology on occasion. If such terminology is readily understandable to practitioners and students in the field, there is no problem. If the terminology is *not* recognizable to any portion of your potential audience, you should (1) use simpler terminology or (2) carefully define the esoteric terms (jargon) that you are using. In short, you should not write for the half-dozen or so people who are doing exactly your kind of work. You should write for the hundreds of people whose work is only slightly related to yours, but who may want or need to know something about your work.

BUREAUCRATESE

Regrettably, too much scientific writing fits the first and third definitions of jargon. All too often, scientists write like the legendary Henry B. Quill, the bureaucrat described by Meyer (1977): "Quill had mastered the mother tongue of government. He smothered his verbs, camouflaged his subjects, and hid everything in an undergrowth of modifiers. He braided, beaded and fringed, giving



elaborate expression to negligible thoughts, weasling [*sic*], hedging, and announcing the obvious. He spread generality like flood waters in a long, low valley. He sprinkled everything with aspects, feasibilities, alternatives, effectuations, analyzations, maximizations, implementations, contraindications and appurtenances. At his best, complete immobility set in, lasting sometimes for dozens of pages."

Some jargon, or bureaucratese, consists of clear, simple words but contains so many of them that their meaning is not readily evident. Examine the following, an important federal regulation (*Code of Federal Regulations*, Title 36, Paragraph 50.10) designed to protect trees from injury; this notice was posted in National Capital Park and Planning Commission recreation areas in the Washington area:

TREES, SHRUBS, PLANTS, GRASS, AND OTHER VEGETATION

- (a) General Injury. No person shall prune, cut, carry away, pull up, dig, fell, bore, chop, saw, chip, pick, move, sever, climb, molest, take, break, deface, destroy, set fire to, burn, scorch, carve, paint, mark, or in any manner interfere with, tamper, mutilate, misuse, disturb or damage any tree, shrub, plant, grass, flower, or part thereof, nor shall any person permit any chemical, whether solid, fluid or gaseous to seep, drip, drain or be emptied, sprayed, dusted or injected upon, about or into any tree, shrub, plant, grass, flower or part thereof except when specifically authorized by competent authority; nor shall any person build fires or station or use any tar kettle, heater, road roller or other engine within an area covered by this part in such a manner that the vapor, fumes or heat therefrom may injure any tree or other vegetation.

(TRANSLATION: Don't mess with growing things.)

Jargon does not necessarily involve the use of specialized words. Faced with a choice of two words, the jargonist always selects the longer one. The jargonist really gets his jollies, however, by turning short, simple statements into long strings of words. And, usually, the longer word or the longer series of words is not as clear as the simpler expression. We challenge anyone to show how "at this point in time" means, in its cumbersome way, more than the simple word "now." The concept denoted by "if" is not improved by substituting the pompous expression "in the event that."

SPECIAL CASES

Perhaps the worst offender is the word *case*. There is no problem with talking about a case of canned goods or even a case of the flu. However, 99 percent of the uses of *case* are jargon. In case you think that 99 percent is too high, make your own study. Even if this percentage is too high, a good case could be made for the

fact that *case* is used in too many cases. Better and shorter usage should be substituted: *in this case* means *here*; *in most cases* means *usually*; *in all cases* means *always*; *in no case* means *never*. (We also have issues with *issues*. And we wish to highlight *highlight*. In formal writing, limit use of these words to their specific meanings.)

Appendix 2 contains some “Words and Expressions to Avoid.” A similar list well worth consulting was published by O’Connor and Woodford (1975). It is not necessarily improper to use any of these words or expressions *occasionally*; if you use them repeatedly, however, you are writing in jargon and your readers are suffering.

Perhaps the most common way of creating a new word is the jargonist’s habit of turning nouns into verbs. One example is use of the word “interface” to mean “communicate”; the only time people can interface is when they kiss. And a classic example appeared in a manuscript that read: “One risks exposure when swimming in ponds or streams near which cattle have been pasturized.” The copy editor, knowing that there is no such word as “pasturized,” changed it to “pasteurized.” (There may be nothing wrong with that. If you can pasteurize milk, presumably you can pasteurize the original container.)

In their own pastures, scientists are, of course, very expert, but they often succumb to pedantic, jargonistic, and useless expressions, telling the reader more than the reader wants or needs to know. As the English novelist George Eliot said: “Blessed is the man who, having nothing to say, abstains from giving us wordy evidence of this fact.”

If you must show off your marvelous vocabulary, make sure to use the right words. Consider the story that Lederer (1987) told about NASA scientist Werner von Braun. “After one of his talks, von Braun found himself clinking cocktail glasses with [an admirer] from the audience.

“‘Dr. von Braun,’ [the admirer] gushed, ‘I just loved your speech, and I found it of absolutely infinitesimal value!’

“‘Well then,’ von Braun gulped, ‘I guess I’ll have it published posthumously.’

“‘Oh yes!’ [the admirer] came right back. ‘And the sooner the better.’”

MOTTOES TO LIVE BY

To continue on this lighter note (and to end this chapter), the following are some common English-language sayings as they might be expressed in scientific jargon. With a little effort, you might be able to translate these sentences into simple English:

1. As a case in point, other authorities have proposed that slumbering canines are best left in a recumbent position.
2. An incredibly insatiable desire to understand that which was going on led to the demise of this particular *Felis catus*.

3. There is a large body of experimental evidence which clearly indicates that members of the genus *Mus* tend to engage in recreational activity while the feline is remote from the locale.
4. From time immemorial, it has been known that the ingestion of an "apple" (that is, the pome fruit of any tree of the genus *Malus*, said fruit being usually round in shape and red, yellow, or greenish in color) on a diurnal basis will with absolute certainty keep a primary member of the health-care establishment absent from one's local environment.
5. Even with the most sophisticated experimental protocol, it is exceedingly unlikely that the capacity to perform novel feats of legerdemain can be instilled in a superannuated canine.
6. A sedimentary conglomerate in motion down a declivity gains no addition of mossy material.
7. The resultant experimental data indicate that there is no utility in belaboring a deceased equine.

If you had trouble with any of these statements, here are the jargon-free translations:

1. Let sleeping dogs lie.
2. Curiosity killed the cat.
3. When the cat's away, the mice will play.
4. An apple a day keeps the doctor away.
5. You can't teach old dogs new tricks.
6. A rolling stone gathers no moss.
7. Don't beat a dead horse.

Lest we beat a dead horse, we will now end this chapter.

CHAPTER 32

How and When to Use Abbreviations

Authors who use abbreviations extravagantly need to be restrained.

—Maeve O'Connor

GENERAL PRINCIPLES

Many experienced editors loathe abbreviations. Some would prefer that they not be used at all, except for standard units of measurement and their Système International (SI) prefixes, for which all scientific journals allow abbreviations. Many journals also allow, without definition, such standard abbreviations as *etc.*, *et al.*, *i.e.*, and *e.g.* (The abbreviations *i.e.* and *e.g.* are often misused; properly used, *i.e.* means “that is,” whereas *e.g.* means “for example.” Because these abbreviations are so often misused or misinterpreted, we favor avoiding them.) In your own writing, you would be wise to keep abbreviations to a minimum. The editor will look more kindly on your paper, and the readers of your paper will bless you forever. More preaching on this point should not be necessary because, by now, you yourself have no doubt come across undefined and indecipherable abbreviations in the literature. Just remember how annoyed you felt when you were faced with these conundrums, and join with us now in a vow to never again pollute the scientific literature with an undefined abbreviation.

The “how to” of using abbreviations is easy because most journals use the same convention. When you plan to use an abbreviation, you introduce it by spelling out the word or term first, followed by the abbreviation within parentheses. The first sentence of the introduction of a paper might read: “Bacterial plasmids, as autonomously replicating deoxyribonucleic acid (DNA) molecules of modest size, are promising models for studying DNA replication and its control.”

The “when to” of using abbreviations is much more difficult. Several general guidelines might help.

First, generally do not use an abbreviation in the title of an article. Very few journals allow abbreviations in titles, and their use is strongly discouraged by the indexing and abstracting services. If the abbreviation is not standard, the literature retrieval services will have a difficult or impossible problem. Even if the abbreviation is standard, indexing and other problems arise. One major problem is that accepted abbreviations have a habit of changing; today’s abbreviations may be unrecognizable a few years from now. Comparison of certain abbreviations as listed in the various editions of the *Council of Biology Editors Style Manual* (which has now become *Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers*) emphasizes this point. Dramatic changes occur when the terminology itself changes. Students today could have trouble with the abbreviation *DPN* (which stands for “diphosphopyridine nucleotide”) because the name itself has changed to “nicotinamide adenine dinucleotide,” the abbreviation for which is *NAD*.

Abbreviations should almost never be used in an abstract. Only if you use the same name, a long one, many times should you consider an abbreviation. If you use an abbreviation, you must define it at the first use in the abstract. Remember that the abstract will stand alone in whichever abstracting databases cover the journal in which your paper appears.

In the text itself, abbreviations may be used if a long word or phrase will appear repeatedly. They serve a purpose in reducing printing costs, by somewhat shortening the paper. More important, they aid the reader when they are used judiciously. Speaking of “important”: We are reminded of a man whose children sometimes refer to him as “the FIP” (fairly important person). They know that he hasn’t yet made it to VIP.

GOOD PRACTICE

It can be advisable, when writing the first draft of the manuscript, to spell out all terms and phrases in every instance. Then examine the text for repetition of long words or phrases that might be candidates for abbreviation. Do not abbreviate a term or phrase that is used only once or twice in the paper. If the term or phrase is used with modest frequency—for example, between three and six times—and a standard abbreviation for it exists, introduce and use the abbreviation. (Some journals allow some standard abbreviations to be used without definition at first use.) If no standard abbreviation exists, do not manufacture one unless the term or phrase is used very frequently or is very long and cumbersome.

Often, you can avoid abbreviations by using the appropriate pronoun (*it*, *they*, *them*) if the antecedent is clear. Another possibility is to use a substitute

expression such as “the inhibitor,” “the substrate,” “the drug,” “the enzyme,” or “the acid.”

Usually, you should introduce your abbreviations one by one, as they first occur in the text. Alternatively, you might consider a separate paragraph (headed “Abbreviations Used”) in the introduction or in the materials and methods section. The latter system (required in some journals) is especially useful if the names of related reagents, such as a group of organic chemicals, are to be used in abbreviated form later in the paper. Another option, such as in review papers and grant proposals, can be to include a table that lists and defines abbreviations. Such tables make definitions easy to find even if a piece is not being read from beginning to end. Also, if chapters of a book might be read individually or in different orders, consider defining abbreviations on first appearance in each chapter. The same principle holds for other lengthy pieces of writing, such as long proposals, that might well be read other than from start to finish.

UNITS OF MEASUREMENT

Units of measurement are abbreviated when used with numerical values. You would write “4 mg was added.” (The same abbreviation is used for the singular and the plural.) When used without numerals, however, units of measurement are not abbreviated. You would write “Specific activity is expressed as micrograms of adenosine triphosphate incorporated per milligram of protein per hour.”

Careless use of the diagonal slash can cause confusion. This problem arises frequently in stating concentrations. If you say that “4 mg/ml of sodium sulfide was added,” what does this mean? Does it mean “per milliliter of sodium sulfide” (the literal translation), or can we safely assume that “per milliliter of reaction mixture” is meant? It is much clearer to write “4 mg of sodium sulfide was added per milliliter of medium.”

SPECIAL PROBLEMS

A frequent problem with abbreviations concerns the use of *a* or *an* with them. Should you write “a M.S. degree” or “an M.S. degree”? Recall the old rule that you use *a* with words beginning with a consonant sound and *an* with words beginning with a vowel sound (for example, the letter “em”). Because in science we should use only common abbreviations, those not needing to be spelled out in the reader’s mind, the proper choice of article should relate to the sound of the first letter of the abbreviation, not the sound of the first letter

of the spelled-out term. Thus, although it is correct to write “a master of science degree,” it is incorrect to write “a M.S. degree.” Because the reader reads “M.S.” as “em ess,” the proper construction is “an M.S. degree.”

In biology, it is customary to abbreviate generic names of organisms after first use. At first use, you would spell out *“Streptomyces griseus.”* In later usage, you can abbreviate the genus name but not the specific epithet: *S. griseus*. Suppose, however, that you are writing a paper that concerns species of both *Streptomyces* and *Staphylococcus*. You would then spell out the genus names repeatedly. Otherwise, readers might be confused as to whether a particular “S.” abbreviation referred to one genus or the other.

SI (SYSTÈME INTERNATIONAL) UNITS

Appendix 3 gives the abbreviations for the prefixes used with all SI units. The SI units and symbols, as well as certain derived SI units, have become part of the language of science. This modern metric system should be mastered by all students of the sciences. *Scientific Style and Format* (Style Manual Subcommittee, Council of Science Editors 2014) is a good source for more complete information, as is Huth’s (1987) *Medical Style and Format*. Briefly, SI units include three classes: base units, supplementary units, and derived units. The seven base units that form the foundations of SI are the meter (or metre), kilogram, second, ampere, kelvin, mole, and candela. In addition to these seven base units, there are two supplementary units for plane and solid angles: the radian and steradian, respectively. Derived units are expressed algebraically in terms of base units or supplementary units. For some of the derived SI units, special names and symbols exist.

OTHER ABBREVIATIONS

Some style manuals in the sciences (for example, Christiansen et al. 2020; Style Manual Subcommittee, Council of Science Editors 2014) list abbreviations that are standard in specific fields. (On a related note: Such manuals also serve as resources on accepted nomenclature.) Use these and other standard abbreviations when strongly warranted. Largely avoid others. Those that you do use should be introduced as carefully as you would introduce royalty.

CHAPTER 33

Writing Clearly Across Cultures and Media

When you write for an Internet venue . . . your words travel the globe in a flash. But . . . what you think you're saying isn't always what the far-flung reader understands.

—Steve Outing

READABLE WRITING

Earlier chapters have presented principles of writing readably: structuring sentences simply, using proper syntax, deleting needless words, condensing wordy phrases, using words accurately, using mainly active voice, avoiding strings of nouns, using verbs rather than nouns made from them, punctuating properly, using short and familiar words, minimizing the use of abbreviations, and defining abbreviations.

Also for readability, generally avoid starting sentences with “It is” or “There is.” For example, change “It is not necessary to remove this structure” to “This structure need not be removed” or (if appropriate) “You need not remove this structure.” Likewise, condense “There is another method that is gaining acceptance” to “Another method is gaining acceptance.”

