Third Edition

Scientific English

A Guide for Scientists and Other Professionals

Robert A. Day and Nancy Sakaduski

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Manufactured in the United States of America

To Joe, Barton, Robin, Sarah, Hilary, Matt, Ian, and Allie

Contents

Preface

> Out of clutter, find simplicity.
>
> —Albert Einstein

Good writing appears effortless. The reader is absorbed by the message and not distracted by the author screaming "Hey, look at me!" Words snap with precision, sentences crackle with clarity, and paragraphs pop from the page without a single wasted word. To the casual observer, the result looks spare, even simplistic.

Take one of the most famous poems of all time, "The Road Not Taken" by Robert Frost. Another writer—a scientist for example—might be tempted to embellish it a little to make the subject matter seem weightier and the author more scholarly:

> The Transportation Thoroughfare Not Selected
>
> An exploratory study was undertaken to evaluate a test subject's preferences with respect to two transportation pathways that diverged in a portion of the Eastern Deciduous Forest. Previous studies have indicated that outcomes are affected by race and stature (Tolkien, 1937). The test subject was allowed only one selection, but was given an unlimited period of time in which to make a decision. Two pathways were introduced and the subject was asked to select one. Pathway A was identified as one containing >50% undergrowth. Pathway B was determined to be comparable, but contained substantially more species in the *Poaceae* family (see Figure 1), indicating less traffic pressure (Barleycorn, 1970). After a time interval of 9.4 minutes, the test subject selected Pathway B. It is doubtful that a time limit would have significantly affected the outcome. At the final conclusion of the study, the subject was questioned regarding his choice. The subject responded that the choice of Pathway B had made a significant impact; in fact he observed it "has made all the difference."[1] This suggests

> that pathways not typically selected may be superior to those often taken. It is clear that additional studies should be undertaken to determine whether this result is replicable.

Too often, scientific writing (like the previous passage) is burdened with redundant words, bloated phrases, and stilted language that do not increase understanding and may actually create confusion.

When we seek to impress, we use *long* words in *long* sentences. We start with a simple thought, but then we surround it in a fog of fancy words and phrases. As a result, we lose clarity. At worst, the thought has been overwhelmed by verbiage; at best, the thought takes second place to the writing.

Some of the most profound thoughts ever expressed have been expressed in simple language.

> One sometimes finds what one is not looking for.
>
> —Alexander Fleming

> Nature does not proceed by leaps and bounds.
>
> —Carolus Linnaeus

> Chance favors the prepared mind.
>
> —Louis Pasteur

> $E = mc^2$
>
> —Albert Einstein

> You can observe a lot just by watching.
>
> —Yogi Berra

Two concepts serve as the thesis for this book: the beauty of science is in the science, not in the language used to describe it; and the beauty of English is its ability, when properly used, to express the most complicated concepts in clear words.

Successful communication in science involves that magic word, *clarity*, a close relation of *simplicity*. Perhaps not just in science, but "In all things, the supreme excellence is simplicity," as Henry Wadsworth Longfellow observed.

To be simple, writing must be concise. But, you say, English has a massive vocabulary, and English professors have concocted a zillion rules; therefore, it is virtually impossible to write in English with clarity and brevity.

Not true. This book provides some simple guidelines to help you improve your knowledge of English and your ability to communicate scientific information in English. If you want to learn about such esoteric things as the subjunctive mood and the pluperfect tense, do *not* read this book; if you want to communicate scientific information with simple, straightforward accuracy, this book just might help.

> The best scientific writing is spare and straightforward. It spotlights the ideas being presented, not the manner of presentation.
>
> —*APA Style*, the American Psychological Association

WHAT'S NEW IN THE THIRD EDITION

The first thing you may notice about this edition is the addition of a coauthor. Robert Day is now a professor emeritus, retired from the world of writing and editing. He enlisted the help of his daughter Nancy, also a published author, to revise and update *Scientific English*. We hope the unique voice of the original author has been preserved and that this book continues to be entertaining as well as informative.

We have incorporated many of the suggestions made by readers of earlier editions. Throughout the text, we have updated examples and replaced generic examples with examples from scientific writing. We have expanded the appendices and added a glossary that provides definitions of grammatical terms.

We have added advice on self-editing (see Chapter 3) to help you review and improve your writing before submitting it for publication. Editors have less time than ever to resuscitate manuscripts that are poorly written. The growing number of online publications, self-published vehicles, and alternative media has made it even more important for writers to serve as their own editors.

The world of publishing has changed substantially since the publication of the second edition. We have added a chapter on electronic media (Chapter 20), a growing force in scientific publishing as in all fields. Throughout the book we have addressed the changes that the Internet, online publishing, and other technological advancements have brought to the world of scientific writing and publication. Although this information will go out of date as technology continues to advance, the changes are too important to ignore.

Electronic media will undoubtedly continue to replace print media. However, the basics of good grammar, concise writing, and clear communication will no doubt stand the test of time. We hope you enjoy this book and find it helpful in your writing.

> Good communication is as stimulating as black coffee and just as hard to sleep after.
>
> —Anne Morrow Lindbergh, *Gift From the Sea*

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1

Principles of Scientific Writing

> In science, the credit goes to the man who convinces the world, not to the man to whom the idea first occurs.
>
> —Sir William Osler

In the past, too many grammarians have established far too many arcane "rules" about the use of our language. Some of these people believed that English can be used precisely only by the literati. Common folk couldn't be expected to master the profusion of arbitrary rules that were supposed to relate to English. When grammarians dangled their rules, many of us got splitting headaches from worry about dangling participles and split infinitives.

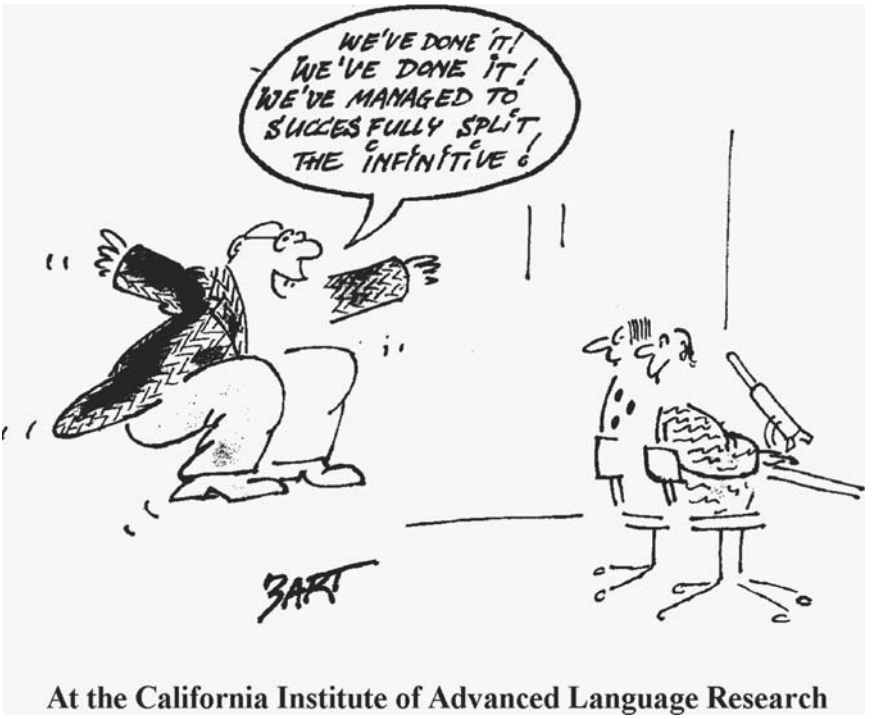
The good news is you *may* split infinitives. In fact, you may, on occasion, violate every one of the "rules" dreamed up by generations of grammatical sticklers. The obvious purpose of grammatical rules is to facilitate clear communication. When rules of grammar do not serve this purpose, they should be disregarded.

A sentence is a unit of *thought*. If you write it down, it becomes a unit of expression. The truth is: If you *think* logically, you *write* logically. A logical sentence is a good sentence. Now let's turn that around: A good sentence is a logical sentence. You will learn to *think* more clearly as you learn to *write* more clearly.

GUIDING PRINCIPLES

The principles of scientific writing derive from the purposes of scientific publications. The basic purposes of scientific publications are (1) to *educate*, (2) to *inform*, and (3) to *record*. (Some might add a fourth purpose: to *persuade*.)

Before undertaking any type of writing, the author should consider the goal or purpose of the work, its intended audience, and its ultimate form (journal article, newsletter, online publication, website, e-mail, blog, oral presentation,



(www.CartoonStock.com.)

grant application). With scientific writing, the goal is often to advance understanding (to educate), so you want to provide information that is clear, complete, concise, and understandable to its intended audience. Scientific writing should also be factual and objective (to inform). In addition, scientific writing must stand up over time, as publications are archived so they can be viewed again in the future (to record). And of course when it comes to writing grant applications, writing must not only be clear, complete, concise, and understandable—it must be persuasive.

The archival use of journals is important, because a journal in a library or electronic archive can be consulted by a great variety of readers, for any number of reasons, over a long time period. Many articles can now be accessed from the publisher's website any time of the day or night, over and over again if desired. These online resources have become a sort of DVR for scientists.

The audience that scientists primarily write for is fellow scientists: people who value precision and demand accuracy. More important, this audience is one that is not reading for entertainment (one hopes) but to increase understanding and perhaps even build on society's base of scientific knowledge. In some cases, the reader may be trying to replicate the results the scientist has reported. Therefore, with the possible exception of cookbooks and bomb-makers' manuals, scientific papers are read more carefully than any other type of writing.

As society has advanced, the importance of clear communication among scientists and between scientists and others has become even greater. While at one time a failure to clearly state a scientific result might have meant the loss of a new technique or an improved method, in today's world a mistake can have devastating results, such as a massive oil spill, tragic transportation accident, uncontrolled epidemic, or other catastrophe. According to Carolyn Boiarsky, a professor in the Professional Writing Program at Purdue University Calumet, many of the memoranda and letters containing warnings of impending disaster relating to the Chicago flood, the Three Mile Island nuclear accident, and the *Challenger* and *Columbia* shuttle disasters were ignored—at least in part—because the writers did not communicate clearly, which led to their being misunderstood.[1]

Failure to clearly explain scientific concepts to the public can result in a citizenry that underestimates the importance of science, misunderstands basic scientific principles, and makes decisions (and votes!) based on erroneous perceptions. Some say that the public's failure to accurately perceive risk and take action on such issues as climate change, human health, and environmental impacts can, at least in part, be attributed to scientists' failure to clearly communicate the information necessary for decision making.

Marshall McLuhan was right when he said "the medium is the message" in the early 1960s,[2] foreseeing the impact of electronic communications decades before anyone Googled or tweeted. His observation that the form of communication matters more than its content is arguable, but the form is clearly important. Scientific journals, popular science magazines, conference posters, PowerPoint presentations, website content, virtual publications, and e-newsletters may all be outlets for scientific writing, but the author must alter the style and format of the writing to match the medium. Even within a particular medium, variations can be considerable. For example, scientific journals have varied requirements, style guides, and acceptance criteria. Scientific organizations often have multiple publications, each with its own mission, even within a relatively narrow field. One of the most helpful things authors can do is

to carefully study the publication outlets they intend to write for *before* putting down the first word.

THE ENGLISH LANGUAGE

> The finest language is mostly made up of simple unimposing words.
>
> —George Eliot

English really *is* simple. Consider this: English has a truly massive vocabulary of some half-million words, but how many different *kinds* of words does it have? The answer is nine—the nine "parts of speech." You could construct nine pigeonholes, and every one of those half-million words would fit into one (or more) of those pigeonholes. Thus, to get a real feel for the use of English, you do not need to master a half-million words (you *will* need to master a few thousand); instead, you need to look at the nine kinds of words and learn a few simple rules about using them.

Then, you can group words into phrases and clauses. How many phrases and clauses are there? There are essentially four main types of phrases and two types of clauses. Of course, you need a few definitions and a few rules—simple rules.

Next, you can combine phrases and clauses into sentences. How many different types exist? A mere six. Every sentence ever constructed in English is of one of these six types. Relatively simple rules for constructing and punctuating these six types of sentences can be stated—and they will be stated, clearly and simply, in this book. Read on.

THE PATH TO SIMPLICITY: ORGANIZATION

> Science is the systematic classification of experience.
>
> —George Henry Lewes

Confused thinking leads to confused writing, so the path to simplicity begins with organizing one's thoughts. As Aristotle said: "A job well begun is half done." Before putting pen to paper (or more likely, fingers to keyboard), consider the organization of the material and the best way to communicate it.

Of course, all types of writing are "organized"; however, scientific writing is rigidly organized—particularly when it comes to scientific papers—and each scientific paper is organized in the same way. (This is true for the vast majority of research papers, less true for other types of writing produced by scientists.)

The type of organization used for most scientific papers is known by the acronym IMRAD (Introduction, Methods, Results, and Discussion), although other formats (such as IRDAM) have become common as well. (Readers interested in a complete discussion of this system should consult *How to Write and Publish a Scientific Paper* by Robert A. Day and Barbara Gastel.)

Communication depends not just upon the broadcasting of information, but upon the receiving (and understanding) of it. If scientists document their work in a manner understandable only to themselves, science will not progress. Imagine what would happen if every scientist wrote in a different language. Studies would be documented, but there could be no sharing of information, and therefore no replication of studies. Without replication, understanding would not advance. Therefore, communicating in a way that enables others to comprehend is a necessary part of being a scientist.

Science relies on precision. The same care that the scientist takes to measure a sample, calculate a standard deviation, or derive a result should be applied to the communication of that information through clear writing.

Organizing before writing helps accomplish two goals: it ensures that all essential material is included and that all unnecessary material is left out. When presenting science, you must give the reader all the information necessary to ensure understanding and, in the case of scientific papers, the information necessary to replicate the work. It is also important to refrain from digression and to avoid including extraneous information, both of which can interfere with comprehension.

A good place to begin is with an outline. An outline:

- Helps the author identify the most important aspects of the study
- Guides the writing process
- Helps organize ideas
- Helps identify areas where more information or research is needed
- Orders complex material in a logical way
- Shows relationships among ideas
- Provides a way to break larger topics into smaller sections
- Defines boundaries and groups
- Helps prevent digression and the inclusion of extraneous information

Before beginning, establish the purpose of the written piece. Determine the audience you are writing for, list all the ideas that you want to include, and list the key points that need to be made. Group related ideas together and arrange material in subsections from general to specific or from known to unknown.

Start by listing the major categories of information in a logical way. In a scientific paper, you would use the IMRAD format or something similar. In other kinds of writing, you would identify the basic topics covered. Under each of these headings, list two or more subordinate concepts or categories of information. If one category has a much larger number of subcategories, you may want to break it into two or more categories. You can then list subordinate points under the subcategories as well. Don't be concerned with letter or Roman numeral systems unless you are working on a large document, such as a book, and find it a helpful way to quickly locate various parts of the outline. It does help to indent or use bullets or hyphens to identify subcategories.

When you have completed the outline, take a step back and look at it critically. Does the order make sense? Will the concepts build logically and the information follow an orderly progression? Is there an appropriate category for every piece of information you need to include? You will save yourself a lot of editing time by organizing your information before you begin writing.

Scientific papers are not the only place for organized writing. Any type of scientific writing benefits from good organization. Complex concepts should be presented step by step, from the general to the specific and from the known to the unknown. Discussions may follow the opposite path, from specific results to where they fit into the larger picture. No matter what structure you use, create a roadmap, follow it carefully, and be sure you don't lose any readers along the way.

> He talked with more claret than clarity.
>
> —Susan Ertz

2

Kinds of Writing

> Writing well means never having to say, "I guess you had to be there."
>
> —Jef Mallett

Writing can be used in many ways to express ideas. Thus, there are many kinds of writing. One writing style might be appropriate for one purpose but totally inappropriate for another. Many writing courses in our colleges and universities are appropriate for teaching literary writing. In some ways, however, they are inappropriate for teaching the principles of scientific and technical writing.

Life would be bleak indeed without the grand heritage provided by our poets, novelists, dramatists, and essayists. However, there is a world of difference between literary writing and scientific writing. The first deals primarily with feeling, emotion, opinion, and persuasion. The second emphasizes the dispassionate, factual recording of scientific investigations. Literary writing uses language of extraordinary beauty and complexity, with fascinating metaphors and other figures of speech; scientific writing uses prosaic words of exact meaning organized simply into precise phrases, clauses, sentences, and paragraphs.

Does this mean that scientific writing never expresses feeling, emotion, opinion, and persuasion? Of course not. The practice of science is engaged in by scientists who have the same complement of good and bad points as anyone else. Thus, the above paragraph is too simplistic, because scientific writing is often—sometimes heavily—infested with persuasion, opinion, and so on. But the ideal of dispassionate, factual recording of the results of scientific investigations is still worth striving for.

Does this mean that scientific writing must be dull? A clear sequence of exciting new information can be fascinating. Dullness can result when writers give up the pretty ornaments of literary writing; however, if clarity is increased, the reader may enjoy the comprehension and not notice the loss of ornaments. In writing, as in fashion, true elegance often results from the simple rather than the ornate.

Admittedly, however, two schools of thought exist even in literary writing, with one school advocating clarity and simplicity and the other school defending complexity and "necessary" difficulty. For scientific writing, most side with the "clarity and simplicity" school.

A feature of literary writing is the author's "voice." Voice can take readers from words on a page to images, senses, and emotions inside their own heads. A good writer uses grammar, word choice, punctuation, writing style, and subtle characterization to develop a voice that creates an impression or even an image in the mind of the reader.

The "scientific voice" requires precise, consistent vocabulary, clear sentences, and a logical, sequential approach to the subject matter. Whereas the literary writer would strive to avoid repetition and thus use synonyms to keep from using the same word over and over, the scientific writer must be consistent to avoid confusion. While a literary writer might take pains to create complex sentences to dazzle the reader, the scientific writer must make an effort to craft simple, elegant sentences that telegraph the information. And while a literary writer often intentionally places scenes out of chronological order to create mystery, the scientific writer must build the story systematically along a path the reader can not only follow but be able to replicate. Complex information must be broken down into simple elements, and difficult procedures must be described one step at a time. The literary writer is the ship's cruise director, casually creating surprises and diversions; the scientific writer is the ship's pilot, carefully guiding the reader toward the destination.

Scientific writing is not the same as *science writing*. They are related, of course, because the subject matter of each is science. However, an important distinction to keep in mind is that scientific writing is written by scientists for an audience of scientists, whereas science writing is written, sometimes by scientists and sometimes by writers who are not scientists, for an audience of nonscientists (or scientists reading outside their own narrow discipline). Thus, the vocabulary, tone, and complexity of these two types of writing differ.

Further, scientists must write in different ways for different purposes, using one language in their research papers, a slightly different language in their review papers, and a very different language in communications directed to lay audiences. They must also vary their writing to match the medium. Style, word usage, length of sentences, and organization of material must be modified based on whether the material will be read in a print journal, viewed online, seen as a PowerPoint presentation, or experienced as an interactive webcast.

The growth of online publishing and the trend toward shorter forms of communication have also led to new options. For example, *mBio*, an online-only publication of the American Society for Microbiology, accepts all of the following: research articles (reports of major advances in microbiology or allied fields), observations (short descriptions of research results of exceptional importance and unusual interest to the broad microbiology community), mini-reviews (brief summaries of important developments in microbiology research), opinions and hypotheses (short articles that present original insights and thoughts without complete supporting data), commentaries (short invited articles that discuss *mBio* papers of special interest), and perspectives (brief reviews on a topic in which opinion and synthesis are encouraged). These new options give scientists many potential outlets for communicating their work.

The Internet also makes possible longer and more complex communication vehicles. For example, a printed article can reference an online supplement that provides additional information and resources. Authors can refer readers to web-based multimedia materials such as additional photos and graphics, PowerPoint presentations, audio and video clips, or interactive activities such as surveys, games, or quizzes. The ability to link to supplemental information online allows scientists to provide much greater depth and context for their research than is possible in printed media alone. Some sites even provide a "Comments" feature that allows other scientists to make remarks, share information, debate controversial points, or provide additional information.

3

Writing Style

> Science is organized knowledge.
>
> —Herbert Spencer

DEFINITION OF STYLE

Style defines the *personality* of a publication. Each publication has its own style, its own personality. Well-edited journals have distinctive styles. Careful writers make it their business to learn the general stylistic conventions used in their field and the specific style requirements of the particular journal for which they are preparing a manuscript. (Writing for electronic media is covered in Chapter 20.)

GENERAL STYLE IN SCIENTIFIC WRITING

The style of scientific writing is distinctive in two principal ways. First and foremost, scientific writing should be simple and clear. Its purpose is not to entertain or to paint pretty pictures, but to communicate complex information.

But, you say, why should scientific writing be simple, plain, and ordinary? Why can't it be *interesting*? It can be. Good scientific writing is often beautiful in its elegant simplicity. However, if you are faced with a choice between expressing a thought with a beautiful but complex metaphor or with simple, concrete words, choose the concrete words. There is really only one essential goal in scientific writing: clarity.

Short words are not necessarily dull. Publisher Bennett Cerf bet Dr. Seuss that he couldn't write a book using only 50 different words. The result was *Green Eggs and Ham*, one of the best-selling children's books of all time. Only one of the 50 words contains more than a single syllable ("anywhere"). One of the most famous speeches in history, Lincoln's Gettysburg Address, contained only 267 words, of which 196 (73%) were one-syllable words.

The second general aspect of style in scientific writing is organization. When writing a scientific paper, this refers to organizing by the IMRAD system or a similar format.

Specific Style in Scientific Writing

Style has so many aspects that entire books have been written on the subject. These books (called style manuals or style guides) are filled with useful information pertaining to specific fields.

Every scientist should own or have easy access to at least one style manual. *Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers*, 7th edition, The Council of Science Editors, 2006, is a good place to start. Chemists should own *The ACS Style Guide: A Manual for Authors and Editors*, 3rd edition, The American Chemical Society and Oxford University Press, 2006. Medical and biomedical researchers should own the *American Medical Association Manual of Style*: *A Guide for Authors and Editors*, 10th edition, 2007. Psychologists should own the *APA Publication Manual*, 6th edition, American Psychological Association, 2009.

Professionals in *any* field can find a wealth of information in *The Chicago Manual of Style*, 16th edition, University of Chicago Press, 2010. Other style guides of note include:

- *The Manual of Scientific Style: A Guide for Authors, Editors, and Researchers*, Elsevier, 2009
- *MLA Handbook for Writers of Research Papers*, 6th edition, Modern Language Association, 2003
- *MLA Style Manual and Guide to Scholarly Publishing*, 3rd edition, Modern Language Association, 2008
- *Electronic Styles: A Handbook for Citing Electronic Information*, 2nd edition, Information Today, 1996
- *Citing Medicine: The NLM Style Guide for Authors, Editors, and Publishers*, 2nd edition, U.S. National Library of Medicine, 2007
- *The Columbia Guide to Online Style*, 2nd edition, Columbia University Press, 2006

Online Resources (some require a subscription or membership for full access)

- AMA (American Medical Association):
  AMA Style
  www.amamanualofstyle.com/oso/public/index.html
- APA (American Psychological Association):
  Tutorial on the basics of APA Style
  www.apastyle.org/learn/tutorials/basics-tutorial.aspx

- Chicago Manual of Style:
  www.chicagomanualofstyle.org/home.html
- IEEE (Institute of Electrical and Electronics Engineers):
  IEEE Standards Style Manual
  www.ieee.org/documents/stylemanual.pdf
- NLM (National Library of Medicine):
  Citing Medicine: The NLM Style Guide for Authors, Editors, and Publishers
  www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=citmed
- Uniform Requirements for Manuscripts Submitted to Biomedical Journals (Vancouver style referencing): International Committee of Medical Journal Editors. Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publications
  www.icmje.org
- Writing Guidelines for Engineering and Science Students
  www.writing.engr.psu.edu

In addition, a number of universities provide online resources for their faculty and students. Some of this information is also available to the public. Here are some examples:

- Purdue University, *The Purdue OWL*, Purdue University Writing Lab
  owl.english.purdue.edu/owl/search.php
- Indiana University, Science Writing Aids www.indiana.edu/~cheminfo/ca_swa.html
- University of Chicago, Science Writing and Style Guides
  http://writing-program.uchicago.edu/resources/grammar.htm
- University of Minnesota, Writing Guides and Style Manuals in the Biological and Health Sciences
  www.biomed.lib.umn.edu/guides/stylemanuals#toc17300

In addition to the appropriate style manual, writers should check to see whether the publisher provides instructions for authors. Every scientist should read the instructions for authors of a journal before starting to write a paper, consult the instructions while writing the paper, and check the paper against the instructions before submitting it. The instructions often contain the highly specific information that defines the editorial and typographical personality of that particular journal as well as the basics of how and where to submit manuscripts. Many journals publish their instructions once a year, often in the January issue, but they are generally posted on the publisher's website as well.

Authors who ignore these specific journal requirements are likely to receive rejection letters.

SPELLING AND GRAMMAR

> Only in grammar can you be more than perfect.
>
> —William Safire

Naturally, proper grammar should be used, and words should be spelled correctly. But correctness may sometimes depend on style. Is it *color* or *colour*? The answer depends on whether the journal uses American English or British English. Is *labeled* or *labelled* correct? Unfortunately, the dictionaries seem to be about evenly split, so both are correct. However, journals and publishers are likely to choose one or the other, and their copy editors will attempt to invoke this adopted style consistently. Is it *ameba* or *amoeba*? Is it *orthopedics* or *orthopaedics*? The simpler (and newer) spelling seems to be replacing the older usage, but some journals retain the older style.

Does this matter? In individual instances, such choices seem to have little meaning. But, collectively, such considerations may have great importance. For one thing, consistent spelling simplifies things for the reader, especially for the reader whose native language is not English. If the same word is spelled two different ways in one article or in one issue of a journal, a reader is likely to assume that the different spellings somehow mean different things. Confusion, or at least delayed comprehension, can result.

More importantly, slight alterations in spelling sometimes do indeed mean different things. Two words commonly confused by some scientists are *phosphorus* and *phosphorous*. Both are correct, but the meanings are different. The word *phosphorus* is a noun, and it refers to the element phosphorus. The word *phosphorous* is an adjective, not a noun; it refers to compounds containing phosphorus, in particular those with a valence lower than the valence in phosphoric compounds.

Are such slight alterations in spelling really important? Yes, because even a slight misspelling can cause confusion of meaning. And as scientists increasingly rely on search engines to locate journal articles, variations in spelling can mean the difference between finding an article and missing it.

Computer spell checkers can be a tremendous help. By highlighting words that are misspelled, spell checkers call our attention to mistakes that might otherwise be overlooked. However, spell checkers only catch misspelled words that are not words, so do not rely on them completely. Won can plane lee sea that spell checkers due knot ketch awl spelling miss takes.

"Are you sure brook is misspelled? It doesn't have a red squiggly line under it."

(www.CartoonStock.com.)

Stylistic conventions relate not only to spelling but to such things as word choice and capitalization. Which is correct: *formalin*, *Formalin*, or *formaldehyde*? The term *formaldehyde* is a generic name, and it is normally acceptable. The term *Formalin* is a registered trademark, and this proprietary status is recognized by the capital *F*. The use of *formalin* without a capital is incorrect. Finally, *Formalin*

should not be cavalierly changed to *formaldehyde* (on the grounds that most journals prefer generic names to proprietary names), because formaldehyde exists as a gas and Formalin is a solution containing a small amount of methanol.

By the Numbers

Because numbers are used so often in science, it will be helpful to memorize the stylistic rule that a great many scientific publications follow: spell out one-digit numbers (one to nine) and use numerals for all larger numbers (10 and up).

One solution turned blue, two turned yellow, and three remained clear.
All 13 specimens were collected in the wild.

Now that you have memorized that simple rule, you must also memorize the main exceptions.

- Spell out any number that starts a sentence.

Thirteen specimens were collected in the wild.

- Use numerals whenever numbers are followed by units of measure.

I added 3 ml of distilled water.

- In a series, use numerals if any number in the series is 10 or more.

I did 4 experiments on Monday, 5 on Tuesday, and 11 on Wednesday.

By Date

The standard style for dates is "March 18, 2011." In shortened form, we say (in the United States and Canada) "3/18/11." However, this is not good usage because this order is not consistent throughout the world. For example, an

American would write March 18, 2011 as "3/18/11," whereas a European would write the same date as "18/3/11."

Therefore, good usage (as sanctioned by the *Chicago Manual of Style*) would be "March 18, 2011." The European style ("18 March 2011") is also acceptable, but either "18/3/11" or "3/18/11" should be avoided.

The International Organization for Standardization (ISO) has stepped in to create a standard for dates and time. This standard, ISO 8601, runs 33 pages and includes representations for the following: date, time of the day, coordinated universal time (UTC), local time with offset to UTC, date and time, time intervals, and recurring time intervals. The standard advises presenting elements from the largest to the smallest element. For example, a date would be expressed in this order: year-month-day (January 18, 2011 would be expressed as "2011-01-18"). A good overview of the standard is available on the organization's website at www.iso.org.

FORMATTING

The careful author consults the instructions for authors *and* a recent issue of the publication before submitting a manuscript. The author needs answers to such questions as these: What types of headings and subheadings are used? Are footnotes allowed? Which style of literature citation is used? What is the format for tables and figures and their legends? How are chemical and mathematical formulas presented? Get all the answers, and then write with style.

Some typographical conventions are virtually universal. For example, the names of newspapers, magazines, and books are normally set in italic type. On the other hand, titles of articles in newspapers and magazines, and chapter titles in books, are usually cited within quotation marks.

The rules for formatting text have changed now that the author's manuscript can be converted directly to type rather than having to be reset. For example, when manuscripts were typed on a typewriter, it was standard practice to follow the period at the end of each sentence with two spaces. Computer-entered text automatically compensates for spacing, so a single space after a period is now standard.

Guidelines for manuscript preparation vary from publication to publication, but there are some general rules to keep in mind. Use a common software program such as Microsoft Word, and a single standard font such as Times Roman. Maintain margins of at least one inch, and do not embed photographs or illustrations in the text. Use black type without any shading, borders, or

color embellishments. In general, the easier you make it for your editor, the easier life will be for you.

SELF-EDITING

> I believe more in the scissors than I do in the pencil.
>
> —Truman Capote

The first and most important editor is *you*. Whether you're writing an e-mail message or a book, check your written work carefully before sending it. Spelling errors, grammatical mistakes, missing words, typographical errors, redundancies, and other problems convey that either you don't care or, worse, don't know. If there are mistakes in your writing, readers may well assume there are mistakes in your science as well.

You should review your writing in at least three ways. First, make substantive changes. Check to be sure the flow is logical and orderly. Move text around, eliminate redundancy, and make sure instructions are clear and complete. Second, make mechanical changes. Correct any grammar, spelling, or punctuation errors. Refer to the publication's style guide or a general reference such as the *Chicago Manual of Style* to ensure consistency. Third, make proofreading changes. Check all numbers, particularly those with decimals. Make sure charts and figures are referenced correctly and that citations are complete.