In general, say what things are, not what they are *not*. If you mean that something is important, do not say that it is “not unimportant.” If you mean that it is substantial, do not say “not insubstantial.” Avoiding such double negatives makes writing more readable.

Many suggestions for making writing more readable also make it shorter. This brevity can especially help if you have a word limit or page limit, such as for a scientific paper or grant proposal.

Over the years, formulas have been devised to estimate the readability of documents. Microsoft Word can compute two such measures of readability, the Flesch Reading Ease score and the Flesch-Kincaid Grade Level score. (Doing so is an option under “When correcting spelling and grammar,” in “Proofing.”) Computing these scores, which are based on average number of words per sentence and average number of syllables per word, can help you estimate how readable your writing is (or how much progress you have made in making it more readable). These formulas, however, do not take into account all aspects of readability. Thus, they are imperfect measures. Indeed, a piece of writing could make no sense but still get an excellent readability score if it consisted of short words in short sentences.

CONSISTENCY IN WORDING

For clarity in scientific writing, keep using the same word for the same thing. Do not feel compelled to vary your vocabulary, as you might in a literary piece, to make your writing more interesting. Readers should be able to focus on the content. They should not need to wonder whether “the mice,” “the animals,” and “the rodents” are the same creatures, or whether “the conference,” “the convention,” and “the meeting” are the same event. Using consistent wording can help make your writing clear and cohesive.

Some words, however—those that are so vivid or unusual that they tend to be remembered—should not be used repeatedly in close succession. In this regard, one can think of “blue jeans words” and “purple plaid trousers words,” in keeping with this analogy presented to American graduate students:

If you wore blue jeans to the laboratory every day, probably no one would notice that fact. Similarly, if you repeatedly used words such as “experiment,” “molecule,” “increase,” and “journal,” probably no one would notice. However, if you wore purple plaid trousers to the laboratory today, people probably would notice if you also did so next week. Similarly, if you used the word “astonishing,” “armamentarium,” “compendium,” or “conundrum” in one paragraph, people probably would notice if you also did so in the next.

Stay mainly with blue jeans words, and feel free to use them repeatedly. Use purple plaid trousers words rarely, if at all.

SERVING INTERNATIONAL READERS

Consistent wording can especially help make your reading clear to readers whose native language is not English. Here are some other things you can do to help serve this readership: Use words that have one meaning or a few meanings, not many, and largely avoid idioms. (For example, in revising material for this book, “a good deal easier” was changed to “much easier”; “watch your similes and metaphors” was changed to “largely avoid similes and metaphors”; “do not bear repeated use” was changed to “should not be used repeatedly”; and “there is no bar” was changed to “there is no barrier.”) Use mainly simple verb forms, and write sentences that are simply structured and not extremely long. Retain optional words that can clarify the structure of a sentence. For instance, write, “I believe that Professor Day knows much about grammar,” not “I believe Professor Day knows much about grammar,” the first part of which might be misread as meaning that you believe Professor Day. Avoid literary and cultural allusions, including sports references, that might be unfamiliar to people in other cultures.

Additional guidance appears in *The Elements of International English Style* (Weiss 2005). Although geared more to the business and technology communities than to scientists, this book can aid in doing scientific writing that is clear to readers regardless of native language. It also can aid in communicating through letters and email to international colleagues.

A FEW WORDS ON EMAIL STYLE

If you are in the sciences, much of your writing may be in email. Although email is rarely published, a little attention to crafting it can help it serve you better.

Begin with a meaningful subject line. And if you want the recipient to take some action, make that fact clear early on. Do not bury such a requirement at the end of a lengthy email message.

Then, for readability, keep the paragraphs fairly short and skip space between them. Indeed, if you want your message to be read, make it relatively brief. Lengthy discourses often are better provided as attachments.

If you are sending email to a large group, spare readers the list of addresses by using the Bcc feature. And speaking of groups: In responding to messages sent to email discussion groups, beware of inadvertently replying to the whole group when you mean to address only the sender. The other members of the group probably do not care about your family vacation.

Beware of trying to convey humor by email: What may appear funny in person with vocal inflections or gestures may come across as hostile or otherwise offensive. You have better things to do than explain that you were really trying to be amusing.

If something in an email message annoys you, take time to cool down. Do not fire off an angry reply in haste. And angry or otherwise, do not say anything that you would not want forwarded. Remember that, other than in secure contexts, email is not private. As one colleague put it: If you would not write it on a postcard, do not put it in email. Clearly, email is not the medium for complaining about your graduate advisor or department head.

Although email tends to be casual, suit the level of formality to the context. When sending email to potential employers, for example, word it carefully, check it for grammatical errors, and proofread it thoroughly. If you have been using a humorous email address, consider having a more formal one for professional communications.

And finally, include a concise, informative signature block in your professional email. In the signature block, provide at least your name, title, and affiliation. If customary in your field or at your institution, perhaps also include a courtesy title (such as “Dr.”) or list advanced degrees. Other items to consider providing in a signature block include your phone number, social media links, and URL. Consider having different signature blocks to use in different circumstances or modifying your signature block to suit the situation. In any case, keep your signature block relatively short. Remember that this is your signature block, not your curriculum vitae.

WRITING FOR ONLINE READING

The scientific papers you publish are likely to appear online. In addition, many of us in the sciences prepare material intended specifically for reading on the web. In preparing such items, consider the following pointers (Gahran 2000, 2001):

- Keep the material short, or break it into fairly self-sufficient chunks of 500 words or less.
- Consider starting with a synopsis to orient readers.
- Break long paragraphs into two or more paragraphs.
- Use clear headings to help readers find what they are seeking.
- Word links clearly and concisely.
- Consider highlighting key words.
- For readability, use bulleted (or numbered) lists instead of lists within paragraphs.

If you have a *blog*—which is short, by the way, for *weblog*—also consider the following advice. In general, keep each post relatively short. Give each post a title that is brief and informative; if feasible, make the title lively. Write in a consistent style. (An informal, conversational style generally suits blogs well. However, still be careful about spelling and grammar, and remember to proof-read.) Provide posts at relatively regular intervals. Consult *Science Blogging: The Essential Guide* (Wilcox, Brookshire, and Goldman 2016), especially for advice on types and contexts of science blogging.

What about writing professionally related posts for social media such as Facebook, Twitter, and LinkedIn? Of course, be concise. Begin engagingly (but not misleadingly), and put key content first. Include visuals to capture attention and to clarify. Be a good community member by sharing resources and commenting positively and constructively on others' posts, rather than just by attracting attention to yourself. Also, remember that posts can last and can reach more than their intended audience; therefore, if something might haunt you in the future, beware of posting it.

Because material posted on the web is accessible worldwide, writing in an internationally understandable way can be especially important. Therefore, keep sentences relatively short and direct, avoid regional idioms, and remember to define terms that might be unfamiliar to readers in other parts of the world (Outing 2001). By following such advice, you can make your material on the web truly a worldwide resource.

CHAPTER 34

How to Write Science in English as a Foreign Language

ESL authors [authors for whom English is a second language] can be more precise about language just because it is their second language.

—Mary Boylan

ENGLISH AS THE INTERNATIONAL LANGUAGE OF SCIENCE

English is currently the international language of science. By no means does this demand that every scientific paper be written in English. Papers on findings mainly of local, national, or regional interest (for instance, in agricultural science, social science, or medicine) generally are best published in the language of those likely to use the content. However, when findings should be accessible to fellow scientists throughout the world, papers generally should appear in English.

For huge numbers of scientists, both in predominantly English-speaking countries and elsewhere, English is a second (or third, fourth, or fifth) language. In addition to facing the usual challenges of writing and publishing a scientific paper, these scientists face the challenges of writing in a foreign language and, often, interacting with editors from another culture. Yet many scientists from around the world have successfully met these challenges. This chapter, which is primarily for readers who are nonnative speakers of English, is intended to aid in doing so. The chapter also may be useful to native-English-speaking scientists who want to work as effectively as possible with colleagues or students for whom English is not their native language.

THE ESSENTIALS: CONTENT, ORGANIZATION, AND CLARITY

Editors of good English-language journals want to publish the best science in the world, and many are eager to include work from a wide range of countries. Therefore, they often are willing to devote extra effort to publishing papers by nonnative speakers of English (Iverson 2002). For example, they sometimes supplement peer reviewers' comments with detailed guidance of their own, and they sometimes allot extra staff time to copy-editing papers that have good content but problems in English-language expression.

Thus, for nonnative as well as native-English-speaking scientists, the editor and the author are allies. Do not be intimidated if you are a nonnative speaker of English. If your research is of high quality and wide interest, editors of good English-language journals will want to publish it. Of course, you will have to do your part.

Your part consists mainly of submitting an informative, well-organized, clearly written paper. Some nonnative speakers worry that their English seems unpolished or clumsy. In fact, some focus so much on making the English beautiful that they neglect more basic aspects. Although good English is certainly desirable, you need not agonize over fine points of style. If your paper is informative, well organized, and clear, the editor and peer reviewers can soundly evaluate your research. And then if your paper is accepted, a copy editor at the journal can readily correct occasional problems with grammar or other aspects of expression.

However, if important information is missing, if a paper is poorly organized, or if wording is unclear, the editor and peer reviewers might not be able to understand the paper well enough to evaluate the research. Even if they wish to publish the research, much difficult work may be needed to make the paper publishable. If the journal lacks the resources for this extra work, it might not be able to publish the paper. Even if it has such resources, such major difficulties may delay the paper's publication.

A copy editor at the journal may *query* you (ask you questions) if items in your paper are unclear or if the copy editor is uncertain whether proposed changes would retain your intended meaning. Reply to queries promptly. If you do not understand a query, ask for clarification. Also, do not assume that copy editors are right because they are experts in English. They might have misunderstood you, and you are responsible for ensuring that your published paper is accurate.

CULTURAL DIFFERENCES TO CONSIDER

Cultures differ in a variety of norms relating to communication. Awareness of such differences can aid in writing and publishing your paper.

When manuscripts arrive from nonnative speakers of English, issues sometimes arise about the level of detail included. For example, in manuscripts by authors from some countries, the materials and methods section tends not to be as informative as the journal requires. Cultures differ in how much information people supply, both in everyday conversation and in professional communications. Notice the level of detail, as well as the types of details, in papers published in the journal to which you will submit your paper. Then write your paper accordingly.

Directness of expression also differs among cultures. In some cultures, expression tends to be indirect; the speaker or writer circles around the main point before eventually stating it—or maybe just implies the main point. In many Western cultures, however, and in leading international journals, expression tends to be direct, with the writer stating the main point and then providing details. In a typical paragraph in such a journal, a sentence at the beginning, known as the *topic sentence*, states the main point, and the other sentences in the paragraph then support that point or present related information. Before writing a paper for an English-language international journal, see how paragraphs in the journal tend to be structured. Then try to use that structure.

Cultures also differ in their attitudes toward time. Some cultures greatly value speed and promptness, whereas others favor an unhurried pace. Prominent international journals typically embody the former attitude. Therefore, reply quickly to inquiries from the journal, and take care to meet the deadlines that the journal sets—for example, for revising a manuscript. If you cannot meet a deadline, inform the editor as soon as possible, so the journal can plan accordingly.

Of concern to many editors is the fact that cultures also differ in their attitudes toward using material taken word-for-word from other people's writing. In English-language scientific papers for international journals, authors are required to use their own wording for the vast majority of what they say and to clearly designate any wording taken from elsewhere. Thus, although authors may look at published papers to find words or phrases to use, they are not allowed to include entire passages from published work unless the passages are put in quotation marks (or, if long, indented) and the sources cited. Otherwise, the author is considered guilty of *plagiarism*. A tutorial helpful in learning to recognize and avoid plagiarism appears at plagiarism.iu.edu.

As noted in Chapter 5, steps for avoiding inadvertent plagiarism include clearly indicating in your notes the source of any material from others' work

that you copy or download. If you inadvertently include in your paper a sentence or paragraph from elsewhere, a reviewer or copy editor might notice the difference in style and, to your embarrassment, ask whether the wording is your own. Woe to you if the passage happens to be by one of the peer reviewers!

SOME COMMON LANGUAGE CHALLENGES

In writing scientific papers, nonnative speakers of English often face challenges relating to particular aspects of the English language—especially verb tenses, prepositions, and articles. With care, authors can minimize errors in these regards. Then, if the manuscript is clearly written, a copy editor at the journal can correct remaining errors.

Verb tenses, which differ among languages, often pose difficulty. As discussed in Chapter 30, the methods and results sections of a scientific paper should normally be written entirely, or almost entirely, in the past tense. The introduction and discussion typically include a variety of tenses, depending on whether, for example, previously established knowledge is being presented (present tense) or the research reported in the present paper is being summarized (past tense). As well as following the general advice in this book, look at the use of verb tenses in the journal to which you are submitting your manuscript.

Deciding which preposition to use can be difficult, even sometimes for native speakers of English. Keeping a list of prepositional phrases commonly used in your field can help. So can consulting textbooks and websites intended to guide nonnative speakers of English.

Likewise, proper use of articles (*a*, *an*, and *the*) can be very difficult, especially for writers whose native languages do not contain articles. Here, too, it can help to consult textbooks and websites for users of English as a foreign language and to use published papers as examples. Other sources of guidance on various aspects of English include the book *Scientific English* (Day and Sakaduski 2011).

Other often-challenging aspects of English include plurals, mass nouns, capitalization, and sentence length and structure. Some authors from native languages without plural forms tend to forget to add an *s* to make English nouns plural. And some nonnative speakers tend mistakenly to add an *s* to mass nouns (such as *information* and *research*). Native users of languages that do not have capital letters, or that follow different capitalization rules from those for English, sometimes neglect to capitalize English words when needed or capitalize excessively. Authors whose native languages tend to have very long sentences sometimes write sentences that should be several sentences in English. And sometimes nonnative speakers use English words but retain the sentence

structure of their native language, with awkward results. (A peer reviewer told an international colleague of ours that her sentences resembled those of the character Yoda!) If any of these aspects of English tend to pose difficulty for you, perhaps pay special attention to them when you revise your writing.

Native writers of some languages tend to have difficulty with spacing in English-language text. For example, sometimes they neglect to skip a space after the period at the end of a sentence, or they insert a space between an opening parenthesis and the word that follows, or they make many spacing errors in bibliographic references. If you tend to have this difficulty, check your manuscript carefully for proper spacing.

MORE STRATEGIES FOR ENGLISH-LANGUAGE WRITING

While teaching scientific writing overseas, an American instructor noticed that papers by one scientist in the class seemed almost as if they had been written by a native speaker of English. When the instructor commented on this fact, the scientist described his strategy: He carefully read several papers on his research topic in leading English-language journals and then, for each section (introduction, methods, etc.), listed words and phrases commonly used; when writing his papers, he consulted these lists. This strategy also can aid other nonnative speakers of English. Likewise, keeping and consulting a list of revisions that copy editors or others have made in one's writing can help in polishing one's English.

Write simply overall. Do not try to impress readers with vocabulary words you have learned for the Test of English as a Foreign Language (TOEFL). Do not try to display your ability to write long, complex sentences in English. Do not try to exhibit your mastery of passive voice. Remember that the goal of a scientific paper is to communicate the science, not to impress readers with your English level. Many readers of your paper may be nonnative speakers who know much less English than you do. Also, relatively simple writing makes a paper easier to understand even for native speakers of English, including editors and peer reviewers.

Draft your paper in English, if possible, rather than writing it in your native language and then translating it. Doing so can help your paper to read well in English. When you are drafting your paper, do not try to make the English perfect, as doing so can disrupt your flow of ideas. Rather, just try to express what you want to say. Then, once you have a draft, go back and, where necessary, improve the English.

If feasible, have someone with an especially strong command of English (and, ideally, knowledge of scientific writing and editing) review your paper before you submit it to a journal. (Indeed, if a paper seems to contain good

science but is written in poor English, a journal may return the manuscript and suggest that it be edited by someone expert in English and then resubmitted.) If possible, the person providing feedback on your writing should be familiar with your field of science. Otherwise, although they may correct grammar problems and other mechanical errors, the person might not detect errors in scientific expression—and might inadvertently introduce errors (such as when one editor repeatedly changed the technical term *contracture* to *contraction*). Possible reviewers include colleagues at your institution or elsewhere who write well in English, professional editors at your institution, and teachers of scientific writing. Some professional English-language scientific-editing services exist. You also may be able to identify suitable editors through organizations such as the Council of Science Editors (www.CouncilScienceEditors.org), the European Association of Science Editors (www.ease.org.uk), and the Board of Editors in the Life Sciences (www.bels.org).

MORE RESOURCES

Many online resources can help nonnative speakers write in English about science. One example is Academic Phrasebank (www.phrasebank.manchester.ac.uk), which lists phrases useful in various parts of a scientific paper. Another is Grammar Girl (www.quickanddirtytips.com/grammar-girl), which provides advice on grammar, punctuation, word choice, and related topics. Websites for users of English as a foreign language—for example, UsingEnglish.com (www.usingenglish.com)—also can be helpful.

You can find many resources through the website of AuthorAID (www.authoraid.info/en/ and www.authoraid.info/es/), a project mainly to help researchers in low- and middle-income countries write about and publish their work. The resource library at this site includes links to many online resources. It also includes Microsoft PowerPoint presentations, articles, and other materials on scientific writing and related subjects. In addition, the AuthorAID site contains a blog on communicating research, and AuthorAID provides free online courses. Through the site, you can also seek a mentor to advise you in your writing and related work. Although primarily for researchers in less affluent countries, AuthorAID resources can also help researchers elsewhere with their writing. As a scientist from Japan said, “When it comes to scientific writing, every country is a developing country.”

A goal of AuthorAID, like that of this book, is to increase researchers' knowledge, skill, and confidence regarding scientific writing and publication. If English is not your native language, do not feel discouraged. And when your paper is accepted by an international journal, consider celebrating twice: once in your native language and once in English.

PART VIII

Other Topics in Scientific Communication

CHAPTER 35

How to Write a Thesis

The average PhD thesis is nothing but a transference of bones from one graveyard to another.

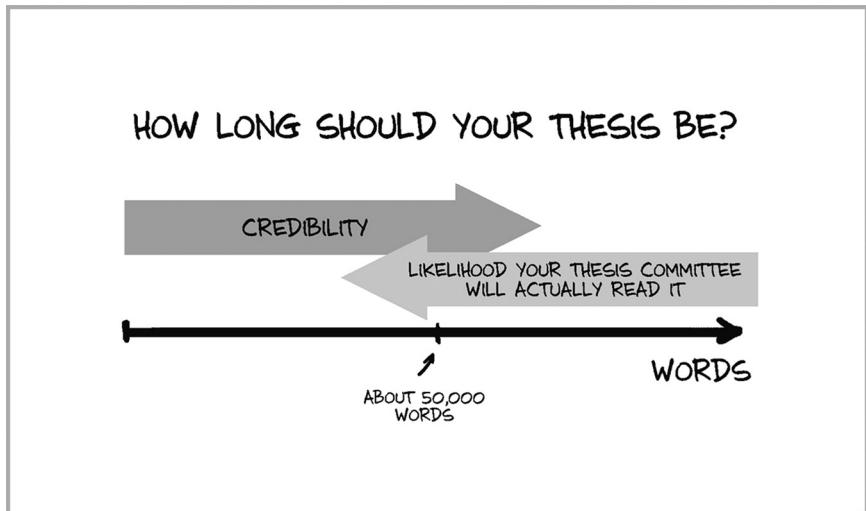
—J. Frank Dobie

PURPOSE OF THE THESIS

A PhD thesis in the sciences presents the candidate's original research. Its purpose is to prove that the candidate can do and communicate such research. Therefore, a thesis should exhibit the same type of disciplined writing that is required in a journal publication. Unlike a scientific paper, a thesis may address more than one topic, and it may present more than one approach to some topics. The thesis may present all or most of the data obtained in the student's thesis-related research. Therefore, the thesis usually is longer and more involved than a scientific paper. But the concept that a thesis must be a bulky, 200-page tome is wrong—dead wrong. Many 200-page theses contain only 50 pages of good science. The other 150 pages comprise turgid descriptions of insignificant details.

We have seen many PhD theses, and we have assisted with the writing and organization of a good number of them. On the basis of this experience, we have concluded that there are almost no generally accepted rules for thesis preparation. Most types of scientific writing are highly structured. Thesis writing is not. The “right” way to write a thesis varies widely from institution to institution, and even from professor to professor within the same department.

Reid (1978) is one of many over the years who have suggested that the traditional thesis no longer serves a purpose. In Reid's words, “Requirements



(“Piled Higher and Deeper” by Jorge Cham. www.phdcomics.com)

that a candidate must produce an expansive traditional-style dissertation for a Ph.D. degree in the sciences must be abandoned. . . . The expansive traditional dissertation fosters the false impression that a typed record must be preserved of every table, graph, and successful or unsuccessful experimental procedure.” Indeed, in many settings, the core of a thesis now normally consists of scientific papers that the student has published.

If a thesis serves any real purpose, that purpose might be to determine literacy. Perhaps universities have always worried about what would happen to their image if a PhD degree turned out to have been awarded to an illiterate. Hence, the thesis requirement. Stated more positively, the candidate has been through a process of maturation, discipline, and scholarship. The “ticket out” is a satisfactory thesis.

It may be useful to mention that theses at European universities have tended to be taken much more seriously. They are designed to show that the candidate has reached maturity and can both do science and write about science. Such theses may be submitted after some years of work and a number of primary publications, with the thesis itself being a “review paper” that brings it all together.

By the way, sometimes the word *dissertation* is used instead of *thesis*. For example, at some U.S. universities, one speaks of a master’s thesis, but a doctoral dissertation. Whatever term one uses, the principles are much the same for preparing the less extensive master’s-level document and the more extensive doctoral one.

TIPS ON WRITING

Few rules exist for writing a thesis, except those that may prevail in your own institution. Check whether your institution has a thesis manual or other set of instructions. If it does, obtain it and follow it carefully. Otherwise, your graduation may be delayed because of failure to use the required thesis format. If you do not have rules to follow (or even if you do), go to your departmental library—or, increasingly, your institutional library's online collection of theses—and examine the theses submitted by previous graduates of the department, especially those who have gone on to fame and fortune. Perhaps you will be able to detect a common flavor. Whatever ploys worked in the past for others are likely to work for you now.

Theses typically consist of several chapters. Sometimes the chapters correspond to the parts of an IMRAD scientific paper: introduction, methods, results, and discussion. Or, if a thesis reports a number of studies, the central part may include a chapter about each study. As already noted, sometimes a thesis consists mainly of a set of published papers. In addition to chapters, common components of theses include a title page, acknowledgments, an abstract, a table of contents, a list of figures and tables, a list of abbreviations, and appendixes.

A thesis also should contain a substantial reference list, helping to demonstrate your familiarity with the literature in your field. In this regard, a thesis can resemble a review paper. Indeed, the introduction or a separate literature-review chapter generally should present a thorough review of previous work to which yours is related. Further, it is often desirable to go back into the history of your subject. You might thus compile a valuable review of the literature of your field, while at the same time learning something about the history of science, which could turn out to be a valuable part of your education.

Start with and work from carefully prepared outlines. Be careful about what goes in what section. If you have one or several results sections, the content must be your results, not a mixture of your results with those of others. If you need to present results of others, to show how they confirm or contrast with your own, you should do this within a discussion section. Otherwise, confusion may result, or, worse, you could be charged with lifting data from the published literature.

Give special attention to the introduction in your thesis for two reasons. First, for your own benefit, you need to clarify what problem you attacked, how and why you chose that problem, how you attacked it, and what you learned during your studies. The rest of the thesis should then flow easily and logically from the introduction. Second, first impressions are important, and you would not want to lose your readers in a cloud of obfuscation right at the outset.

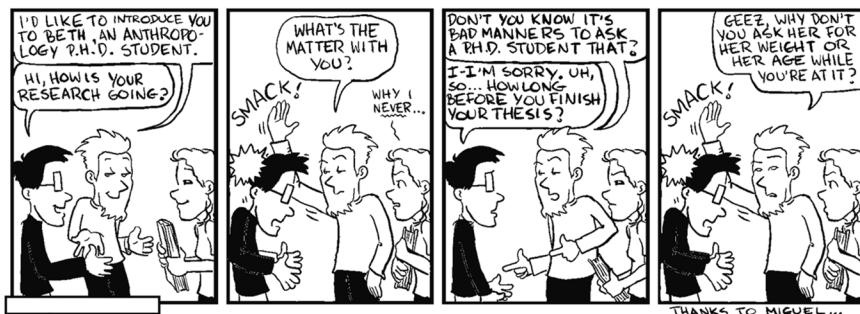
Writing a thesis is a good chance to develop your skill in scientific writing. If a committee of faculty members is supervising your thesis research, seek feedback on one or more drafts of your thesis from committee members, especially the committee chair. (If you can choose the committee members, try to include someone who writes very well and is willing to help others with writing.) Seek feedback early from the committee chair and others, to help prevent the need for extensive revisions at the end.

Universities keep copies of theses so that those interested can read them. Commonly, they require electronic copies for this purpose. Use of electronic rather than paper copies saves space in libraries, can make theses easier for readers to obtain, and can let you include materials, such as videos or animations, that are difficult or impossible to provide in a bound thesis. Be sure to find out how your institution requires you to submit your thesis and what the instructions are.

WHEN TO WRITE THE THESIS

You would be wise to begin writing your thesis long before it is due. In fact, when a particular set of experiments or some major facet of your work has been completed, you should write it up while it is still fresh in your mind. If you save everything until the end, you may find that you have forgotten important details. Worse, you may find that you lack time to do a proper writing job. If you have not done much writing before, you might be amazed at how time-consuming it can be. You are likely to need a total of at least three months to write the thesis, on a relatively full-time basis. You will not have full time, however, nor can you count on the ready availability of your thesis advisor. Allow at least 6 months.

As implied in the preceding paragraph, a thesis need not be written from beginning to end. Work on the literature review section generally should start



("Piled Higher and Deeper" by Jorge Cham. www.phdcomics.com)

early because your research should be based on previous research. Regardless of whether you do laboratory research or other investigation (such as field research or social-science surveys), you should draft descriptions of methods soon after methods are used, while memory is still complete. Often, the introduction is best drafted after the sections presenting and discussing the results, so the introduction can effectively prepare readers for what will follow.

Of course, ideas for any part of your thesis may occur to you at any time. Early in your research, consider establishing a physical or electronic file for each part of your thesis. Whenever ideas for the thesis occur to you, put the ideas in the appropriate file. Similarly, if you come across readings that might be relevant to a given section, include or mention them in the file. Such files help keep you from losing ideas and materials that could contribute to your thesis. They also give you content to consider using as you begin drafting each section.

Perhaps you noticed that we said “drafting,” not “writing.” Much to the surprise of some graduate students, a good thesis is likely to require multiple drafts. Some graduate students think that once the last word leaves the keyboard, the thesis is ready to turn in. However, as with journal articles, considerable revision commonly is needed for the thesis to achieve its potential. Indeed, using feedback from one’s graduate committee to strengthen the content, organization, and wording of one’s thesis can be an important part of one’s graduate education. Be prepared to need more time than expected to put your thesis in final form. Both in terms of the quality of the product and in terms of learning obtained that can aid in your future writing, the time is likely to be well spent.

RELATIONSHIP TO THE OUTSIDE WORLD

Remember that your thesis will bear only your name. Theses are normally copyrighted in the name of the author. The quality of your thesis and of any related publications in the primary literature probably will affect your early reputation and your job prospects. A tightly written, coherent thesis will get you off to a good start. An overblown encyclopedia of minutiae will do you no credit. The writers of good theses try hard to avoid the verbose, the tedious, and the trivial.

Be particularly careful in writing the abstract of your thesis. The abstracts of doctoral dissertations from many institutions appear in databases such as ProQuest Dissertations and Theses Global, thus being made available to the larger scientific community.

Writing a thesis is not a hurdle to overcome before starting your scientific career. Rather, it is a beginning step in your career and a foundation for your

later writing. Prepare your thesis carefully, and use the experience as a chance to refine your writing skills. The resulting document and abilities will then serve you well.

FROM THESIS TO PUBLICATION

People sometimes speak of “publishing a thesis.” However, theses themselves are rarely, if ever, publishable. One reason is that theses commonly are intended partly to show that the graduate student has amassed considerable knowledge, so they tend to contain much material that helps demonstrate scholarship but would not interest readers. Extracting one or more publications from a thesis generally entails considerable trimming and condensation. More specifically, writing one or more scientific papers based on a thesis requires determining what in a thesis is new and of interest to others and then presenting it in the appropriate format and at an appropriate level of detail. In fields in which books present new scholarship, converting a dissertation to a book (Germano 2013) often includes decreasing the manuscript to a marketable length, dividing it into more chapters, using fewer quotations and examples, and otherwise making the manuscript more readable, cohesive, and engaging.