If you do nothing else, let your work sit overnight and read it again in the morning. You will be amazed at what you find. Better yet, get a colleague to read it. Fresh eyes—your own or someone else's—are an essential editing tool. Even e-mail messages benefit by being saved as drafts and reread later before sending. Some people swear that reading aloud helps. Another trick is to read each sentence separately, from the bottom to the top of the passage. It helps to proofread from a printed copy. For some reason, it's easier to miss a mistake on a screen.

For longer works, review multiple times. An approach that works well is to look for a particular type of problem each time you read the material. Like a pilot before take-off, go through a checklist to make sure you are ready for launch:

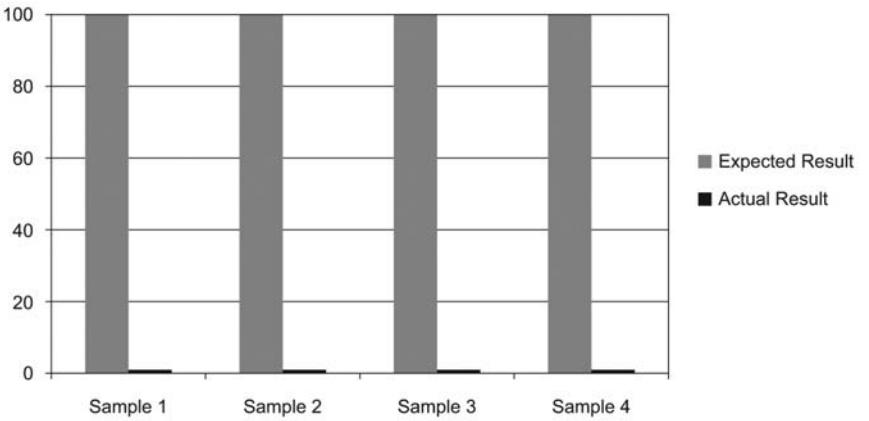
1. Is the content organized logically (IMRAD, chronological, or another system)?
2. Is the manuscript complete?
3. If an experiment or procedure is described, are all steps included, described clearly, and presented in a logical sequence?
4. Are all necessary charts and graphs present, accurate, and labeled correctly (to match the text)?

5. Are all citations present, accurate, numbered correctly, and matched to the text?
6. Are there any grammatical errors (check sentence structure, tense, verb agreement, parallelism, punctuation, and pronoun usage)?
7. Is the writing as clear and as concise as possible (no redundancies, jargon, unexplained abbreviations, or jarring transitions)? (Review the list of problem words and phrases in Appendix 2.)
8. Are there any spelling errors? (Don't just rely on the spell checker's red squiggles. Look for proper capitalization, commonly misspelled words, words that can be spelled more than one way, and words with apostrophes).
9. Are there any number errors? Check decimal points, measurements (both the number and the scale), dates, sample sizes, and other numbers against the original source and for common sense.
10. Have you correctly identified everyone involved in the work (name spellings, titles, degrees, and affiliations)?

Most people have a writing quirk or two. One person may tend to overuse dashes, while another frequently repeats the phrase *in other words*. You might find that you confuse *their* and *there*, or use *less* where *fewer* is correct. Be aware of your quirks and check your manuscript carefully for them.

CHARTS, TABLES, AND GRAPHS

Present information graphically only when a visual image improves comprehension. Some kinds of information benefit from graphic treatment, while



Example of an unnecessary graph

To Show	Use
Trends, relationships, effects over time	Line graph
Relative quantities, comparisons, ranges	Bar graph, histogram
Complex data, exact numbers	Table
Procedure	Flow chart, illustration
Proportions, parts of a whole	Pie chart*
Process, events, interactions	Diagram or flow chart
Spatial relationships	Map
Physical appearance	Drawing, photograph

*Generally not a good choice in scientific writing.

others are better described with words. Don't use a graph just for the sake of using a graph.

The preparation and proper use of charts, tables, and graphs is covered in detail in *How to Write and Publish a Scientific Paper*, but here are some general guidelines:

Label clearly, using common language. Avoid abbreviations (except measurements or other standard abbreviations) and express fractions as decimals. Provide enough information that the chart, table, or graph can stand alone, and then let it do just that. The text should not *repeat* information that is shown on a chart, table, or graph; the text should *refer* the reader to the information provided by the chart, table, or graph.

4

The English Language

> Language is the only instrument of science, and words are but the signs of ideas.
>
> —Samuel Johnson

THE BEAUTY OF ENGLISH

Modern science contends with some extremely complicated problems. Hence, the language in which scientists communicate must be capable of precise descriptions of complex problems and concepts.

Fortunately, scientists have such a language in English. The skilled user of English has a rich supply of words to describe and differentiate the finest gradations of meaning. We can even play games. For example, the word *stand* has many different meanings: two common usages are "to rise to an erect position" and "to tolerate." Thus, we can describe a person who doesn't like desk work as one who might say "I can't stand sitting." The remarkable thing, of course, is that the English language has this tremendous array of words that can be constructed into phrases, clauses, and sentences in a seemingly inexhaustible variety of ways if we play by the rules of logic.

ENGLISH—THE INTERNATIONAL LANGUAGE

It has often been said that science is international. Now it can be said that English is international. For scientists especially, English is virtually the *only* language, at least when it comes to publication.

Look at what has happened in the field of microbiology. For many years, the principal language of this science was German, and the leading journal was the renowned *Zentralblatt für Bakteriologie.* This distinguished journal is still published, and the title remains the same. But the articles are in English.

The *Journal of Antibiotics*, published in Tokyo, is perhaps the most important journal in the world dealing with this subject. Every word is in English.

For French, perhaps the denouement (one of many useful words that came into English from French) to its use as a language of science occurred in 1989, when the January issue of the famous *Annales de l'Institut Pasteur* was published under a new name, *Research in Immunology.* Every article was in English, as were the instructions for authors, the book reviews, and even the small-print subscription information. An accompanying editorial had this to say:

> Times have changed . . . biological sciences, and immunology in particular, have evolved, with an enormous increase in the volume of research work performed and very distinct requirements in terms of scientific communication. . . . All journals must now find their roots in the international community at large and interact with a wide network of scientists and institutions. Such will be the case for "Research in Immunology," which will now replace the one hundred and one year old "Annales."

UNIVERSALITY OF ENGLISH

> If you can speak three languages you're trilingual. If you can speak two languages you're bilingual. If you can speak only one language you're an American.
>
> —Author unknown

English is not just the international language of science. It is the international language of business and technology.

In late 1986, PBS presented a six-part series (later published in book form) titled "The Story of English." In the first scene of the first episode, viewers saw and heard the conversation between an airplane pilot and a control tower operator while the plane was being brought in for a landing. Every word was in English. Eventually, the narrator broke in to inform the audience that they were witnessing a pilot-tower conversation during a flight originating and ending in Italy. The tower, of course, must handle both domestic and international flights, and use of a single language is a necessity.

The world is getting smaller indeed, and English is becoming the international language. Any final resistance to this trend is being smothered by the Internet. Not only do adults communicate easily across international lines via the Internet, but children participate in interactive games with their friends in countries all over the world. Instant messaging and chat rooms make it easy for them to communicate—in English.

> The Internet: where men are men, women are men, and children are FBI agents.
>
> —Unknown source

With the growing sophistication of computer software, some people hope that there will come a time when writers can enter information in any language and have the software automatically translate the material into a different language. Translation software has improved greatly and offers some help to those struggling with a phrase or two, but, at this time, these programs are of little help to scientists. Translations are often clumsy, and most programs are not capable of translating scientific terminology.

RESPONSIBLE USE OF ENGLISH

So, if English is now the international, universal language, what does this mean to scientists? Broadly, it means that scientists must use English with precision. All scientists, wherever they are in the world and whatever their native language, must acquire reasonable fluency in English. Except in a few small scientific backwaters, it simply is no longer possible to do science except in English. No longer can a scientist keep up with the literature or contribute to the literature without command of the English language. No longer can one depend on colleagues for help in literature searches or for translation of manuscripts. Just as modern scientists must learn the intricacies of increasingly complicated laboratory equipment and experimental protocols, they must also learn to weigh out their words, in English, with the same precision they must use to weigh out their reagents in their laboratories.

Scientists (and perhaps scholars in all fields) should learn to use English *simply*. Short, simple words—in short, straightforward sentences—usually convey meaning more clearly than do esoteric words and convoluted sentences. This concept is a bit controversial, because the skilled writer, using that wonderful, massive vocabulary we have available in English, can paint word pictures of overwhelming beauty. On the other hand, clarity and meaning can easily fade into the background.

The other reason for using simple English in scientific papers, however, should not be controversial. English is the international language of science; however, most scientists grew up using a language *other than* English.

Much of the growth in scientific research is in countries where English is not the primary language. According to Jonathan Adams, research evaluation director at Thomson Reuters, in terms of growth in scientific research, China is now second only to the United States, with a 64-fold increase in peer-reviewed scientific papers since 1981. If it continues on its trajectory, China will be the largest producer of scientific knowledge by 2020.[1] India and Brazil

have also seen a substantial increase in articles published in peer-reviewed journals.

Therefore, as many scientists around the world are struggling to master English, scientists should all do whatever they can to write clearly and simply. Language, like science itself, can lead to confusion when we are not careful.

English has a number of idiosyncrasies. In English, you can say "I spent the evening with my professor" and no one knows whether your professor is male or female. In many other languages, words such as *professor*, *neighbor*, and *friend* can only be expressed as either male or female. In Spanish, for example, you would use *el profesor* or *la profesora* to refer to a male or female professor respectively. Languages such as French, Spanish, German, and Russian also assign a gender to inanimate objects. So in Russian, *water* is a "she," in German *apple* is a "he," and in French *fork* is a "she" (while it's a "he" in Spanish). Note the use of *it's* to refer to the fork at the end of the previous sentence. This is possible because English does not assign a gender to inanimate objects.

What English does do is assign a *timing*. English verbs indicate when the action took place: *eat*, *eating*, and *ate* by their form tell the reader whether the action takes place in the future, present, or past. In Chinese, the same form of the verb can be used. The timing of actions is obviously a critical part of conducting an experiment, so being clear about when an action takes place is essential.

> The chief merit of language is clearness, and we know that nothing detracts so much from this as do unfamiliar terms.
>
> —Galen

5

Grammar

A philosopher once said, "Half of good philosophy is good grammar."
—A. P. Martinich

RULES OF GRAMMAR

You have no doubt heard a number of the basic rules of English grammar: do not split infinitives; do not end sentences with a preposition; do not use singular subjects with plural verbs; do not use double negatives. Over time, some of those rules have become more like guidelines to be ignored when the greater good is at stake. That greater good is *clarity*.

To achieve clarity, we advise using the "grammar of meaning." After all, the goal of the writer is to convey meaning to the reader. The critical question, then, is whether a sentence conveys clear meaning. If it does, it is a good sentence, no matter how many so-called rules have been broken. If the sentence is not clear, it is a poor sentence, no matter how impeccable the grammar.

PARALLELISM

The term *parallelism* simply refers to logic: putting like with like and unlike with unlike. In fact, it is the logical organization of sentences that defines the essence of grammar.

Sentences and paragraphs should be consistently logical. What does it take to write this way? First, it takes a solid understanding of the basic structure of the four types of declarative sentences (see Chapter 16). Secondly, we must consistently keep the words in our sentences, and the sentences in our paragraphs, in logical order. In other words, we must keep our apples together with other apples and not mix them up with oranges.

Now, look at the above paragraph. Is it in any way lacking in parallelism (logic)? Yes. It contains an obvious (but extremely common) error. The paragraph contains a *First* and then a *Secondly*. To be logically consistent, it should

be *First* and then *Second* or perhaps *Firstly* and then *Secondly* (although the *-ly* words require extra keystrokes and provide absolutely no additional meaning).

Aluminum is light, ductile, and has strength.

Remember that adjectives should be parallel with other adjectives, verbs with verbs, phrases with phrases, and clauses with clauses. The above example should read as follows:

Aluminum is light, ductile, and strong.

This mistake is often made with bulleted lists.

The sedimentary and geological context of the new find indicates that the two hominids:

- died around the same time
- Debris flow carried them to their place of burial.
- The fossils were found along with a wide range of other animals, including saber-tooth cats, hyenas, and wild dogs.
- Many of the fossil skeletons are intact and well preserved, suggesting they were trapped in the cave where they could not be reached by scavengers.

Using parallel construction makes the list easier to read and understand:

The sedimentary and geological context of the new find indicates that the two hominids:

- died around the same time
- were carried by debris flow to their place of burial
- were found along with a wide range of other animals, including saber-tooth cats, hyenas, and wild dogs
- were intact and well preserved, suggesting they were trapped in the cave where they could not be reached by scavengers

AGREEMENT OF SUBJECTS AND VERBS

If there is any grammatical rule that makes sense, it is the one that says that singular subjects take singular verbs and plural subjects take plural verbs. Most verbs have a form, usually ending in *s*, that goes with singular subjects and another form, without the *s*, that goes with plural subjects.

She runs.
They run.

You should always keep this rule in mind, and you should follow the rule most of the time. A person who says or writes something like "They was going to the party" is likely to be accused of bad grammar and not invited to the next party.

Do not follow this rule rigidly, however, because, like all grammatical rules, there are many exceptions. In a sense, the rule is indeed valid once you understand the grammar of meaning.

A series of experiments (was, were) performed.
A number of experiments (was, were) performed.

Is *was* or *were* correct in the above sentences? In both, the subjects appear to be singular in number. (The subject of the first sentence is *series*; the subject of the second sentence is *number*. The word *experiments* in each sentence is the object of a preposition, a word used to relate a noun or a pronoun to some other part of the sentence.) In the first sentence, the word *series* (which can be either singular or plural) almost certainly refers to a related group of experiments considered as a whole or as one group. Therefore, the singular verb form is correct: A series of experiments *was* performed.

In the second sentence, the word *number* is seemingly singular, but the grammar of meaning would tell us that "a number of experiments" is almost certainly more than one (or the author would have said "One experiment"). Thus, we must logically use the plural verb form: A number of experiments *were* performed.

In this case, a milligram of logic is grammatically more important than a kilogram of rules. Consider the following sentences:

A bunch of grapes (is, are) on the table.
A bunch of apples (is, are) on the table.

Following the grammar of meaning, we ask what really is on the table. In the first sentence, we do not have a number of unconnected grapes on the table; we have a "bunch," which (when applied to grapes) means a connected group. Thus, one "bunch" takes a singular verb: A bunch of grapes is on the table.

In the second sentence, the word *bunch* applies to apples, which grow singly and not as connected groups. Here, *bunch* is used, a bit informally, to indicate a group of these single entities. Thus, we have many apples, and logically we must have a plural verb: A bunch of apples *are* on the table.

Scientific and technical writers should use this same logic in sentences containing units of measure. Is it "3 ml was added" or "3 ml were added"? Logic tells us that "3 ml was added" is correct, because *one quantity* was added; whether that quantity was 1 ml or 750 ml is irrelevant. (Rarely, 3 ml of a reagent might be added sequentially, 1 ml at a time; in such an instance, "3 ml were added" would be correct.)

Many errors in agreement relate to a different kind of meaning, and that is simple dictionary meaning.

If this criteria is met, we will have no problem.
This media lacks glucose.
This data is incomplete.

In these sentences, the writers were evidently unaware that *criteria* is the plural of *criterion*, *media* is the plural of *medium*, and *data* is the plural of *datum*. Other errors occur because the writer is confused by intervening elements and forgets to match the subject with the verb.

The use of various acids and other reagents often result in marred surfaces.

The person who wrote this sentence thought the plural verb *result* should follow the plural *acids* and the plural *reagents*. However, *acids* and *reagents* are objects of the preposition *of*. The subject of the sentence is the singular *use*, so the sentence should say "use . . . *results* in marred surfaces."

SPLIT INFINITIVES

> When I split an infinitive, God damn it, I split it so it stays split.
>
> —Raymond Chandler

Many people seem to find English, and perhaps life itself, difficult in the absence of rigid rules or laws. Nevertheless, there is no valid rule against split infinitives, and those people who insist on not splitting infinitives often end up with awkward or confusing sentences. Using a split infinitive, you can say:

I fail *to completely understand* rigid rules.

People who abhor split infinitives would place *completely* just before or just after the infinitive or at the end of the sentence.

I fail completely to understand rigid rules.
I fail to understand completely rigid rules.
I fail to understand rigid rules completely.

Note how the meaning of the original sentence ("completely understand") has been drastically altered in the first revision (in which the reader assumes that I "fail completely") and also in the second revision (in which the reader assumes that I am talking about "completely rigid" rules). In the final revision, the reader can't really assume anything because *completely* could modify either *fail* or *understand*. Thus, in this very common kind of sentence, the only safe place for the adverb (*completely*) is smack in the middle of the infinitive phrase ("to completely understand").

And if you aren't convinced, imagine where we would be without the most famous split infinitive in the universe:

> Space . . . the Final Frontier. These are the voyages of the starship Enterprise. Its five-year mission: to explore strange new worlds; to seek out new life and new civilizations; *to boldly go* where no man has gone before.

DOUBLE NEGATIVES

The rule is sometimes expressed as "Don't use no double negatives." Like most rules, this one makes sense if it is used as a general guideline rather than

as a rigid rule. Often, two (or more) negatives can be used in the same sentence successfully. The meaning of the following sentence is crystal clear, even though it contains a quintuple negative:

> Ain't nobody around here who knows nuthin' about nuthin' nohow.

On the other hand, a second negative sometimes has the effect of canceling the first, giving the sentence an unintended positive meaning. These we have to watch for. Few of us would have problems with such obvious double negatives as "I ain't got no money." Such constructions sound ungrammatical, and they are, although their meaning is clear (and negative). These are easy to spot when obvious negatives (*no*, *not*, *nor*, *never*) are used. More troublesome are the hidden negatives. For example, *unwell* is a negative of *well*.

> She is well.
> She is not well.
> She is not unwell.

The meaning of the first two sentences is clear. The third sentence, however, contains two negatives, the second canceling the first. (If she is not unwell, she must be well.) If she really is well, the sentence should be stated positively.

> *Double negative*: None of the specimens were not contaminated.
> *Restated as a positive*: All of the specimens were contaminated.

Other common (and confusing) double negatives are "not infrequently" and "hardly uncontroversial." Some of the worst sentences are those that start out with confusing double negatives, such as "Although it is not unknown for scientists to . . ." In such sentences, comprehension is lost before we even get to the main clause.

> Sometimes students who are new to lab duty feel uncertain about asking for help. Don't.

This example is not a double negative; it is a single negative. But what is being negated? Are students being told not to do lab duty, not to feel uncertain, or not to ask for help? Whenever possible, use a positive construction rather than a negative one. A good rule is to follow the words of the old song: "Accentuate the positive; eliminate the negative; and don't mess with Mr. In-Between."

An English teacher once taught the lesson on double negatives by explaining that two negatives actually create a positive. However, he continued, two positives can never make a negative. From the back of the room a student interjected "Yeah, right."

SYNTAX

Syntax is the branch of grammar dealing with word order. For a sentence to make sense, the words must be presented in a logical sequence. In some languages, word order is less important (the emphasis is in the inflection), but in English it is critical. If the words are not in reasonable order, the result can be at least confusing and sometimes ridiculous.

I knew a man with a wooden leg named George.

Was the man named George, or was the wooden leg named George? Most likely, the sentence should have read "I knew a man named George with a wooden leg." (This could, however, be construed as referring to a man named "George with a wooden leg." A better construction would be "I knew a man named George who had a wooden leg.")

Consider the title of this article from *JADA* (Vol. 141, February 2010, pg. 171): "Restorative Treatment Thresholds for Occlusal Primary Caries Among Dentists in the Dental Practice-Based Research Network." Presumably it was the patients with the caries, not the dentists.

Few people can recognize participles, dangling or otherwise. However, there is no great need to learn about participles and other arcane niceties of English. What you need to learn is the fundamental principle of syntax: *modifiers should be as close as possible to the words, phrases, or clauses they modify.* This "rule" is nothing more than logic: if words relate to each other, they should be near each other.

Some modifiers really "dangle," in that they have nothing to modify.

While having lunch, the reaction mixture exploded.
In analyzing the data statistically, the *Salmonella typhimurium* infections were indeed rare.

Obviously, the reaction mixture was not having lunch. Presumably, a scientist or a student or somebody was having lunch, but the sentence does not yield this information; therefore, the sentence is silly. The second sentence is just as silly because *S. typhimurium* infections can't analyze data (statistically or otherwise). Yet sentences like these, in which the agent of the action has been omitted, abound in poor scientific writing.

Single words, usually adverbs, can cause problems if the writer is careless about where such words are inserted in the sentence. The most common offender is the word *only*. For example, *only* can be inserted anywhere in the following sentence. However, read the versions of the sentence carefully, and you will note considerable variations in meaning.

Only I hit him in the eye yesterday.
I *only* hit him in the eye yesterday.
I hit *only* him in the eye yesterday.
I hit him *only* in the eye yesterday.
I hit him in *only* the eye yesterday.
I hit him in the *only* eye yesterday.
I hit him in the eye *only* yesterday.
I hit him in the eye yesterday *only*.

The variations in meaning range from "Only I" to "yesterday only," visiting a one-eyed man ("the only eye") along the way.

Even the best of writers occasionally get their *only*s in the wrong place:

Politics are almost as exciting as war, and quite as dangerous. In war you can only be killed once, but in politics many times.
—Winston Churchill

In the above sentence, "you can only be killed' is not good syntax. (The connotation is that you can *only* be killed, not tortured, not drawn and

quartered, not sent to a secret prison.) What Churchill should have said was "In war you can be killed *only* once."

The word *only* is not the only word to watch; the syntactical location of the word *just* is just as important.

> *Just* today we visited my aunt.
> Today *just* we visited my aunt.
> Today we *just* visited my aunt.
> Today we visited *just* my aunt.
> Today we visited my *just* aunt. (For someone who also has an *unjust* aunt.)

Consider that there is almost $1,000 worth of difference between the following two sentences:

> I almost wrote a check for $1,000.
> I wrote a check for almost $1,000.

Finally, don't worry about syntax. It's all right if you forget you ever heard of it. But remember logic. If you think and write logically, you will not be guilty of writing a sentence such as the following:

> I went to a town that was 20 miles away on Tuesday.

You might not notice the problem in syntax. The prepositional phrase *on Tuesday* is too far away from the word it modifies (*went*). But you should notice the problem in logic: if the town was 20 miles away on Tuesday, how far away was it on Monday?

THERE'S THE RUB

There is nothing wrong with a sentence beginning with *There*. (See, we just did it.) However, this form of indirect expression is wordy and should rarely be used. The first *there* in the above sentence could be deleted and the sentence reworded to say "Nothing is wrong with a sentence beginning with *There*." There are many other sentences that can be improved by avoiding the *There*

opening. (Many other sentences can be improved by avoiding the *There* opening.)

> A country girl enrolled at the state university. In her first term, she fell in love. When she went home for the winter holidays, she wanted to be honest. So she said to her father, "Paw, there's something I have to tell you. I ain't a good girl anymore." Her father replied, "What? Your mother and I scrimped and saved for years so that you could go to that big city university. Then, after three full months, you come home, and you're still saying 'ain't'!"

6

Words

> Never use a large word when a diminutive one will suffice.
>
> —Unknown source

THE TAXONOMY OF WORDS

Because of its rich vocabulary, the English language can be used to describe both thoughts and things with exquisite precision. Many of these words have unique meanings. Other words have nebulous meanings or mean the same as one or more other words in the language. The unique words, those of certain meaning, are obviously the words of first choice (even if they are long words). More often, however, the choice is between or among words that are essentially synonymous; here, the writer should use the short word or the common word. Usually, the most common word *is* the shortest. However, these choices are seldom easy. The very richness of the English language is daunting to all writers, not just scientists.

> I would never use a long word where a short one would answer the purpose. I know there are professors in this country who "ligate" arteries. Other surgeons only tie them, and it stops the bleeding just as well.
>
> —Oliver Wendell Holmes

CHOICE OF WORDS

English can be daunting. The word *oversight* can mean responsibility or the lack of it. The words *valuable* and *invaluable* mean the same thing. A *reckless driver* is not likely to be a *wreckless driver.* Nonetheless, in spite of the oddities, we can use English reasonably if we try to use the short word, the known word, and the word with certain meaning.

The short word is usually obvious. What is the *known* word? Usually, the known word is the common word. But common to whom?

Two small boys were playing. One said: "I found a condom on the patio." The other asked, "What's a patio?"

While scientists are used to technical terminology, define technical terms that are not likely to be known by your readers. It would not be necessary to define the term *quantum* in a publication geared to physicists, but *the anomalous Hall effect* deserves a short definition. When defining a technical term, avoid using another technical term or any variation of the word being defined. It helps to provide context (the general group the term falls within), followed by specifics (what differentiates the term from related terms). Include in the definition any details that are pertinent to the study you are describing.

The strongest signal of natural selection came from endothelial Per-Arnt-Sim (PAS) domain protein 1 (*EPAS1*), *a transcription factor involved in response to hypoxia*.[1]

Choose the right form of the right word and stick with it. In English courses, you were probably taught to use synonyms (other words that mean the same thing) to avoid repeating the same word. That is fine for literary writing but not for scientific writing. Keep in mind that every such variation can be confusing, especially to nonnative readers who are struggling to understand English. Using stilted or archaic words and phrases such as *incumbent upon* and *behoove* does not make your writing more impressive; it makes it less comprehensible. Consult Appendix 2 for some particularly troublesome words and expressions.

Science depends on specifics: sample sizes, means, standard deviations, measurements, and other quantitative information. Be as specific in your writing as you would be in your work. Don't say "several prior studies," say "four prior studies." Rather than "we spent several weeks preparing the specimens," say "we spent three weeks preparing the specimens," and then explain *how* you prepared them. Just as you would not use generalities when giving directions ("drive several miles and then continue a few blocks"), do not be vague in your writing. If the number is unknown, say it is unknown, but if it is known, state it.

A good grasp of Latin and French is admirable, but foreign terminology may not be familiar to all readers. *Exempli gratia*, for example, means "for example."

You could use its common abbreviation, *e.g.*, or you could just say "for example" and everyone will know what you mean and not confuse it with *id est* (*i.e.*), which means "that is" or "in other words." In general, unless the foreign terms are standard usage (Latin species names, for example), it is better to stick to English. Otherwise, readers may be confidently making their way through your work when they encounter *sensu stricto*, *viz.*, *a posteriori*, *en echelon*, or the like. The result may be that they become *ad nauseum*, and eventually get *sic*. In other words, reserve your foreign words, phrases, and abbreviations for wooing lovers, and use English when explaining scientific information.

METAPHORS

> Sometimes it's just a short swim from the shipwreck of your life to the island paradise of your dreams—assuming you don't drown in the metaphor.
>
> —Robert Brault

Many of us enjoy metaphors and other figures of speech. They can add great interest to our writing. Yet such devices should be used sparingly in your professional writing. Whenever a word or phrase is used in other than its literal meaning, we risk losing the comprehension of our readers.

Phrases like "made in spades," "we aren't out of the woods yet," and "that's what she said" may indeed cause confusion in some situations. We should remember that readers, especially nonnative English readers, can look up *words* in a dictionary, but words and phrases used in a nonliteral sense can be incomprehensible.

If you must use metaphors, at least avoid using two or more simultaneously (mixed metaphors). Of course, once you have mastered this art form, you might be able to craft a beauty like this (used to describe U.S. senators facing a politically sensitive vote):

> There are a lot of shaky knees with clay feet on thin ice.

or these:

> I can see the carrot at the end of the tunnel.
>
> —Stuart Pearce

> If we hit that bullseye, the rest of the dominoes should fall like a house of cards. Checkmate.
>
> —Zapp Brannigan ("Futurama")

Similes (comparisons using *like* or *as*), on the other hand, can be quite useful when explaining scientific concepts or unfamiliar objects to nonscientists. Comparing something unfamiliar to something readily understood can be a time-saving way to explain size, shape, behavior, or other characteristics. Unlike a metaphor, a simile uses *like* or *as*, which makes it clear that the author is making a comparison.

> The vampire squid, *Vampyroteuthis infernalis*, is a small, deep-sea cephalopod with fins that project like ears from the sides of the mantle.

THE PARTS OF SPEECH

Fortunately, the taxonomy of English words is relatively simple. If we take the roughly 500,000 English words and sort them into nine taxonomic pigeonholes, we can learn some simple definitions and rules about these nine categories. Then we can use, confidently and with precision, thousands of the words we have at our disposal. If we once get it clear in our heads what a verb is, for example, we can then effectively use many of the verbs available to us in the English language.

These nine pigeonholes are referred to as the "parts of speech": nouns, pronouns, verbs, adjectives, adverbs, conjunctions, prepositions, interjections, and articles. (Some words fit into more than one pigeonhole.) These parts of speech are briefly discussed in the next four chapters.

Parts of Speech

Three little words you often see
Are ARTICLES, *a*, *an*, and *the*.

A NOUN's the name of anything;
As *school* or *garden*, *hoop*, or *swing*.

ADJECTIVES tell the kind of noun;
As *great*, *small*, *pretty*, *white*, or *brown*.

Instead of nouns the PRONOUNS stand;
Her face, *his* face, *our* arms, *your* hand.

VERBS tell of something being done;
To *read*, *count*, *sing*, *laugh*, *jump*, or *run*.

How things are done the ADVERBS tell;
As *slowly*, *quickly*, *ill*, or *well*.

CONJUNCTIONS join the words together;
As men *and* women, wind *or* weather;

The PREPOSITION stands before
A noun, as *in* or *through* a door.

The INTERJECTION shows surprise;
As *oh! how pretty! ah! how wise!*

The whole are called nine parts of speech,
Which reading, writing, speaking teach.

—Anonymous

BIASED LANGUAGE

> Sticks and stones will break our bones, but words will break our hearts.
>
> —Robert Fulghum

Words can hurt, so it is worth taking the time to make sure that the words you choose do not indicate bias, promote stereotypes, or cause discomfort. The past few decades have seen changes in the ways people want to be described and the terms society feels comfortable using. This has led to the use of the derogatory phrase *politically correct* to mock the changing landscape of acceptable language. Yet it *is* important to avoid insulting your audience.

For many years it was considered proper usage to use male pronouns to mean both males and females.

> If a doctor is consulted, he is likely to advise surgery.

By now, most everyone is aware that this practice is wrong. Not all doctors are men, and to use the pronoun *he* indicates a doctor cannot be a woman. The problem is that English does not have a singular pronoun that includes both sexes (like the plural pronoun *they*). This situation has led to all sorts of grammatical gymnastics. Some writers like to use *he or she*, which is wordy and becomes downright annoying after the fifth or sixth time. Others prefer *he/she* or the unpronounceable *s/he*. Still others volley back and forth, giving

equal time to each, distracting the reader and creating even more confusion. A better solution is to simply reword the sentence. In most cases, the pronoun can simply be removed.

If consulted, a doctor is likely to advise surgery.

An even easier solution is to use the plural form.

If doctors are consulted, they are likely to advise surgery.

Although it is becoming common usage, most grammarians agree it is incorrect to use the plural form with a singular subject.

Wrong: If a scientist wants to submit a paper for publication, they should first review a copy of the journal.
Correct, but awkward: If a scientist wants to submit a paper for publication, he or she should first review a copy of the journal.
Better: If scientists want to submit papers for publication, they should first review a copy of the journal.

Substitute neutral terms for words that include the word *man*.

Chair, not *chairman*
First-year student, not *freshman*

Do not include gender qualifiers unless they are relevant. Terms such as *lady professor*, *female judge*, or *women doctors* imply that a particular role is male unless specifically labeled as female. (Terms such as *male nurse* are just as biased.) This kind of language promotes stereotypes.

Avoid biased language when describing racial, ethnic, religious, cultural, or other kinds of groups. The *APA Style Guide* provides a good guideline: "Describe at the appropriate level of specificity." The example they use is "at-risk" children. If you use this term, you should specify what the children are at risk for, whether it's school problems, early pregnancy, or homelessness. The *Guide* also advises not to mention race, ethnic identity, sexual

orientation, disability, or even marital status unless it is relevant. Many style guides provide information on how to avoid biased writing. Another source of information is Casey Miller and Kate Swift's *The Handbook of Nonsexist Writing*, 2001. Calling attention to differences that play no factor in the information being presented promotes stereotyping and could even lead the reader to falsely assume that a racial, ethnic, or other characteristic affected the results.

When referring to groups, a good guideline is to call people what they want to be called. Gender identity, cultural affiliation, and religious associations, for example, are self-defined. If an individual or group expresses a preference for a particular descriptor, that is the one that should be used. Keep in mind that the acceptability of these kinds of terms can change over time. Stop and think before using any of these descriptors. Consider the packing list for a widely sold Nativity set that specified an "*African-American* Wise Man."

In all cases, write about people as individuals, not as labels, and don't make assumptions. Elderly people can be students, marathon runners, or sex addicts. Teenagers can be entrepreneurs, arthritis patients, or knitters.

Avoid language that promotes stereotypes and "loaded" terms such as *avowed*, *admitted*, or *acknowledged* when referring to a person's belief system or sexual orientation. No one would refer to someone as an avowed Christian, an admitted heterosexual, or an *acknowledged student*, yet these adjectives are routinely used to marginalize minority groups. Use words that have neutral connotations, such as *international* rather than words that can have a negative meaning, such as *foreign*.

When discussing disabilities, a good guideline is to use "person-first" language. Instead of *handicapped people*, use *people with disabilities*. Rather than *blind person*, use *person who is blind*. Avoid words like *afflicted*, *stricken*, and *victim*. Do not use the term *normal* as the opposite of having a disability. If the disability isn't pertinent, leave it out.

SCIENTIFIC NOMENCLATURE

When referring to a plant or animal in scientific writing, use binomial nomenclature, the system for classifying plants and animals that uses a two-part Latin name. The first part of each name is the genus and the second part is the specific epithet (in botany) or specific name (in zoology). Together, the two words name the species, as in *Homo sapiens*. Binomial nomenclature is an essential classification system that transcends language differences and ensures specificity.

When using Latin species names, the first term (the genus) should be capitalized, the second (specific epithet or specific name) should be lowercase, and both should be italicized. The name should be italicized even when abbreviated or when the genus name is used alone. If the species is unknown or unspecified, the genus name (in italics) should be followed by "sp." When referring to more than one species in the genus, use "spp." These abbreviations are not italicized. Common names, if used, are not italicized or capitalized unless they contain a proper noun. As common names for plants and animals vary from area to area and may refer to more than one organism (*daisy*, *wolfhound*, *fruit fly*), they should not be used in scientific writing without the Latin species name.

Cercis canadensis
American redbud
Drosophila melanogaster
Drosophila spp.
fruit fly
Escherichia coli
E. coli

For genes and proteins, use the approved names and symbols. If the approved name has changed, use the approved name followed by "(previously known as ___)" in the first use, and use the approved name alone thereafter. Approved gene names and symbols for many species can be found in the National Center for Biotechnology Information's Entrez Gene database at www.ncbi.nlm.nih.gov/gene.

Conventions for gene and protein nomenclature vary by species. For example, full names for mouse and rat genes are not italicized, but gene symbols are italicized and the initial letter is capitalized. Human gene symbols are italicized and shown in all uppercase. Greek symbols are never used in gene symbols or protein designations, and hyphens are very rarely used. For mRNA and cDNA, use the gene symbol and formatting conventions. To distinguish between mRNA, genomic DNA, and cDNA, include the appropriate prefix in parentheses. Nomenclature rules for rat, mouse, and chicken genes can be found at www.informatics.jax.org. For human genes consult www.genenames.org.

insulin-like growth factor 1
Igf1 (gene symbol, nonhuman)
IGF1 (gene symbol, human)

FOXN1 (human)

Foxn1 (mouse)

(mRNA) *Rbp1*

Words derived from Latin or Greek follow the same rules for forming plurals as the original language. Thus *bacteria*, not *bacterias* or *bacteriums*, is the plural of *bacterium*.

SCIENTIFIC LINGO

There are some words and phrases used in scientific writing that require translation. These are not the technical terms that scientists learn in college or graduate school, but the lingo that has developed over time into its own special language. For the benefit of those new to the language, we offer a short list of translations:

"It has long been known" (I didn't look up the original reference.)

"A definite trend is evident." (These data are practically meaningless.)

"While it has not been possible to provide definite answers to these questions" (An unsuccessful experiment, but I still hope to get it published.)

"Three of the samples were chosen for detailed study." (The other results didn't make any sense.)

"Typical results are shown." (This is the prettiest graph.)

"These results will be in a subsequent report." (I might get around to this sometime, if pushed or funded.)

"In my experience" (Once.)

"In case after case" (Twice.)

"In a series of cases" (Thrice.)

"It is believed that" (I think.)

"It is generally believed that" (A couple of others think so too.)

"Correct within an order of magnitude" (Wrong.)

"According to statistical analysis" (Rumor has it.)

"A statistically oriented projection of the significance of these findings" (A wild guess.)

"A careful analysis of obtainable data" (Three pages of notes were obliterated when I knocked over a glass of beer.)

"It is clear that much additional work will be required before a complete understanding of this phenomenon occurs." (I don't understand it.)

"After additional study by my colleagues" (They don't understand it either.)

"Thanks are due to Joe Blotz for assistance with the experiment and to Cindy Adams for valuable discussions." (Mr. Blotz did the work and Ms. Adams explained to me what it meant.)

"A highly significant area for exploratory study" (A totally useless topic selected by my committee.)

"It is hoped that this study will stimulate further investigation in this field." (I quit.)[2]

Obviously, these translations are meant to be humorous. The point is that scientists tend to rely on phrases that, although common, are wordy and unnecessarily complicated. When describing complicated material, you should use the simplest language possible. If readers struggle, it should be with the complexity of the science, not with the obtuseness of the language.

7

Name Words (Nouns and Pronouns)

> What's in a name? That which we call a rose by any other name would smell as sweet.
>
> —William Shakespeare

NOUNS

A noun is a word for a person, place, thing, quality, or idea. Nouns are the words that name the things around us. No one knows for sure, but it is likely that nouns were the first words uttered by human beings in prehistoric times: *me*, *you*, *food*, *fire*, *Republican*.

Proper and Common Nouns

There are two types of nouns: proper nouns and common nouns. A proper noun is a *specific* person, place, thing, or idea. Proper nouns include specific persons (Yang Fuyu, Stephen T. Colbert), places (Oxford, Zhejiang Province), things (East Asia Summit, Academy Award), and ideas (Existentialism, Islam). Some nouns can be either proper nouns or common nouns, depending upon whether they refer to a *specific* person, place, or thing.

ground zero (the point of detonation of a bomb)

Ground Zero (the site of the World Trade Center in New York)

mother (a woman who has a child)

Mother (a particular mother, as in "However, Mother called them 'broad beans.' ")

The department chair

Ovaltine Jenkins, Chair, chemistry department

Department of Chemistry professor

Professor Venkman

A common noun is any noun *except* a proper noun. Said another way, common nouns name a general type of person (*doctor*, *librarian*), place (*country*, *desert*), thing (*chemical*, *building*), or idea (*beauty*, *bravery*). Here are two useful rules: First, proper nouns are virtually always capitalized, whereas common nouns are not. Second, proper nouns, being specific, are usually singular; common nouns can be either singular or plural. There is only one Mississippi River, but there can be one river or many rivers. There are many lakes, but only one Lake Michigan; however, Lake Michigan is one of the Great Lakes. "Great Lakes" is plural in construction, but there is only *one* set of Great Lakes in the world.

Keep in mind that most words derived from proper nouns are also capitalized. From the proper noun *America*, we can derive the adjective *American* and the verb *Americanize* as well as other nouns such as *Americanism* and *Americanization*.

graduate degree in microbiology
graduate degree in English

In scientific writing, it helps in many ways to keep in mind the distinction between proper and common nouns. Two frequent problems faced by scientists are the distinctions between generic names and proprietary names of manufactured products and pharmaceutical preparations, and between scientific names and common names of organisms. Here are some examples, with the proper nouns on the left and common nouns on the right.

Doxycycline	tetracycline
Streptococcus	streptococci
Augmentin	amoxicillin
Trypticase	soy agar
Neisseria gonorrheae	gonococcus

Note that final example. *Neisseria* is capitalized because there is only one genus *Neisseria*. The species name *gonorrheae* is not capitalized. These proper-common distinctions do not always hold up, but they usually provide a good guideline to capitalization.

Most eponyms (names derived from people) are capitalized, but only the proper noun portion of the term is capitalized (*Gram stain*, *Bunsen burner*). Adjectives derived from a person's name generally are not capitalized

(*gram-negative bacteria*, *mendelian*). Eventually, eponyms often enter the common domain and lose their capitals. For example, the petri dish, named after Julius R. Petri, a bacteriologist who died in 1921, is no longer capitalized.

Concrete and Abstract Nouns

It is sometimes useful to keep in mind that common nouns can be subdivided again into concrete nouns and abstract nouns. The concrete nouns are those persons, places, or things that we can detect with our five senses (e.g., *chair, apple*). Abstract nouns are those nouns, usually ideas or concepts, not directly detected by our senses (e.g., *peace*, *friendship*).

Collective and Mass Nouns

Two special types of common nouns are troublesome: collective nouns and mass nouns. A collective noun indicates a group or collection of countable persons, places, things, or qualities (*audience*, *committee*, *personnel*, *army*, *class*). The general rule is that such nouns are plural in meaning but singular in form:

The *audience* is restless.
The *committee* meets on Tuesdays.

Unfortunately, this rule often breaks down. Whenever the individuality of members of a group is emphasized, the plural form of the verb is used.

The *couple* do not live together.
The *committee* of scientists were from several scientific disciplines.

The best rule for handling collective nouns is to decide whether the *meaning* is singular or plural. Which of the following two sentences is correct?

A total of 48 petri dishes *were* in the autoclave.
A total of 48 petri dishes *was* in the autoclave.

Scientists who have a poor knowledge of English grammar would choose the verb *were*, thinking that the subject of the sentence is *dishes*. Scientists

with a good knowledge of English would choose *was*, recognizing that *dishes* is the object of a preposition and that the subject of the sentence is the singular word *total*. Scientists with an *excellent* command of English would apply the rule of meaning and would select *were*. To determine meaning, we must ask ourselves what was in the autoclave. Was it the singular "total" or was it a whole mess of petri dishes? Obviously, it was the dishes; thus, the verb *were* is correct.

Another collective noun that comes up frequently in scientific writing is *number*. Do we say "A number of test tubes is on the table"? No. Following the rule of meaning and recognizing that the plural word *tubes* is proof that more than one test tube is on the table, we say, "A number of test tubes are on the table."

But, while following the simple rule of meaning, do not simplistically conclude that words like *total* and *number* always take plural verbs. Look at these sentences:

A number of test tubes is on the table.
The number of test tubes on the table is four.

The first example, as already stated, is wrong; the verb *are* is needed to give logical meaning. However, the word *is* in the second example is correct. Why? Because there is only one number, "four." Actually, the distinction here is caused by the difference between the definite article *the* and the indefinite article *a* (see Chapter 9).

Another confusing type of noun is the mass noun. A mass noun is a concrete noun that represents a mass rather than countable units. Mass nouns are singular; many do not have plurals (*air*, *water*, *wheat*).

One of the most common grammatical errors is the misuse of the mass noun *amount* in place of the word *number*. "An amount of people" is poor English, because people are countable individuals. We should say "The number of people on the elevator is nine." (Conceivably, we could weigh the people on the elevator. Then it would be correct to say "The amount of people on the elevator was 1,400 pounds.")

A related problem is the choice between *fewer* and *less*. We use *less* to modify nouns that can't be counted, and we use *fewer* to modify a noun with countable units.

There is *less* liquid in this test tube.

There are *fewer* specimens in that container.

Years ago, jazz guitarist Les Paul was invited to play a concert for Adolf Hitler in Nazi Germany. He felt uncomfortable about it, so he took along a friend, Les Jenkins. Les Paul arrived at the concert hall before Les Jenkins, and discovered that Hitler wasn't there because he had gone to meet with Mussolini. So the question is, in the end, were there less Leses or fewer fuhrers?

Functions of Nouns

In sentences, nouns usually do something or something is done to them. A noun that does something is the *subject* of the sentence. If something is done to the noun, it is the *object* of a verb or of a preposition. (Remember, a preposition is a word used to relate a noun or a pronoun to some other part of the sentence.)

John prepared the media.

The proper noun *John* is the subject of the sentence; *media* is the object of the verb *prepared.*

John prepared the media in the petri dish.

Again, *John* is the subject, *media* is the object of the verb, and *petri dish* is the object of the preposition *in.*

In some sentences, nouns don't *do* anything, nor is anything done to them. Such sentences usually present definitions or characteristics of these nouns. Typically, these sentences contain some form of the linking verb *to be.*

Penicillin is an antibiotic.
Scientists are nice people.

PRONOUNS

A *pronoun* is a word used to replace a noun. The noun that the pronoun replaces is called the *antecedent*. Pronouns can be a bit tricky, because there are six

different types of pronouns (personal, demonstrative, relative, interrogative, indefinite, and reflexive) and they have different forms that are easy to confuse.

The antecedent of a pronoun must agree in number with the pronoun (i.e., a singular pronoun must have a singular antecedent).

> If a chemist publishes 30 papers, will their value to the university increase?

In the above example, the plural pronoun *their* does not agree with the singular *a chemist*. The sentence should read "If a chemist publishes 30 papers, will his or her value to the university increase?" Or both the pronoun and the antecedent can be made plural: "If chemists publish 30 papers, will their value to the university increase?"

Make sure that the antecedents of your pronouns are clear. Otherwise, you might be guilty of a sentence such as the following, collected by Richard Lederer:

> When Lady Caruthers smashed the traditional bottle of champagne against the hull of the giant oil tanker, she slipped down the runway, gained speed, rocketed into the water with a gigantic spray, and continued unchecked toward Prince's Island.

Personal Pronouns

A personal pronoun replaces a noun indicating a person. The form of the pronoun changes depending on whether the pronoun is used as a subject, an object, or a possessive. The personal pronouns are as follows:

I, me, my, mine
you, your, yours
he, him, his
she, her, hers
it, its
we, us, our, ours
they, them, their, theirs

In scientific writing, don't use substitutes for personal pronouns. Make it clear who was the agent of the action.

Wrong: The study concluded that the element administratium is inert.
Better: The authors concluded that the element administratium is inert.
Best: We concluded that the element administratium is inert.

The personal pronouns cause comparatively few problems; we learn about *his* and *hers* during toilet training (and later, divorce proceedings). When writing or revising, however, you are wise to examine each pronoun to make sure that it has an appropriate antecedent. Otherwise, you might write such confusing sentences as this one about (seemingly) human kidneys in dogs:

No one yet had demonstrated the structure of the human kidneys, Vesalius having examined them only in dogs.

> Only kings, presidents, editors, and people with tapeworms have the right to use the editorial "we."
>
> —Mark Twain

Confusion is more common when it comes to *it*, *its*, and *it's*. The word *it's* is a contraction of "it is," and this contraction is often mixed up with the possessive pronoun *its*.

Wrong: It's fur is fuzzy.
Right: Its fur is fuzzy.
Wrong: Its not good science.
Right: It's not good science.

In addition to being wrong grammatically, you also risk misinforming your reader if you choose the wrong *its*, as in this pair of examples:

A dog knows *its* master.
A dog knows *it's* master.

The easiest way to decide which to use is to read the sentence with *it is* in place of *its*. If your meaning is retained, you should use *it's*. Otherwise, stick to *its*.

Another problem with *it* is that the antecedent may be unclear. Unlike the other personal pronouns, the neutered *it* can stand in for virtually any noun in the sentence. So, watch *it* or you may be guilty of writing sentences like this:

> It is all right to give raw milk to your baby, but first boil it.

Ideally, a pronoun should be as close as possible to its antecedent (the noun that the pronoun is standing in for). In a novel by Lillian O'Donnell (*Lockout*, G.P. Putnam's Sons, New York, 1994, p. 94), the author described a robe belonging to a man named Watts: "Watts' was burgundy. As he leaned forward to put the fork into his mouth, it fell open to reveal dark chest hair." Unless Watts had chest hair in his mouth (unlikely, let's hope), it was *it* that caused confusion again.

In addition to *it* and the personal pronouns, other pronouns also need clear antecedents, like *most* in the following example.

> He stole seven bicycles from neighborhood kids. Most were later found in pieces.

Demonstrative Pronouns

Demonstrative pronouns single out the thing referred to. These are common in English writing. (Note that *These* in the preceding sentence is a demonstrative pronoun, the antecedent being *Demonstrative pronouns*.) There are only four demonstrative pronouns: *this*, *that*, *these*, and *those*.

> *This* is my lab.
> *That* is a mistake.
> *These* won't do.
> *Those* are O.K.

Demonstrative pronouns also need clear antecedents.

> The astronomer used a telescope to view the night sky. *That* was clear.

What was clear? Certainly not the meaning of that sentence.

These four words (*that*, *this*, *these*, and *those*) are not only used thousands of times as demonstrative pronouns, but they are also often used as adjectives (as in "these four words" in the first clause of this sentence).

Relative Pronouns

Relative pronouns substitute for nouns *and* connect parts of sentences. These are the common relative pronouns: *who*, *whom*, *which*, *whose*, *that*, *what*, *whatever*, *whoever*, *whomever*. They serve as subordinating conjunctions (see Chapter 10).

The laboratory director, *whose* office was on the second floor, was responsible for all research activities.

The word *that* can be either a demonstrative pronoun (see above) or a relative pronoun. As a relative pronoun, *that* is often confused with *who*. Properly, *who* should be used to replace people, and *that* should be used to replace animals or inanimate objects.

The researcher *who* discovered uranium was a bright person.
I weighed the rat *that* was used in the experiment.
This is the beaker *that* caused the problem.

Conscience is the inner voice *that* warns us somebody may be looking.
—H. L. Mencken

The word *that* can also be a conjunction *that* leads to the endless "that-which" argument, *which* is discussed under "Which Hunting" in Chapter 15.

Interrogative Pronouns

Interrogative pronouns are essentially the same as relative pronouns, except that the interrogative pronouns ask questions. The common ones are *who*, *whom*, *which*, *whose*, and *what*. Their purpose is to introduce questions.

Who is it?
Where is he?
What happened? (Which is sometimes shortened to "wtf?")

Indefinite Pronouns

Some pronouns are "indefinite" in that they replace nouns but not a *particular* person, place, or thing. Examples are the following: *all*, *another*, *any*, *anyone*, *anything*, *both*, *each*, *either*, *everybody*, *few*, *many*, *most*, *much*, *neither*, *nobody*, *none*, *several*, *some*, and *such*.

Anyone can be lucky, but *few* succeed.

Reflexive Pronouns

The least-used type of pronoun is the reflexive pronoun (*myself*, *yourself*, *herself*, *themselves*, etc.). However, these pronouns are frequently misused. Correctly used, a reflexive pronoun reflects the action of a verb back on the subject.

I hit *myself*.

It is incorrect to use a reflexive pronoun either as a subject or as the object of a preposition.

Wrong: John and *myself* will go home.
Right: John and *I* will go home.

Wrong: He hit John and *myself*.
Right: He hit John and *me*.

Reflexive pronouns are sometimes used as intensives, words used to intensify meaning or resolve.

I *myself* will do it.
I'd rather do it *myself.*

The rules are simple: The *-self or -selves* words are used for two purposes: first, to emphasize ("Mother, I'd rather do it *myself*"), and second, reflexively, so that the action is turned back on the grammatical subject:

I never quite accustomed *myself* to the altitude of Denver.

> I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.
>
> —Sir Isaac Newton

8

Action Words (Verbs)

> The whole of nature, as has been said, is a conjugation of the verb to eat, in the active and passive.
>
> —W. R. Inge

FUNCTION OF VERBS

In the preceding chapter we discussed nouns and pronouns. As the subject of a sentence, something that has been named (a noun or a pronoun) is likely to be followed by a word that does one of two things: describes the existence or a characteristic of the named subject, or describes an action of the subject.

She *is* intelligent.
He *hit* the roof.
The chemist *added* hydrochloric acid.

TYPES OF VERBS

All verbs can be divided into two types: transitive and intransitive. All this means is that some verbs (transitive) take an object (a noun following a verb); others (intransitive) do not.

He *gave* me a hammer.
She *ran* home.
They *died.*

In the first example, *gave* took an object (*hammer*, with *me* being an indirect object). In the second example, *ran* has a direct object (*home*). The third example has no object; hence, the verb *died* is intransitive.

Some verbs can be used either transitively or intransitively.

He *grows* roses.
The guinea pigs *grow* well.

In the first example, *roses* is a noun, the object of the transitive verb *grows*. In the second example, the only word after the verb is the word *well*, which is an adverb, not a noun; thus, the sentence has no object and *grow* is intransitive.

The "existence or characteristic" verb (which is intransitive) is often some form of *to be* (*is*, *are*, *was*, *were*, etc.), but other "linking" verbs (e.g., *become*, *taste*, *smell*, *grow*) are used frequently.

Sulfuric acid *is* a common reagent.
I *am* lonely.
This *tastes* terrible.

Two or more verbs having the same subject are called compound verbs, and they are not separated by commas:

I *went* to the store and *bought* a loaf of bread.

NOMINALIZATIONS

One of the most frequent faults of scientists as writers is that they often confuse actions (verbs) with agents of the action (usually nouns). Such failures result in sentences that are difficult at best and incomprehensible at worst. The three most common types of agent-action confusion tend to result from (1) the reluctance of scientists to use first-person pronouns, (2) the overuse of the passive voice, and (3) the regrettable tendency to turn sharp action words (verbs) into weighty nouns. The first two of these faults are dealt with in more detail in Chapter 18. The third, called nominalization, is castigated here. (Nominalizations are castigated again in Chapter 11. Such a cardinal sin merits repeated sermons.)

If someone says "I studied the effect of A on B," you know what was done, you know who did it, and you know approximately when it was done (probably recently, certainly during the lifetime of "I"). However, if we turn the verb *studied* into a noun (*study* or, in the unfortunate jargon of scientists, *investigation*), if

we omit the agent of the action ("I"), and if we put the whole thing into the passive voice, we have something like this:

> An investigation was undertaken to determine the possible effect of A on B.

Now, in more words, we have a sentence of a type that is all too typical in science, a sentence that says almost nothing. We no longer know that A affects B; we know only that there is a "possible effect." We do not have the foggiest idea of who conducted the investigation (another awful phrase scientists love to use); it might be "I," it might be the author's Aunt Mary, or it might have been Julius Caesar. Nor do we know when this observation was made (another awful phrase; why not use the active voice "I observed" or "they observed"?); the "observation" might have been "made" last week, 20 years ago, or 2,000 years ago.

"We rejected that theory." Now that is a clear statement. Turn the verb into a nominalization, and we have "The rejection of that theory has been reported."

Get into the habit of looking for nominalizations; many end with *-tion*. Almost always, the action verbs will give the clearest meaning. *We investigated* is much better than an anonymous *investigation. They produced* is better than a vague *production.* And *consumed* is certainly better than *consumption. I informed him* is good. *I told him* is better. *The information was communicated to him* is terrible. Look carefully at the next two examples.

> The installation of the new operating system can be performed in three hours.
> We can install the operating system in three hours.

The second example is much clearer than the first.

You should also avoid hedge words and phrases (*might*, *tend to*, *sometimes*). While such language is popular with used-car salesmen and tobacco manufacturers, it has no place in scientific writing, where precision is paramount.

The flip side of nominalizations (verbs as nouns) is verbification (nouns as verbs). This is when you don't *set priorities*, you *prioritize*, and you don't *give someone a gift*, you *gift* it. Some of these uses have become accepted (to *contact* someone, for example), but others are at best unnecessary and at worst confusing.

New technologies (particularly social media) seem to be a favorite inspiration for verbification. Some of these terms have become so common they must be considered part of the language. People no longer look something up, they *Google* it. Friends don't talk, they *tweet*. You may not have seen someone, but you *Facebooked* him. You may like a new product, but did you *Digg* it? Terms such as these are considered slang, and as such do not belong in scientific writing.

From the cartoon Calvin and Hobbes:

Calvin: I like to verb words.

Hobbes: What?

Calvin: I take nouns and adjectives and use them as verbs. Remember when "access" was a thing? Now, it's something you do. It got verbed. Verbing weirds language.

Hobbes: Maybe we can eventually make language a complete impediment to understanding.

> Language is in decline. Not only has eloquence departed but simple, direct speech as well, though pomposity and banality have not.
>
> —Edwin Newman

9

Descriptive Words (Adjectives, Adverbs, and Articles)

> I'm glad you like adverbs—I adore them; they are the only qualifications I really much respect.
>
> —Henry James

THE DESCRIBERS

The agents of the action (nouns, pronouns) can be modified (described or qualified). These modifiers are called *adjectives*. The action (verb) can also be modified. These modifiers are called *adverbs*. Even modifiers can be modified (by adverbs). In English and some other languages (but not Japanese, for example), there is also a group of words called *articles*. In English, these are the three words *a*, *an*, and *the*. They are often treated as adjectives, but their usage is so peculiar that they must be looked at separately.

ADJECTIVES

An adjective modifies a noun or a pronoun.

A *large* grant.
The grant is *large*.

Usually, adjectives precede the nouns they modify (as in the first example). Sometimes, adjectives follow the noun and a linking verb (as in the second example).

Two or more adjectives can modify a noun.

A *large government* grant.
A *large, prestigious government* grant.

It is sometimes important to get modifiers into logical order. The arrangement of words in the next two examples indicates different meanings.

The large red doctor's house.
The doctor's large red house.

The second example is preferable if the house is red. If the doctor is red, the first example is acceptable. Again, a dollop of logic is better than a grammatical rule.

Avoid unnecessary adjectives. (Avoid *an*y unnecessary words.)

He drew his *bright* sword.

"He drew his bright sword" may suggest to the reader that "He" has two or more swords and that he drew the bright one.

Adjectives not only state a quality of the noun or pronoun they modify, but they can also be used with various degrees of intensity. Each adjective can be "compared" as follows:

cold (positive)
colder (comparative)
coldest (superlative)

Unfortunately, some English adjectives are irregular and do not follow the *-er -est* style:

much (positive)
more (comparative)
most (superlative)

Words can also be compared without the use of the *-er* and *-est* endings, even if the adjectives are not irregular. Instead of *cold*, *colder*, and *coldest*, we can say *cold*, *more cold*, and *most cold*.

Finally, English has a number of "absolute" words that are not subject to comparison, such as *unique*, *perfect*, *exact*, *correct*, and *infinite*. Something is either unique or it isn't; it can't be more or less unique than something else.

Superlatives that involve opinion or emotion do not have a place in scientific writing, except perhaps in letters to the editor (your attorney might disagree). Words such as *gigantic*, *ridiculous*, *fantastic*, *reckless*, *disgusting*, and so forth are certainly not appropriate for building a logical argument or presenting a case.

> Two college students partied all weekend even though they had a chemistry test Monday morning. On Monday, they were so hung over they missed class, so they decided to tell their professor that they had gone to another school that weekend, had a flat tire on the way back, and couldn't get to class in time for the test. The professor thought about it and decided to let them take the test the following day. So that morning the professor gave each of them a copy of the test, and put them in separate rooms. As it turned out, the test had only one question: "Which tire was flat?"

ADVERBS

Adverbs are words that modify verbs, adjectives, other adverbs, or whole sentences.

He went *slowly*.
It was *very* small.
He went *very* slowly.

In the first example, the adverb modifies a verb; in the second, the adverb modifies an adjective; in the third, the adverb *very* modifies the adverb *slowly*.

Many adverbs end in *-ly* and are thus easy to identify. Others do not and thus are not. Many adverbs have related adjectives with which they can be confused. For example, the adjective *real* is often used inappropriately in place of the adverb *really*:

This soup is *really* good.
This soup is *real* good.

The first example is correct; the second is substandard usage. Either *really good* or *very good* is preferable.

I feel *bad.*
I feel *badly.*

Both of these examples are correct (if used properly), but they mean different things. In the first example, *bad* is an adjective (modifying *I*), and the sentence means that I feel lousy. In the second example, *badly* is an adverb (modifying *feel*), and the sentence means that I have poor tactile sense.

With all modifiers, the key to good usage is to get them close to the words they modify. Adjectives usually fit into place easily, because the nouns or pronouns they modify are usually clear. Adverbs, however, can modify verbs, adjectives, and other adverbs. Thus, their exact placement in a sentence is important to the meaning of the sentence. Adverbs such as *only*, *often*, and *never* are often misplaced in scientific writing, leaving sentences that are unclear. (See Chapter 5.) Precision with English requires careful word order, which is known as syntax. In every sentence, the agent of the action must be clear, the action or state of being must be clear, and any modifiers used to describe the agent of the action, the action itself, or the object of the action must be carefully placed.

Adverbs can also modify entire sentences.

Fortunately, the specimen remained viable.
Ideally, all the test tubes will be the same size.

Hopefully, you will not use *hopefully* in this manner, as in this sentence. *Hopefully* means "in a hopeful manner" and therefore does not modify the entire sentence.

Hopefully, she will take the job.

Does this sentence mean that the writer hopes she takes the job or that person the sentence refers to will take the job in a hopeful state of mind? A better construction is: "*I hope* she will take the job."

Another adverb that is frequently misused is *literally*. The word *literally* means the strict definition of the word. So if you say someone "literally exploded with rage" you should have needed a mop and bucket.

Juliet O'Hara: Detective Lassiter is literally on fire today.