When you finish your thesis, promptly prepare and submit any manuscripts based on it, if you have not yet done so. Do so even if you are tired of your thesis topic—and tired from writing and defending the thesis. The longer you wait, the harder it is to return to your thesis and prepare a suitable manuscript based on it. And importantly, having one or more thesis-based writings published or in press can help catapult you into the next stage of your career.

CHAPTER 36

How to Prepare a Curriculum Vitae, Cover Letter, and Personal Statement

My one regret in life is that I am not someone else.

—Woody Allen

WHAT'S A CURRICULUM VITAE? WHAT'S IT GOOD FOR?

Whereas those in business write résumés, we in the sciences generally prepare curricula vitae (CVs). Both a résumé and a CV present key facts about one's professional background. However, the two differ somewhat in content and structure.

Literally, *curriculum vitae* means the course of one's life. A CV shows the course of your professional life. Figure 36.1 shows a CV of a fictional graduate student. Although the facts of this person's life are imaginary, the kinds of information provided are fairly typical: address and other contact information, education, honors, research, teaching, publications, and other professionally relevant experience.

A CV has many uses. You may be required to provide one with your thesis. Supplying one is standard when you apply for a job. Grant applications commonly include CVs. You will need to submit one if you are being considered for tenure, and you might need to provide one for your annual review. If you are nominated for an award, you may be asked to submit a CV to the selection committee. You should not, however, offer your CV when asking someone out on a date (as one socially awkward young scientist did).

If you are seeking a position in industry, you may be asked for a résumé rather than a CV. Early in one's career, a CV and a résumé may be almost the same. However, a résumé commonly states an objective at the beginning. Also, duties generally are listed for jobs held. Whereas a CV can run several pages or

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Education

XYZ University, PhD, Molecular ABCology
WXY University, MS, ABCology
JKL College, BS, ABCology, magna cum laude

Expected May 2023
August 2019
May 2017

Honors and Awards

Best Student Poster, ABCology Society Annual Meeting
Regents Fellowship, XYZ University
Outstanding Teaching Assistant Award, WXY University
Alumni Memorial Scholarship, JKL College

October 2021
2019 to present
2019
2013–2017

Research

Molecular ABCology of DEF	2021–present
Laboratory of Sally Scientist	
XYZ University	
ABCological Characteristics of GHI	2018–2019
Laboratory of Rahm J. Researcher	
WXY University	
Effect of D on E	June–August 2016
Annual Summer Undergraduate Research Program	
National Institute of ABCology. Washington, DC	

Teaching Experience

Instructor, Survey of ABCology, XYZ University	Fall 2021
Teaching Assistant, Basic ABCology, WXY University	2018–2019
Tutor (ABCology, calculus), JKL College Learning Center	2015–2017

Selected Extracurricular Activities

Graduate Student Association, XYZ University (co-organizer, Student Research Week, 2022)	2019–present
JKList (student research journal, JKL College) (editor-in-chief, 2016–2017)	2013–2017

Publications

Smith JP, **Zhang J**, Scientist S. Inhibition of DEF by GHI. *Mol ABCol.* (in press)
Zhang J, Researcher RJ. ABC chromatography of GHI. *ABCology*. 2020;27:463–467.
doi: xxx.yyy.zzz
Zhang J. ABCology: historical highlights and current trends. *JKList*. 2016;5:79–81.

Figure 36.1. Sample CV.

more, a résumé normally is limited to one or two pages, thus sometimes requiring that information be condensed. Many websites, books, and university career centers offer guidance on résumé preparation and provide sample résumés. If you need to prepare a résumé, consider using such resources.

WHAT TO PUT IN (AND WHAT TO LEAVE OUT)

Sometimes you may be told what types of information to include in a CV, what format to use, or both. For example, some colleges have detailed instructions for faculty CVs. Likewise, some funding agencies specify what to include in a CV in a grant application. Typical content and structure of CVs can differ among scientific fields and among institutions. Thus, it can be useful to look at others' CVs and have others review a draft of yours. For ideas of what to include in your CV and how to present it, consider looking online at the CVs of members of your department or of scientists elsewhere who are leaders in your field.

Of course, list your publications in your CV. Also list major presentations, such as papers given at national conferences. List as well the grants that you have received. In listing your publications, use a standard format for references (see Chapter 15), such as the one employed by a leading journal in your field; in the author list, consider putting your name in boldface for clear identification. In some contexts, such as when a person is being considered for tenure, it can also be appropriate to list the numbers of citations that papers have received. If a paper has been accepted but not yet posted or published, list it as "in press" or "forthcoming." If it has been submitted but not yet accepted, or if it is still being prepared, do not list it under "Publications." You may, however, mention it in the "Research" section of your CV.

Your CV should focus on your professional history. Normally, it should not include personal information such as date of birth, marital status, health, or hobbies. Do not list your Social Security number or other personal identification numbers, especially given the possibility of identity theft.

Of course, do not exaggerate your accomplishments. In addition to being dishonest, doing so can harm your career if any discrepancy is discovered. If there is nothing to list in a given category, omit that category. Do not be like the student who included the heading "Honors" in her CV and then wrote under it, "None."

OTHER SUGGESTIONS

CVs commonly are structured in reverse chronological order. In other words, within each category, items are listed from the most recent to the least. Some CVs, however, use chronological order. Whichever order is used, be consistent.

Do you use a nickname instead of your given name? If so, you may put it in parentheses. Ditto if you go by an English-language name in addition to the name in your native language. If readers might not know how to address you, consider including your preferred courtesy title, such as “Ms.” or “Mr.” Of course, if you have a doctorate and people read the education section of your CV, they should know to address you as “Dr.”

Include some contact information that is likely to be long-lasting in case recipients wish to be in touch with you much later. For example, if you are a student, some of your contact information might well change. Therefore, consider listing items such as an email address and mobile phone number that are expected to stay the same.

If the nature of something listed might not be clear from its title, include a brief explanation in parentheses. You might say “Huth Award (for excellence in scientific writing)” or “Johnson Club (astronomy interest group).”

Consider having different versions of your CV for different uses. If you are seeking jobs at both research laboratories and teaching institutions, one version may focus mainly on your research experience and another may also list your teaching experience in detail. Even if the same information is included, it may appear in different orders in different versions of your CV.

Keep your CV up to date, so it is ready when needed. And, of course, proofread it carefully.

PREPARING A COVER LETTER

If you are applying for a job, you probably will need to accompany your CV with a cover letter. This letter provides further opportunity to introduce yourself, and it can help demonstrate your communication skills. Commonly, such a letter runs a single page. Rarely should it exceed two pages.

If possible, address the recipient of the letter by name. Be sure to spell the name properly. If you are unsure what courtesy title to use before the recipient’s surname, try to find out (for example, by checking online whether the person has a doctorate), so you can address the person appropriately. If this information is unavailable, address the person by full name (for example, “Dear Kelly Jones”) rather than using a courtesy title (as in “Dear Mr. Jones”). If the name of the recipient is not available, you may use “To Whom It May Concern” or, if applicable, a more specific salutation such as “Dear Selection Committee.” Do not use “Dear Sir” unless you are sure the recipient is male. In a formal letter, normally a colon rather than a comma follows the salutation.

At the beginning of the letter, make clear what you are applying for. Do not use general wording such as “the opening in your department,” lest your application end up with those for the wrong position. Also, consider including

in the opening sentence your main qualifications. For example, you might say, “As a recent recipient of a Ph.D. in molecular ABCology from XYZ University, I am applying for the postdoctoral position in DEF research that was announced in *Science* last week.”

In the middle of the cover letter, discuss your qualifications. You may introduce them by referring to your CV (“As noted in the accompanying curriculum vitae . . .”). Show how your qualifications match those requested in the position description. Doing so can provide a chance to elaborate on items listed in your CV. For example, you may summarize research you have done or identify techniques with which you are adept, or you may specify duties you had as a teaching assistant.

Do not discuss salary in your cover letter. Any such discussion should come later, once the employer expresses a desire to offer you a position.

End the letter positively, but not overconfidently. Avoid overly assertive statements such as “Thus, I am the ideal candidate for the assistant professorship in molecular ABCology. I look forward to receiving an interview.” An example of more appropriate wording: “Thus, I believe that my background qualifies me well for the assistant professorship in ABCology. I hope to hear from you soon about the possibility of an interview.”

WRITING A PERSONAL STATEMENT

Applications for some opportunities require personal statements. For example, you may need to write a personal statement if you are applying to professional school or seeking some types of fellowships.

A *personal statement* is a brief essay that describes your professional development as it relates to the opportunity being sought. Often, it is best structured mainly in chronological order. You may begin with a paragraph providing a brief overview, then summarize how your interests have developed thus far, describe your main current activities, and finally discuss directions that you anticipate taking. If feasible, show that your decision to seek the opportunity is well informed (for example, by discussing related experience).

If you have a nontraditional background—for instance, if you pursued a different career before—or if you experienced a delay during your education, you generally should address the matter in your personal statement. Do not leave readers wondering why, for example, the dates in your CV do not seem to add up. If you discuss problems you have overcome, do so positively and without defensiveness, and show that you addressed the problems maturely and thoughtfully.

Be confident, but not arrogant. In keeping with principles of good writing, show rather than tell. For example, to show that you have leadership abilities,

you could state that you have held several leadership roles, note the main such roles, and mention a leadership award that you received. Do not emulate the medical-residency applicant who wrote, “First, I have a great bedside manner. . . . Second, I have excellent technical skills. . . . Third, and most important, I have a humble spirit.”

In a personal statement, generally avoid or minimize discussion of aspects of your background that are not professionally related. In particular, do not discuss your political or religious views. Not only may doing so alienate readers whose views differ from yours; even if readers agree with your views, you may seem unprofessional or unfocused.

Finally, word your personal statement readably, in keeping with advice in this book. Those who review applications containing personal statements tend to be busy. Help them to understand quickly where you are coming from, where you are now, and where you are going. You will then be more likely to receive their support in obtaining the opportunity you seek.

CHAPTER 37

How to Prepare Grant Proposals and Progress Reports

The successful grant writer, to a large extent, lives by selling his ideas: a successful grant [proposal] is a marketing document.

—Janet S. Rasey

PREPARING A GRANT PROPOSAL

Scientific research costs money. Typically, the needed money comes as grants from government agencies, private foundations, or other sources. Thus, to survive professionally, most scientists must apply successfully for grants.

The purpose of a grant proposal, sometimes called a *grant application*, is to persuade a funding source to fund a project. To do so, it must persuade those making the decisions that

- the goal of the proposed research is worthwhile,
- the goal is relevant to the funding body's mission,
- the proposed research approach is sound,
- the staff is capable of doing the proposed work,
- adequate facilities will be available, and
- the requested amount of funding is reasonable.

Considerable competition exists for research funds, and careful preparation of a grant proposal can make the difference between being funded and not. As when writing a scientific paper, keys to success include using good models, following instructions carefully, and revising, revising, revising.

Identifying Potential Sources of Funding

How can you identify sources of funding that might be suitable for your work? During your research training, you probably became aware of major funding sources in your field. Indeed, if you were part of an active research group, your research supervisor might have spent considerable time writing grant proposals.

Your mentor may remain a good source of advice on finding funding sources. Colleagues and administrators also may be helpful. At many institutions, grant offices and research offices publicize opportunities to apply for funding. Published or posted requests for proposals, as well as published or posted guides to funding opportunities, also can help. Email lists in your field or at your institution may include announcements of chances to seek funding, and internet searching sometimes discloses further possibilities. Also, when you read scientific papers on work related to yours, notice the funding source, which may be specified in the acknowledgments section or in a note near the beginning or end of the paper. Doing so may disclose funding sources that you had not thought of pursuing.

As you identify potential sources of funding, start noticing their requirements for grant proposals. For example, when are the application deadlines? How does one access the instructions for applying? Can one proceed directly to submitting a grant proposal, or must one first submit preliminary information on what one wishes to propose? Has the funding source posted proposals that can be used as examples?

Preliminary Letters and Proposals

Some funding sources require prospective grant applicants to begin by submitting preliminary information. Sometimes all that is required is a *letter of intent*, saying that one plans to respond to a given request for proposals and briefly describing the research that will be proposed. The funding source can then use this information to plan its work—for example, by starting to recruit peer reviewers with appropriate expertise to review your proposal once it arrives.

In other cases, prospective grant applicants must submit a *preliminary proposal*, sometimes also known by other names, such as *letter of inquiry* or *preproposal*. A preliminary proposal is essentially a short version of the proposal that one hopes to submit. On the basis of the preliminary proposals, the funding source, often with guidance from peer reviewers, decides which applicants can submit full proposals. Feedback about preliminary proposals can help applicants develop their full proposals and prepare future preliminary

proposals. Requiring preliminary proposals can save funding agencies the work of reviewing full proposals for research that it is very unlikely to fund, and it can give them the opportunity to help shape research. It also can save scientists the work of preparing extensive proposals for research that the source is very unlikely to fund.

Preparing a preliminary proposal entails careful work. Much of the same rigorous thinking is required as for a full proposal. And writing concisely, so that the preliminary proposal is informative despite being brief, can pose special challenges. (For guidance on communicating concisely, see Part VII of this book.) Because the opportunity to submit a full proposal is at stake, time spent writing and refining a preliminary proposal can be a valuable investment.

Common Parts of a Proposal

If your preliminary proposal is accepted, or if you will apply directly for a grant, determine the appropriate size and structure of the proposal. The instructions are likely to provide at least some guidance in this regard. Some aspects, however, may be left to your own judgment.

Proposals range greatly in length, depending on the requirements of the funding source. Proposals for small internal grants at universities sometimes are limited to one page. Major proposals can run many pages.

Regardless of length, a good proposal generally includes background information relating to the proposed endeavor, a statement of goals, a research plan (or a program plan, in the case of an education or service project), a budget, and information about the qualifications of those who are to do the work, such as curricula vitae (CVs). If a proposal runs several pages or more, it may well include a title page and an abstract.

Especially if a proposal is lengthy, other items may be required or advisable. These may include a letter of transmittal (analogous to the cover letter accompanying the manuscript for a scientific paper), a table of contents, a list of tables, a list of figures, a description of the predicted impact of the project, a plan for disseminating the results, and information on facilities that are available. A substantial research proposal generally cites references and includes a reference list.

Some proposals include appendixes for reviewers to consult if they want further information. Items that appendixes sometimes contain include scientific papers that have been accepted but not yet published, letters of support from prospective collaborators, and additional details about activities planned. Authors of grant proposals should keep in mind that reviewers typically are not obligated to look at appendixes. Thus, all key information should appear in the main body of the proposal.