Shawn Spencer: "Literally on fire" as in Michael Jackson in the Pepsi commercial, or as in a misuse of the word "literally?" —*Psych*, television show

ARTICLES

The articles *a*, *an*, and *the* are the most common words in scientific or any other kind of writing. The words *a* and *an* are called indefinite articles; *the* is called the definite article. The indefinite article *a* is used before words that begin with a consonant sound. The article *an* is used before words starting with a vowel sound.

a noun
a woman
an apple
an orthopedic procedure

It doesn't matter whether the word that follows starts with a vowel or a consonant; what matters is the *sound*. This rule is particularly needed in placing an article before an abbreviation.

a Master of Science degree
an M.S. degree

Both of these examples are correct. We say *a Master* because the *M* in *Master* is obviously the consonant sound, but we say *an M.S.* because we pronounce the *M.S.* as "em ess," meaning that the *sound* is now the vowel *e*. Likewise, *an mRNA* is correct because the reader will read "emRNA," not "*messenger* ribonucleic acid."

The British tend to put *an* before such words as *historian*, whereas most Americans would write *a history* rather than *an history*. On the other hand, in a word such as *honor*, the *h* is silent and *an honor* is the correct American usage.

Articles, if used carefully, can serve as guides to the reader. The primary purpose of an article is to identify a noun. Because a huge number of words in English can be either nouns or verbs, we need the articles to point to the nouns. Without an article, this sentence is confusing:

Plan moves slowly.

In this sentence, two of the three words (*plan*, *moves*) are words that can be either nouns or verbs. As written, this sentence probably means "[You should] plan moves slowly." But note how the addition of an article clarifies the meaning:

Plan the moves slowly.
The plan moves slowly.

Additional clues are provided by the use of an indefinite article or a definite article. Recall that collective nouns can take either singular or plural verbs. However, the choice of article can make clear which verb form is needed.

A number of apples *are* on the table.
The number of apples on the table *is 14.*

In the first example, *a number* is almost certainly meant as more than one; thus, it sounds plural, and in this case it is. On the other hand, *the number* signifies one number (even though it may be a large number); thus, it sounds singular, and in this example it is.

Some languages (Japanese, for example) do not have articles. Native speakers of such languages may have great difficulty mastering the English articles. When do we say "*a* river," when do we say "*the* river," and when do we just say "river" without an article? Unfortunately, the rules are not clear. Here are a few guidelines: Say "*a* river" if you are referring to an unspecified river. Say "*the* river" when you are referring to a single, specific river. Normally, *river* would not be used without an article.

However, in the plural, usage is different. Now we can talk about "rivers of love" (with no article) or, if we want to be more specific, we can say "*the* rivers of love." We can't say "*a* rivers" because *a* and *an* are used only in the singular, whereas *the* can be used in either the singular or the plural.

Because mass nouns refer to things that cannot be counted (unlike collective nouns), they do not take indefinite articles (*a*, *an*) unless a unit of specification is added. Mass nouns can also be used with no article. If the noun refers to something specific, the definite article *the* can be used.

Wrong: A water is wet. (mass noun with indefinite article)
Right: Water is wet. (mass noun with no article)
Right: A glass of water is on the table. (mass noun with unit specification)
Right: The water is wet (mass noun with definite article)
Wrong: Committee met. (collective noun with no article)
Right: A committee met. (collective noun with indefinite article)
Right: The committee met. (collective noun with definite article)

> Syzygy, inexorable, pancreatic, phantasmagoria—anyone who can use those four words in one sentence will never have to do manual labor.
>
> —W. P. Kinsella

10

Function Words (Conjunctions, Prepositions, and Interjections)

> The most exciting phrase to hear in science, the one that heralds new discoveries, is not "Eureka!" but "That's funny. . . ."
>
> —Isaac Asimov

English has agents of action (nouns and pronouns), actions (verbs), and descriptions of the agents (adjectives) and the actions (adverbs). In addition, English has some words which have little meaning but which perform functions. Such words often act as a glue holding the parts of a sentence together.

CONJUNCTIONS

Conjunctions are used to connect words, phrases, or clauses.

Matt *and* Brittanie are conducting the studies.
She is neither in the lab *nor* in the classroom.
He ran, *but* she walked.

Some conjunctions express equal weights of the joined words, phrases, or clauses; these are called *coordinating conjunctions*. The most common conjunctions are the seven coordinating conjunctions: *and*, *but*, *or*, *for*, *nor*, *so*, *yet*. These words can connect the two clauses of a compound sentence: He ran, *but* she walked. Because these seven words are among the most commonly used English words, and because your ability to punctuate sentences depends upon your ability to recognize these seven coordinating conjunctions, they are worth memorizing. As a mnemonic device, you might try remembering the acronym FANBOYS (as opposed to "fangirls"), which stands for *for*, *and*, *nor*, *but*, *or*, *yet*, and *so*.

Another class of conjunctions is called *subordinating conjunctions*. These connect *unequal* parts; for example, they are used to connect an independent clause with a dependent clause. (Don't get panicky. Clauses will be fully explained in Chapter 15.)

Joe went to a party *after* he left the office.

A clause introduced by a subordinating conjunction is a *subordinate* (or *dependent*) clause. These conjunctions often indicate a time relationship or some other limiting function. The most common are the following: *although*, *before*, *after*, *because*, *if*, *where*, *than*, *since*, *as*, *unless*, *that*, *though*, *when*, *whereas*, and *while*.

When the party was over, he went home.

Still another class of joiners is the *coordinating adverbs*. These are like the coordinating conjunctions in that they are used to connect independent clauses. However, coordinating conjunctions are often preceded by a comma, whereas coordinating adverbs are preceded by a semicolon and followed by a comma. Coordinating adverbs include the following: *however*, *moreover*, *therefore*, *further*, *consequently*, *nevertheless*, *nonetheless*, *besides*, *accordingly*, *also*, and *too*.

Brad decided to go to the party; *however*, Jennifer decided to go home.
We ran out of beer; *therefore*, the party was over.

But do not get carried away and put a semicolon before every *however*, because *however* and other coordinating adverbs can also serve as normal adverbs and are punctuated accordingly.

I hope you learn this lesson, *however* long it takes.
The yield is *therefore* small.

Coordinating adverbs (also called conjunctive adverbs) can also coordinate two sentences.

We ran out of beer. Nevertheless, the party lasted until 4 a.m.

PREPOSITIONS

Prepositions combine with nouns or pronouns to form a phrase. There are about 70 prepositions in the English language, most of them expressing direction or location.

to the right
in the middle

Scientists and others have four main types of problems with prepositional phrases. The first, as with other building blocks of English, is syntax. If the phrase is not close to the word it modifies, we may cause syntactic mayhem, as in:

For sale: car owned by lady with dent in rear.

The above short sentence fragment has four prepositional phrases, showing how very common these are in English. The first ("For sale") is acceptable because it is immediately followed by "car," the item for sale. The "by lady" follows "owned" and the "in rear" follows "dent," as they should. However, "with dent" is much too far from "car," which it presumably modifies, and much too close to "lady," which it does not modify (unless the lady is indeed unfortunate).

A second but frequent problem is the doubling of prepositions.

Inside of the park, many animals lived.
That question is *outside of* my field of expertise.

Because *inside* and *outside* are prepositions, as is *of*, the doubling of prepositions is redundant. The phrases should read "Inside the park" and "outside my field." Here is a similar example: "Arnold raced *out of* the door." If Arnold were a termite, perhaps he could have "raced out of the door."

> Outside of a dog, a book is a man's best friend. Inside of a dog it's too dark to read.
>
> —Groucho Marx

The third problem often afflicting prepositions has to do with *case*. Prepositions are usually followed by *objects*. Thus, prepositions always take the objective case, never the nominative. (*Objective* relates to objects; *nominative* relates to subjects.)

> The argument was between he and I.

In this example, the preposition *between* is erroneously followed by the nominatives *he* and *I*. The preposition should be followed by pronouns in the objective case, and the sentence should read: "The argument was between *him* and *me*."

The fourth common problem is the use of a preposition to link an adjective (rather than a noun or pronoun) to another part of a sentence. The *of* should be deleted from the following sentence.

> She is too good *of* a person to complain.

Some grammarians have argued that a preposition should not end a sentence. It was this rule that prompted Winston Churchill's famous rejoinder: "This is the kind of nonsense up with which I will not put." Not to worry: modern grammarians agree with Churchill.

On the other hand, sentences ending with a preposition are often awkward.

> Chemical engineering was what he took his degree in.

Such sentences can easily be recast to make shorter, clearer sentences.

> He took his degree in chemical engineering.

Nonnative English speakers often have difficulty with prepositions. Is it "research in microbiology" or "research of microbiology"? Sometimes it helps

to do an online search of each phrase (in quotes). If one phrase has many more "hits" than the other, the more popular phrase is more likely to be correct. In this example, "research of microbiology" produced 41 hits, whereas "research in microbiology" produced 8,490,000.

> A child was upstairs in bed waiting for his nighttime story. His mother called up that she would read him his favorite book about Australia. He yelled "no," but she brought it up anyway. Feeling confident that modern grammarians wouldn't object, the child asked: "What did you bring that book I didn't want to be read to out of about down under up for?"[1]

INTERJECTIONS

An interjection is a word, phrase, or sentence expressing emotion.

Hey!
Of course!
I thought so!

Strong interjections (those followed by exclamation points) are rarely used in scientific writing. Mild interjections, which are usually separated from the rest of the sentence by commas, are used occasionally.

Oh, *well*, it was worth a try.
Waksman, *indeed*, was the discoverer of streptomycin.

If we might interject a thought about interjections, it would be: don't use them!

> Interjections are needed in conversation to fill gaps—some of us say "uhh" and some use interjections, to about the same effect—but writers do not leave gaps, assuming they take the time to think through their ideas and to rewrite for succinctness.
>
> —Gregory A. Barnes

11

Prefixes and Suffixes

> I find the growth in use of the prefix "pre" in biology especially galling. It seems to have spread, like a plague, from manufacturers' catalogs to methods sections. It is used in conjunction with many words; some of the most common are pretreated, prewashed, and presterilized, which mean, of course, treated, washed, and sterilized.
>
> —Peter Kulakosky

PEAT AND REPEAT

In the preceding (*pre*ceding) chapters, we have briefly described the various kinds of words in the English language. English, being the incredibly rich language that it is, further adds to its vocabulary a large number of bits and pieces of words; we call these prefixes and suffixes. We can use these prefixes and suffixes to give different meanings to words. Thus, we can take the form of a particular word that best suits our meaning. Take the word *take*.

We can *take* it once.
If we can take it once, it is *takeable*.
If we do it again, we can *retake* it.
Having shown that we can do it again, we know that it is *retakeable*.
If we can't do it at all, it is *untakeable*.

Unfortunately, these beginnings (prefixes) and endings (suffixes) do not fit every word. When a word starts with *re*, we cannot assume that a prefix is being used (as indicated by the heading of this section, "Peat and Repeat"). The *re* in *repeat* is not a prefix; nor can we add *re* to *repeat*, because *rerepeat* would not make sense. Similarly, the *re* in *recover* is not a prefix when we *recover* a lost article; *re-* is a prefix, however, when we *re-cover* our sofa. Note that this *re-cover* takes a hyphen to distinguish it from the other *recover.* (We hope that you will recover from all of this.)

Probably all prefixes have similar exceptions. You can be *overstimulated* or just *stimulated*; you can also be *overjoyed*, but you cannot be *joyed.* Back to *peat* and *repeat*, sportscasters (who have found many ways to abuse our language) commonly refer to a third successive championship as a *threepeat*.

The prefix *pre-* can be used before a great many words (*prebirth*, *preexamine*, *prehistory*) and even numbers (*pre-1900*). The very word *prefix* has *pre-* as a prefix. But, of course, *pre* is not always a prefix. A doctor who uses good English could *scribe* for a patient, but most likely the message would be different if he or she were to *prescribe* for the patient.

NEGATIVE PREFIXES

Perhaps the best use of prefixes is to provide meanings exactly the opposite of the original meanings. A *political* person is intensely interested in politics; an *apolitical* person has no interest in politics. (Because *a* can be either a prefix or an article, oddities occur; *a theist* believes in God, whereas an *atheist* does not.) A *starter* can win a horserace; a *nonstarter*, never. It is good to be *well*; it is not good to be *unwell.*

Do not get carried away, however, and assume that negative prefixes always provide negation. The *in-* in *insignificant* gives the meaning "not significant," and *inappropriate* indeed means "not appropriate." However, the *in-* in *invaluable* does not mean "not valuable"; here the *in* is strongly positive rather than negative. The word *invaluable* means "valuable beyond estimation."

> Two atoms bump into each other. One says "I think I lost an electron!" The other asks, "Are you sure?," to which the first replies, "I'm positive."

SPELLING WITH PREFIXES AND SUFFIXES

Prefixes and suffixes are normally set solid with no space or hyphen between the prefix or suffix and the root word. Only a few prefixes (*ex-*, *half-*, *quasi-*, *self-*) normally take a hyphen. In a Mexican restaurant, the *refried* beans are more accurate if not more tasty than *re fried* beans or *re-fried* beans. Some people argue that hyphens aid comprehension, particularly when a letter is doubled (*re-enter, anti-insect*). Hyphens can also be helpful for those still learning English.

Sometimes, the use of a hyphen creates entirely different words. For example, if you have a material that was *un-ionized*, we know what you mean; if it was *unionized*, don't forget to sew on the union label.

If you get into the habit of joining the parts, you will be right most of the time. But remember that this advice applies only to real prefixes (such as *re-*, *co-*, and *pre-*). Some "prefixes" are complete words that often precede others. Take *sea* as an example. Some *sea* word combinations are separate from each other (*sea bass*, *sea breeze*, *sea level*); other combinations are joined (*seabird*, *seacoast*, *seaport*). How can you tell which are joined and which are not? The sure way is to check the dictionary. However, such word combinations come up so often that you won't get much writing done if you stop to check each combination. You can make the right determination almost every time *if* you know how the combinations are pronounced. If the two parts are stressed equally, they are separated by a space (*sea lane*, *sea power*). If the first part is stressed, that "word" has become an accented syllable, and the two "words" have become one (*seafood*, *seashell*).

CONFUSING PREFIXES

Some prefixes are confusing. One million microphones do not equal one phone and a million phones do not equal one megaphone (for that matter, 2,000 mockingbirds do not equal two kilomockingbirds). The word *flammable* probably refers to something that can catch on fire; theoretically, something *inflammable* would not catch fire. However, we then recall that the word *inflame* means to set fire, and we thus worry about a substance that might be "highly inflammable." When such confusion arises, it is best to dispense with the prefixes: say *flammable* or *not flammable*. The prefix *bi-* can also create problems. Although most people know *bi-* means "two," does *biweekly* mean every two weeks or twice a week? (It can mean either, although it usually refers to twice a week.) To avoid confusion, use "every two weeks" or "twice a week."

SUFFIXES

Prefixes normally change the meaning of the words that follow. Suffixes, on the other hand, normally do not change the meaning of preceding words; instead, the suffixes change the status of the words, changing nouns to verbs, nouns to adjectives, and so forth.

Frequently, suffixes are added to verbs to turn them into nouns. The verb *develop* becomes *development*; *govern* becomes *governance*; *reject* becomes *rejection*; and so on. These nouns are often useful. However, a strong and regrettable tendency in scientific writing is to use the noun form, covering up the real action going on in a sentence. These nouns (called nominalizations; see Chapter 8) are often combined with the passive voice, resulting in wordy sentences in which both the agent of the action and the action itself are hidden in the underbrush:

The rejection of the manuscript was performed by the editor.
Our results were in agreement with theirs.

By adding action to these two sentences (and reducing the number of words) we have the following:

The editor rejected the manuscript.
Our results agreed with theirs.

Here is another example:

The preparation of the microbiological media will be performed by the technologist.

If we eliminate "performed" (monkeys and talk radio hosts "perform," not scientists) and if we change the nominalization (*preparation*) to its verb (*prepare*), we have a better sentence:

The microbiological media will be prepared by the technologist.

But let's go all the way here and change this sentence from the passive voice (see Chapter 18) to the active voice, giving us an even better version:

The technologist will prepare the microbiological media.

Surely, you will agree that the third version of this sentence is the best. Even if it were not the best, it could be defended for its conciseness. Note that the first version has 13 words. By eliminating the nominalization, we reduced the second version to 10 words. The third version, without the nominalization and in the active voice, contains only 8 words. Thus, if you measure out your words as carefully as you measure out your reagents, you will avoid nominalizations and the passive voice whenever possible.

On the other hand, you can turn nouns into verbs by adding a suffix:

idol	idolize
type	typify

Such words can be useful. However, some suffixes (*-ize,* for example) are used to create jargon (*blenderize*). The use of *-wise* is often appropriate (*length-wise*); sometimes it is questionable (*policywise*); sometimes it is silly jargon (*philosophywise*).

Suffixes, like prefixes, are normally set solid (no hyphens). However, some suffixes are hyphenated if the letters are doubled (e.g., *camel-like*), whereas others (e.g., *openness*) are not. Again, it seems clear that the language war is being won by the joiners. When in doubt, avoid the hyphen (and save a keystroke). Of course, you can consult a dictionary. For efficiency, you can wait until you have completed a draft of a manuscript and then check *all* the spellings about which you are unsure (computer spell checkers can help, but do not rely on them alone).

> Language is the means of getting an idea from my brain into yours without surgery.
>
> —Mark Amidon

12

Redundancies and Jargon

I simply hate, detest, loathe, despise, and abhor redundancy.
—Oscar Wilde

DOUBLESPEAK

Redundancy in engineering is a good thing: duplicating critical components reduces the risk of system failure. Redundancy in language is not a good thing. It dilutes the message and can create confusion. Redundancies come in different varieties; one common redundancy is the simple doubling of words that have the same meaning. For example, *free* and *complimentary* have the same meaning. A close relative is *free gift*. Even worse is *free, complimentary gift*, a double redundancy.

USELESS WORDS

Many of the words we use are useless, but we go on using them by habit. We think we are impressing people. Here are some examples, the italicized words being useless or of questionable value.

absolutely unique
active consideration
alternative choice
armed gunman
closely scrutinize
complete stop
completely accurate
component part
definite decision
end result
exact same
fewer *in number*
firmly commit
following after
fully recognize
grave emergency
hollow tube
honest truth
immediate vicinity
in order to
join *together*
local neighborhood
mix *together*
new innovation

one *out* of three	*qualified* expert	*terrible* disaster
past experience	rarely *ever*	*totally* useless
perfectly clear	repeat *again*	*truly* significant
personal belongings	*securely* fastened	*twelve* noon
possible potential	shiny *in appearance*	*unfilled* vacancy
present incumbent	sweet *tasting*	

Even worse are whole constellations of words that roll off the tongue or the pen, most or all of the words adding nothing of substance.

> The trend seems to suggest that perhaps A affects B.
> In the present paper, the authors show that A affected B at 37°C.
> In the second part of the paper, it is shown that A affected B at 37°C only in the presence of exceedingly small concentrations of protease.
> The paper concludes with a summary of the evidence indicating that A may be, under carefully limited circumstances, an effective agent against infections caused by gram-negative organisms.

These examples include phrases that abound in the scientific literature. What do they mean? In the first example, "the trend seems to suggest that perhaps" means nothing more than *perhaps*. In the second example, "In the present paper" (a common phrase in introductions, along with *in this investigation*, etc.) is wasted breath, and constructions like *the authors show* (or, worse, *the authors will show*) add little more. In the absence of a literature citation (and a statement in the present tense), it should be understood that *we* (not *the authors*) did it and that we are reporting it *in this paper.* The third example, a typical transitional sentence, is even worse. "In the second part of the paper, it is shown that" can be deleted. The important thing is that "A affected B." Certainly, we don't need the "it was shown"; obviously, the authors of the paper (*we*) showed it. The passive-voice *it was shown* kind of phraseology should *never* be used. Better is *we showed that*; best is *A affected B*, with it being understood that the authors of the present paper showed it. If Smith showed it, *it was shown by Smith (2010) that A affects B* is a poor substitute for *A affects B (Smith, 2010)*.

The worst example is the final one. If any part of a scientific paper should be written with straightforward clarity, obviously it is the conclusions. To say that "The paper concludes with a summary of the evidence" is to state the

obvious. Everybody knows that. And how about the rest of the sentence? Any conclusion containing the verb *may be* is not much of a conclusion, especially if it is immediately qualified by (unstated) "carefully limited circumstances."

Watch for the word *different*, which is often used unnecessarily in scientific writing. Too often, we see "mice of three *different* strains," or "DNA of seven *different* species." In these examples, obviously it would have been only one strain or species if they did not differ.

Another kind of redundancy is to follow an acronym with a word that is included in the acronym. For example, *PCR reaction* would be redundant because the *R* in *PCR* stands for "reaction." For the same reason, you shouldn't use *HIV virus* because that would mean "Human Immunodeficiency Virus virus." An easy way to check for this when you proofread your work is to read all abbreviations and acronyms as the words they represent.

Additional redundancy results when you use bloated phrases in a number of successive sentences:

> The framistan is red in color.
> The framistan is round in shape.
> Also, as is well known, the framistan is an object that is made out of wood.

If we take out the padding and combine the sentences, the result is much shorter and more digestible.

> The framistan is a red, round, wooden object.

The Ultimate Redundant Paragraph

In order to help stamp out and abolish redundancy, needless duplication, and repetition, I ask your active consideration in determining an alternative choice to closely scrutinize your position and to arrive at a full and complete stop. To be completely accurate, we need to establish a consensus of opinion to determine the exact same conditions and firmly commit, or fully recognize, the immediate vicinity of the range of attitudes. If we join together or mix together our past experiences, past history will make it perfectly clear that light snacks are not the problem. Students should be perceived as qualified experts when it comes to their own personal belongings. It is totally useless to consider that

present incumbents are securely fastened to their present attitudes. It would be truly significant, or at least utterly unique, to think otherwise.

—Jacques J. Pene, School of Life and Health Sciences, University of Delaware, adapted from the examples listed in Chapter 17 of the first edition of Robert A. Day's Scientific English: *A Guide for Scientists and Other Professionals*

OXYMORONS

One fine day in the middle of the night,
Two dead boys got up to fight,
Back to back they faced each other,
Drew their swords and shot each other,

—Anonymous

An oxymoron is two words of opposite meaning that are put together. Here are a few common oxymorons:

accurate estimate
advanced beginner
authentic replica
clearly ambiguous
constant variable
controlled chaos
definite possibilities
discovered missing
feel numb
genuine imitation
half full
ill health
important trivia
light heavyweight
liquid gas
living dead
may certainly
medium large
objective opinion
only choice
open secret
original copy
partially complete
pretty ugly
real simulation
required elective
routine emergency
same difference
strangely familiar
tentative conclusion
thoroughly inadequate
working vacation

Sometimes oxymorons are in the eye of the beholder. Here are some word combinations that some consider to be oxymorons:

academic salary
adult male
airline schedule
American culture
business ethics
cafeteria food
creation science
educational television
family vacation
government worker
legal ethics
marital bliss
military intelligence
tax return
understanding editor

WORDS AND EXPRESSIONS TO AVOID

Some words should be avoided because shorter, simpler words are available. Many expressions should be avoided because they are too wordy. There is nothing wrong with them, and all of us use such phrases on occasion. But habitual use of such expressions adds clutter and reduces clarity. Many of these "heavy breathing" expressions are listed in Appendix 3. Here are just a few examples; the left-hand column gives the wordy expressions and the right-hand column gives suggested replacements:

a considerable amount of	much
a majority of	most
a number of	many
are of the same opinion	agree
at this point in time	now
based on the fact that	because
despite the fact that	although
due to the fact that	because
etiology	cause
first of all	first
for the purpose of	for
has the capability of	can
in many cases	often
in my opinion it is not an unjustifiable assumption that	I think

in order to	to
in the event that	if
it is worth pointing out in this context that	note that
it may, however, be noted that	but
lacked the ability to	could not
needless to say	(leave out, and consider leaving out whatever follows it)
of great theoretical and practical importance	useful
on a daily basis	daily
perform	do
blue in color	blue
take into consideration	consider
the question as to whether	whether
through the use of	by
with a view to	to

JARGON

Jargon can mean any kind of obscure, pretentious, or unintelligible language, but is usually the word used to describe specialized, often technical, terms used within a group. Within the group, the terms are well understood and used routinely, but they may be unknown to people outside the group. For example, New Yorkers listening to the traffic report understand that a "40-minute delay upstairs on the outbound George" means they better take the lower span of the George Washington Bridge if they are leaving Manhattan, but out-of-towners may be mystified.

Sometimes it is difficult to determine what constitutes jargon when it comes to the sciences. One person's jargon may be someone else's everyday speech. If you have any doubts about how off-putting jargon can be, read jargon from another discipline. Like other people's children, jargon from other professions is much less appealing than one's own. Which is not to say that jargon can't be fun. An online search yields numerous "jargon generators" that allow you to create phrases in business jargon (*virtual enterprise simulation*),

educational jargon (*exploit integrated units*), medical researcher jargon (*concentrated experimental benchmark*), and even yoga jargon (*radiate peacefully with grace*).

In scientific writing, jargon and unexplained abbreviations, although understandable to peers, should be avoided. Students and those for whom English is a second language benefit from such consideration. Doubtless, a great many bad (incomprehensible) papers that appear in our journals are bad because the authors ignored the archival and student audiences for their papers and wrote in the arcane shorthand of laboratory jargon. Moreover, scientists sometimes go out of their way to flaunt this jargon, and they (only the worst of them, fortunately) often combine their jargon with an incredibly verbose style that leads to confusion.

A close relative of jargon is the buzzword. Buzzwords are trendy words, usually technical in origin, used (often incorrectly) by nontechnical people. By the way, the word *buzzword* is itself a buzzword. Corporations are abuzz with buzzwords. *Leverage*, *tipping point*, *disconnect*, *bandwidth*, and *benchmark* are just a few of the common buzzwords bandied about in corporate boardrooms by people attempting to demonstrate their superior knowledge. This has led to the development of Buzzword Bingo, a game in which members of the audience check off buzzwords on prepared cards as the speaker mentions them, silently mouthing "Bingo!" when they can fill out a row or column. (For those who prefer electronic games, there is an iPhone app.) The problem with buzzwords is that, like jargon, they are used not to improve communication but to purposefully exclude members of the audience.

Some expressions are so common that we no longer think of them as jargon, but they may not be easy for all readers to decipher. People for whom English is a second language look up unfamiliar words in a dictionary. Consider the literal translations of the following phrases: *frame of reference, news splash, game plan, back burner, across the board, hammer out, know the ropes, off the record, on the fence,* and *sacred cow.*

As the goal of scientific writing is to clearly communicate to a wide audience, buzzwords, jargon, slang, and words that are either meaningless or ephemeral should never be used in scientific papers. Try to write for readers of all backgrounds.

> He multiplieth words without knowledge.
>
> —Job 35:16

CLICHÉS AND IDIOMS

Even worse than today's buzzwords and phrases are yesterday's. An expression, especially an apt metaphor, might be useful when it is new. But stale expressions are boring at best and annoying at worst. Overused and dated expressions such as "it's as American as apple pie" do not add anything and may well irritate your readers.

Idioms, or phrases that aren't taken literally, have no place in scientific writing. Many break the rules of grammar ("that's where it's at") or are confusing to readers not completely fluent in English (why would I *put my nose to the grindstone*?).

Look for dated clichés and idiomatic expressions in your writing. When you notice them, delete them and replace them with clear, literal explanations.

EUPHEMISMS

When writers search for an inoffensive replacement for a word that they are uncomfortable using, they are looking for a euphemism. Euphemisms are fine for toilet training, first dates, and episodes of "Whose Line is it Anyway?" but they have no place in scientific writing. So genitals are not *private parts*; people do not *pass away*; and old age is definitely not *the golden years*.

> Euphemisms are unpleasant truths wearing diplomatic cologne.
>
> —Quentin Crisp

13

Abbreviations, Acronyms, and Initialisms

> If there is any doubt, write the term out. Otherwise, your reader may be in the position of the farmer who shot a crow and read the tag on his leg that said "Wash. Biol. Surv." The farmer remarked that he washed the crow, boiled it, and served it, but it still tasted awful. If there is any doubt, write the term out.
>
> —Deborah C. Andrews and Margaret D. Blickle

DEFINITIONS

The word *abbreviation* refers to any shortened form of a word or a phrase. An acronym is an abbreviation of a special type that abounds in technical and scientific writing. An acronym is a word (such as *NATO*, *radar*, or *laser*) formed from the initial letter or letters of each of a series of words. Strictly speaking, pronounceable "words," such as *BIOSIS* (BioSciences Information Service), which is pronounced "bī-ō´-sis," are acronyms, whereas abbreviations such as *DNA* (deoxyribonucleic acid) are initialisms. (You don't try to pronounce "d-na"; you spell out "d," "n," "a.") Some abbreviations are partially pronounced, such as *JPEG* ("j-peg") and *CD-ROM* ("c-d-rom"). Other abbreviations can be pronounced either as individual letters or as a word, as in the case of Individual Retirement Accounts ("i-r-a" or "ira"). And then there are those that are pronounced with shortcuts such as the abbreviation for the Institute of Electrical and Electronics Engineers (IEEE), pronounced "i triple e."

USE OF ABBREVIATIONS

Abbreviations have become part of daily life, thanks to the need for speed in communications such as e-mail, instant messaging, and texting (not to mention personalized license plates). This has led to shortcuts such as *ttyl* (talk to you later), *nqa* (no questions asked), *ptb* (powers that be), and the dreaded *pos*

(parent over shoulder). These sometimes include symbols (*$ = Starbucks) or letters that, when pronounced, create words (fx = effects). William Steig was way ahead of the curve on this trend, publishing a book in 1968 with text made entirely of individual letters, numbers, and symbols. The book, *CDB!* ("See the bee!") contained exchanges such as this one: "R U C-P?" "S, I M." "I M 2." ("Are you sleepy?" "Yes, I am." "I am too."). Abbreviations such as these, while often clever, have no place in scientific communications, where clarity, not creativity, is the fundamental requirement.

Abbreviations can be a useful way to make writing and speaking more concise, less repetitive, and more accessible to nonscientists. (Imagine a line of dialogue from *NCIS* with no abbreviation: "DiNozzo, take this hair and have Abby run a deoxyribonucleic acid test on it.") However, abbreviations can become annoying if used to excess, and can be confusing if not explained at their first use, particularly as the same abbreviation can have more than one meaning (*GC* can mean either *general counsel* or *gonococcus*, but perhaps that's a poor example).

This does not mean you should use abbreviations at every opportunity. Generally speaking, never use an abbreviation in the title of a book, article, or paper. If there is a common abbreviation for a word that is key to your work, you may want to use it once in the abstract to make sure keyword searches for that abbreviation are able to locate your paper. Otherwise, do not use abbreviations in an abstract. In text, abbreviate only if a long word is used many times and a standard abbreviation exists. Be sure to introduce the abbreviation the first time you use it. You can often avoid using abbreviations by using the appropriate pronoun (*it*, *they*, *them*) if the antecedent is clear. Or, you can substitute a generic description such as *the chemical*, *the hormone*, *the enzyme*, or *the acid*.

Use only standard abbreviations—never create one yourself. Consult a style manual (See page 95) for a list of generally accepted abbreviations.

Resist creating acronyms for every committee, activity, department, compartment, project, procedure, and team. This leads to a confusing cacophony of acronyms. The overuse of acronyms has become so commonplace that it has led to the formation of the Acronym Sense Society (ASS), an organization created to oppose the widespread overuse of acronyms (WOA).

It also pays to be conscious of acronyms and initialisms when creating names for organizations, products, or services. Here are some examples of poor choices:

Suffolk County Accessible Transportation
Baltimore Youth Oversight Bureau
Friends of Ancient Road Transportation
Student Help In Technology
Brotherhood of Independent Truck and Car Haulers
Technological Institute of Textile Sciences

(www.CartoonStock.com.)

HOW TO ABBREVIATE

The "how" is easy. In science, clear-cut conventions have been established. First, the abbreviation should be introduced *at first use* in the text. It is not necessary to introduce common abbreviations such as *e-mail*, *etc*., *RSVP*, and *DVD*. Do not capitalize the first letter of each word unless the word is normally capitalized. Second, the abbreviation is introduced within parentheses immediately after the spelled-out word or term that it abbreviates. Third, the abbreviation is *normally* given in capital letters (except units of measure), without periods and without spaces.

> The reaction proceeded at standard temperature and pressure (STP).
> The virus was a close relative of tobacco mosaic virus (TMV).

In the biological sciences, it is customary to abbreviate names of organisms after they are introduced. At first use, you would spell out *Staphylococcus aureus*. In later usage, you would abbreviate the genus name but not the specific epithet: *S. aureus.* If you are writing a paper that includes more than one species with a name beginning with a particular letter, you must spell out the genus names repeatedly. Otherwise, readers might be confused as to whether a particular abbreviation referred to one genus or another. Note that italics are maintained in the abbreviated form of the name. Unless you are writing for the public (and perhaps not even then), do not use other forms of abbreviation, such as *staph*.

Acronyms and initialisms are generally spelled without periods (*NASA*, not *N.A.S.A.*) and may or may not be capitalized, depending upon how the word or phrase it represents is written (*JPEG*, *sonar*, *AIDS*).

Avoid redundancy with acronyms. If a word is represented in the acronym, do not repeat it.

> *Right:* AIDS
> *Wrong:* AIDS syndrome
> *Right:* HIV
> *Wrong:* HIV virus

Although style guides may differ, most require the use of an apostrophe before the *s* only for possessives.

He stored the data on three *DVDs.*
The *DVD's* label was blue.

Abbreviations that might cause confusion are spelled with periods and apostrophes.

M.A. degree
M.A.*'s*

WHAT TO ABBREVIATE

The "what" is not easy. In deciding whether to abbreviate a word or term, you should ask yourself three questions.

First, is there a *standard* abbreviation readily available? If so, use the abbreviation. (Some journals allow a few well-known, standard abbreviations to be used without introduction.) You may need to check the instructions for authors of your target journal or the principal style manual in your field.

Second, is the word or term long or short? A word like *acid* is obviously too short to merit abbreviation (and the abbreviation *A* would be confusing). A term such as *nitric acid* is still too short to merit abbreviation (and *NA* could also mean "not applicable"). However, when we get to a mouthful like *deoxyribonucleic acid*, we have a term that cries out for abbreviation.

Third, how often is the word or term used in the paper? If the word or term is used frequently, use the abbreviation. If it is used rarely, do *not* use an abbreviation. If an abbreviation (unless it is a standard one) is introduced in the introduction and then not used again until the discussion, it is likely that the reader will have forgotten what the abbreviation means, so it should be reintroduced.

WHAT ABBREVIATIONS NEED NO INTRODUCTION

Units of measure do not have to be spelled out at first use. The standard metric units are known throughout the world (among scientists at least). The abbreviations for these units are usually lowercase, without periods and without spaces.

I added 4 ml of distilled water to the reaction mixture.

Does that mean that units of measure are always abbreviated? No. They are abbreviated *only* when used with numbers. Furthermore, if they are used with a spelled-out number (at the start of a sentence), they are spelled out.

I added a few milliliters of acetone.
Four milliliters of acetone was added.

Incidentally, to avoid starting a sentence with a numeral or with a spelled-out number and unit, simply get the real subject of the sentence up front.

Acetone (4 ml) was added.

Chemical elements and compounds, like metric units, are known throughout the world, so these abbreviations need not be introduced. However, it is still wise to follow the "short" rule. It makes sense to use *HCl* in place of hydrochloric acid, but it isn't wise to use H_2O in place of water (except in a formula involving waters of hydration).

In American publications, the abbreviations for the states of the United States need not be introduced. State names are usually spelled out when used alone. But when the name of the state is preceded by the name of a city, use the U.S. government-sanctioned two-letter abbreviation (capitals, no periods), especially when followed by a zip code, as in mailing addresses. Examples of these accepted abbreviations are *AK* (Alaska), *NM* (New Mexico), and *WY* (Wyoming). The full list can be found on the Postal Service website at www.usps.com.

Keep in mind that abbreviations that seem universally understood may be universally understood only among Americans. Abbreviations such as *mgr.* (manager), *admin.* (administration), and *hrs.* (hours) may not be familiar to people outside the United States and therefore should not be used.

> Do not write so that you can be understood, write so that you cannot be misunderstood.
>
> —Epictetus

A List of Selected Style Guides

American Anthropological Association (AAA)
AAA Style Guide, American Anthropological Association, 2009.
http://www.aaanet.org/publications/style_guide.pdf

American Chemical Society (ACS)
The ACS Style Guide: Effective Communication of Scientific Information. Ed. Anne Coghill and Lorrin Garson. 3rd ed. Washington, DC: American Chemical Society, 2006.

American Medical Association (AMA)
AMA Manual of Style: A Guide for Authors and Editors. Cheryl Iverson et al. 10th ed. New York: Oxford Univ. Press, 2007.

American Institute of Physics (AIP)
AIP style manual (4th ed.). New York, N.Y.: American Institute of Physics, 1990.

American Political Science Association (APSA)
Style Manual for Political Science. Rev. ed. Washington, DC: American Political Science Association, 2006.

American Psychological Association (APA)
Concise Rules of APA Style. 6th ed. Washington, DC: American Psychological Association, 2010.
Publication Manual of the American Psychological Association. 6th ed. Washington, DC: American Psychological Association, 2010.

American Sociological Association (ASA)
ASA Style Guide. 3rd ed. Washington, DC: American Sociological Association, 2007.

Chicago Manual of Style
Chicago Manual of Style. 16th ed. Chicago: Univ. of Chicago Press, 2010.

Council of Science Editors (CSE)
Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers. 7th ed. Reston, VA: Rockefeller Univ. Press, 2006.

Institute of Electrical and Electronics Engineers (IEEE)
IEEE Editorial Style Manual
http://www.ieee.org/documents/stylemanual.pdf

Modern Language Association (MLA)
MLA Style Manual and Guide to Scholarly Publishing. 3rd ed. New York: Modern Language Association, 2008.

14

Phrases

He can thread a needle with a well-turned phrase.

—Don Hewitt

KINDS OF PHRASES

The words from the nine pigeonholes (nouns, pronouns, verbs, adjectives, adverbs, prepositions, conjunctions, interjections, and articles) of the English language can be assembled into phrases, clauses, and, ultimately, sentences, the basic units of thought and communication. But how do we string these words together?

First, some definitions. A *phrase* is a group of two or more grammatically related words that do not make a full statement, that is, a group of related words that does not include both a subject and a verb. On the other hand, a *clause* (see Chapter 15) does contain both a subject and a verb.

If a phrase is a group of related words, we could say (and grammarians do) that a noun with its associated adjectives is a "noun phrase." Thus, we can have noun phrases, verb phrases, adverbial phrases, and a bewildering taxonomic array. It is better to let adjectives quietly modify their nouns, for example, without worrying about noun phrases. Instead, let us look at those words that *as a group* act as a part of a sentence or modify some other element in a sentence. Fortunately, there are only four of these: prepositional phrases, infinitive phrases, participial phrases, and gerund phrases. In assembling these phrases into sentences, there is one overriding rule: get them as close as possible to the sentence elements they modify.

PREPOSITIONAL PHRASES

A prepositional phrase consists of a preposition, its object, and any words that modify the object. Normally, prepositional phrases act as adverbs or adjectives.

For dinner, he went *to the most popular and most expensive restaurant in the city.*

In the above example, only the two words *he went* are not parts of prepositional phrases. The sentence has three prepositional phrases: *For dinner* modifies *went* and is thus serving as an adverb; *to the most popular and most expensive restaurant* is a much longer prepositional phrase, also modifying *went*; *in the city* is a prepositional phrase modifying the object of the preceding prepositional phrase (*restaurant*), and it is thus serving as an adjective.

Note that *For dinner* in the above example is followed by a comma. Here is a rule: when a sentence starts with a preposition, insert a comma after the prepositional phrase. Many grammarians would argue that such commas are not necessary, particularly if the phrases are short. However, the use of such commas *is never wrong,* and use of commas after every introductory prepositional phrase will provide consistently clear sentences. In the example above, no confusion results if a comma is not used following *For dinner.* However, try this one:

For the first time scientists have been able to treat this disease.

If no comma is used after the opening prepositional phrase ("For the first time"), the reader may for a moment mistakenly assume that the sentence refers to "first time scientists." Thus, even though introductory prepositional phrases need not always be followed by a comma, insert the commas anyway. Then you need not worry about when to use a comma and when not, and you will never be wrong.

Because prepositional phrases act as adjectives or adverbs, they can modify nouns, pronouns, verbs, adjectives, or adverbs. Thus, get them as near as possible to the word they modify.

Wrong: A large mass of literature has accumulated *on the cell walls of staphylococci.*
Right: A large mass of literature *on the cell walls of staphylococci* has accumulated.

INFINITIVE PHRASES

An infinitive phrase consists of *to* plus a verb and any objects or modifiers.

> *To pass this course,* you must be willing *to study diligently.*

Infinitive phrases are easy to use. The only rule: place the infinitive phrase as close as possible to the word it modifies, and forget the old rule against splitting infinitives. (A "split infinitive" has one or more words between the *to* and the verb.) That is not to say that infinitives should always or even usually be split. In the above example, for example, "to study diligently" perhaps flows more smoothly than "to diligently study."

> The treatment failed to delay further signs of infection.

In the above example, however, the reader may infer that "delay" will lead to "further" (additional) signs of infection. If we split the infinitive (*to further delay*), the reader knows we mean additional delay and not additional signs of infection. (Split infinitives are treated in greater detail in Chapter 5.)

PARTICIPIAL PHRASES

A participial phrase consists of a participle (an *-ing* verb used as an adjective), its object, and its modifiers.

> Using good sense, you can write good sentences.

A participial phrase functions as an adjective, so it must modify a noun or a pronoun; in addition, it must be close to the word it modifies. If the sentence contains no noun or pronoun that the participle can modify, or if the noun or pronoun is too far away from the participle, the participle is said to "dangle."

Here's a good dangler:

> Lying on top of the intestine, you can perhaps make out a thin transparent thread.

Because a participle *should* modify the nearest available noun or pronoun, the unwary reader of the above sentence would assume that "you" are "lying on top of the intestine." Presumably, the writer was trying to say that the thread was on top of the intestine. As written, the very first word in this sentence (the participle *Lying*) actually modifies the very last word in the sentence (the noun *thread*); thus, syntactically, the sentence could not be more wrong. The problem is solved by turning the sentence around:

You can perhaps make out a thin transparent thread lying on top of the intestine.

Most dangling participles occur when the main clause following the participle begins with *it is*.

Going home, it is wise to be careful.

Obviously, "it" is not going home. Because there is no noun or pronoun that the participle can modify, it dangles.

Whenever you start a sentence with a participial phrase, it is a good practice to check to make sure that the noun or pronoun immediately following it is the one you intended to modify. After writing the sentence above, you would ask yourself "Who is going home?" (The answer would be "it" and you would see your mistake.)

The above examples are "present participles." "Past participles" are similar, except that the verbs have *-ed* endings rather than *-ing* endings.

The man, infected with the influenza virus, grew weak.

> Penetrating so many secrets, we cease to believe in the unknowable. But there it sits nevertheless, calmly licking its chops.
>
> —H. L. Mencken

GERUND PHRASES

A gerund is an *-ing* verb used as a noun. A gerund can be used alone.

Running is my favorite sport.

Or, by giving the gerund an object (with or without modifiers), we can create a gerund phrase. Such gerund phrases can be used as the subjects of sentences.

Writing this chapter was a difficult task.

Gerund phrases can also be used as objects.

We enjoyed writing this chapter.

Fortunately, gerund phrases seem to fall naturally into place when used in sentences. Rarely do they cause the kinds of confusion so often caused by participial phrases.

> Every single phrase is a string of perfect gems, of purest ray serene, strung together on a loose gold thread.
>
> —George du Maurier

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Clauses

> Sentences beginning with "and," "but," or "or" are acceptable provided the practice is not overdone. Indeed, nothing that is overdone is ever acceptable, be it language or lamb chops.
>
> —Theodore M. Bernstein

KINDS OF CLAUSES

A clause functions as a part of a sentence; unlike a phrase, however, a clause has both a subject and a verb. Fortunately, clauses are easy to understand because there are only two main types of clauses: independent and dependent.

> Groucho: "That's in every contract, that's what you call a sanity clause."
> Chico: "You can't a fool a me, there ain't no sanity clause."
>
> —The Marx Brothers, *A Night at the Opera*

Independent Clauses

An independent clause is a set of words, including a subject and a verb, that makes a complete statement. Thus, an independent clause could stand alone as a complete sentence. However, if it stood alone, it would be called a sentence and not a clause. As a clause, it is attached to some other sentence element (another independent clause or a dependent clause).

> No amount of experimentation can prove me right; a simple experiment may at any time prove me wrong.
>
> —Albert Einstein

The above sentence includes two independent clauses separated by a semicolon. Note that the semicolon could be replaced by a period, and the two independent clauses could indeed stand as sentences. Einstein, however,

wanted to show a close relationship—a contrast between these two related thoughts; therefore, he expressed these thoughts as two clauses rather than as two sentences.

Independent clauses are usually separated from each other in one of three ways. First, a semicolon can be placed between the two clauses.

> I don't agree with mathematics; the sum total of zeros is a frightening figure.
> —Stanislaw J. Lec, *More Unkempt Thoughts*

Second, a semicolon plus a coordinating adverb (e.g., *however*, *therefore*, *moreover*) can be used; when independent clauses are joined in this way, a semicolon always precedes the coordinating adverb, and a comma always follows it.

> I planned to measure fizz plumes generated by Mentos; however, someone drank all the soda.

Third, two independent clauses can be joined by a comma and a coordinating conjunction (*and*, *but*, *for*, *nor*, *or*, *so*, *yet*).

> I do not like it, and I am sorry I ever had anything to do with it.
> —Erwin Schrödinger, Austrian physicist and Nobel Prize winner, speaking of quantum mechanics

> It is almost always a greater pleasure to come across a semicolon than a period. . . . You get a pleasant little feeling of expectancy; there is more to come; read on; it will get clearer.
> —George F. Will

Dependent Clauses

A dependent clause, like an independent clause, has both a subject and a verb. However, a dependent clause is introduced by a subordinating word that makes the clause dependent on (subordinate to) another (independent) clause. Many of these subordinating words express time constraints (*when*, *after*, *before*) or doubt (*if*, *whether*).

If your experiment needs statistics, then you ought to have done a better experiment.
—Ernest Rutherford

If you're not part of the solution, you're part of the precipitate.
—Henry J. Tillman

When we try to pick out anything by itself, we find it is tied to everything else in the universe.
—John Muir

In the final example, the independent clause is "we find it is tied to everything else in the universe"; the dependent clause is "When we try to pick out anything by itself." Obviously, the dependent clause could not stand alone as a sentence. Note that a comma follows the dependent clause, indicating to the reader that the dependent clause is ending and that the independent clause is beginning. This is a rule: when a sentence begins with a dependent clause, end the clause with a comma. The rule can be extended to indicate that a comma should follow any dependent clause preceding an independent clause.

Actually, the above rule is not always correct because (rarely) a dependent clause can be used as a subject of an independent clause; since it is a cardinal rule that a comma cannot separate a subject from its verb, a comma is not used.

That you are enjoying this book is very likely.

The above is a kind of reverse sentence. (Most people would probably write "It is very likely that you are enjoying this book.") Nonetheless, the example is grammatically correct; *That you are enjoying this book* is serving as the subject of the sentence. Note also that, in the parenthetical sentence, *that you are enjoying this book* is used as a predicate adjective. In fact, dependent clauses can serve as nouns (as in the first example), as adjectives (as in the revised example), and as adverbs:

We will all go together *when we go.*

In this example, note that a comma is not used before the dependent clause, whereas a comma would be used if the dependent clause started the sentence:

When we go, we will all go together.

When a dependent clause appears in the *middle* of an independent clause, two commas (balancing commas) are usually used, one before and one after the dependent clause.

A cynic is a man who, when he smells flowers, looks around for a coffin.
—H. L. Mencken

She, whom I have known for many years, arrived yesterday.

Note that the "whom" clause has commas fore and aft. Note also that the clause modifies the pronoun *she*, which means that the clause is adjectival. (By definition, adjectives modify nouns or pronouns.) In passing, note that the objective case, *whom*, is used. It appears that *whom* is slowly passing out of the language; many writers today would say "She, who I have known for years, arrived yesterday." However, if one can distinguish between the nominative and objective cases, it still usually sounds better to use *whom* as an object. Admittedly, in many cases, as in the above example, it is not easy to distinguish between the cases. In the above example, the normal subject-verb-object syntax ("I have known whom") has been inverted ("who or whom I have known"), making the *who* look like a subject even though in reality it is an object.

Finally, note that the *whom* clause separates the subject of the sentence (*She*) from its verb (*arrived*). Whenever any interrupting element (a word, phrase, or clause) separates a subject from its verb, *two* commas must be used, one before the interrupting element and another after it.

WHICH HUNTING

Many grammarians and editors love to play games with *which* and *that*. Sooner or later, every author will have a manuscript returned by an editor who has changed all of the *which*es in the manuscript to *that*s and vice versa. Such "which hunters" believe that dependent clauses can be divided into two

types: restrictive and nonrestrictive (or defining and nondefining). By their definition, restrictive clauses (those that are essential to the meaning of a sentence) are preceded by *that*; nonrestrictive clauses (not essential) should be preceded by *which*.

Unfortunately, as with other grammatical rules, the *that-which* rule is impossible to invoke across the board. Some dependent clauses are obviously restrictive, supplying essential information, and others are obviously supplying only incidental information. However, who can possibly define which modifiers are essential and which give only additive information?

Normally, such distinctions should be made by *authors*, not *editors*, because only the author of a sentence knows whether something is "essential" to his or her message. And often it simply doesn't matter, to the author or to anybody, whether *that* or *which* is used.

Beef is a meat (*that*, *which*) is high in protein.
This is an experiment (*that*, *which*) will succeed.

According to the "rule," *that* should be used in these sentences. (A sentence saying "Beef is a meat" wouldn't make much sense until the restrictive clause is added.) Does that mean *which* would be wrong in the above sentences? In zillions of such sentences, either *that* or *which* can be used and the meaning of the sentences will be exactly the same.

Further, writers who worry excessively about whether to use *that* or *which* seldom note the vast number of sentences in which the use of *that* or *which* is wrong or at least verbose. Look again at the above two sentences. The first is better written as "Beef is high in protein," and the second is better as "This experiment will succeed." We thus save four words in the "beef" sentence and three words in the "experiment" sentence, making the sentences shorter and clearer.

And still further, some writers substitute *where* for *which* or *in which*.

I am looking for a position *where* I can broaden my knowledge of civil engineering.

The problem with *where* is that it connotes a geographical location when one was not intended; in the above sentence, *in which* provides clearer meaning than *where*.

However, someone just raised a hand and said "Does that mean we can forget the *that-which* rule?" The answer is no, absolutely not.

Antibiotics (*that*, *which*) are produced by microorganisms are effective in treating most infectious diseases.
Alkaloids (*that*, *which*) contain nitrogen can be poisonous.

Does it matter whether *that* or *which* is used in the above sentences? It certainly does. In the first sentence, if *that* follows *antibiotics*, the implication is that some antibiotics are produced by microorganisms and others are not. If *which* follows *antibiotics* (and especially if a comma precedes *which* and a balancing comma follows *microorganisms*), the sentence then means that *all* antibiotics are produced by microorganisms. Likewise, in the second example, use of *that* would suggest that some alkaloids contain nitrogen and others do not, whereas use of *which* would indicate that *all* alkaloids contain nitrogen.

Therefore, you need not be a "which hunter," but you should occasionally watch for *which*es, especially on Halloween. In choosing between *which* and *that*, you might try writing the sentence twice with a *which*, once with commas around the clause, once without:

Alkaloids, which contain nitrogen, can be poisonous.
Alkaloids which contain nitrogen can be poisonous.

In this way, the distinction in meaning (if any) will become clear. If the material between the commas could be deleted from the sentence without destroying the sentence, the clause indeed is nonrestrictive, and the *which* and the commas should be retained. The basic sentence "Alkaloids can be poisonous" now has a nonrestrictive addition: "Alkaloids, *which contain nitrogen*, can be poisonous." If, however, the material within commas cannot be deleted without ruining the sentence, the commas should *not* be used (and, ideally, the *which* should be changed to *that*). If your meaning is not that alkaloids can be poisonous but that only those alkaloids containing nitrogen can be poisonous, your meaning is then expressed clearly by saying "Alkaloids that contain nitrogen can be poisonous."

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Sentences

> Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that a writer make all his sentences short, or that he avoid all detail and treat his subjects only in outline, but that every word tell.
>
> —William Strunk, Jr.

KINDS OF SENTENCES

Words, phrases, and clauses are the building blocks of sentences. The sentence is the basic unit of thought and expression. If you can build sentences logically, you can communicate clearly. It is easy to build effective sentences because—in all of the millions of books, journals, and other written documents—exactly six types of sentences are used. Learn how to organize and punctuate these six types of sentences and you will be able to write clearly. These six types are questions, exclamations, and the four kinds of declarative sentences (simple, compound, complex, and compound-complex).

QUESTIONS

> Why are things as they are and not otherwise?
>
> —Johannes Kepler

A question is any sentence that asks something and, therefore, ends with a question mark. True, the word *question* can be used more broadly (e.g., "the question before the house"), and some indirect questions are not followed by

(www.CartoonStock.com.)

question marks. However, such "questions" become declarative in form, so it is best to simply accept the idea that questions end with question marks.

What is a question?
How should I know?
Did you hear about the zoologist who was so dumb the other zoologists noticed?

By further definition, a question is a sentence that needs a response.

Why did the chicken cross the Mobius strip? To get to the same side.

A neutron walks into a bar; he asks the bartender, "How much for a beer?" The bartender looks at him, and says "For you, no charge."

How many evolutionists does it take to change a light bulb? Only one, but it takes eight million years.

Some sentences that start like a question do not need a response.

Would you turn in this assignment next Tuesday, please.

In the above example, you do not really expect an answer. In fact, you are commanding a response, rather than asking for one. Although it *looks* like a question, it is a declarative sentence (and thus it ends with a period).

A physics student recognizes Einstein in a train and asks: "Excuse me, professor, but does New York stop by this train?"

EXCLAMATIONS

> There ain't no rules around here! We're trying to accomplish something!
> —Thomas Alva Edison

An exclamation is any sentence that ends with an exclamation point (or "bang"). While in the business of giving simple definitions, we will also define declarative sentences (all four types) as those that end with periods. Now do you see how simple English is?

Exclamations can be single words, phrases, clauses, or full sentences.

When I am good and ready!
Almost ready!
Ready!
I'm ready, already!

But don't use too many exclamation points! Exclamation points lose their force when authors use them frequently! They can also annoy readers when they are used to conclude seemingly inconsequential remarks such as this one! Exclamations imply emotional involvement rather than objectivity. They are fine for detective fiction and advertising copy, but should generally be avoided in scientific writing.

Sign on the door to an optics lab: "CAUTION! Do not look into laser with remaining good eye."

In Spanish, both questions and exclamations start with an inverted mark that tells the reader what is coming.

¿Que pasa?
¡Esto es un libro tremendo!

Unfortunately, English gives no such warnings.

In rare cases, a question mark and an exclamation mark are used together.

What the . . . ?!
She said what?!

The awkward nature of this punctuation combination inspired an advertising executive (who else?!) to develop a new punctuation mark that combines an exclamation point and a question mark: **‽** He even solicited names for his invention. This inspired such Stephen Colbert-worthy contenders as *exclarotive*, *exclamaquest*, *quesclamation mark*, and the winner, *interrobang*. Surprisingly, the new mark never caught on.

Multiple punctuation marks (an exclamation point and question mark, two or more exclamation marks, or two or more question marks) are fine for casual communications but have no place in scientific writing. So please save them for sentences ending with "lol."


!!!!!!!ATTENTION!!!!!!!!
DO NOT STORE LAB SPECIMENS
IN THIS REFRIGERATOR!!!!!!!!!!!
FOR LUNCHROOM USE ONLY!!!
OZ HAS SPOKEN!!!!

DECLARATIVE SENTENCES

> There isn't any thought or idea that can't be expressed in a fairly simple declarative sentence, or in a series of fairly simple declarative sentences.
>
> —E. B. White, "Fro-Joy"

Simple Declarative Sentences

A simple declarative sentence consists of one independent clause. That is, the sentence contains a subject and a verb; it may also contain an object.

People everywhere love Windows.

—Bill Gates

Science is the systematic classification of experience.

—George Henry Lewes

Scientists are explorers. Philosophers are tourists.

—Richard Feynman

Black holes are where God divided by zero.

—Steven Wright

The normal structure of the simple declarative sentence is subject, verb, and object (if any) or predicate adjective (if any).

The world exists.
A meteorite hit the Earth.
She is intelligent.
The modern physician must keep abreast of mammography.

A simple declarative sentence is one unit of thought. Such straightforward, uncluttered statements should form the basis of good scientific writing. Other

sentence structures are needed from time to time, but most good writers recognize the expressive power of the simple declarative sentence.

Simple sentences are not necessarily short. Modifying words and phrases can be added to subjects, verbs, and objects. Furthermore, simple sentences can have more than one subject (called a compound subject), more than one verb (a compound verb), and more than one object. All of the following are simple declarative sentences:

He ran.
He and she ran.
She ran and jumped.
He and she ran and jumped.
She painted the house, the barn, and the town.

Note that third example: the sentence "She ran and jumped" has two verbs but only one subject. Thus, the two verbs are called a compound verb. If the subject were repeated, "She ran, and she jumped" would then be a compound sentence. (The comma would then be appropriate, whereas a comma should not be placed between the parts of a compound verb.)

Compound Declarative Sentences

Compound sentences contain two (or more) independent clauses. Almost any two simple sentences can be joined together to form a compound sentence. If the two thoughts in the two simple sentences are not closely related, the sentences should be retained as separate sentences; if there is a fairly close connection between the two thoughts, the two sentences should be fused into one.

The two independent clauses of a compound sentence are usually joined in one of three ways: (1) with a comma and a coordinating conjunction (*and*, *or*, *but*, *for*, *nor*, *so*, *yet*), (2) with a semicolon, or (3) with a semicolon and a coordinating adverb such as *however*, *therefore*, *thus*, *moreover*, or *nevertheless*.

The scientist identified the problem, but he found it difficult to solve.
The scientist identified the problem; he found it difficult to solve.
The scientist identified the problem; however, he found it difficult to solve.

The above three punctuation choices are the standard ways of joining two independent clauses. Rarely, the second clause may relate very closely to the first clause, and the writer might want to show this close association by using either a dash or a colon.

> The scientist identified the problem—the experiment had no control.
> The solution was obvious: experiments must include a control.

Two independent clauses *cannot* be joined by a comma without a coordinating conjunction.

> Seek wealth, it's good.
>
> —Ivan Boesky

The error in the above sentence is called a "comma splice." (Mr. Boesky spent three years in prison, but his sentence was not for his grammatical error.)

Complex Declarative Sentences

A complex sentence has one independent clause and one or more dependent clauses.

> Because many poor adults were born into poverty, poor pregnant women are disproportionately likely to have experienced prenatal and early-life poverty-related stressors.
> Therefore, while enactments of state credits improve birth weight, we have no evidence that the size of credits matters.
> Because enactment of a state EITC increases poor women's incomes, but should be uncorrelated with unmeasured characteristics, this supports a causal effect of prenatal poverty.[1]

Complex sentences are simple sentences to which a qualifier (in the form of a dependent clause) has been added. Qualifications are often essential in scientific writing. The clear meaning of the simple sentence is qualified by *if*, *when*, *whereas*, *although*, or some other limiting word.

When the temperature decreases, less activity is observed.
If glucose is added, the medium will support growth.

Often, the dependent clause adds useless words, and the sentence would be stronger if the dependent clause were deleted.

Although I am not absolutely sure of what I am saying, I think that A equals B.

Compound-Complex Declarative Sentences

A compound-complex sentence has at least two independent clauses and at least one dependent clause. Although such sentences tend to be longer than the other three types of declarative sentences, they need not be difficult. The independent clauses are joined together exactly as they would be in a compound sentence. A dependent clause is added as it would be in a complex sentence; for example, a dependent clause at the start of a compound-complex sentence should be followed by a comma.

Although the surgeon located the problem, she found it difficult to repair; in fact, she determined that a transplant would be needed.

When I sell liquor, it's called bootlegging; when my patrons serve it on silver trays on Lake Shore Drive, it's called hospitality.

—Al Capone

A man who has never gone to school may steal from a freight car; if he has a university education, he may steal the whole railroad.

—Theodore Roosevelt

You can assemble and punctuate accurately all four types of declarative sentences if you learn to recognize the differences between the two types of clauses. In short, an independent clause is a complete statement; a dependent clause is incomplete, and it requires an independent clause to complete its meaning. A good test is to look at the clause and imagine that the first word

starts with a capital and the last word is followed by a period. If it seems complete, it is an independent clause. If it somehow leaves you hanging, waiting for additional information, it is a dependent clause. In time, your eye and ear will recognize the distinctions, and the commas and semicolons can be inserted appropriately.

The four types of declarative sentences can be summarized as follows. You *must* be able to construct and properly punctuate these four types of sentences because nearly all the sentences you will ever write will be of these types.

1. A *simple* sentence is used to make an unqualified observation.
2. A *compound* sentence is used to make two (or more) unqualified observations, often in comparison or contrast.
3. A *complex* sentence adds a qualification or subordinate idea to an observation.
4. A *compound-complex* sentence presents two primary observations, one or both of which are qualified.

LENGTH OF SENTENCES

Short sentences are better than long sentences as a rule. Our eyes and our minds can grasp the meaning quickly if the words are presented in short groups.

Having said that, let's look at sentences from a somewhat different perspective. For example, does a sentence really have to be a full statement (with subject and verb)? No. The preceding "sentence," the word "No," would be called a "fragment," and many grammarians believe that a "frag" (which they love to mark on students' papers) is always wrong. We disagree, and we have used a number of "frags" in this book. Many writers use them to good effect.

> A little knowledge is a dangerous thing. So is a lot.
>
> —Albert Einstein

The first of these two sentences is a full sentence. The second is a fragment. Together, the two "sentences" are very effective. However, you must know what you are doing. A skilled writer can fire off a wonderful fragment. Not so an unskilled writer.