Preparing to Write the Proposal

Only if a proposal matches the priorities of a funding source is it likely to be funded. Therefore, before writing, make sure the proposed work falls within the scope of what the source supports. Look carefully at written materials from the source in this regard. Also, feel free to consult staff members at the funding source (sometimes known as *program officers*) whose role includes advising prospective grant applicants. As well as saying whether a proposed project is likely to be considered seriously for funding, such individuals may be able to advise you on how to gear a proposal to help maximize chances of success. If one funding source seems to be a poor match, seek another.

In preparing grant proposals, as in other scientific writing, following good models saves time, avoids guesswork, and promotes success. If possible, look at one or more examples of successful proposals for the same category of grant from the same funding source. Colleagues who have received such grants may be willing to share copies of their proposals. Likewise, staff at the funding source may be able to provide examples. Other examples of well-prepared grant proposals, or of material therefrom, appear in books on grant application (for example, Gerin, Kinkade, and Page 2017) or more broadly on technical writing (for example, Penrose and Katz 2010). In addition, examples of successful grant proposals have been posted on the web (for example, at www.niaid.nih.gov/grants-contracts/sample-applications).

Writing the Proposal

Start working on the proposal long before the application deadline. For a lengthy proposal, at least six months beforehand can be advisable, particularly if others will collaborate in preparing it. Especially if you have little experience writing proposals or if written English is not among your strengths, consider obtaining help from a professional scientific writer or editor, either at your institution or on a freelance basis. For greatest effectiveness, such an individual should be involved early in the process; when handed a proposal the day before it is due, an editor generally can do little more than make superficial improvements.

Read all instructions carefully and follow them precisely. Be sure to provide all required information and strictly follow requirements regarding length and other formatting aspects. Realize, for example, that commonly a funding agency requires a biographical sketch in its own specialized format rather than accepting a regular CV; take the time to prepare or update your biosketch in keeping with current specifications. Proposals not complying with

instructions may be disqualified without review. So, before submitting the proposal, check the instructions again.

Match the technical level of the proposal to the background of the reviewers. Government agencies typically have scientists in the researcher's field evaluate the grant proposal; thus, a proposal to such a funding source should be fairly technical. At some private funding sources, however, boards containing interested laypeople evaluate proposals. In the latter case, the proposal may need to be no more technical than a science article in a popular magazine. If in doubt as to how much background reviewers will have and therefore how technical the proposal should be, consult the funding agency.

Whatever the background of the reviewers, the proposal should be readably written. Scientists of sufficient prominence to review proposals are among the busiest in their fields, and commonly they have many proposals to review; they lack time to puzzle over what a proposal means, and so those proposals that can be easily read and rapidly understood have an advantage. And of

DREAMS OF ACADEMIC GLORY



"Dear Professor Hummel:

Not only have we awarded you a grant, but we have decided that your beautifully written grant application is publishable as it stands."

(© Vivian S. Hixson, reproduced by permission)

course, readable writing aids comprehension by lay reviewers of proposals. For readability, organize the writing carefully; present overviews before details; use simple, common language where possible; avoid wordy phrases; make effective (but not excessive) use of devices such as headings, boldface, and italics; and otherwise follow guidelines for readability. If doing so would aid communication, and if it is permitted, include tables, graphs, or other visuals in the proposal. Of course, make sure that any such items are well prepared and suitably placed.

If a proposal is to include an abstract, devote particular care to it. An informative, well-organized, clearly worded abstract can be important for a number of reasons: Some funding sources choose reviewers for a proposal at least partly on the basis of the abstract; therefore, if an abstract is misleading or confusing, the proposal may be assigned to reviewers who are not the most suitable, and thus it might not receive the most valid review. Also, reviewers generally gain their first impression of a proposal by reading the abstract, so a poor abstract may bias the reviewers unfavorably. And reviewers commonly reread abstracts to refresh their memories before discussing proposals; at this stage too, a good abstract serves the applicant well.

Give the proposal a clear, concise title too. Doing so makes your focus apparent immediately, aids in capturing readers' attention, and helps create a good initial impression. Such a title also makes it easy for reviewers and others to refer to your proposal. In addition, drafting a succinct, unambiguous title can help prepare you to write a strong, focused proposal (Friedland and Folt 2009). Do not feel obligated, though, to retain the initial title. As you and others prepare and refine the grant proposal, the title too may benefit from revision. The main point: The title deserves careful attention. It should not be a near-afterthought, added the hour before the proposal is due.

For many proposals, the applicant must use forms from the funding source. These forms commonly can be accessed through the web. Often, the completed forms constituting proposals can—or must—be submitted electronically. Carefully follow the instructions for preparation and submission.

If part or all of the proposal will consist of freestanding text, format it readably. If the funding source specifies items such as typeface, type size, and margins, be sure to follow the instructions. If such items are not specified, you generally should use a standard typeface (for example, Times Roman), 10- to 12-point type, and margins of 1 inch (about 25 mm) or slightly more. Also, unless otherwise stated, the right margin should be unjustified (ragged) rather than justified (straight). Do not use tiny type or minuscule margins in order to fit more words on the allotted pages; rather than helping your case, doing so is likely to rile the reviewers and thus undermine it.

Common Reasons for Rejection

Experienced reviewers of grant proposals have noted common reasons for rejection, as have staff members at funding agencies. By knowing about and avoiding these problems, you can increase the likelihood that your proposal will be accepted.

A common reason for rejection—and presumably an easy one to avoid—is simply failure to follow the instructions for application. Poor writing or otherwise sloppy presentation also contributes to rejection. So does seeming unfamiliarity with relevant published work. Review the literature carefully, and cite it where appropriate; be sure all citations are accurate. Remember that scientists reviewing your proposal probably know the literature in your field thoroughly. Indeed, they may well have written items that you have cited or should cite.

Other reasons for rejection include lack of originality, a superficial or unfocused research plan, and lack of a valid scientific rationale. (Are one or more well-conceived hypotheses being tested, or is the proposed research just a “fishing expedition,” in hopes of finding something interesting?) Problems with the experimental approach—for instance, lack of suitable controls or failure to mention, if relevant, methods you plan to use if initial methods fail—also can lead to rejection. So can lack of experience with key methods (or failure to disclose such experience). And so can absence of enough experimental detail to persuade reviewers that the research is carefully planned. Looking at proposals accepted by the funding source can aid in determining how much detail to include and how technical the description of methods should be.

In many contexts, the word *ambitious* is a compliment—but not so, in general, for grant proposals. Proposing an unrealistically large amount of work can lead to rejection. Remember that experimental difficulties, unrelated interruptions, and other factors can slow a project. It is better to propose a somewhat modest endeavor that reviewers feel confident that you can complete than one that appears too ambitious.

Unrealistic budgeting also can contribute to rejection. Carefully determine the anticipated costs. If a budget is much too high, you may appear naive or greedy. You may likewise seem naive if the budget is much too low—and woe to you if the proposal is then approved and you are left to do the project with insufficient funds.

Other Problems to Watch For

Also, take care to avoid other common problems—some substantive, some editorial.

For some types of research, proposals typically contain preliminary data. Find out whether such data are expected and proceed accordingly.

Justify budgetary items sufficiently. Do not, for example, expect a funding source to cover the cost of a new computer or a trip to Hawaii unless you show why it is important to the proposed project. At many institutions, staff members who are experts on preparing grant budgets can provide assistance. Such an individual has published a chapter (Lewis 2008) giving researchers detailed guidance on grant-budget preparation; it includes a fictitious example of an extensive budget and budget justification.

If you are proposing a service project (for instance, in science education), include sufficient information on plans for evaluating it. Especially for such projects, consider including a timeline to show that you have carefully planned what is to be accomplished when.

Edit the proposal carefully. In doing so, be especially alert for inconsistencies, which can arise if, for example, you alter the research plan but neglect to revise the abstract accordingly. Also, be alert for confusingly extensive use of abbreviations. In general, use only or mainly those abbreviations that reviewers of the proposal should already know. If many abbreviations will be used, consider including a table of definitions for reviewers to consult.

Resubmitting a Proposal

If your proposal is not funded, do not become overly discouraged. Funding sources commonly receive proposals for many more projects than they can support. And some funding sources often accept revised versions of proposals that they rejected on first submission.

Funding sources commonly provide feedback on proposals that they review. Especially if the reviewers' feedback is favorable overall, try, try again, either by submitting a revised proposal to the same funding source or by seeking funding from another source. In preparing a revised proposal, as in revising a scientific paper for resubmission, make good use of suggestions from reviewers.

If you are submitting a revised proposal to the same funding source, you generally should accompany it with a list showing, point by point, how the reviewers' advice was followed. (Of course, check the instructions for resubmissions.) If the reviewers identified a problem and you decided to correct it in a way other than that suggested, say what you did and why. Also, if appropriate, indicate the changes typographically, such as by using the Track Changes feature of Microsoft Word. Seriously consider consulting the program officer responsible for the grant program to which you are applying. The program officer, who probably observed the peer review of your proposal, may have extra insights on how to strengthen your proposal and almost certainly knows

well the resubmission process. Therefore, this person may be able to guide you helpfully regarding both the content and the presentation of your revised proposal.

Keep trying, for writing successful grant proposals can require both skill and persistence. In the long run, the important thing is to obtain sufficient funding for your work. Along the way, preparation even of proposals that don't get funded can bring you knowledge, ideas, and contacts that will ultimately contribute to your work.

Two Closing Comments

Two final thoughts on preparing grant proposals:

First, a suggestion: As you prepare and refine your grant proposal, envision yourself writing scientific papers about the completed research. Will you have all the needed information? If not, revise your research plan.

Second, a comment on wording: People sometimes speak of "writing a grant." However, the grant is the money—not the proposal or application. When colleagues say they are writing grants, one is tempted to respond, "While you have your checkbook out, please write a grant for me."

WRITING A PROGRESS REPORT

Some funding sources for grants, and some other supporters or supervisors of work in science, require progress reports at given intervals during projects that they fund or oversee. These reports help readers determine whether the work is progressing adequately, and thus whether adjustments should be made in the plans, the funding level, or both. The prospect of preparing such reports can spur those doing the work to keep up. Writing such a report can aid in assessing one's own progress and, if advisable, adjusting one's approach. Also, such reports can be useful for drafting presentations and scientific papers.

Basic Structure

If the intended recipient of a progress report specifies a structure to use, of course use it; if forms (for example, regarding use of funds) are required, complete them as instructed. As when preparing a grant proposal, also follow any other instructions. If you have access to relevant examples of progress reports, consult them as models.



"OUR PROPOSAL DIDN'T GET THE GRANT, BUT THEY
WANT US TO TEACH PROPOSAL WRITING."

(ScienceCartoonsPlus.com)

Commonly, progress reports contain three main sections: background information, a description of current status, and conclusions. Typically, the background section mainly summarizes the project plan. The section on current status presents achievements thus far, compares progress made with that anticipated, and describes any important problems encountered. The conclusions section can provide an overall assessment and describe and justify proposed modifications of the original plan.

Some Suggestions

Before writing a progress report, review the proposal (or other written plan) for the work. In general, structure the progress report similarly to the proposal. For example, if the proposal included sections on three subprojects, include a section on each in the progress report and use the same headings as before.

Be specific in your report. For example, include relevant numbers, names, and dates. If appropriate, include tables and figures. To guide readers, consider using headings and other typographic devices.

Strive to sound positive, competent, and confident. However, do not hide problems. If you identify problems, say how they are being addressed.

If you write a series of progress reports on a project—for example, annual reports on work supported by a five-year grant—put each one in the same basic format. In addition to making the report easier to write, a consistent structure aids readers in comparing the content of successive reports. With a word-processing program, you can easily copy your previous report and update it to yield the current one. Remember, however, to make all needed changes.

Edit your progress report carefully. Double-check it for accuracy and ensure that it is complete, clear, and concise. Your report can then both document your progress and serve as continuing evidence of your professionalism.

CHAPTER 38

How to Write a Recommendation Letter—and How to Ask for One

That's the news from Lake Wobegon, where all the women are strong, all the men are good looking, and all the children are above average.

—Garrison Keillor

Even as graduate assistants, those in the sciences often are asked to write recommendation letters for undergraduate students. Later, scientists also receive requests for recommendation letters for graduate students, postdoctoral fellows, and peers. Writing recommendation letters can consume much time. However, with a well-organized approach, you can efficiently write good recommendation letters, thus serving qualified candidates well while conserving your time. Likewise, with a well-considered approach, you can considerately and effectively obtain recommendation letters when you need them for yourself.

DECIDING WHETHER TO WRITE THE LETTER

A request to write a recommendation letter is just that: a request. Thus, you can decline. If you cannot honestly provide a favorable assessment, or if you cannot complete the letter by the deadline, promptly decline the request so the requester can seek another recommender. When you cannot provide a favorable recommendation, a tactful statement such as “I think someone who knows you better could write a more convincing recommendation” may send the requester seeking a letter from someone else. If the requester persists, blunter wording may be needed.

If you know the requesters fairly well and think they may be seeking opportunities poorly suited to them, consider meeting to discuss the decision. The

requester may provide information that will change your mind and help you to write a more persuasive letter. Or you may find that the requester agrees with you but feels pressured to seek the opportunity. (“I’d rather do field research, but my family has always wanted me to become a physician” or “I thought I’d be letting you down if I didn’t seek the summer fellowship.”) With you as an ally, the requesters can then better pursue their best interests.

Requesters cannot reasonably expect you to write recommendation letters immediately. If you tend to receive many requests for recommendation letters, consider letting it be known how much notice you generally need.

If there are people for whom you would be especially pleased to write letters, tell them. Doing so can relieve them of needless stress and help ensure that well-qualified candidates receive strong recommendations.

GATHERING THE INFORMATION

In preparing a recommendation letter, as in writing a scientific paper, preliminaries include obtaining instructions, gathering materials, collecting data, and familiarizing yourself with examples.

As well as finding out when the recommendation is due and how to submit it, gather materials that are needed or would be useful. These may include a recommendation form to complete (if an electronic link to one has not been provided), a description of the opportunity or honor for which the candidate is being recommended, a résumé or curriculum vitae (CV) of the candidate, and examples of the candidate’s work. They may also include items from your files, such as grade lists from your courses and previous letters that you have written on the applicant’s behalf. If the candidate is to have filled out part of a recommendation form, check that that has been done completely.

Norms regarding content and length of recommendation letters can differ among fields and cultures. Therefore, if you have not seen recommendation letters of the type that you are to write, try to obtain some examples. Senior colleagues in your field may be able to show you some recommendation letters they have written or they may offer feedback on a draft. If you serve on selection committees, you may see many such letters and gain a sense of the norm.