Short, simple declarative sentences can be logical, perhaps even pretty. But are they *complete*? A short sentence that says it all is the ideal; however, a

short sentence that omits something important is not a good sentence. Scientists, especially, must always remember the necessity of qualifications. Rarely can you write a simple sentence such as this:

> Compound A increased the survival rate by 40 percent.

Perhaps the survival rate was indeed increased by 40 percent, but over what period of time, under what conditions? You may need to add one or more dependent clauses and perhaps another independent clause. True, some additional material is best added in the form of additional sentences. But two sentences suggest to our mind's eye that there is a strong degree of independence between the two thoughts. When we need to show *close* relationships, it is often better to add clauses to a sentence.

> When the infected animals were treated for 3 days, compound A (100 ng per mg of body weight) increased the survival rate by 40 percent.

A short sentence is not necessarily a good sentence, and a long sentence is not necessarily bad. Short sentences *can* be confusing. Very long sentences *can* be very easy to read if their phrases and clauses are presented in logical order with proper punctuation.

Various experts have proposed readability formulas and indexes designed to measure the difficulty of written materials. Although short words are better than long words and short sentences are better than long ones, writing by the numbers does not make good sentences any more than painting by the numbers makes good art. The effective writer should seek to excise unneeded words from all sentences, short or long. The good writer should use the most meaningful, exact words, short or long.

> You'll never get anywhere with all those damned little short sentences.
> —Gregory Clark to fellow *Toronto Star* newspaperman Ernest Hemingway

17

Paragraphs

> Paragraphs are not just chunks of text; at their best, they are logically constructed passages organized around a central idea often expressed in a topic sentence. A writer constructs, orders, and connects paragraphs as a means of guiding the reader from one topic to the next, along a logical train of thought.
>
> —Victoria E. McMillin

ORGANIZING THOUGHTS

A sentence is the basic unit of communication. A paragraph consists of one or more sentences on essentially the same subject. If each set of closely related sentences is neatly packaged in its own paragraph, the reader has no difficulty following related items; then, with the start of a new paragraph, the reader is automatically prepared for a new set of thoughts, perhaps additional information related to the preceding paragraph, or perhaps material contrasting with the preceding paragraph. If paragraphs are created with care, they are of great value to the reader in following the writer's logical development of thoughts and arguments.

PARAGRAPH STRUCTURE

An effective paragraph should have an obvious beginning, middle, and end. The beginning (often just the first sentence) should state clearly the subject of the paragraph. The next group of sentences should marshal the evidence in support of or describing the subject. The final part of the paragraph (often the final sentence) usually provides a conclusion or a summary of what has been said in the paragraph, or it provides a transition to the next paragraph.

The first sentence (called the topic sentence) is the key. If the general subject of the paragraph is not clear, the details that follow in the body of the paragraph will hardly interest the reader.

The last sentence is usually important also, underlining the conclusion or at least the gist of the paragraph. Some paragraphs, however, must end without a

definite concluding statement. When this happens, the first sentence of the *next* paragraph should make it clear that a transition in subject or development has occurred. Fortunately, English has many words and phrases that can be used as transitional signposts to aid the reader. If the new paragraph will present different but supportive information, the first sentence might start with such expressions as

In addition,
Moreover,
We also noted that
Smith et al. (2010) obtained somewhat similar results, showing

If the new paragraph will present contrasting information, suitable transitions might be

On the other hand,
However,
Contrary to this suggestion,

If the new paragraph is to serve as a conclusion to the previous paragraph, group of paragraphs, or perhaps the entire paper, transitional openings might be

Thus,
Consequently,
In conclusion,

Below is a paragraph about sediment in the Magdalena River Basin in Columbia. Note how the topic sentence introduces the general topic of "sediment trapping." The next three sentences support the topic sentence, moving from the general (sediment often doesn't reach a river's mouth) to the specific (the Magdalena River and information on sediment patterns in the Magdalena). The final sentence provides an obvious conclusion.

Sediment trapping in large river systems is very common. A significant amount of the suspended sediment never reaches the river mouth, as it becomes sequestered in riverbeds, on floodplains, and in reservoirs (e.g., Dunne et al. 1998; Goodbred and Kuehl 1998; Aalto et al. 2002). The Magdalena River crosses a floodable area termed the Mompox tectonic depression, which is located at

> the confluence of the Magdalena River and the Cauca and Cesar tributaries and extends over 6000 km^2 (fig. 1). Overflow and levee failures cause extensive flooding from April until November, and sediment has been deposited over the last 7500 yr at a rate of 3–4 mm yr^1, in places creating >30-m-thick deposits (Plazas et al. 1988; Bray 2006). On the basis of 27 yr of observation, Restrepo et al. (2006*b*) estimate that 14% of the total annual Magdalena sediment load is trapped in the Mompox depression.[1]

Should paragraphs be short or long? A too-long paragraph may leave the reader gasping for air. Too many short paragraphs make jerky reading. The point to remember is that each paragraph should tell a story. Some of these stories will be short, and some will be long.

LISTS

Sometimes, information is best presented as a list. Lists

- can be bulleted (like this one) or numbered (to show an order)
- can be used to show choices, list steps, or group items that share a common feature
- make the information easy to scan

If you use a list to present information, make sure the items on the list are parallel in structure (see Chapter 5 for more information on parallelism). All items in the list should be either full sentences or fragments, but not a mixture of both. Capitalize the first letter if the list item is a full sentence. If it's a sentence fragment, you can choose whether to capitalize the first letter or not. If you do capitalize the first letter, do so for every item. Be sure to check the publication's instructions for authors to see whether it specifies a format for lists.

Use numbered lists for information that is sequential, such as steps in a procedure, or when you want to emphasize the order of importance.

To operate the autoclave

1. Open the autoclave door.
2. Place items in the autoclave bag.
3. Put autoclave indicator tape on the bag.
4. Place the bag in the autoclave.
5. Close the autoclave door.

Use letters when you want to refer to items from the list.

All new lab employees should

a. Observe all safety precautions
b. Obtain I.D. cards
c. Park in designated areas
d. Get lunch for their coworkers

For item (b), consult the Employee Manual.

Put items in a bulleted list in order of importance, alphabetically, or in an order that groups like items together.

Tenured professors

- are given frequent sabbaticals
- cannot be fired
- differ from terrorists in that you can negotiate with terrorists

Use a colon for a list when it follows a complete sentence and when you could substitute the word *namely*.

Scientists have distinctive attributes:

- an admiration for MacGyver
- the ability to turn a TV remote control into a stun gun
- a power of concentration that occasionally leads to being pronounced dead prematurely
- the ability to discuss the expected results for an hour of a test it takes five minutes to run

> Science is built of facts the way a house is built of bricks; but an accumulation of facts is no more science than a pile of bricks is a house.
>
> —Henri Poincaré

18

Voice, Person, and Tense

> There is such a thing as the poetry of a mistake, and when you say, "Mistakes were made," you deprive an action of its poetry, and you sound like a weasel.
> —Charles Baxter (*Burning Down the House: Essays on Fiction*)

VOICE

English has two "voices": active and passive. If the subject of the sentence is the "doer," the sentence is in the active voice; if the subject of the sentence is the recipient of the action, the sentence is in the passive voice.

Active: John hit Jim.
Passive: Jim was hit by John.

These two sentences say the same thing, but note that the active sentence has three words and the passive has five words. Passive-voice sentences are always wordier than active-voice sentences. Therefore, the guideline should be: the passive voice should be avoided. Uh-oh. That's not right. Let's try again: avoid the passive voice.

Note that we did not say the passive voice should never be used. Use the active voice most of the time because it is usually more direct and always less wordy.

You should also avoid passive voice when referring to participants in a study. The *APA Style Manual* considers the use of passive voice in this context a form of biased language. Acknowledge the participants' role in the experiment. Instead of "the subjects were given a questionnaire," you should rephrase as "the subjects filled out a questionnaire."

Some sentences are *better* in the passive voice because the writer wants to emphasize the action rather than the agent of the action.

Streptomycin, the first effective cure for tuberculosis, was discovered by Selman Waksman.
Selman Waksman discovered streptomycin, the first effective cure for tuberculosis.

The first example (in the passive voice) emphasizes the antibiotic and the disease, rather than the discoverer of the antibiotic. The active voice version brings Waksman to the fore but has the effect of deemphasizing the antibiotic and the disease. If the writer is mainly concerned with tuberculosis or streptomycin, the passive version would be the better choice; if the main concern related to Waksman, the active version would be better.

Furthermore, many passive sentences really can't be converted to the active voice.

Petri dishes are made of plastic.

A sentence such as this is passive of necessity. One does not have the choice of saying "Make petri dishes out of plastic."

In addition, the subject of a sentence may be unknown or unimportant. The passive voice is then used.

The mistake was overlooked.
His invention has been superseded.

And some active-voice sentences would simply be ridiculous. Certainly, the passive "I was born in Illinois" is better than the active "My mother bore me in Illinois."

PERSON

The main reason for avoiding the passive voice is not its wordiness but the confusion it causes as to who is doing what to whom. More often than not, the confusion results from avoidance of first-person pronouns. Much violence has been done and is being done to the English language by people whose foolish false modesty prevents them from using the personal pronouns *I* and *we*.

Instead of saying "I showed that substance A affected agent B," such writers hide the agent of the action and convert the sentence into the passive voice:

> It was shown that substance A affected agent B.

Now we have confusion (in addition to the added wordiness). *Who* showed? *When* was it shown? (The *I* or *we* would at least limit the time to the life of the author; the "it was shown" version could refer to prehistoric times.)

Sometimes, writers will switch person, which adds even more confusion. In one place they might write "We found that substance A affected agent B," and later state "The authors determined that this effect was not permanent." The reader now wonders who these "authors" are. They might be the authors of this paper, or they could be the authors of a paper previously cited. The consistent use of *I* or *we* eliminates any confusion.

TENSE

In scientific writing, only two tenses are normally used: present and past. Occasionally, the future tense might be used, in pointing to the need for further experimentation, for example. Only rarely should one use the so-called perfect tenses.

> Researchers *have* used this common procedure for a variety of tests.
> Researchers *had* used this common procedure for a variety of tests.

When perfect tenses are used, be careful to distinguish between the past perfect and present perfect. The use of *have* in the first example indicates that the procedure is still in use. The *had* in the second example indicates that the procedure is no longer in use.

In citing references, many authors habitually write "Jones (2010) has found that. . . ." The use of past tense saves a word in each such instance, and the meaning is the same: "Jones (2010) found that. . . ." *It was found* is shorter and clearer than *it has been found*. (But *I found* wins the prize.)

The present tense is used for established knowledge and for previously published work (including your own).

The Earth *is* round.
The first quinone to be reduced *is* tightly bound (Jones, 2010).

Knowledge has not been established, however, until *after* publication in a primary scientific journal. Thus, give your present experimental results in the past tense.

The subclones containing the D-helix substitutions *were* reassembled into plasmid P112924.
Table 4 *shows* that the L- and M-subunit genes *were* separately subcloned into M13 derivatives.

In the example immediately above, the past-tense *were* was properly used to describe present results. However, note that the present-tense *shows* was also used. This follows the rule of *presentation.* The results in a table or figure are available in the present for the reader to examine, and thus the present tense is used.

Figure 1 *indicates* that . . .
This formula *suggests* that . . .

Another rule relates to attribution. To show respect for established knowledge (previously published work), use the present tense; however, *attribution* is given in the past tense.

Jones (2010) *showed* that the first quinone to be reduced *is* tightly bound.

Thus, we have four tense rules that should normally be followed in scientific writing:

1. Established knowledge (previous results) should be given in the present tense.
2. Description of methods and results in the current paper should be in the past tense.
3. Presentation ("Table 1 shows that . . .") is given in the present tense.
4. Attribution ("Jones reported that . . .") is given in the past tense.

In the typical scientific paper, these four rules will result in frequent tense changes, often in the same sentence. But these rules should be followed carefully, particularly the rule that specifies that your present results should be in the past tense. Otherwise, the reader will have difficulty in distinguishing your new results from previously published work.

> The two words "information" and "communication" are often used interchangeably, but they signify quite different things. Information is giving out; communication is getting through.
>
> —Sydney J. Harris

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Punctuation

> For most of us, punctuation is not an aesthetic challenge but a practical housekeeping problem: We engage it only long enough to keep things straight. And yet, deployed carefully and sensitively, commas, colons, and semicolons can make our sentences not only clear but even a bit stylish. Good punctuation won't turn a monotone into the Hallelujah Chorus, but a bit of care can produce gratifying results.
>
> —Joseph M. Williams

THE MARKS AND THEIR MEANING

Punctuation is easy. Compared with grammar and its profusion of rules, most of them outmoded if not outright wrong, punctuation has a number of clear, simple rules. They work, and they are easy to learn if you try. (These suggested rules are briefly listed in Appendix 1.)

Professor Williams (quoted in the epigraph) says that punctuation is "housekeeping." Here's a different metaphor, although it doesn't have a Hallelujah Chorus: Think of words as an almost endless movement of automobiles along roads, through intersections, entering into hospital and school zones, and needing a great many signals to avoid collisions, traffic jams, and potential mishaps of many kinds. Now think of punctuation marks as a set of traffic lights and road signs, which, if well designed and well placed, will keep traffic moving smoothly along the highway of writing. Some signs will say "stop." Others will say "slow down." Still others will indicate, in a variety of ways, how to drive safely through the sentences of our writing.

English has only 13 punctuation marks. If you try, you can learn the rules for using each. If you then apply these rules, your words and sentences will flow smoothly and deliver your passengers (readers) safely to their destination: the meaning of what you are writing.

PERIODS

> A period is to let the writer know he has finished his thought, and he should stop there if he will only take the hint.
>
> —Art Linkletter

A period is used to indicate the end of every sentence that is not a question or an exclamation. Thus, all four types of declarative sentences (see Chapter 16) end with periods. Think of a period as a *full stop* (which is what the British wisely call it). That is really all you need to know about periods, except for a few special uses as follows.

Periods are used after some abbreviations.

R. A. Day
Feb.
Prof. Stewart

Style regarding the use of periods after abbreviations varies among journals and changes from country to country, so be sure to check the appropriate style guide or instructions for authors. In England and France, a period is not used if the abbreviation includes the last letter of the full word (*Dr*, *Mme*). In America, periods are used for some abbreviations (*Dr.*, *Ms.*), but not for many initialisms (*PC*, *USA*, *TV*, state abbreviations). The *MLA Style Manual* suggests not using periods or spaces in abbreviations composed solely of capital letters, except in the case of proper names. The trend is certainly toward abbreviations without periods, particularly in electronic writing such as texting, where abbreviations are commonly used but punctuation is not. Social media like Twitter that limit the number of characters are a contributing factor.

Periods have two additional purposes. In quoted material, three periods (an ellipsis mark) are used to indicate that material has been omitted. If the omission occurs at the end of a sentence, four periods are used (one ellipsis mark and one period ending the sentence).

> May every young scientist remember and not fail to keep his eyes open for the possibility that an irritating failure of his apparatus to give consistent results may . . . conceal an important discovery.
>
> —Patrick Blackett

> How wonderful that we have met with a paradox. Now we have some hope. . . .
> —Niels Bohr

Another use of periods is as "leaders," especially in lists and in tables, to help the reader.

> Penicillin ---------- 5 g
> Dihydrostreptomycin ---------- 2 g

Avoid ending sentences with a website address because people may think the period is part of the address. Instead, put the website address in the middle of a sentence or enclose it in parentheses.

QUESTION MARKS

Question marks are easy. Place one at the end of any sentence that asks a question.

> What time is it?

Some sentences look like questions, but in fact are not questions.

> Would you please stop doing that.

This sentence is in the form of a question, but it is really an order; a period is therefore the appropriate punctuation mark.

> He asked me whether I was going.

This sentence is an indirect question. Such "questions" are followed by periods rather than question marks.

Unlike a period, a question mark can be used at the end of a parenthetical clause within a declarative sentence.

On Monday (or was it Tuesday?), I completed the experiment.

EXCLAMATION POINTS

An exclamation point follows any word, group of words, or sentence that expresses excitement, fear, surprise, or alarm.

Ouch!
Wow!
Get out of here!

Exclamation points are rarely used in scientific and professional writing. In fact, they should be used with relative rarity in any kind of writing, or they lose their force.

What a day!
What a day.

Which example is correct? It depends on the force the writer intends. Exclamation points, like the other punctuational road signs, communicate the writer's intent. In the first example, if the day referred to had brought a tornado or an earthquake, the sentence certainly should end with an exclamation point. If the day were simply a busy day, however, the mild exclamation (ending with a period) would be appropriate.

COMMAS

Periods, question marks, and exclamation points are used to signal the ends of sentences. All of these marks clearly tell the reader "Stop. This sentence is over."

For those of you who don't know a comma from a long sleep, we will define the comma as a road sign that says "Slow down." Commas are used within sentences, never at the end. Commas have many uses within sentences, but the signal always has the same intent: slow down, pause, take a breath. (How is

a cat different from a comma? A cat has claws at the end of its paws; a comma is the pause at the end of a clause.) People who don't know how to use commas tend to haphazardly sprinkle them over the page.

A common use of the comma is to separate the clauses in a compound sentence. Such usage (see Chapter 16) requires a coordinating conjunction in addition to the comma.

> Men love to wonder, and that is the seed of science.
>
> —Ralph Waldo Emerson

Many authorities say that a comma is not necessary between independent clauses if both are short.

> Who is up and who is down?

However, it is a good idea to get into the habit of using the comma for this purpose. *It is never wrong.* And then you won't have to keep asking yourself whether the clauses are short enough to be attached without a comma.

Another common use of commas is to signal the end of an introductory word, phrase, or clause and the start of the main clause.

> Equipped with his five senses, man explores the universe around him and calls the adventure Science.
>
> —Edwin Powell Hubble

> In essence, science is a perpetual search for an intelligent and integrated comprehension of the world we live in.
>
> —Cornelius Bernardus Van Neil

> In particular, commas are important.

Again, many authorities say that a *short* introductory phrase or clause need not be followed by a comma. However, look at the last example above. "In particular" is certainly a short phrase, but, without a following comma, the reader

cannot quickly make sense out of "In particular commas." That is why it is best to use a comma after every introductory word, phrase, or clause. The road sign will usually be helpful to the reader.

Unfortunately, this rule does not hold for phrases and dependent clauses that *follow* the main clause. A comma is sometimes used, sometimes not, depending on whether the writer wants the reader to slow down.

You will be visited by the first of these spirits when the bell tolls one.
You will hear the bell, if it rings.

Commas are also used to set off interrupting elements in the middle of a sentence.

Pure mathematics is, in its way, the poetry of logical ideas.
—Albert Einstein

We have been running a nuclear seminar, in addition to the usual ones, trying to make some order out of the great chaos. . . .
—Robert Oppenheimer, in a letter to his brother

Note that the interrupting element is preceded by a comma and followed by a comma. Both commas (called balancing commas) are necessary, and they have the effect of taking the enclosed material out of the main sentence. Usually, parentheses could be used to replace the commas.

Balancing commas are also used around appositives (as in the first example below). Incidental (parenthetical) information within an independent clause can also be set off with commas.

We gave the student a test, the Yale-Brown Obsessive-Compulsive Scale, to assess the symptom severity.
Marie Curie, best known for her discovery of radioactivity, was the first woman to win a Nobel Prize.

We could almost say that any phrase or dependent clause placed in the middle of an independent clause should be set off with balancing commas.

Rarely, however, an intervening phrase or clause is essential to the meaning of the independent clause; such elements are not parenthetical and commas are not used.

Commas required: Calculus, like other branches of mathematics, is useful to scientists.
Commas not used: People like him should be admired.

These examples are identical in construction, but the "like" prepositional phrase in the first is parenthetical (not essential to the meaning of the statement), whereas the "like" phrase in the second is essential. (Without it, the sentence would be "People should be admired.")

Three or more words or groups of words in a series are separated by commas.

He visited labs in Bangkok, Berlin, and Beijing.
The five types of white cells are neutrophils, eosinophils, basophils, monocytes, and lymphocytes.
The program can deliver services through public organizations, private agencies, or institutions.

The big argument is whether a comma should be used before the *and* (or *or*) in the series. This is the serial comma (known to Vampire Weekend fans as the Oxford comma). Newspapers leave the serial comma out to save space, and it's less common in the United Kingdom, but in the United States, most style guides suggest using it for clarity. People who never use the serial comma, or who use it only selectively, write many sentences that are hard to read and a few that are incomprehensible. If you use commas to separate the three parts of a series, you will never write a sentence like this:

He had a large head, a thick chest holding a strong heart and big feet.

The only way to get the feet out of that poor guy's chest is to put a comma before the *and*.

The system consists of an engine, tubing to bring fuel to the cylinders and associated mounting bolts.

This sentence is incomprehensible, like many constructed by people who fail to use serial commas. Possibly, the tubing brings fuel to the mounting bolts. (If so, the sentence would be improved by putting an *and* before *tubing*.) More likely, the tubing takes fuel to the cylinders and *not* to the bolts. If so, a good old serial comma intelligently placed before the *and* clears up all confusion.

When a list is being presented, as in the above two examples, it is usually best to arrange the list from simple to complex. The items are then in a logical order, and the need for the serial comma is not as great (but use the comma anyway). Organized this way, the sentences would read:

He had big feet, a large head, and a thick chest holding a strong heart.
The system consists of an engine, associated mounting bolts, and tubing to bring fuel to the cylinders.

Commas are sometimes used to separate adjectives that modify the same noun, especially when three or more adjectives are involved. With two adjectives, the comma is used if the adjectives are totally unrelated to each other.

It was a dark, cold, stormy night.
It was a dark, stormy night.
It was a dark green dress.

In the third example, the dress is "dark green"; therefore, *dark* is not separated from *green*. (Because *dark* modifies *green* rather than *dress*, many writers would use a hyphenated expression: "dark-green dress.")

Whenever a writer wants the reader to pause for a moment, perhaps for emphasis or contrast, a comma is the appropriate road sign.

He sent the message, again.

Commas are needed when we address someone. Commas are desperately needed after the word *go* in the first example below and after *eat* in the second.

Should we go John?
Why do we eat children?

Commas are used to set off small units from larger ones.

Newark, DE

Commas may be used to separate numbers (but not numbers within a year).

1,000
10,000,000
2010

Use commas before degrees and titles.

Rosa Sanchez, Ph.D.
Al Franken, U.S. senator
Ace Ventura, Pet Detective

In a sentence, such degrees and titles give incidental information, so balancing commas are used.

Chen Chang, Ph.D., is the project leader.

A comma, rather than an exclamation point, is used after a weak exclamation.

Well, so it goes.

A comma can be used to indicate the omission of words in a sentence.

She went to the right; I, to the left.

Finally, a comma may *not* be used to separate a subject from its verb or a verb from its object, unless a balancing comma is used.

Wrong: I an immunologist, tested the serum samples.
Right: I, an immunologist, tested the serum samples.

The first example is wrong because the subject (*I*) is separated from the verb (*tested*). The second example is acceptable because the balancing commas effectively take the appositive (*an immunologist*) out of the sentence.

Used appropriately, commas add the needed structure to many sentences.

Handy guide to science: If it's green or wriggles, it's biology. If it stinks, it's chemistry. If it doesn't work, it's physics.

SEMICOLONS

Once you have learned that a semicolon is something other than half a colon, you will find that semicolons are easy to use. Their main purpose is to separate the independent clauses in a compound sentence. A comma will suffice if a coordinating conjunction accompanies it**.** Often, however, the writer may want to indicate the equivalence of the clauses by directly welding them together with a semicolon.

Most institutions demand unqualified faith; but the institution of science makes skepticism a virtue.

—Robert K. Merton

The doubter is a true man of science; he doubts only himself and his interpretations, but he believes in science.

—Claude Bernard

I don't want to achieve immortality through my work; I want to achieve immortality through not dying.

—Woody Allen

If you connect two independent clauses with a *conjunctive adverb* (*however*, *moreover*, *therefore*, *still*, *consequently*, *otherwise*, *similarly*, *nevertheless*,

thus, etc.), you must use a semicolon after the first clause and a comma after the adverb.

> The researchers examined the role of discourse in the implementation of organizational change; however, their study was limited to not-for-profit organizations.
> The solution turned blue; therefore, we concluded that the result was positive.

If the two clauses are joined by *a coordinating conjunction* (*and*, *or*, *so*, *but*, *for*), the comma is not necessary.

> The researchers examined the role of discourse in the implementation of organizational change; but the study was limited to not-for-profit organizations.
> The solution turned blue; so the result was positive.

The only other use for the semicolon is to separate the parts of a series that has one or more internal commas. A semicolon should precede the *and* in the series, just as the comma precedes the *and* in a simple series.

> On the table were oranges from Florida; pears from Washington, Oregon, and California; and apples from Oregon.

COLONS

A colon is used to introduce a word, a phrase, a clause, or a sentence.

> There is one thing that can prevent caries: sealants.

> I have had my results for a long time: but I do not yet know how I am to arrive at them.
> —Karl Friedrich Gauss

> Orgel's Second Rule: Evolution is cleverer than you are.
> —Francis Crick

The colon often introduces a list. However, words like *the following* should be used to signal to the reader that a list is coming.

Wrong: The lab order included: flasks and Red Bull.
Right: The lab order included the following: flasks and Red Bull.
Also Right: The lab order included flasks and Red Bull.

Grammatically, the first sentence is incorrect because the colon separates a verb from its object. In the second example, "the following" becomes the object, and "flasks and Red Bull" becomes an appositive.

A colon is used after a clause that would be a sentence on its own.

Graduate students are like cats: they are creatures of the night, can sleep almost anywhere, and show a lack of respect for authority.

Rarely, a colon is used in place of a semicolon to separate two independent clauses. This is done when the second clause has a strong relationship to the first.

Publicity is like poison: it doesn't hurt unless you swallow it.
—Joe Paterno

A semicolon would not be incorrect in this example, but the colon does a better job of unifying the two clauses.

Colons are often used to separate a book, chapter, or article title from a subtitle; a semicolon, though often used in these instances, is incorrect.

Scientific English: A Guide for Scientists and Other Professionals

The only other uses of the colon are certain conventional uses, such as at the end of salutations in letters, in between hours and minutes, and in ratios.

Dear John:
2:30 a.m.
1:3
1:3::2:6

(www.CartoonStock.com.)

HYPHENS

The hyphen has a number of uses, most of them confusing.

Hyphens are used to indicate end-of-line word division in printed materials. This should not be a problem; any good dictionary will indicate where a word may be broken (between the syllables, of course). However, you will need to proofread computer-generated word breaks carefully. Computers do not always

get it right. Every bad break will slow down the reader, and some bad breaks lead to total confusion.

So, check a dictionary for proper placement of end-of-line hyphens. But also check your head. The dictionary may say that *analogy* is divided *anal-o-gy*; however, if it comes out *anal-ogy* in your paper, your readers could be confused. Because many words in English can be confusingly divided, proofread carefully and make sure that words are divided sensibly.

Note that end-of-line word breaks will probably change when your material is edited and prepared for publication, so do not force word breaks by adding a hyphen and a line change.

A second use of hyphens is to link the parts of certain compound words. When the plural is formed, only the primary part of the term takes an *s*.

mother-in-law	mothers-in-law
attorney-general	attorneys-general
brother-in-law	brothers-in-law

> I want to be the white man's brother, not his brother-in-law.
>
> —Martin Luther King, Jr.

And now we come to what is sometimes called the unit hyphen. When two words modify a third, it is sometimes necessary to link them with hyphens to indicate that they are acting together.

> I don't like Smith's third-rate book.

In this example, the unit hyphen must be used to link *third* and *rate*. It is not Smith's "third book." (It may be her first.) It is not a "rate book." We must have the hyphen to show that it is a "third-rate book."

> a light red tie
> a light, red tie
> a light-red tie

Of these three examples, the first is the least satisfactory. Is the tie a "light" tie (perhaps a lightweight fabric) or is it "light red"? The second example makes it clear that the tie is both "light" and "red." The unit hyphen in the third example makes it clear that the tie is "light red."

a new car owner
a new-car owner
a new car-owner
imported-car dealer

Again, the first of these four examples is imprecise because we don't know what is "new." The second example is clear: the owner has a new car. The third example is also clear: we have a new "car-owner." (Presumably, this person has not previously owned a car.) The fourth example is correct with the hyphen; nobody would import car dealers.

In scientific writing, the unit hyphen is used many, many times. It should be used whenever two words are linked together to modify a third word. Some common examples include the following: riboflavin-binding protein, penicillin-resistant streptococcus, gram-negative bacteria. Also use a hyphen between a number and a unit of measure when they modify a noun (e.g., "a 5-ml inoculum"). Use a hyphen when a numeral is followed by *fold*, but do not use a hyphen if the number is spelled out (fourfold).

I once took an expensive course of treatment from a homeopathic practitioner. When I got his bill, I reduced my payment 10,000-fold.

Finally, hyphens are sometimes used to join prefixes and suffixes to words. Although conventions have changed, modern practice is to eliminate such hyphens. Link standard prefixes (e.g., *re-*, *pre-*, *non-*, *bi-*) to their following words without a hyphen.

More controversial is the use of a hyphen when the prefix causes a doubling of vowels. For example, some would accept *retest* and *predetermine*, but they would insist on *re-elect* and *pre-eminent*, particularly if it makes it easier for nonnative English speakers. The trend is toward the joiners, but check the appropriate style guide to be sure.

One exception you need to watch for are prefixes followed by proper nouns or numbers. These always take hyphens.

pre-Sputnik
pro-Democratic
pre-1900

Suffixes are also joined to the root word as a rule. However, if this brings about doubling or tripling of a letter, or if the word is very long, the hyphen should be used.

lifelike
weasel-like
pleuropneumonia-like organism

Another type of hyphen is the "suspensive hyphen." This is the hyphen that leaves you hanging.

After a two- or three-minute rest, resume the procedure.

Suspensive hyphens imply the second part of the compound (*minute* in the example) without having to repeat it.

> If you take the hyphen seriously, you will surely go mad.
>
> —John Benbow

DASHES

There are actually two different dashes, neither of which is the same as a hyphen. The *em dash* (sometimes called the grammatical dash) is a long dash (the width of the letter *m*). The *en dash* is a short dash (the width of the letter *n*). The en dash is used (in publications that include such usage) primarily to show a range of numbers, especially in tables. The idea is that the hyphen is too short to separate numbers (e.g., 10-20 owls), the em dash is too long (10—20 owls), and the en dash is just right (10–20 owls).

Dashes do not appear on a standard keyboard, but if you type two hyphens in a row in running text, Word and other word-processing programs automatically

convert them to an em dash. You will also find both kinds of dashes under the "Special Characters" menu if you use the "Insert Symbol" function in Word. There should be no space before or after either of the dashes.

Dashes are overused by many writers, especially inexperienced writers. Writers who do not understand the niceties of balancing commas and parentheses are likely to dash their sentences to death.

The en dash shows a range of time or numerical value.

Monday–Friday
2–3 hours

The en dash is also used to connect equal weighted words in a compound adjective.

New York–Beijing flight

Em dashes can be used to set off appositive or contrasting information.

One of the symmetry principles—the symmetry between the left and the right—is as old as human civilization.[1]

During the epoch of the first star formation—not later.

Singly or in pairs, em dashes can be used to set off words that summarize or provide examples.

She was studying mycoplasma species—*M. mycoides*, *M. capricolum*, and *M. genitalium*.

With further experiments, Yamanaka then found that only four genes—Oct4, Sox2, Klf4 and c-Myc—were actually necessary to produce iPSCs.[2]

An em dash, like a colon or semicolon, can be used to link two independent clauses. An em dash is a good choice if the second clause provides a surprise or contrast.

> Satellite photos of the area showed changes in the tundra—only dwarf shrubs had survived.

> Our language is funny—a fat chance and slim chance are the same thing.
> —J. Gustav White

An em dash can be used to set off interrupting words.

> Sue found the pipettes had been washed—for a change—but had not been put away.

Em dashes can be used to clarify the syntax of a sentence.

> When a sentence contains commas-as-parentheses (balancing commas), and perhaps parentheses (or other marks of complexity), dashes—like these—can be effective in guiding the reader through the complex syntax.

QUOTATION MARKS

Whenever you are directly quoting someone else, use quotation marks. In the United States, double quotation marks are used. Single quotation marks are used to indicate quotations within quotations. In the United Kingdom, usage is considerably different, both as to the type of quotation marks used and as to placement of other punctuation marks within or outside closing quotation marks. The British use single quotation marks around quotations and use double quotation marks only for quotations within quotations.

Below, we will describe the American system of double quotation marks and the American system of placement of other punctuation marks within or outside quotation marks.

He said, "I love you."
"I love you," he said.

Note the placement of the period in the first example and the comma in the second. You may now memorize Quotation Rule 1: Commas and periods *always* go inside closing quotation marks.

He said, "I love you"; she said, "Get lost."
"I love you": those were his words.

These examples illustrate Quotation Rule 2: Colons and semicolons *always* go outside closing quotation marks.

Question marks and exclamation points are placed inside the quotation marks if the person quoted is asking the question or exclaiming.

He asked, "When are we going?"
She shouted "Fire!"

Question marks and exclamation points are placed outside the quotation marks if the writer is asking or exclaiming.

Did he say, "The rent is due"?
When offered the money, she said "No, sir"!

Because it would be surprising for anyone to say no to the offer of money, the exclamation point in the second example is appropriate, and it is placed correctly.

If both the writer and the person being quoted are asking questions or exclaiming, the marks go inside the closing quotation marks.

Did he ask, "When are we going?"
In terror, I yelled, "Get out of here!"

Quotation Rule 3 thus states that question marks and exclamation points go either inside or outside closing quotation marks. If the quoted person is asking or exclaiming, the marks go inside; if the author is asking the question or exclaiming, the marks go outside; if both the writer and the quoted person are asking or exclaiming, the marks go inside the closing quotation marks.

> The lion roared: "Who's King of the Jungle?" The gazelle answered, "You, oh King!" The lion roared again: "Who's King?" The monkey answered, "You, of course!" Once more the lion roared, this time right into the face of the elephant. Whereupon the elephant picked up the lion in his trunk, slammed him on the ground several times, and threw him in a heap under a tree. The lion said, "Hey, you don't have to get mad just because you didn't understand the question!"

The above rules relate to the American system. These are the rules that apply to the majority of American publications, rules sanctioned by *The Chicago Manual of Style* and many other style manuals.

An important exception is for computer instructions. When you are providing instructions that include what to type as a computer command, place any punctuation marks outside the quotation marks to avoid confusion.

> After you type "msconfig", press "Enter".

If you quote a long passage, you should begin each new paragraph with quotation marks. Closing quotation marks should be placed *only* at the end of the final paragraph. But if you indent quoted material, or have it set in small type, you should not use quotation marks at all.

Never alter a quotation. If you omit material from a quotation, indicate this with an ellipsis mark (three periods). If you add anything to a quotation, the added material should appear within brackets. You should not even correct a misspelled word if one occurs in a written quotation. (It is often wise to put *sic* within brackets after the misspelling to indicate that the misspelling appears in the original.) Use brackets to change pronouns or verb tenses if necessary. Examine the following sentence:

> He boasted that he "can do twice as much work as I can."

Almost certainly, the person quoted must have said "I can do twice as much work as you can." The example above should either be paraphrased (by eliminating the quotation marks) or rewritten with bracketed insertions.

He boasted that he can do twice as much work as I can.
He boasted that "[he] can do twice as much work as [I] can."

Quotation marks are conventionally used to enclose titles of poems, articles, stories, and chapters of books. (Quotation marks should not be used for titles of books or journals; these should be italicized.) Words that are used as words can be in italics or within quotation marks.

The word *love* means many things.
The word "love" means many things.

Quotation marks can also be used to indicate irony. These are sometimes called "sneer quotes" because they impart a sense of disdain.

Fast-food hamburgers contain a quarter pound of "meat."

Never use quotation marks to indicate emphasis. This usage is not only incorrect grammatically, but may also lead the reader to assume you meant to be ironic. Sign makers seem especially prone to this and often produce unintentionally hilarious results, as in this example from an actual sign:

Fireworks "You Can Trust" Sold Here

Use smart quotation marks ("curly quotes") and apostrophes rather than straight quotes ("straight quotes") and apostrophes unless you are designating inches (12′) or feet (3′).

APOSTROPHES

Apostrophes are used to show possession. They must be placed carefully.

The boy's dog
The boys' dog

Note the different meanings in these examples. In the first example, one boy has a dog; in the second example, two or more boys have a dog.

People worry about when to add an *-s* to the apostrophe when forming possessives. In the singular, add the apostrophe *and* the *-s* in almost all instances.

Yang's Rule
Jones's Rule
Weiss's Rule

Even with the tripling of the *s* in the third example, this guideline can be defended.

In the plural, add an apostrophe and *-s* to a word that does not end in *s*.

We sell men's clothing.

If a word ends in *s*, add only an apostrophe.

Professors' salaries are low.

Sometimes this gets tricky. The *New York Times Book Review* noted that Stieg Larsson's first book was called "*The Girl Who Kicked the Hornets' Nest*" in Britain, while in the United States it became "*The Girl Who Kicked the Hornet's Nest*."

Is it *farmer's* market, *farmers'* market, or *farmers* market? In general, go by whether you want to show ownership or just describe something using an adjective.

farmer's market (one farmer owns the market)
farmers' market (several farmers own the market)
farmers market (the market is made up of farmers)

Conventions have changed regarding the use of possessives in scientific and medical terms derived from the name of an individual (eponyms). The nominative form is now preferred.

Old usage: Down's syndrome
Preferred: Down syndrome

Old usage: Planck's constant
Preferred: Planck constant

Apostrophes are also used in contractions; however, contractions should seldom be used in scientific writing.

I can't do it.
It's in the bag.

In the first example, *can't* is a contraction of *cannot*; in the second example, *It's* is a contraction of *It is*. Unfortunately, *it's* is often confused with the possessive pronoun *its*, which does not have an apostrophe. Get into the habit of looking at your *its*. When the *its* means "it is," put the apostrophe in its (not *it's*) place.

Wrong: Its important to use apostrophe's correctly.

In the above example, *Its* should be *It's* (contraction of *It is*) and *apostrophe's* should not have an apostrophe (because *apostrophes* is a simple plural).

Apostrophes can sometimes be used to form plurals, although most style guides discourage this usage.

three 4's
two *a*'s
several DNA's

Many publishers hold that scientific abbreviations are singular, not plural. Thus, you should not use *several DNA's* or *several pH's* (with or without the

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apostrophes). Instead, you should refer to *several DNA preparations* and *several pH values*.

PARENTHESES

Parentheses can be used around words, groups of words, or whole sentences that add incidental information.

> The control group (participants not given two doses) exhibited no symptoms.

If a parenthetical element appears at the end of a sentence, the period goes outside the closing parenthesis.

The control group exhibited no symptoms (fig. 2).

A complete sentence within parentheses starts with a capital and ends with a period; the period should be inside the closing parenthesis mark.

(The control group exhibited no symptoms.)

However, if the parenthetical sentence is within another sentence, neither a capital nor a period is required.

Some participants (this did not include the control group) experienced an increased heart rate after the procedure.

BRACKETS

Rarely, you may need to give additional information within material that is already in parentheses. Brackets can be used for this purpose.

(The cost was 3 pounds [about 5 dollars].)

Another use for brackets is to enclose alterations or additions to quoted material.

"According to [chimpanzee researcher] Jane Goodall, The greatest danger to our future is apathy."

SLASHES

The slash is sometimes considered to be a mark of punctuation, but should not be so used. It can be used as a mark of division.

4/2 = 2

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But, precisely because it means "four divided by two," it should not be used grammatically. People who use *he/she* certainly do not mean "he divided by she." People who use *noise/signal ratio* usually mean "signal to noise ratio." People who use *and/or* do not know what they mean.

The slash (often distinguished as either a "forward slash" or "backward slash") is commonly used in URL addresses and computer file location designations. This is another reason to avoid its use as a punctuation mark, which could cause confusion.

For those of you who have found this chapter to be heavy going, there is still hope. Perhaps everything will become clear when you read Appendix 1, "Principles of Punctuation Presented Plainly."

20

Writing for Electronic Media

Television has raised writing to a new low.

—Samuel Goldwyn

THE TREND TOWARD ONLINE MEDIA

Not many years ago, all scientific writing was destined for print media, primarily books or journals. Then publishers began to archive publications electronically, which allowed scientists, librarians, students, and others to easily locate previously published articles and, in some cases, to read them electronically. Now, rising costs, concern for the environment, expediency, and the universal availability of the Internet have created a growing trend toward online publication.

Some publishers make print publications available online (often requiring an access charge or membership fee), while others have ceased publishing a printed version. Many are bridging the gap. The *Journal of the American Medical Association* (JAMA) has been published in print since 1883, but if you subscribe today, you are asked to choose "print and online" or "online only." This weekly publication is already quite current, but online readers can access "early release articles" within a few days of publication.

Even the good old Oxford English Dictionary has gone digital. The current printed edition, a 20-volume, $1,165 set published in 1989, has been upstaged by an online version available to subscribers for less than $300 a year. Although schools still rely primarily on printed dictionaries, many people prefer to look up words on the Internet. So instead of lugging around a 130-pound dictionary, one needs only a smartphone to look up the definition of *anachronism*.

Many new web-based scientific publications have entered the market due to the ease and low cost of online publishing. Some of these are small entrepreneurial efforts, but others are traditional publishers responding to rising costs and demand for current information. For example, the American Society

for Microbiology, which has published print journals such as the *Journal of Bacteriology* for nearly a century, also offers *mBio*, an online-only publication.

Journal articles that were once read by flipping through paper pages while sitting at a desk or lab bench can now be viewed on a computer screen, e-reader, or even a cell phone while sitting on an airplane or in line at the grocery store. The American Chemical Society has an iPhone app called *ACS Mobile* that provides readers with a searchable, multi-journal, up-to-the-minute live stream of new peer-reviewed research content from the Society's scholarly research journals, including the *Journal of the American Chemical Society*.

Another new development is the virtual journal. Virtual journals are created by selecting articles from various sources, often in a narrow field of study. For example, the *Virtual Journal of Nanoscale Science & Technology* contains articles that deal with the science and technology of nanometer-scale structures. It does not accept article submissions directly, but instead its editor and editorial board select articles on that subject from a variety of participating journals. This type of journal is extremely valuable to scientists in highly specialized fields, where a dedicated print journal might not be financially feasible.

The tools scientists use to write papers have also changed. Sophisticated word-processing programs allow the writer to quickly find a particular point in the text, rearrange large sections of text, transfer material from one document to another, and make or undo changes, all without having to crumple up a sheet of paper and start over. With a few keystrokes, the scientist can create outlines, tables of contents, and indexes. Managing references and citations, once a time-consuming and error-prone task, can now be done electronically with special software.

The guidelines for writing traditional research papers for online publications (IMRAD organization, use of proper grammar, adherence to style manuals) are the same as for print publications. What has changed is the routine use of electronic communications, which has had an impact in the way scientists communicate with each other and with the rest of the world.

THE NEW SHORTHAND

A friend of ours was using his teenage son's cell phone when a text message came in from his son's girlfriend. He thought he'd have a little fun so he texted her back, knowing she would think it was his son responding. He carried on quite a conversation until he received a text saying "sorry Mr. G., I have to go."

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Puzzled, he asked her how she knew it was him. Her answer was one word: "punctuation."

Instant messaging, texting, and to some extent e-mail are by nature short, fast, and casual forms of communication. An e-mail can be a single word ("Agreed."); a text can be a few letters ("ttyl" for "talk to you later"). Capitalization and punctuation are used sparingly, if at all, and abbreviations stand in for common words and phrases. E-mail spell checkers instantly correct misspelled words, place apostrophes, and even recognize (and capitalize) proper nouns, making sending a message as close to brainless as possible. Emoticons (happy faces and the like) have replaced explanations of feelings or intent (or, God forbid, personal contact).

Text messaging is developing a language of its own. A list of text messaging and chat abbreviations compiled by *Webopedia* contains well over 1,000 entries, and it's growing.

Time will tell to what degree written English will be affected by this trend. For the young people who spend their days firing text messages back and forth (and for whom e-mail seems antiquated), this new English is the norm. They can talk for hours without ever constructing a complete sentence, much less a coherent paragraph. It could be that one day the correct use of grammar, spelling, and punctuation will be viewed with as much nostalgia as today we read about our ancestors dressing for dinner.

What is likely, however, is that in the sciences, where clarity is key, standard English will remain the rule. The risk that the reader might misunderstand the message "cu @ *$" ("see you at Starbucks") is low when compared to the risk of getting the steps of an experiment or the measurement of a sample wrong. So as far as scientific English (and really any professional communication) is concerned, the rules of grammar and spelling are still in full force.

E-MAIL

E-mail communications make it easy to get messages back and forth quickly, across the hall or across the ocean. It's difficult to imagine how we managed before e-mail. E-mail allows scientists to keep up to date, share ideas, make appointments, submit papers, and do at least a thousand other things, yet the convenience comes at a price.

E-mail is not necessarily private. Offices are shared, computers are borrowed, e-mails get forwarded (or sent to the wrong person), and e-mail accounts can be hacked. For these reasons, never put anything confidential in an e-mail. In fact, never put anything you wouldn't want someone else to read in an e-mail. Once you send a comment like "Just ignore Ted—he's an idiot" and then realize you accidently hit "Reply All," you will remember this lesson forever. For the same reason, using the blind copy (bcc) can be risky—and unfair to the parties involved, who don't realize that the head of the lab was privy to the message. A valid use of the blind copy is when sending a message to a large list of recipients (if you want to avoid a long list of addressees) or when you do not want to disclose e-mail addresses to other parties. In these situations, you should address the e-mail to yourself and blind copy everyone. Do not use e-mail for sensitive matters, where face-to-face

communication is more appropriate, or for messages that are critical ("you didn't get the e-mail I sent about the bridge being out?").

In e-mail communications, start with a clear subject line. Most people scan e-mail subject lines quickly, so a coy or amusing subject line could easily get your e-mail deleted, ignored, or even marked as spam. Although spam blockers have improved, avoid the use of red-flag words such as *free*, *offer*, *urgent*, or anything with sexual overtones. Commonly abused drug names are also flagged as well, so if your research involves oxycodone or any drug for erectile dysfunction, good luck getting your e-mails through. Do not include multiple hotlinks (clickable links to websites).

Be specific. "Conference" isn't very helpful to someone scanning their e-mail, whereas "AAAS Conference Registration" probably won't be overlooked. If the e-mail contains essential information, put it in the subject line: "Agenda for Today's Meeting," "Microscope Order," "Environmental Engineer Hired," or "Entomology Picnic Cancelled Due to Raid."

E-mail is a brief medium. Use it for information that is easy to convey. Get to the point quickly. If you have many points to make on different subjects, consider more than one e-mail (or a telephone conversation—remember those?). Keep paragraphs short, and if an action is required, be clear: "Please review the attachment and send me your comments by September 20."

Brief does not mean incoherent. People tend to get lazy and drop the "actors" in their e-mails: "Heard Bob got the grant. Called to say we need to meet. Told work needs to start immediately." Who called—Bob or the person sending the e-mail? Who needs to meet? Who said the work needs to start immediately? Nothing about this e-mail is clear except that Bob got the grant.

If you are responding to a previous communication and that text is not contained in your reply, be sure to reiterate the issue concerned as a courtesy: "Regarding your request for a reprint of my publication 'Utilization of Nanotechnology to Detect Cardiac Tissue in Attorneys . . .' " If the e-mail has been volleyed back and forth so many times that the visible subject line is a string of "Re: Re: Re: Re:," change the subject line.

Be a courteous e-mail correspondent. Don't request a receipt unless you are sending a Nobel Prize notification or serving a summons. Routinely requiring receipts slows down e-mail and indicates you don't trust recipients to respond and want proof that you did indeed send them an e-mail. Reserve the "high priority" red flag for extremely important or urgent communications. If you overuse this function, people will ignore you when you need them to pay attention.

Most people get more e-mail than they want. Do your part by not sending unnecessary e-mail messages. If you find the need to send more than a couple of e-mail messages to the same recipient on the same topic, use the phone. And unless someone has specifically asked you to, don't forward sentimental stories (nearly always apocryphal), virus warnings (nearly always hoaxes or viruses themselves), scary alerts about various dangers (nearly always bogus), jokes (nearly always not as funny as you think they are), or political or religious diatribes (nearly always unnecessary if the recipient agrees with you and unwelcome if the recipient does not).

The formality (or informality) of e-mail varies by country. Many Americans think nothing of launching into an e-mail message and firing it off with neither a salutation nor a closing. Most Europeans use a letter style ("Dear ___") and end messages with "Regards," "Best Regards," or "Bugger Off." Therefore, play it safe and at least start out using a formal style. If your recipient responds more casually, you can adjust accordingly.

Punctuation counts, even with e-mail. Use too many exclamation points and you will not be taken seriously (and will likely end up in a spam folder). Leave out commas, periods, and other signposts, and you leave your recipient wandering around with no GPS.

Be careful with the tone you use in your e-mail. Short, fast notes may seem abrupt or even discourteous to the recipient, at least to people not from New York. "Read this," "I need it by tomorrow," "Not today," and the like are easy to type but read as demanding, and therefore may not help you achieve your goal. Remember, it doesn't take very long to type those magic words *please* and *thank you*.

In any country, THIS IS SCREAMING. Using all capitals is not only annoying to the recipient and more difficult to read, it is another flag for spam. The same is true of special characters, so if your communication requires the use of scientific notations and characters, you may be better off creating a document and sending it as an attachment. You should also resist composing e-mails in color, or using unusual fonts, embedded images, or graphic elements.

As a courtesy, create a "signature," an address block containing your full name and title, department, street address, building or room number, phone number, and e-mail address. You can direct your e-mail program to place the signature at the bottom of every e-mail you send. This ensures that your recipient has all your contact information without having to ask for it.

Be conscious of file sizes. In some countries, many people still have dial-up connections. Even those with high-speed service can have trouble with huge files. Large attachments can slow down or clog up the recipient's e-mail

system. Compress large files, save photos to a smaller size (or compressed format), send multiple e-mails for multiple attachments, or use an online file exchange service.

As e-mail is often used as a substitute for a telephone call or personal visit, the most important thing to keep in mind is that the other party cannot see your face or hear your voice, two primary cues to meaning. Therefore, humor, particularly sarcasm, can be tricky. This is how emoticons became popular. You can say something like "you always were a pig" but then follow it with a little ☺ and presumably your recipient then realizes you are kidding.

The best advice is the simplest: read your e-mail carefully and make sure it says what you intended before you hit the irrevocable "Send."

WRITING FOR THE WEB

If you are writing content that will be viewed on a screen, you should consider that it will probably be skimmed. Most people read online content, even scientific information, faster and with less care than print publications. Therefore, when you write something for the Web, you should make it easy for readers to find the information they seek.

Web search engines are getting faster and more sophisticated. Google Instant, introduced in 2010, was the first to provide search results as the user begins to type, often after just a few letters of the first word. The user no longer has to hit enter or click on "Search." In some cases, a single letter is enough, although typing a *w* is more likely to pull up *Walmart* than *wormholes*.

When writing for the web, you should include any key words in the title and put key words or concepts ahead of any introductory matter. Eliminate phrases such as "An Investigation into the Practice of . . . ", "A Study to Determine Whether . . .", or "An Evaluation of the Factors Contributing to. . . ."

Use devices that make quick reading possible. Highlight major ideas using boldface or typestyle changes. Break down complex information into smaller pieces, using bulleted lists where possible. Keep material in chronological order or use subheads to identify separate thoughts. Do not be shy about using blank space to separate sections. Crowded pages discourage readers. When you think about writing for the Web, think in terms of writing an outline, with links to additional information.

The Internet is an interactive medium, and readers expect a certain amount of control over the information. Provide avenues for readers to access graphics, additional information, multimedia content such as audio or video

clips or PowerPoint presentations, site maps, and ways to provide input (an e-mail link, at a minimum). Keep information up to date, and provide navigation tools (buttons, drop-down menus, hyperlinks) that are easy to understand and use. Link to research that is similar to your own or to references that are pertinent to the work.

Keep in mind that people using the Internet for research often move quickly, deciding in a second or two whether they think your webpage has information of interest. This means that both the title and short description the search engines pull up, and the information and graphics immediately visible on your home page, must be relevant, instantly understandable, and appealing. To paraphrase Jerry Maguire, you have to "have them at 'Hello.' "

Consider who is reading your material and why. If you are writing for a mainstream audience, provide some context and explain complex concepts and technical terms. If you are outlining your research for colleagues in your field, don't include lengthy explanations of the obvious. Highlight the key points of your work and why they are important. If you are writing for scientists who may want to replicate your work, use specifics and cover all the steps, just as you would in a paper. Keep in mind that regardless of your intended audience, if your work is posted in an open-access environment, anyone can view it. If your work involves human health, controversial or high-profile research, or areas where litigation is common, nonscientists are likely to find and view your material.

Consider what the audience wants to know, not just what you want to tell them. Try to anticipate questions readers might have and provide the answers. Use hyperlinks to refer readers to related online resources. And don't forget to provide a way for people to reach you with a question (or offer of a lucrative speaking engagement).

If you are including information from or about others, be sure to respect their privacy. Rather than showing e-mail addresses (they can be captured by spammers), use e-mail links or forms. Ask before putting anyone's personal information or professional contact information online.

THE SCIENCE BLOGOSPHERE

Science blogs published by amateurs and professionals provide ways to share scientific information and resources, monitor trends, and advance knowledge. Some even operate like journals, inviting scientists to make submissions, but only publishing what they deem worthwhile. Nearly immediate publication

means the information is timely. The ability to post comments provides an element of self-policing while allowing for online dialogs that can be as interesting and informative as the original post.

Blogs tend to be even more specialized than journals. Blogs such as Science-Based Medicine (www.sciencebasedmedicine.org) provide a forum for exploring controversial issues and debates, a valuable service to advancing science. Blogs such as Cancer Research UK (scienceblog.cancerresearchuk.org) allow scientists in specific geographic areas or within a particular field to stay current and discuss issues of interest. The Social Science Research Council has developed a series of blogs (www.ssrc.org/blogs), each edited by an expert in the appropriate field. Their website states: "We hope the blogs will create new opportunities for discussion, debate, analysis, and networking among social scientists and interested readers."

Blogs are often an offshoot of a website or a social networking environment. The World Association of Young Scientists (ways.org/en) has created a global social network designed and optimized for researchers to "promote their work, seek help, share information, look for job opportunities and develop knowledge and relationships." While it includes a blog, the site has many other features as well.

AuthorAid (www.authoraid.info) helps researchers in developing countries publish and otherwise communicate their work. This site offers networking opportunities, training workshops, mentoring, links to references such as style guides, blog posts on scientific English, and other valuable resources to scientists around the world.

Blog aggregators provide a way for scientists to locate blogs of interest. ScienceBlogs (scienceblogs.com) provides links to blogs in the categories of Life Science, Physical Science, Environment, Humanities, Education, Politics, Medicine, Brain & Behavior, Technology, and Information Science. Alltop (science.alltop.com) lists posts from a variety of blogs and allows users to create a "personal, online magazine rack" of favorite websites and blogs.

Before posting to a blog, review and edit your material carefully, just as you would any piece of writing. Check spelling, punctuation, grammar, and clarity. Make sure you haven't left any words out or missed something you meant to include.

Post only material that you think will be useful, interesting, and informative. Use key words to help people looking for content on your subject to find your post. Be sure to include links to websites that provide more information on the subject.

If your work is of interest to nonscientists, consider posting on mainstream blogs that address subjects related to your research. This is an excellent way to inform the public, generate interest in your topic, and provide research-based information. Take care not to insult this audience by "dumbing down" your material, but do explain technical terms or provide common names as well as scientific terms when possible.

> Q. How many bloggers does it take to change a lightbulb?
> A. 100. 1 to change the lightbulb and 99 to comment on how it should have been done differently.

FACEBOOK AND TWITTER

The moment this book hits the presses, this section will be out of date, but we do need to mention the increasingly important (at least at the moment) role of social networking. Keeping colleagues, students, and, dare we say, *fans* up to date on research progress, grant status, and other developments is what makes social media relevant in the scientific community. The key is to provide the kind of worthwhile content that invites followers. If ever there was an example of "build it and they will come," it is social media. If your posts are limited to what you had for dinner and what television program you're watching, don't expect many people to pay attention to what you write. On the other hand, make your information timely, informative, and pertinent to people's interests, and they will hang on your every word—at least for a few seconds.

GRAMMAR, SPELLING, AND PUNCTUATION

Standard rules for grammar, spelling, and punctuation apply to writing for electronic media, but there are some idiosyncrasies.

Avoid placing an e-mail address or website URL where it will not fit on a single line. If you must break the address, do not use a hyphen. Hyphens are often used as part of a website address, so a hyphen in the middle may be interpreted as being part of the address. For the same reason, avoid breaking the address at a "dot" or other punctuation mark that is part of the address. A good place to break is at a forward slash. In general, avoid placing any punctuation marks (including < >brackets) in front, behind, or in the middle of an e-mail or website address.

Spell out a website address exactly as it appears. Website addresses should be written in all lowercase. Do not use the word *at* for the symbol @, or the

word *underscore* for an underscore symbol, _. The trend is away from including *http://* in every website address, and some writers leave off *www* as well, but consult the appropriate style guide to find the proper format.

www.zoology.emu.edu
james.kirk@enterprise.gov

The *World Wide Web*, or its shortened form, *Web*, is a proper noun and should be capitalized (the longer term is rarely used). The common nouns *website*, *webpage*, *homepage*, and *database* are all single, unhyphenated words that should not be capitalized unless used at the beginning of a sentence. The common nouns *e-mail*, *e-journal*, and *e-newsletter* (the *e-* standing in for "electronic") are, at least at the time of this writing, hyphenated and not capitalized unless used at the beginning of a sentence.

Do not use hyperlinks (or show URLs as underlined or in blue) for website addresses unless the document will be viewed online and the link is "hot" (linked to the site). Some word-processing programs automatically convert website addresses into hyperlinks. To remove them, either change the default settings for the program or right-click on each URL and select "Remove Hyperlink." If you want to use a hyperlink in an online publication, check each hyperlink before publication to confirm that the link is still active, that it is linked to the correct website, and that the website still contains the content you intended to provide. Provide the name of the website as well, so your readers can find the site even if the URL changes.