WRITING LETTERS

Having a usual format to follow can facilitate writing recommendation letters, just as it can for preparing a scientific paper. Here is one format that often works well:

In the first paragraph, indicate who is being recommended for what. An example of such a paragraph, which often runs only one sentence, is the following: "I am very pleased to recommend [name of candidate], a senior at [name of university], for admission to the graduate program in [name of field] at [name of university]." Placing the candidate's name in boldface can help recipients quickly see who is being recommended and file the letter appropriately.

In the next paragraph, say how you know the candidate. An example: "I have known Ms. [surname of applicant] for more than a year. As a junior, she took my course [title of course]. She also has worked in my laboratory since June through our university's undergraduate research program."

Then, in the following paragraph or two, provide your assessment of the candidate. Try to be specific. For example, rather than saying only that a candidate is an excellent student, specify the student's achievements and perhaps rank the student relative to others. If applicable, note the candidate's academic or professional strengths and relevant personal traits. Of course, gear what you say to what the person is being recommended for.

In the final paragraph, sum up the recommendation. For example, you might write: "In sum, I consider Mr. [surname of applicant] an outstanding candidate for [name of opportunity]. I recommend him with enthusiasm." After a standard closing such as "Sincerely," "Sincerely yours," or "Yours truly," sign your name. Your name and your professional title, such as "Assistant Professor of [name of field]," should appear under your signature. Normally, the letter should appear on official letterhead.

Sometimes a candidate may request several recommendations, for instance for graduate school or jobs. To be efficient, try to prepare all, or several, of these recommendations at once. Although, for example, different graduate programs may have different recommendation forms to complete, preparing the recommendations as a batch generally saves time. When there are forms, you may have the option of either writing your comments on them or attaching letters. If you already are writing a recommendation letter for a candidate, or if you are completing multiple recommendations for them, the latter option tends to be faster.

Especially if you think the candidate may ask you later to provide additional recommendations, keep copies of completed recommendation forms and save copies of your recommendation letters. Preparing additional recommendations for this candidate should then be relatively quick and simple.

A LIGHT ASIDE

With regard to letters of recommendation, concern sometimes has existed that "the candidate may later exercise the legal right to read the letter, and perhaps even sue if the contents are not to his liking and are insufficiently substantiated" (Thornton 2003). To address this concern, a professor at Lehigh

University has devised a “Lexicon of Inconspicuously Ambiguous Recommendations, or LIAR” (Thornton 1987). An example: “To describe a candidate who is not particularly industrious: ‘In my opinion you will be very fortunate to get this person to work for you.’” Further examples along these lines appear in the book *L.I.A.R.: The Lexicon of Intentionally Ambiguous Recommendations* (Thornton 2003).

IF YOU'RE SEEKING RECOMMENDATION LETTERS

What if you are seeking recommendation letters? The tips here—which follow largely from the advice given already in this chapter—can help you obtain them effectively and considerately.

Scientists and others providing recommendation letters generally are busy. Therefore, if possible, approach them well in advance. At a minimum, try to provide 2 weeks to write the letter. If you are asking for several recommendations, ideally provide at least 4 to 6 weeks.

If you think the potential recommender might not remember you at first, try to jog the person's memory. For example, if approaching the person by email, perhaps attach a photo of yourself. Or provide other identifying information, such as the topic on which you prepared a presentation.

Gauge the recipient's reaction to the request. If the person seems glad to write the recommendation, promptly provide the information needed to do so. But if they seem hesitant or are slow to reply, ask whether finding another recommender might be wise. You may save yourself from an awkward situation or a late or lukewarm recommendation.

Supply, in an organized way, items required to prepare the recommendation well. Such items may include, in addition to needed forms, your CV or résumé, descriptions of programs to which you are applying, and samples of your work.

Recommenders sometimes tell you, by email or otherwise, when the recommendations go out. If you do not hear, a polite inquiry a few days before the deadline can be appropriate.

Follow up on the recommendation. Thank the recommender, at least by email; especially if someone has written multiple recommendations, sending a thank-you card can be a nice gesture. When you gain your objective, inform the recommender. For instance, say where you will attend graduate school or embark on a job—and thank the recommender again.

In short, treat recommenders as you would wish to be treated in such roles. With luck, you will indeed be treated the same way.

CHAPTER 39

How to Work with the Media

When a reporter approaches, I generally find myself wishing for a martini.
—Jonas Salk

BEFORE THE INTERVIEW

Your scientific paper will be published soon, and a news release about it has attracted reporters. Or an earthquake, epidemic, or policy issue has drawn attention to your topic. Or maybe you are receiving an award. For whatever reason, a reporter calls. How can you work with the reporter to help ensure that the public receives accurate scientific information?

First, why work with the reporter? If your research is government funded, the public has a right to know. Also, as an important part of our culture, science merits coverage. Scientific information can help individuals and groups make sound decisions. Public information about science can draw students to scientific careers. Further, coverage in the popular media can promote public support for science in general and your institution in particular.

At your institution, members of the media relations staff may prepare news releases and help reporters find experts to interview. They can also give guidance, such as tips on being interviewed for television. Other sources of advice include the SciDev.Net Practical Guide “What Journalists Want from Scientists and Why” (www.scidev.net/global/practical-guides/what-journalists-want-from-scientists-and-why) and material from professional organizations such as the American Association for the Advancement of Science (www.aaas.org/resources/communication-toolkit). Books providing guidance include *A Scientist’s Guide to Talking with the Media* (Hayes and Grossman 2006), *Communicating Science: A Primer for Working with the Media* (Menninger and Gropp



"REMEMBER, A BREAKTHROUGH IS NOT A BREAKTHROUGH UNLESS YOU HAVE SOME GOOD P.R. FOR IT."

(ScienceCartoonsPlus.com)

2008), *Am I Making Myself Clear? A Scientist's Guide to Talking to the Public* (Dean 2009), and *Explaining Research* (Meredith 2021).

News releases (also known as *press releases*) informing reporters about your research may be prepared by your institution or by the journal publishing your paper. They are then disseminated to the media. A news release, which can be published as is or can lead to a story by a reporter, is structured like a newspaper article; for many examples of news releases, see the science news website EurekAlert! (www.eurekalert.org). Those preparing a news release about your work will normally consult you. By answering their questions and then checking a draft, you can help ensure accuracy. Realize, though, that a news release will be much less technical and much less detailed than a scientific paper.

When reporters contact you, ask about their background, task, and timetable. Those writing science stories range from general reporters with minimal science background to science journalists with doctorates in the sciences; knowing whether the reporter is a specialist can help you respond appropriately. Also, find out what the reporter is seeking; for example, will the article focus on your research or is a general article being written about your research field? Finally, what is the reporter's deadline? Is the reporter writing a news story due today or a feature article due next month? Knowing the answers to such questions can help you respond most suitably. Of course, if you lack the

expertise being sought, decline the interview and, if possible, direct the reporter to someone appropriately qualified.

Unless the reporter must talk with you immediately, think beforehand about what you want to say. Identify the main message that you wish to present. Especially for the broadcast media, come up with a short and snappy way to state it—in other words, a *sound bite*.

Before the interview, if possible, provide written materials or direct the reporter to some. Such materials may include news releases, papers you have written, and sources of general information about your research topic. Providing such materials facilitates the reporter's work, promotes efficient use of interview time, and fosters accuracy.

DURING THE INTERVIEW

When interviewed, try to word your responses in ways directly suitable for the reporter's audience. For example, use mainly simple, common language, define technical terms, and relate what you say to familiar concepts (for instance, by providing analogies). Consider presenting the information as you would to a nonscientist neighbor or a bright high school student. Suiting the material to the audience minimizes the need for the reporter to "translate," and thus decreases the chance of error. It also gives the reporter quotable content or sound bites.

Try to present information accessibly, but without condescension. Avoid thinking of "watering things down," which tends to yield indigestible bits in an insipid broth. Rather, think of "building bridges" between what you will present and what the audience already knows and cares about. Consider using techniques presented in Chapter 26, "How to Write for the Public," to present your content clearly and engagingly.

If you have key points to convey, make them even if the reporter does not ask. You may be able to do so by tactfully reframing a question. ("That's an interesting idea, but actually the issue we were studying was. . . .") Alternatively, you can add points at the end of an answer or the end of the interview. Also, if you have photographs or other visuals that might enhance the story, inform the reporter, even if not asked.

Stay focused during the interview. In particular, do not make offhand remarks that you would not want published.

Consider checking the reporter's understanding. For instance, you can say, "I'm not sure I've presented this concept clearly. Perhaps you could explain it back to me so I can check." Then, if a misunderstanding has occurred, you can provide clarification.



(ScienceCartoonsPlus.com)

Before the interview ends, encourage the reporter to contact you if questions arise while writing the story. You may also offer to review part or all of the story for technical accuracy. Traditionally, journalists have not shown drafts to their sources for fear of being pressured to change content inappropriately. Some journalists, however, welcome such review when writing about technical topics. Limit any suggested changes to matters of technical accuracy. The writing style is the writer's and editor's domain.

AFTER THE INTERVIEW

Once the story appears, have realistic expectations. Of course, it will be briefer and less technical than a journal article. It also will focus mainly on aspects of greatest interest to the public. Thus, it is likely to emphasize conclusions and implications, and it is unlikely to describe your methods in detail or to list your eight coauthors. In evaluating the story, often the relevant question is not "Was everything captured precisely?" but rather, "Will a member of the public come away with the correct idea?"

If a story is especially good, or if it has serious errors, consider providing feedback. Often, reporters hear only if others are displeased. If you think the reporter has done especially well, tell the reporter—and, if possible, also tell the editor. If a story has a major inaccuracy, also inform the reporter. Good reporters want to know so they can avoid repeating mistakes. If an error is serious, a correction may be published or aired.

Finally, think back on your interactions with the reporter. What did you do that turned out well? What could you have done better? Considering such questions can help you be even more effective the next time a reporter calls.

CHAPTER 40

How to Provide Peer Review

Honest criticism is hard to take, particularly from a relative, a friend, an acquaintance, or a stranger.

—Franklin P. Jones

RESPONDING TO A REQUEST FOR PEER REVIEW

Once you have become an author, you may receive invitations to be a peer reviewer—in other words, to evaluate work by others in your field. Journal editors may ask you to review papers being considered for publication. Funding agencies may ask you to review grant proposals. Book editors may ask you to review the proposals or manuscripts for books. Given that preparing peer reviews can entail much time and effort, why should you accept such invitations? And when should you decline them?

Peer review helps editors decide what to publish, and it helps authors improve their work. Similarly, peer review of grant proposals helps funding agencies make sound decisions and helps scientists refine their research. Others in your field provide this service to you when they review items that you have written. Being a good citizen in the scientific community includes providing this service in return.

In addition, peer review can have other benefits. It can help you keep up in your field and maintain your critical skills. It can improve your own writing by helping you discern what affects the quality of writing. Listing entities for which you peer-review can enhance your curriculum vitae (CV). Peer-reviewing for a journal can lead to serving on its editorial board and becoming an editor of the journal. Although peer-reviewing generally is unpaid, sometimes reviewers are paid or otherwise compensated. For example, reviewers of book

manuscripts commonly receive a little money in appreciation of their efforts; if they prefer, sometimes they receive some books of their choice from the publisher instead.

Sometimes, though, you should refuse the invitation to peer-review or ask the editor whether to refuse it. If you lack time to complete the review adequately by the deadline, decline the opportunity and, if possible, suggest other potential reviewers. Also, if you believe that you lack sufficient expertise to prepare a sound review, inform the editor. The editor may then ask you to suggest potential reviewers whom you consider better suited. Or the editor may explain that you were approached because of your expertise regarding one aspect of the research, and other reviewers will evaluate other aspects.

If you decide not to accept a request to peer-review, be sure to inform the journal. Do so promptly, so the editor can seek a different reviewer. Do not assume that failure to reply will be seen as declining the invitation. The editor—and the author—should not be left in limbo.

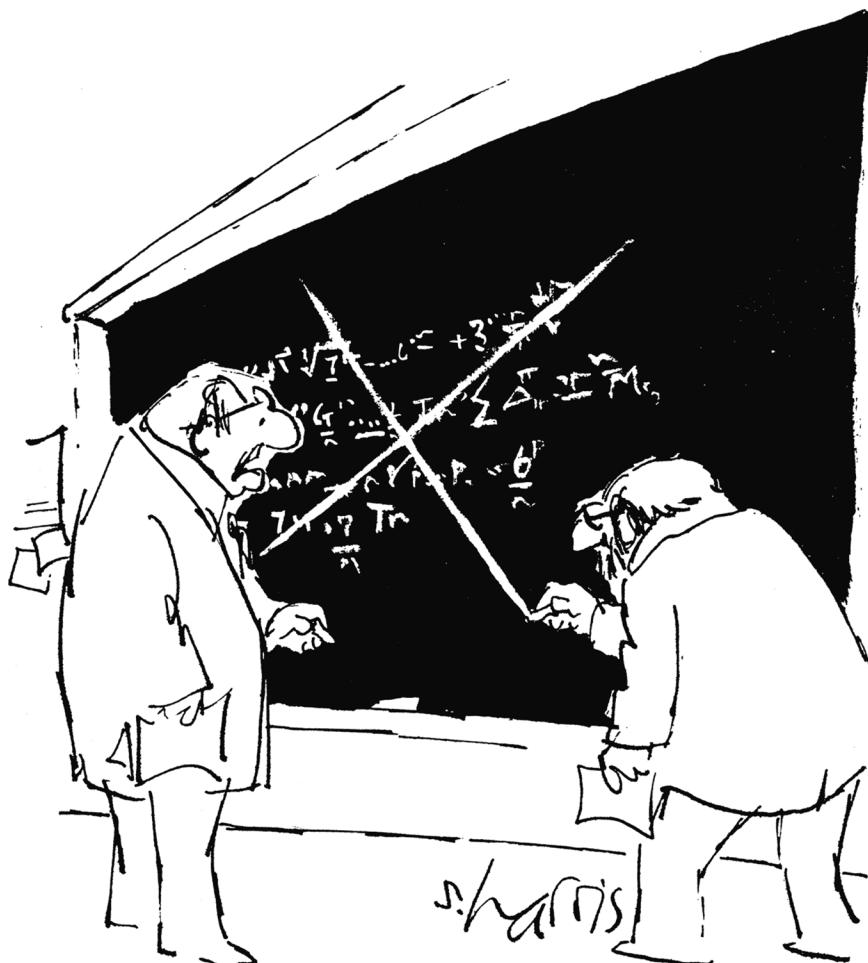
Inform the editor if you have conflicts of interest—that is, anything in your background that could interfere, or appear to interfere, with your objectivity in doing the review. For instance, if you have collaborated with any of the authors, if you have a financial interest relating to the research, or if an author is your friend, enemy, or former spouse, tell the editor. Some journals routinely ask potential reviewers to state anything that might be a conflict of interest. Even if the journal does not, inform the editor if you think you might have one. The editor then can decide whether to retain you as a peer reviewer, while keeping the item in mind, or whether to seek a different reviewer.

What if you want to become a peer reviewer but have not been asked? Volunteer. For some journals, you can apply online to be added to the pool of potential reviewers. If the journal website does not include such an application, contact the editor to express your interest. Journals almost always are seeking more reviewers, and they are eager to enlarge and diversify their reviewer pools. Volunteering can aid the journal and your own career.

PEER-REVIEWING A SCIENTIFIC PAPER

If you are a peer reviewer, realize that the item being reviewed is confidential. Do not reveal its content. Do not discuss with those around you the authors' writing skills (or lack thereof). Do not ask others to collaborate on the review without first obtaining permission from the editor. If there is a valid reason for collaboration—for instance, if a colleague could better evaluate part of the research, or if collaborating on the review could help educate a graduate student or postdoctoral fellow—the editor is likely to grant you permission. However, permission should be sought, not assumed.

Journals commonly use online systems for submission of peer reviews. Whether or not it does so, a journal is likely to seek two types of input from each reviewer: a confidential evaluation, for use by the editors only, and comments for the editors to share with the authors. Some journals supply forms for these purposes. The form for feedback to editors may contain rating scales and provide room for comments about the quality of the work and whether the work should be published. Examples of items that the rating scales may



"THAT'S IT? THAT'S PEER REVIEW?"

address are the importance of the research question, the originality of the work, the validity of the methods used, the soundness of the conclusions, the clarity of the writing, and the suitability for the journal's readership.

Your comments for the editor to share with the authors typically should begin by listing what you perceive as the main strengths and main limitations of the paper. You should not, however, tell the authors whether you consider the paper publishable in the journal; that decision is up to the editor. After the general comments, you generally should provide a section-by-section list of comments on the specific content of the paper. For ease in identification, it usually is best to specify the items you comment on by page, paragraph, and line. Both evaluate what is present and note omissions. Strive for balance; do not nitpick, but do not hesitate to note real problems either. Be sure your points are worded clearly. If reasons for recommendations might not be obvious, provide explanations.

In preparing the review, of course avoid bias. Also, avoid taking advantage of insider information; before the paper is published, you should not use the paper's content to advance your own research or (if the paper concerns a product) to decide about investments. Also, avoid undue delays; the editor and author are waiting. If you find that you cannot submit the review on time, promptly inform the editor.

Your main task as a peer reviewer is to evaluate the content of the paper. Is the research of high quality? If not, what are the problems? Has all the appropriate content been provided? Should any content be deleted? In answering the last two questions, you may find it useful to review the sections of this book on the respective sections of a scientific paper. Other potentially useful resources include a checklist (Task Force of Academic Medicine and the GEARIME Committee 2001) that appeared in a report providing guidance for peer reviews. Although some items in this checklist apply only to some types of research, it provides a useful framework.

As a peer reviewer, you are not expected to comment in detail on the writing. Your task does not include identifying every punctuation error and misspelling; if the paper is accepted, a copy editor can correct such problems. However, it can be worthwhile to comment in general on the clarity, conciseness, and correctness of the writing; to note passages that are ambiguous; to suggest any reorganization that could improve the paper; and to remark on the design of figures and tables. If the paper contains highly specialized wording that you think that a copy editor might have difficulty revising properly, consider providing some guidance. Also, consider giving extra help with wording if you can tell that the author's native language is not English.

In preparing comments intended for the authors, remember that the authors are human beings. Almost certainly, they care greatly about their work, are sensitive about it, and will be most receptive to feedback if it is given

in a constructive tone. Therefore, avoid sarcasm and phrase your comments tactfully; try to ensure that suggestions are specific enough for the authors to follow. Set a positive tone by first stating the strengths of the paper; then, after offering suggestions, perhaps end the review with words of encouragement. Although the section-by-section or line-by-line comments should be mainly suggestions, an occasional compliment can be included. Whether or not the journal accepts the paper, the review can help educate authors and thus improve their current paper and later ones. Indeed, if an author appears to be a beginning researcher or seems to come from someplace where international norms of scientific publication are not well known, consider taking extra effort to make the review educational, either directly or by suggesting resources that can improve one's scientific writing.

Should you sign your review, or should it be anonymous? Policies in this regard differ among journals. Advocates of anonymous review, which is common in the sciences, say that it allows reviewers to be more honest—especially when, for instance, a young researcher is evaluating a paper by someone much senior. On the other hand, advocates of signed reviews say that they encourage reviewers to be more responsible. Some journals allow reviewers to decide whether to identify themselves. The journal's instructions for reviewers should indicate its policy. If in doubt, ask whoever invited you to do the review.

Finally, keep track of your reviewing. Perhaps add the reviewing to your CV. (Because peer review generally is confidential, as previously noted, one normally lists just the journal, granting agency, or book publisher reviewed for, not the specific item reviewed.) Consider documenting your reviewing through the tracking service Publons (publons.com/about/home). When applicable, let publishers update your ORCID (Open Researcher and Contributor ID) record to indicate your reviewing (see info.orcid.org/documentation/workflows/peer-review-workflow). Likewise, for purposes such as annual performance reviews, perhaps keep track of entities reviewed for and the number of reviews completed.

PROVIDING INFORMAL PEER REVIEW

Because of your knowledge of science and of writing, you may be asked to comment on drafts before submission. Such reviewing can be a valuable service, especially to students, junior colleagues, and others who may not be thoroughly versed in English-language scientific communication. The following suggestions can aid in providing such informal peer review.

Find out what level of review is being sought. For example, is the draft an early one, and thus is the author seeking feedback mainly on content and organization? Or is the draft nearly final, so that the time has come to comment

on the finer points of expression? Although you should feel free to note problems on other levels, knowing the type of feedback sought can help you make appropriate use of your time.

Consider serving a criticism sandwich: praise, then criticism, then praise. Also, show sensitivity to the author's feelings in other ways. For example, express criticisms as perceptions rather than facts ("I found this section hard to follow" rather than "This section is totally unclear"). And criticize the work, not the person ("This draft seems to contain many punctuation errors," not "You have a dreadful command of punctuation"). If you are providing feedback electronically on a manuscript, use word-processing features such as Track Changes in Microsoft Word, or distinguish comments by placing them in triple brackets or using colored type, italics, or boldface. Avoid typing comments in all capital letters, which can give the impression that you are screaming. Similarly, if you write comments on hard copy, consider using green ink, which seems friendlier than red ink but also tends to be easy to notice.

Through providing informal feedback, you are teaching: By following your suggestions, authors can both improve their current drafts and become better writers in the long run. And by assimilating what you say and how you say it, they themselves can learn to be better peer reviewers in both the informal and the formal sense.

FOR MORE ON REVIEWING

If you would like more about peer reviewing, resources include the section "Reviewer Roles and Responsibilities" in a Council of Science Editors (2020) white paper, the international congresses held periodically on peer review (see peerreviewcongress.org), and *Peer Review Week* (see peerreviewweek.wordpress.com). The Science Careers essay "Reviewers, Don't Be Rude to Nonnative English Speakers" (Romero-Olivares 2019) makes good points to remember. And a *Nature* editorial (2020) conveys a key message through its title: "Communication Is Key to Constructive Peer Review." As noted in this editorial, reviewers, editors, and authors are working together to help ensure that the scientific literature is of high quality. Contribute to that high quality by providing fine peer reviews.

CHAPTER 41

How to Edit Your Own Work

There is no great writing, only great rewriting.

—Justice Louis Brandeis

PREPARING TO EDIT YOUR WORK

If you have reached this point in the book, or if you turned immediately to it, you probably know that good writing is much-revised writing. But how should you approach editing your own work? What should you look for? Is there anyone who can help? This chapter addresses these questions. In doing so, it reviews some key points from earlier chapters, such as about features of good scientific writing.

First, though: Why edit your own work? Doing so can increase the likelihood that your paper or proposal will be accepted. It can decrease the amount of revision that reviewers and editors request. It can minimize editing by others—and thus minimize the chance that inaccuracies will be introduced. Most important, it helps ensure that you communicate effectively with readers. Also, some journals now provide little copyediting; they do little or no polishing and sometimes require authors whose papers are deemed unpolished to obtain editing on their own. Thus, editing one's own work before submission may be even more advantageous than before.

Challenges in editing one's own work include gaining distance and objectivity. Letting time elapse and changing the physical appearance of your work can help. If feasible, set your writing aside for at least a few hours. You might then be able to approach the piece much as a reader would. Perhaps also change the look of the piece (Hancock 2003) to aid in encountering the writing afresh. For instance, if you have been viewing the writing on a computer, print

it out. Or change the typeface or margins. Maybe print the piece on colored paper. Such changes can assist in viewing your writing with new eyes.

Also, use your ears. Read your draft aloud. In doing so, you may notice more easily where words are missing or wording is awkward.

Once you are ready to edit, in what order should you proceed? The choice is yours. Some authors start by considering large-scale aspects, such as overall content and organization. No need, they say, to bother with details right away since parts of the writing might be deleted anyway. Other authors start by polishing the language so they can see the piece more clearly before considering larger-scale changes. Such polishing can start with the text or with elements such as tables, figures, or references. Regardless of the order you use, thoroughly editing your work (or anyone else's) usually entails more than one round. The final round should proceed from beginning to end, so you can better notice problems in the order of items.

ITEMS TO NOTICE: 8 Cs

Professional editors sometimes speak of checking for the “4 Cs”—which, depending on which editor you ask, can stand for “clarity, coherency, consistency, and correctness” (Einsohn and Schwartz 2019, p. 3) or variants such as “correctness, clarity, consistency, and conciseness.” When editing your own work, consider checking for “8 Cs”: compliance, completeness, composition, correctness, clarity, consistency, conciseness, and courtesy. Writing that achieves all eight Cs is likely to excel at communication, which is the C that is the overall goal.

Regarding *compliance*, ensure that the writing complies with all instructions, such as journals’ instructions to authors and funders’ directions for grant proposals. In addition, ensure that you have complied with relevant conventions in your field, such as those regarding terminology and document structure. If your research involves animals or human subjects, also confirm that you have documented compliance with requirements in that regard.

Check for *completeness*. Does the document contain all the necessary components? Does each component contain all the information that it should? Are necessary details included, for instance in the methods section?

Evaluate the *composition* of the piece. Is the overall structure appropriate? Is every section logically organized? Are paragraphs well structured, with strong topic sentences? Does one idea lead smoothly to the next? Are tables and figures well designed?

Check *correctness* of content and expression. Make sure that all information is correct, both in the body of the text and in the tables, figures, and references. See whether all the logic is valid. Also, ensure that the grammar, spelling, punctuation, and word use are proper. If some aspects of such mechanics pose particular difficulty for you, devote special attention to them. For example,

if you know that you struggle with verb tenses, perhaps review your draft an extra time, checking specifically for them.

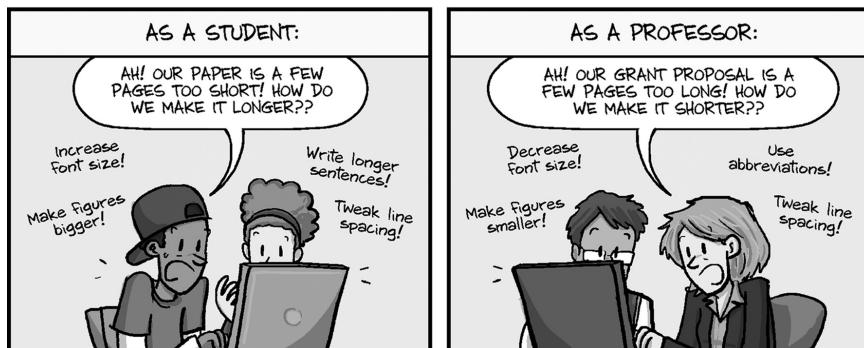
Pay attention to *clarity*. If some words or phrases might be unclear to readers, make sure that they are defined. Likewise, ensure that abbreviations are defined on first use. See whether antecedents of words such as *it* are clear. Look for places where the wording could be made clearer or where relationships of ideas could be clarified by using transitional words (such as *also*, *first*, *then*, and *however*). Seek to improve passages where your reasoning might not be explicit enough for readers to follow. Identify sentences that are too long or too complex to understand easily, and divide or otherwise restructure them.

Look for *consistency* as well. Is all the information consistent—or, for example, do numbers differ between tables and text? Is the content of the abstract consistent with that of the body of the piece? Is the terminology consistent throughout? Is the formatting (for example, of subheadings) consistent? Do items appear in consistent order? Where appropriate, are tables and figures consistently formatted?

Both to save space and to aid readability, try to increase *conciseness*. In keeping with the examples in Appendix 2, replace long words with shorter equivalents and condense wordy phrases. Remove redundancies. Delete tangential or irrelevant content. In seeking conciseness, however, take care not to decrease clarity or diminish meaning.

Finally, keep *courtesy* in mind. Make sure that you have been courteous to those whose work you discuss, others you mention, and your readers. Replace language that is unintentionally derogatory (such as “Previous researchers have failed to explore”) with neutral language (such as “Previous researchers did not explore”). Revise any language that is not inclusive or that seems disrespectful of some population groups. To be courteous to readers, make sure you have attended to other Cs that help make writing easy to read—such as

PAGE LIMITS



(“Piled Higher and Deeper” by Jorge Cham. www.phdcomics.com)

clarity, conciseness, and compliance with conventions, as already discussed. The effort that you invest in editing can save your readers effort and thus help ensure that your work will be read, understood, and appreciated.

A GOOD CHOICE: CHECKLISTS

Checking for all eight Cs at once can be hard or impossible. Therefore, generally check writing in several phases. To guide yourself, consider using checklists.

One good strategy is to use both a core checklist on general aspects of writing and a specialized checklist geared to the type of document that you have

SOME GENERAL QUESTIONS TO ASK: EDITING ONE'S OWN WRITING

1. Is the content complete, or should any content be added?
2. Should any content be deleted?
3. Is all the content accurate?
4. Is all the logic sound?
5. Do the content and crafting of the piece suit the audience?
6. Does the piece follow appropriate conventions regarding overall format?
7. If subheadings are allowed, are they used effectively?
8. Are sections and paragraphs of appropriate length?
9. Should any tables or figures be added or deleted?
10. If tables or figures are included, are they well designed?
11. Would typographic devices, such as italics or bullets, be helpful anywhere?
12. Is the piece well organized at various levels?
13. Are grammar, spelling, punctuation, and usage correct throughout?
14. Are verb tenses appropriate?
15. Are antecedents of all pronouns clear?
16. Have all acronyms been defined (and are all the acronyms worth using)?
17. Are sentences of appropriate length and structure?
18. If references are cited, are they in the appropriate format? Do all cited references appear in the reference list, and are all listed references cited in the text?
19. Is the writing clear, exact, and concise?
20. Have all instructions been followed?

Figure 41.1. Sample core checklist for editing one's own writing. A version of this checklist also appears in Gastel B. 2015. Editing and proofreading your own work. AMWA J. 30(4):147–151.

SPECIALIZED CHECKLIST: EDITING ONE'S DRAFT OF A SCIENTIFIC PAPER

1. Does the title accurately and concisely indicate the content?
2. Are the appropriate people listed as authors?
3. Does the abstract accurately reflect the content of the paper? Is the abstract a suitable length?
4. Does the introduction provide sufficient context?
5. Does the introduction make clear what gap the research was intended to fill?
6. Does the introduction indicate the hypotheses or research questions?
7. Does the methods section provide sufficient information to replicate the research?
8. Does the methods section provide sufficient information to evaluate the research?
9. In the methods section, are sources of materials and equipment identified?
10. If the research was on humans or animals, are appropriate approvals noted?
11. Are the results presented in logical order?
12. Are the results presented in appropriate detail?
13. Are statistics appropriately presented?
14. Does the discussion address the hypotheses or research questions posed in the introduction?
15. Does the discussion put the results in sufficient context?
16. If relevant, does the discussion address strengths and weaknesses of the research?
17. If relevant, does the discussion identify applications or implications of the research?
18. Have the appropriate parties been acknowledged?

Figure 41.2. Example of a checklist for editing one's own scientific paper. Such a checklist could best be used along with a more general editorial checklist, such as shown in Figure 41.1. A version of this checklist also appears in Gastel B. 2015. Editing and proofreading your own work. AMWA J. 30(4):147–151.

drafted. Figure 41.1 is an example of a core checklist. Figures 41.2 and 41.3 are examples of specialized checklists for a scientific paper and for a grant proposal, respectively. Consider using these checklists or modifying them to suit your needs. Also, consider obtaining or developing such checklists for other types of documents. Of course, if your target journal or other intended recipient provides a checklist, be sure to consult it.

**SPECIALIZED CHECKLIST:
EDITING A DRAFT OF ONE'S GRANT PROPOSAL**

1. Does the title clearly and accurately convey the focus?
2. Is the abstract informative and clear? Ditto for any other sections serving as summaries?
3. Are the goals or hypotheses clear?
4. Is the originality of the work apparent?
5. Is the proposed work clearly relevant to the mission of the funding source?
6. Is the importance of the proposed work explained?
7. Is sufficient context provided?
8. Is the amount of proposed work realistic?
9. Is it clear that the personnel are capable of doing the proposed work?
10. Are sufficient justifications provided for choices, for example of methods?
11. Is sufficient supporting evidence included?
12. Is sufficient justification provided for budgetary items?
13. If there will be cost sharing, is sufficient information provided?
14. If preliminary studies are required or advisable, is there enough information about them?
15. If a timeline would be advisable, is one included?
16. If evaluation plans are needed, are they sufficient?
17. If dissemination plans should be included, are they sufficient?

Figure 41.3. Example of a checklist for editing one's own grant proposal. Such a checklist could best be used along with a more general editorial checklist, such as shown in Figure 41.1. A version of this checklist also appears in Gastel B. 2015. Editing and proofreading your own work. AMWA J. 30(4):147–151.

FINDING AND WORKING WITH AN AUTHOR'S EDITOR

Especially if you are a beginning author, consider seeking guidance from a manuscript editor. Individuals known as *author's editors* specialize in revising authors' work before submission. They can also help authors after submission, such as in improving a paper as requested by a journal.

How can you find an author's editor or the equivalent? Some universities, research institutions, and departments employ editors to assist scientists and scientists-in-training. In fact, some, such as the Mayo Clinic and The University of Texas MD Anderson Cancer Center, have scientific-publication units with multiple editors to provide such help. There also are freelance author's editors and freestanding editorial companies. Unfortunately, just as there are predatory journals, there are predatory editing services (Linacre and Syed

2020). These entities claim to provide skillful editing but do not do valid work. Beware if you receive a typo-filled email offering to proofread your manuscript!

Networking with fellow researchers can aid in finding editors and editorial services that others regard highly. Lists of individuals who identify themselves as freelance editors appear on the websites of some universities (for example, through the thesis office or writing center). Editors available for freelance work who have passed a rigorous examination in life science editing can be identified through the Board of Editors in the Life Sciences website (www.bels.org). Some commercial editing services are listed at www.authoraid.info/en/resources/details/750, and editorial guidance from volunteer mentors can be sought through the AuthorAID project (www.authoraid.info/en/mentoring/). Although authors may benefit most from an editor who can meet with them face to face, email and video conferencing technologies allow effective communication with an author's editor in another city, or even another country.

Before giving your writing to an author's editor, edit it yourself insofar as feasible. Doing so helps use the editor's time efficiently, which may be especially desirable if that person has many authors wanting help or if you yourself will pay for the time spent. More important, doing some editing yourself can make the writing easier for the editor to understand, thus facilitating the provision of suitable editorial feedback.

Communicate with the editor or editorial service about the desired extent of editing. Do you want the editor only to correct errors in grammar, punctuation, and other mechanics? Are you seeking more extensive help, including improvement of wording and sentence structure? Or do you desire whatever may strengthen the piece, including reorganization if deemed advisable? Ideally, once the editor has looked at the writing, find out what level of editing this person considers suitable and discuss how to proceed. Be available to answer questions. Realize that an author's editor is an advisor, and thus final decisions about the writing are yours.

A good author's editor, like a good peer reviewer, also serves as a good teacher. Notice revisions that the editor makes and learn from them. If you are uncertain why a recurrent or major change was made, ask the reason if circumstances permit. Maybe compile a master list of changes made in order to help avoid similar problems in future writing. If you use checklists in editing your work, perhaps revise them to reflect insights gained from the editor's feedback. In short, make the editor an ally and instructor in editing your own work.

CHAPTER 42

How to Seek a Scientific-Communication Career

Reporting on science and writing about it is like attending a never-ending graduate school of unlimited diversity.

—David Perlman

CAREER OPTIONS IN SCIENTIFIC COMMUNICATION

Some of us in science find the communication aspect so well suited to our interests and abilities that we focus on it in our careers. And increasingly, careers in science communication are being recognized as alternatives to those in research. Opportunities include writing and editing materials for fellow scientists and communicating science to general audiences.

Because you know your scientific discipline, its community, and its culture, you can bring much to publications for other scientists. Various niches exist in this realm. At a major journal, you may be an editor determining scientific content, a manuscript editor, or a writer or editor for the news section, if any. At a magazine or newsletter for scientists, you may be a writer or an editor. At a publisher of scientific books, you may be an acquisitions editor who generates topics, recruits authors, and oversees evaluation of proposals and manuscripts. At a corporation focusing on science or technology, you may write or edit specialized materials such as submissions to regulatory agencies. At a university or research institute, or on a freelance basis, you may be an author's editor, working directly with authors to refine their writing before submission. Because English is the international language of science, considerable demand exists for author's editors with strong English-language skills. An article by Kanel and Gastel (2008) summarizes career options in science editing.

Alternatively, you may pursue a career in the popular communication of science. For example, you may be a science reporter, writer, or editor for a newspaper, newsletter, magazine, or online publication. Or you may work in broadcast media. You may write popular science books. You may prepare public-information materials for an organization or government agency concerned with science, technology, the environment, or medicine. At a university, you may write news releases, work on a research magazine, prepare podcasts, or pursue other public-communication activities. Likewise, you may work in media relations or public communication for a corporation. You may help prepare exhibits or other items for science museums. On a freelance basis, you may write about science for various media and institutions. Similarly, you may prepare science-communication materials for various outlets as an employee of a consulting firm.

AN ADMITTEDLY UNVALIDATED QUIZ

Many from the sciences who choose communication careers seem to share certain traits. Based on this observation, here is an informal quiz. As social scientists might point out, this quiz has not been validated systematically. But the smiles of recognition it evokes seem to suggest, literally, a sort of face validity.

So, is a science communication career for you? To help find out, consider the following 10 items:

1. Have you enjoyed courses in both science and other fields? Did you consider majoring in English or another area of liberal arts? Did you minor in such an area?
2. Are you an avid reader? Do you find yourself editing what you read? Do topics for writing often occur to you?
3. Do you like word games? For example, do you enjoy working crossword puzzles and playing Scrabble?
4. Have teachers or others complimented you on your writing?
5. In high school or college, did you serve on the school newspaper or another student publication? If not, did you consider doing so?
6. Do you consider yourself a science generalist? Rather than wanting to focus on a narrow research area, do you like to learn about various aspects of your field, or of science in general? Do you find yourself more interested in knowing what other researchers are doing than in doing your own research?
7. Do you like to view science in its broad context? Are you interested not only in research itself, but also its applications and implications?

8. In laboratory projects, are you often the team member who writes things up? Do you find this role satisfying?
9. Do others ask you to edit what they wrote? Do they otherwise approach you for help with their writing?
10. Does a science-communication career sound like fun to you? Is writing or editing something you would look forward to doing each day?

If you answered “yes” to most of these questions, a career in science communication might well be for you. And if after reading these questions, you exclaim, “That’s me!”—let us be the first to welcome you to the field.

CAREER PREPARATION

Some people enter scientific-communication positions directly from science. Serving as a peer reviewer and on the editorial board of a journal can lead to such a position. Some formal training, though, seems increasingly common, especially for those wishing to work in the popular communication of science. Such training can be in science journalism, scholarly publishing, technical communication, or a related field. It can consist of a degree program, a certificate program, or simply one or more courses. Resources for identifying educational opportunities include the list of environmental journalism programs and courses from the Society of Environmental Journalists (www.sej.org/library/education-environmental-journalism-programs-and-courses), which also contains some listings more generally in science communication; an analogously broad list from the American Medical Writers Association guide to becoming a medical writer (info.amwa.org/ultimate-guide-to-becoming-a-medical-writer#medical_writer_resources); a list from the Knight Science Journalism Program at MIT (ksj.mit.edu/resource/being-a-science-journalist/schools); and Maps of TPC Programs (tek-ritr.com/techcomm-programmatic-central/maps-of-tpc-programs), a set of maps showing locations of U.S. educational programs in technical and professional communication.

Some organizations offer workshops or other brief instruction that can help one develop professional skills in scientific communication. For example, the Council of Science Editors precedes its annual meeting with several concurrent short courses on aspects of science editing. Likewise, the annual conference of the American Medical Writers Association includes a wide array of three-hour workshops, some of which also are available as self-study modules (www.amwa.org/page/Essential_Skills). Increasingly, professional organizations in the communication of science have been providing educational offerings online.

Reading on one’s own also can aid in preparing for a career in scientific communication. If you wish to enter scholarly or technical scientific

communication, works that may be useful include, in addition to the current book, guides to writing papers in specific fields of science (such as Ebel, Bliebert, and Russey 2004; Lang 2010; Sternberg and Sternberg 2016; and Zeiger 2000), style manuals commonly used in the sciences, *Regulatory Writing: An Overview* (DeTora 2020), *The Copyeditor's Handbook* (Einsohn and Schwartz 2019), and *The Copyeditor's Workbook* (Bůky, Schwartz, and Einsohn 2019). New editions of the style manuals, as well as some of these other books, appear periodically—so be sure to obtain the most recent edition. Works that can assist those hoping to enter the popular science communication field include *Ideas into Words: Mastering the Craft of Science Writing* (Hancock 2003), *Health Writer's Handbook* (Gastel 2005), *A Field Guide for Science Writers* (Blum, Knudson, and Henig 2006), *The Science Writers' Handbook* (Writers of SciLance 2013), *Handbook for Science Public Information Officers* (Shipman 2015), *The Craft of Science Writing* (Carpenter 2020), and articles posted on The Open Notebook website (www.theopennotebook.com).

Internships or fellowships in the communication of science can strengthen your skills, increase your visibility to potential employers, and aid in exploring career options. Sites of internship or fellowship programs in the communication of science have included international research centers (such as CERN and the International Centre for Theoretical Physics), U.S. government entities (such as Fermilab and the National Cancer Institute), journals (such as *Science* and *JAMA: The Journal of the American Medical Association*), magazines (such as *Science News* and *The Scientist*), and other settings such as the public information offices of universities and of organizations. Also, since the 1970s, the American Association for the Advancement of Science has placed science graduate students at media sites each summer through its Mass Media Science and Engineering Fellows Program. In addition, sometimes communication offices without formal internship programs are willing to host interns on request; thus, if there is a setting where you might like to do an internship, take the initiative to ask about doing so.

ENTERING THE FIELD AND KEEPING UP

How can you find job opportunities in scientific communication? Look at position announcements posted on employment websites, published in journals, and disseminated by groups such as the Council of Science Editors, the National Association of Science Writers (NASW), and the American Medical Writers Association. Keep informed about job openings through social media. Whether or not job opportunities are announced, make yourself known to potential employers. Network, through organizations and otherwise.

Those in scientific communication, like those in scientific research, need to keep up with new developments. The never-ending graduate school of a science-communication career can aid in staying current with science, and further reading and listening can help fill the gaps. With regard to scientific communication, relevant organizations can help you keep up with trends, technologies, and issues; obtain practical advice; and establish or maintain a network of others doing similar work. Examples of such organizations include those mentioned in the preceding paragraph, as well as the European Association of Science Editors, the World Association of Medical Editors, the Association of Earth Science Editors, the Society of Environmental Journalists, the Association of Health Care Journalists, and the Society for Technical Communication, as well as associations in more general communication fields (for example, the Society of Professional Journalists, the International Association of Business Communicators, and ACES: The Society for Editing). Read the publications of such associations, attend their conferences if you can, and take advantage of their social media engagement. And as your career develops, consider helping with their educational activities as well. You may one day be helping others from science who are entering scientific-communication careers.