Columbia University Department of Anthropology, doctoral dissertations
www.columbia.edu/cu/anthropology/graduate/main/dissertations/index.html

Glossary

abstract noun: a name for something that isn't tangible, usually an idea or concept (*justice*, *grief*, *peace*)

acronym: a word made from the first letters of each word in a series of words, usually pronounced as a word (*AIDS*, *sonar*, *radar*)

active voice: the grammatical voice in which the subject is performing the action ("James tested the sample") rather than being acted upon ("The sample was tested by James")

adjective: a word that modifies a noun or pronoun (*large*, *blue*, *tired*, *many*)

adverb: a word that modifies a verb, an adjective, or an other adverb, usually telling how, when, where, in what way, or to what extent (*quickly*, *very*, *often*, *badly*)

antecedent: the noun that a pronoun replaces

appositive: a noun or noun phrase that renames the noun next to it ("the organism, *E. coli*, caused . . .")

article: the words *a*, *an*, and *the*, which are used to identify a noun (*an apple, a chair, the book*)

biased language: words or phrases that contain a secondary meaning that demeans, insults, or stereotypes

buzzword: a trendy, often technical word used (frequently incorrectly) by non-technical people

clause: a group of words containing a subject and a verb

cliché: an overused expression such as *don't upset the apple cart* or *to beat a dead horse*

collective noun: names that are singular in form but refer to a group (*jury*, *team*, *committee*)

common noun: name for a person, place, or thing that is not a specific person, place, or thing (*apple*, *student*, *city*)

complex declarative sentence: a sentence that has one independent clause and one or more dependent clauses.

compound declarative sentence: a sentence that contains two (or more) independent clauses

compound-complex declarative sentence: a sentence that has at least two independent clauses and at least one dependent clause

concrete noun: those persons, places, or things that can be detected with the five senses (e.g., *chair, mother, apple*).

conjunction: a word that connects words, phrases, or clauses (*and*, *but*, *nor*)

conjunctive adverb: an adverb that connects two clauses and shows cause and effect, sequence, contrast, comparison, or other relationships (*therefore*, *however*, *also*, *finally*, *moreover*, etc.)

coordinating conjunction: a word that joins two or more items of equal importance, such as words, main clauses, or sentences; the common coordinating conjunctions are the FANBOYS: *for*, *and*, *nor*, *but*, *or*, *yet*, and *so*

declarative sentence: a sentence in the form of a statement (as opposed to a question or exclamation)

demonstrative pronoun: a pronoun that singles out the thing being referred to (*this*, *that*, *these*, and *those*)

dependent clause: a clause (group of words containing a subject and a verb) that cannot stand on its own as a sentence

digression: leaving a topic to provide unrelated information or to expand on a seemingly unrelated topic ("which reminds me of the time. . .")

double negative: two forms of negation used in the same clause ("we don't need no education")

em dash: a long dash that introduces a list or a restatement ("the lab ordered all the necessary supplies—petri dishes, pipettes, glass slides, and water balloons"), or that sets apart additional nonessential information ("the lab director—far from perfect himself—expected perfection from his techs")

en dash: a short dash that shows a range of time or numerical values ("the lab is staffed Monday–Friday")

eponym: name derived from a person (*Apgar score*, *mendelian*, *Doppler effect*)

euphemism: an inoffensive substitute for a potentially offensive term or phrase such as *facilities* instead of *toilet*

FANBOYS: the common coordinating conjunctions *for*, *and*, *nor*, *but*, *or*, *yet*, and *so*

gerund: a verb ending in *-ing* that is used as a noun (that student is majoring in sleeping)

idiom: a phrase that has a meaning different from its literal translation, such as *kick the bucket*, *a shot in the dark*, or *out on a limb*

IMRAD: A commonly accepted order for organizing a scientific paper: Introduction, Methods, Results, And Discussion

indefinite pronoun: a pronoun that does not refer to a specific noun (*everyone*, *someone*, *none*, *few*, *several*)

independent clause: a clause (group of words containing a subject and a verb) that makes a complete statement

infinitive phrase: a phrase that consists of *to* plus a verb and any objects or modifiers

interjection: a word, phrase, or sentence expressing emotion (*Oh!*, *Oh my!*, *Oh my pants are on fire!*)

interrogative pronoun: a pronoun that introduces a question (*who*, *whom*, *which*, *whose*, *what*)

intransitive verb: a verb that does not need a direct object to complete its meaning (*sleep*, *die*, *run*)

jargon: obscure or technical language used by members of a particular group

mass noun: a name for something tangible that can't be counted (*blood*, *air*, *energy*)

metaphor: a figure of speech in which an unrelated word or phrase is substituted in order to provide a comparison between unlike objects or concepts ("Laughter brings the swelling down on our national psyche, and then applies an antibiotic cream." [Stephen Colbert])

modifier: a word or group of words that affect another word by limiting, describing, or changing it

nominalization: the use of a verb, an adjective, or an adverb as a noun (*the investigation* instead of *investigated*), or the use of a noun and verb instead of just a verb (*conducted an investigation* instead of *investigated*)

nominative case: the form of a noun or pronoun used as the subject of a sentence or clause rather than its object.

noun: the name of a person, place, or thing

object: a noun or pronoun that is the recipient of an action or another object; to what or to whom the action of the sentence is being done

objective case: the form of a noun or pronoun used as the direct object of a verb, the indirect object of a verb, or the object of a preposition

oxymoron: a figure of speech that combines seemingly opposite terms (*living dead*, *controlled chaos*, *pretty ugly*)

parallelism: using the same form of words in a list, for example, all having *-ly* endings

participle: an *-ing* verb form used as an adjective

participial phrase: a participle, its object, and its modifiers

passive voice: the grammatical voice in which the subject is being acted upon ("The sample was tested by James") rather than performing the action ("James tested the sample")

perfect tense: a construction, sometimes called "retrospective," indicating that at the time it is used an action has been completed, is being completed, or will be completed in the future. It consists of the appropriate tense of the verb *to have* combined with the past participle of the verb. The three perfect tenses are present perfect, past perfect, and future perfect ("I *have read* the book, I *had read* the book, I *will have read* the book").

person: in writing, a perspective or point of view (writing in first person, the point of view is "I" or "we"; in second person it's "you"; and in third person it's "he," "she," or "they")

personal pronoun: a word that replaces a "person" noun, such as *I*, *my*, *yours*, *him*, *she*, *its*, *us*, *ours*, *they*, *them*, and *theirs*

phrase: a group of two or more words that does not contain both a subject and a verb

predicate: the part of a sentence that contains a verb and modifies the subject or object

preposition: a word used to relate a noun or a pronoun to some other part of the sentence; usually placed before a noun, as in "*through* the window" or "*in* her arms"

pronoun: a word that takes the place of a noun (*she*, *none*, *it*, *you*, *they*, *I*, etc.)

proper noun: name for a specific person, place, or thing (*Mexico*, *Prime Minister Smith*, *Democratic Party*)

redundancy: unnecessary repetition (*end result*, *free gift*, *false pretense*)

reflexive pronoun: a pronoun that reflects the action of a verb back on the subject (*myself*, *herself*, *himself*)

relative pronoun: a word that substitutes for a noun and connects parts of sentences (*who*, *whom*, *which*, *whose*, *that*, *what*, *whatever*, *whoever*, *whomever*)

serial comma: the last comma in a series (also known as the Oxford comma), as in "He ordered test tubes, beakers, test strips, and slides."

simile: a comparison between two unlike objects or concepts, using the word *like* or *as* ("tight as a drum")

simple declarative sentence: a sentence that consists of one independent clause

slang: informal words or expressions that are not part of the standard language

split infinitive: a phrase that has one or more words between the *to* and the verb

style: the result of a writer's choices of words, voice, and person; the term *style guide* refers to grammar and punctuation specifications established by an organization or publisher in order to maintain consistency

subject: what the sentence is about; answers the question "What?" or "Whom?"

superlative: the form of an adjective or adverb that indicates its strongest form (*greatest*, *best*, *tallest*)

syntax: the part of grammar dealing with word order

tense: something people sleep in when camping, or a form of a verb that expresses time (present tense—*she sleeps*; past tense—*she slept*)

transitive verb: a verb that requires a direct object to complete its meaning (*bring*, *prefer*, *give*)

verb: a word that shows action or a state of being

verbal: a verb used as another part of speech

voice: the way the author "sounds" when the written piece is read, or the relation of the subject of the verb to the action of the verb (see "active voice" and "passive voice")

APPENDIX 1

Principles of Punctuation Presented Plainly

> Everything should be made as simple as possible, but not simpler.
> —Albert Einstein

APOSTROPHE

To show possession, add an apostrophe and an *s* to a singular noun.

The lab's door is open.

To a plural already ending in *s*, simply add an apostrophe to show possession.

The scientists' experiments were completed.

To a plural not ending in *s*, add an apostrophe and an *s*.

The deer's habits are interesting.

To names, add an apostrophe and an *s*.

Yang's Rule
Jones's Rule
Weiss's Rule

Apostrophes are also used in contractions to show that letters have been left out.

don't
haven't
it's

Contractions are a casual form of communication and therefore should be avoided in formal writing (including scientific writing). Spelling these words out will also help your international readers, who may find contractions difficult to decipher.

Do not use an apostrophe for dates and numbers.

the 1990s
the low 80s
tens of thousands

BRACKETS

Use brackets to clarify quoted material.

"She [the wife of Alexander Graham Bell] invented the mute button," he said.

Brackets are also used as parentheses within parentheses.

(This sentence [the one you are reading] is not essential.)

Editors use brackets to insert comments so they are not taken to be additions to the text.

The test results were inconclusive [use a different word here].

COLON

A colon is used to introduce a word, phrase, or clause.

There were two kinds of physicists in Berlin: on the one hand there was Einstein, and on the other all the rest.
—Rudolph Ladenburg

Manuscript: something submitted in haste and returned at leisure.
—Oliver Herford

COMMA

Use a comma after an introductory word (often an adverb) in a sentence.

Fortunately, this is sound advice.

Use a comma after any introductory phrase.

On the whole, this is sound advice.
To write well, you should follow this advice.

Use a comma at the end of a dependent clause that precedes the independent clause.

If you write well, your readers will thank you.

Use a comma and one of the seven coordinating conjunctions (*for*, *and*, *nor*, *but*, *or*, *yet*, *so*) as one way to separate the two independent clauses in a compound sentence.

This is a good rule, and your readers will thank you for using it.

Use a comma after a coordinating conjunction separating two independent clauses.

This is a good rule; however, it is not easy to follow.

Use two commas to set off appositive or interrupting words within a clause or sentence.

The director of the laboratory, Dr. Bhabha, is a good supervisor.
Mars, named after the Roman god of war, is conspicuous for its red color.

Use a comma before the *and* or *or* in a series of three or more items, and of course use commas between the other items in the series.

I like apples, oranges, and pears.
Use the right word, phrase, or clause.

Do *not* use a comma between a subject and its verb or between a verb and its object. However, an interrupting word or group of words between a subject and its verb, or between a verb and its object, can be inserted by the use of two (balancing) commas.

Wrong: I, personally will see to it.
Wrong: I personally, will see to it.
Right: I, personally, will see to it.

Wrong: John Jones, on the first pitch hit a home run.
Wrong: John Jones on the first pitch, hit a home run.
Right: John Jones, on the first pitch, hit a home run.

DASH

Dashes should be used rarely in scientific writing. Commas or parentheses are usually preferable. A dash might be appropriate if a real contrast or surprise is intended.

My new physician is an odd duck—I have heard that he is a quack.

ELLIPSIS

The ellipsis (three periods) should be used when material has been deleted from quoted text. The meaning of the quotation should not change.

Christopher Anne Easley said in a paper published in the *Journal of Applied Behavioral Science*: "Our world is very culturally and ethnically diverse . . . the multiplicity of cultures can be very challenging when working to evoke change."

EXCLAMATION POINT

Put an exclamation point after every real exclamation.

Stop right there!

As a rule, however, do not use exclamations in scientific writing. Of course, if you discover a new planet or a cure for cancer, you are entitled to say:

Eureka!

HYPHEN

When two words jointly modify a third, the two should be linked with a hyphen.

This is a first-rate book.

In general, use a hyphen to link related words and thus to avoid confusion. A sentence referring to "an old house owner" could lead to confusion; however, *an old-house owner* would clearly refer to an old house, and *an old house-owner* would clearly refer to an elderly owner.

Hyphens are also used to "break" words at ends of lines, to combine the parts of compound words (such as *mother-in-law*), and (rarely) to join certain prefixes and suffixes (*pre-Sputnik*, *bell-like*).

PARENTHESES

A full sentence within parentheses should start with a capital letter and end with a period; the period should be inside the closing parenthesis mark.

(We hope you like this rule.)

If the material within parentheses is not a full sentence, any needed comma or period should be placed outside the closing parenthesis mark.

When you have mastered these rules (punctuational pointers), you will write more confidently.
When you have mastered these rules, you will write more confidently (as a rule).

If the question mark or exclamation mark applies only to the material inside the parentheses, place the mark inside (like this!). Note that the closing punctuation for the sentence is still required and is placed outside the parentheses. (If the question mark or exclamation mark applies to the full sentence, the mark goes inside the parentheses, and no closing punctuation is needed!)

PERIOD

Periods are easy to use. Place one neatly at the end of every sentence you write, except questions or exclamations.

This is an easy rule.

QUESTION MARK

Place a question mark at the end of every question.

Are all rules of punctuation so easy?

Some sentences look like questions, but they may instead be commands. End such sentences with periods. The traffic cop is not asking a question when he or she says

"Would you please pull over."

QUOTATION MARKS

Periods and commas go inside closing quotation marks.

"What is his name?" she asked. He said, "I am Dr. Quackenbush."

Semicolons and colons go outside closing quotation marks.

"I'm king of the lab"; when she heard those words, she went ballistic.
"I'm king of the lab": those were his words.

Question marks and exclamation points go either outside or inside closing quotation marks. They go inside the quotation marks if the quoted person is asking or exclaiming.

She asked, "Did you think *you* were king of the lab?"
"Absolutely!" he said.

If it is the narrator who is asking or exclaiming, the question marks or exclamation points go outside.

Did he say, "I'm king of the lab"?
I was amazed when he said, "I'm king of the lab"!

If *both* the narrator and the person being quoted are asking or exclaiming, the marks go inside.

Did she say, "May I have Absolut vodka, please?"
His quick response was, "Absolutly!"

Or, if the question mark or exclamation point appears in the middle of a sentence (which they can do, unlike the period), the mark goes inside the quotation marks.

The geologist said "My sediments exactly!" when responding to my comment.
My girlfriend asked "Is that gneiss?" to which he exclaimed "No, it's a load of schist!"

SEMICOLON

A semicolon can be used to splice together two independent clauses.

We didn't lose the game; we just ran out of time.
—Vince Lombardi

Copy from one, it's plagiarism; copy from two, it's research.
—Wilson Mizner

I have an existential map; it has "you are here" written all over it.
—Steven Wright

A semicolon and a coordinating adverb (such words as *therefore*, *however*, *moreover*, and *nevertheless*) may be used to link together two independent clauses.

This face rings a bell; however, it is not a pleasant sound.

Semicolons can be used to separate a series when one or more parts of the series already contain commas. (Note that a semicolon should precede the *and* in the series, just as a comma precedes the *and* in the usual series.)

He gave small bells to Bell, the inventor; middle-size bells to Gram, the painter; and large bells to Ringer, a dead ringer for Bell.

SLASH

Do not use slashes in scientific (or any other) writing, except to indicate division.

$10/5 = 2$

> Punctuation rules are important. They are devised to eliminate ambiguities in language. Learn punctuation. Find a handbook such as *The Chicago Manual of Style* and keep it on your writing desk. Few things undercut the authority of a piece of writing more than a simple mistake in punctuation.
>
> —Michael Alley

APPENDIX 2

Problem Words and Expressions

> In all science, error precedes the truth, and it is better it should go first than last.
> —Hugh Walpole

A-AN

Should it be "a history" or "an history," "a hypothesis" or "an hypothesis," "a herb" or "an herb"? It is now correct in the United States (less so in the United Kingdom) to use *a* before any word starting with *h* if the *h* is pronounced, even slightly. Therefore, we say "a history" and "a hypothesis," but we add "an herb" to our soup. In the United States, you stay at "a hotel"; in the United Kingdom, you may stay at "an hotel."

ABILITY-CAPACITY

Ability means "the physical or mental power to do something." *Ability* is also generally used to describe a power that must be learned.

Hans has the *ability* to solve equations.

Capacity has to do with volume or containment. When referring to people, it means a trait one was born with.

The computer has a *capacity* of 400 gigabytes.
Hans has the *capacity* for reasoning.

ABOUT-AROUND

About means "in the area, nearly, or approximately." *Around* means "here and there" but can also mean "approximately," so in casual usage, the terms are used

interchangeably. Neither has a place in scientific writing, where precision is required.

Wrong: After *around (about)* 30 minutes, I added the second substrate.
Right: After 30 minutes, I added the second substrate.

ACCEPT-EXCEPT

Accept means "to receive willingly or give approval to." *Except* means "to take out or leave out."

He *accepted* the Nobel Prize.
He was *excepted* from consideration.

ACCESS

Access is often used as a verb.

I will *access* that file.

It can also be used as a noun.

May I have *access* to your laboratory?

Some writers, realizing that *access* was originally a noun, might use the expression *gain access to*; this expression is acceptable grammatically, but it would be simpler to say *enter.*

ADVERSE-AVERSE

Adverse means "acting against" or "unfavorable."

The preparation caused an *adverse* effect.

Averse means "reluctant" or "disinclined."

He is *averse* to writing grant applications.

AFFECT-EFFECT

The word *affect* is a verb (except in certain psychiatric usage); *effect* is usually a noun.

A bribe will not *affect* my judgment, unless it is big enough.
Your bribe had an *effect.* (It was big enough.)

Occasionally, *effect* is used as a verb, when its meaning is to bring about or accomplish something.

Your bribe *effected* a change in my opinion.

AFTER-FOLLOWING

After is the more precise word if a time sequence is involved. If the clowns appear *after* the parade, they will perform after the parade is over. If the clowns appear *following* the parade, they may be performing at the tail end of the procession.

ALL OF THE

Say "in all experiments" instead of "in all of the experiments." Similarly, say "both" instead of "both of the," "many" instead of "many of the," and so forth. Such "of" constructions are not *wrong*, but their repetitive use leads to bloated writing.

ALL TOGETHER (See *altogether-all together*)

ALREADY-ALL READY

Already means "previously," as in "I have *already* done that experiment." *All ready* means "completely prepared," as in "We are *all ready* to go on vacation."

ALRIGHT-ALL RIGHT

When is it *alright* to use *all right*? It is always *all right* to use *all right*. It is also *all right* to use *alright*. Some grammarians insist that *all right* is more formal (and therefore correct), but *alright* really is *alright*.

ALTHOUGH-WHILE

These subordinating conjunctions are often used interchangeably, but like *because* and *since* (see below) one of them (*while*) connotes time and the other does not. It is therefore safer to use *although* whenever a time constraint does not exist. "*Although* I love you" could be a dependent clause introducing many possibilities in the following main clause. "*While* I love you," on the other hand, may immediately suggest the temporary nature of my love.

ALTOGETHER-ALL TOGETHER

Altogether means "completely"; *all together* means "everybody in the same place."

I am not *altogether* happy with your work.
We were *all together* when the bad news arrived.

AMONG-BETWEEN

Between should be limited to a comparison of two items, and *among* should be used to compare three or more. *Between* you and me, this rule makes good sense; *among* the great unwashed, few people are aware of this distinction.

AMOUNT-NUMBER

Use *amount* when you refer to a mass or aggregate; use *number* when countable units are involved. For example, you can say "The *number* of people in our laboratory is 55." You should not say "The *amount* of people" unless you have weighed them, in which case you can say "The amount of people in our laboratory is about 10,000 pounds."

AND/OR

Certainly, this doesn't mean *and* divided by *or.* This slipshod usage can be so confusing that it properly has no place in scientific writing. Theodore Bernstein has described *and/or* as "a visual and mental monstrosity." You should say "A and B," "A or B," or "A or B or both," depending on your meaning.

AS (See *like-as*)

ASSURE-ENSURE-INSURE

These three words all mean making "sure" of something, and they are often used interchangeably. Their connotations sometimes vary as follows: *assure* suggests some kind of assurance or guarantee; *ensure* means making certain of something; *insure* relates to taking protective measures ("insurance").

Let every nation know, whether it wishes us well or ill, that we shall pay any price, bear any burden, meet any hardship, support any friend, oppose any foe to *assure* the survival and the success of liberty.
—John F. Kennedy

You must study hard to *ensure* good grades.
You should *insure* your car against fire and theft.

A WHILE-AWHILE

A while means "a time" and is a noun phrase (the *a* article is a hint that *while* is being used as a noun). *A while* can be replaced with another noun phrase.

The experiment took *a while*. (The experiment took *four months*.)

Awhile means "for a time" and is an adverb.

The lab director wanted to work *awhile*.

Note that *for* is part of the definition of *awhile*, so *for awhile* is redundant.

AVERSE-ADVERSE (See *adverse-averse*)

BECAUSE-SINCE

The word *since* connotes time, and it can sometimes be confusing if used in place of *because*. "*Because* the dog barked" will clearly lead to an explanation, whereas "*since* the dog barked" may refer to the time interval "since" the bark.

BELIEVE-FEEL

The short word is usually preferred to the long word. In this pair, however, *feel* is overused and can lead to confusion. The word *believe* has a clear meaning; *feel* sometimes means "believe," but it often means "touch." If you really *believe* something, say so. If you *feel* something, the reader may assume that you are groping in the dark. In some instances, *think* is an even better choice.

BESIDE-BESIDES

Beside means "near to"; *besides* usually means "in addition to."

Besides scientific books and journals, I keep mystery novels *beside* my bed.

BETWEEN (See *among-between*)

BOTH OF THE (See *all of the*)

CAN-MAY

These words are often used interchangeably, but confusion sometimes results if you forget that *can* has the connotation of "ability to" and *may* denotes a grant of permission. Thus, a graduate student should say "I *can* do that experiment" if the student has the ability to do it. If the lab director has authorized a particular experiment, the student *may* do it.

CAPACITY-ABILITY (See *ability-capacity*)

CASE

A *case* of canned goods is fine. A *case* of flu is fine, but you don't feel fine. In most cases, however, the word *case* is used thoughtlessly and repetitively. In some cases, *case* is used to mean "instance" or "example." In other cases, it is not clear what the writer means. In any case, *case* is one of the most overused words in scientific writing. In case you are one of the people who repeatedly use *case*, try to eliminate it from your writing, not just in a few cases but in almost all cases.

COMPARE-CONTRAST

You *compare* two or more items in terms of similarity; you *contrast* differences.

COMPLEMENT-COMPLIMENT

A *complement* fills up or completes something; a *compliment* is an expression of praise.

As yet, I have not had my *complement* of *compliments*.

COMPOSE-COMPRISE

Comprise means "to contain" and *compose* means "to make up." So while the meanings are similar, use *comprise* when starting with the whole and *compose* when starting with the parts.

The building *comprises* 10 laboratories.

Ten laboratories *compose* the building.

CONSISTENTLY-CONSTANTLY

Consistently means "regularly" and "free from variation."

The rabbits *consistently* chose Sample B.

Constantly means "continuously" and "without interruption."

The water flowed *constantly*.

CONTINUOUS-CONTINUAL

A *continuous* action is one that is without interruption.

Stir the solution *continuously* for five minutes.

A *continual* action is of long duration, but with interruptions.

The technician *continually* interrupted the lab director during the presentation.

CORRELATED WITH-CORRELATED TO

Although things may be related to one another, things are *correlated with* one another.

CRITERIA-CRITERION

A *criterion* (singular) is a standard or principle for evaluating or testing something. Two or more of them are *criteria*.

DEGREE-EXTENT

Degree refers to a step or stage.

We increased the dosage by *degrees*.

Extent refers to the range or scope of something.

We determined to what *extent* the dosage affected behavior.

DIFFERENT FROM-DIFFERENT THAN-DIFFERENT TO

When in doubt, use *different from.* It is rarely wrong. The word *from* is a preposition, so *different from* is correct whenever *different* is followed by a prepositional phrase.

A longitudinal wave is *different from* a transverse wave.

Or you can use the shorter *differs from*.

A longitudinal wave *differs from* a transverse wave.

Because the word *than* is a conjunction, *different than* is correct in those relatively few sentences in which *different* is followed by a clause.

This experiment posed problems in ways *different than* I had ever imagined.

However, *different than* sentences may sound odd, even if they are grammatically correct (whatever that means). As an alternative, give the pronoun *from* an object, so that you can say, comfortably and correctly,

This experiment posed problems in ways *different from* any I had ever imagined.

Do not use *different to* in an American journal.

This antibiotic is *different to* others produced by *Streptomyces griseus.*

In this example, *different from* is clearly correct in American usage. However, *different to* is accepted in Great Britain. In this instance, British usage is more logical than American. The British can consistently use *different to* and *similar to*, whereas the Americans are stuck with *different from* and *similar to.* But, then, whoever said English grammar is consistent, on either side of the Atlantic?

DISINTERESTED-UNINTERESTED

The prefixes *dis-* and *un-* usually have the same negative meaning. To "disengage the simulator" is the same as to "unengage the simulator." However, if you are interested, *uninterested* means "not interested," whereas *disinterested* means "impartial." An *uninterested* jury is likely to render a poor verdict; a *disinterested* jury is likely to reach a just verdict. Put another way, the disinterested jury will reach a just verdict; the uninterested jury will just reach a verdict.

EACH-EVERY

Each and *every* are singular and mean the same thing so there is no reason to say *each and every.*

EFFECT (See *affect-effect*)

E.G.-I.E.

The abbreviation *e.g.* stands for *exempli gratia*, which means "for example."

> Use a clear liquid, *e.g.,* water, white vinegar, or club soda.

The abbreviation i.e. stands for *id est*, which means "that is" or "in other words."

> Use an inert gas, *i.e.,* one that is non-reactive.

ENSURE (See *assure-ensure-insure*)

EPIDEMIC-EPIZOOTIC

An *epidemic* affects many people in a population; a *pandemic* is the same, except that the epidemic occurs over a wide geographic area and affects an exceptionally high proportion of the population. However, some people don't realize that these words come from *demos*, which means "people." Thus, we

often hear of "epidemics" among horses, rabbits, and so on; that is, we have an epidemic of epidemics, but "epidemics" among animals should be called *epizootics*.

EXCEPT-ACCEPT (See *accept-except*)

EXPLICIT-IMPLICIT

Explicit means "fully revealed," whether referring to directions for operating an autoclave or a script for an adult movie.

> She gave *explicit* instructions that the test tubes should not be used as shot glasses.

Implicit means "capable of being understood from something unexpressed."

> The lab director's suspicions were *implicit* in her instructions.

FARTHER-FURTHER

The word *farther* connotes physical distance ("far"), whereas *further* connotes a figurative distance.

> I pushed the lever *farther* than he did.
> Furthermore, I intend to go *further* into this subject.

FEWER-LESS

The word *less* should be used with quantities and qualities; *fewer* should be used with countable units. No matter how many ads you see on television, it is wrong to say that something has "less calories." On the other hand, it is often correct to assume that the advertised product has "less taste." Remember that it takes *less* effort to do *fewer* experiments.

FOLLOWING (See *after-following*)

FORGO-FOREGO

Forgo means to do without.

I shall *forgo* the conference in Fargo.

Forego means to go before; often, the form *foregoing* is used.

Forgo the spelling "forgoing" in the *foregoing* examples.

FRACTION

A fraction of scientists carelessly say or write such things as "A fraction of the mice survived." Because "a fraction" can be large or small, the expression is useless. If 1,000 mice were used, "a fraction" of survivors could be anywhere from 1 to 999.

FURTHER (See *farther-further*)

HANGED-HUNG

People are *hanged*; inanimate objects are *hung* (except for the sheriff in *Blazing Saddles*).

HOWEVER

Don't use *however* several times in a paragraph, as it's confusing to change direction multiple times.

I.E.-E.G. (See *e.g.-i.e.*)

IF-WHETHER

These terms are often used interchangeably as "conditional" words, but *if* is the better choice for a conditional sentence

> *If* the substrate is blue, it may be useless.

Whether is the better choice when two alternatives are possible.

> I need to decide *whether* to attend the conference.

Note that since two alternatives are implied, *or not* is not necessary after *whether.*

> If nurses in intensive-care units exhibit unusual stress-related symptoms, we should determine *whether* lighting is a contributing factor.

IMPACT

A large meteorite can make a real *impact* on our Earth. And for this word to have much *impact*, we should preserve this meaning. Unfortunately, *impact* as a verb is now frequently used as a buzzword in place of *affect.* (Perhaps this book will *impact* your use of English.)

IMPLICIT-EXPLICIT (See *explicit-implicit*)

IMPLY-INFER

A writer may *imply* something; the reader may *infer* something from what was written. We could *imply* that you are now reading a superb book; from that evidence, you might *infer* that we are bragging.

IN ORDER TO

This three-word phrase is used relentlessly by every gasbag in the world. All the three words mean is *to.* To learn to write well, learn not to write "In order to learn to write well."

INSURE (See *assure-ensure-insure*)

IN VIEW OF THE FACT THAT

Say *because* because (in view of the fact that) one word is better than six.

IRREGARDLESS

There is no such word; use *regardless.*

ITS-IT'S

These two words are confused many times by many writers. The problem is that the apostrophe normally indicates possession, so one is tempted to say "You can't tell a book by it's cover." Unfortunately, this *it's* is wrong, because *its* (without the apostrophe) is used to show possession (*its* cover) and *it's* (with the apostrophe) is used only as a contraction of *it is.* A good way to check yourself is to say "it is" each time you want to use *it's.* If the sentence makes sense, use *it's. Its'* (with the apostrophe after the *s*) is never correct.

LAST-LATTER

The word *latter* should be used to indicate the second of two named items. To indicate the final named item in a list of three or more, use *last* or *last-named.*

LAY-LIE

People *lie* down; you *lay* an object down.

LESS (See *fewer-less*)

LIKE-AS

The word *like* can be used as a preposition; *as* is a conjunction. You should not say, "*Like* I said, I am a botanist." You should say, "*As* I said, I am a botanist."

LITERALLY

The word *literally* means the strict definition of the word. So if you say you "literally froze your butt off," your pants should need taking in.

MANY (See *much-many*)

MANY OF THE (See *all of the*)

MAY (See *can-may*)

METHODOLOGY

Because of the *-ology* suffix, *methodology* means "study of methods." In most scientific papers, you should refer to a *method*, not a *methodology*.

MUCH-MANY

Much is properly used to describe a quantity or degree, not a number. It is incorrect to say "Pittsburgh led by as *much* as 34 points." Say "as *many* as 34 points."

NUMBER (See *amount-number*)

PERFORM

An unsuspecting person might think that scientists are monkeys or some other kind of circus animal. They are always *performing*. It is time for scientists to stop *performing* experiments. It is much better to just *do* them and be done with it.

PERSONS-PEOPLE

There is so little distinction between these words that you should feel free to use them interchangeably. It used to be that some people thought the rule was "a few *persons* but many *people.*" However, it now seems well established that you can use *people* whether you are talking about three *people* or three million *people.* If you like to use the word *person*, however, perhaps you should use three *persons* but not three million *persons.*

PREDOMINATE-PREDOMINANT-PREDOMINATELY

Predominate is a verb and only a verb. *Predominant* is the adjective; *predominately* is the adverb. *Predominate* (which means "to prevail") is a good word, but erroneous usage of these three words predominates.

> I hope that the principles of scientific English will *predominate.* If these principles become *predominant*, scientific writing will improve. Improvement will result because these rules are *predominately* correct.

PREVIOUS TO (See *prior to-subsequent to*)

PRINCIPLE-PRINCIPAL

Principle is a noun meaning "a rule of action or conduct." *Principal* is usually an adjective, meaning "most important." (*Principal* as a noun means a person in charge of a school, or it means a participant in a business deal or some other undertaking.) And no matter the size of your grant, you are *not* a "principle investigator." Remember the principal principle involved here; you must learn to distinguish between these two words.

PRIOR TO-SUBSEQUENT TO

Prior to and *previous to* mean "before," and *before* is shorter and better; *subsequent to* means "after," nothing more and nothing less. *Before* and *after* are words you should use; *prior to* and *subsequent to* are awful.

QUITE

The word *quite* is used *quite* frequently in scientific writing, but the word is *quite* useless. If you see the word *quite* in any sentence you have written, strike it out and read the sentence again. You will find that, without exception, *quite* is quite unnecessary.

REGARDLESS (See *irregardless*)

SHALL-WILL

Some grammarians used to go on at great length about the importance of distinguishing between *shall* and *will.* The main part of this "shall" game was that *shall* should be used to indicate simple future tense in the first person, and *will* should be used in the second and third persons.

I *shall* go to Chicago next week.
They *will* go to Chicago next week.

Then, if we wanted to show *determination*, we were supposed to reverse them and use *will* in the first person and *shall* in the second and third.

I *will* go to Chicago next week.
They *shall* go to Chicago next week.

Well, the grammarians set the rules for this party, but nobody came. People simply do not make these silly distinctions. Would anybody say that Winston Churchill lacked *determination* when he gave his famous "We shall fight on the beaches . . . we shall never surrender" speech? Of course not. Therefore, make no distinction between *shall* and *will.* Fire at will with either *shall* or *will.* By the way, this same silly distinction once applied to *should* and *would.* So, again, you would be wise to use either *should* or *would* without regard to the pronoun attached.

SHOULD-WOULD (See *shall-will*)

SINCE-BECAUSE (See *because-since*)

STATIONARY-STATIONERY

Stationary means "a fixed, unmoving position"; *stationery* means "paper used for writing."

SUBSEQUENT TO (See *prior to-subsequent to*)

THEN-THAN

Then has to do with timing; *than* provides a comparison.

He ate, *then* he left.
He ate more *than* his partner.

UNINTERESTED (See *disinterested-uninterested*)

UNIQUE

The word *unique* means "having no like or equal." Something is either unique or not unique. If it is unique, it can't be "very unique," "most unique," or "completely unique."

UTILIZE

Why use a three-syllable word when a one-syllable word will do? Instead, *use* the one-syllable word. Whether utilizing plumbing facilities or utilizing the most complex scientific instruments, the word *use* is always shorter and always better. Don't use *utilize* and your writing will be much more *user* friendly.

VARIOUS-VARYING

If *various* concentrations of a substance were added, they would be defined concentrations (e.g., 10, 15, or 20 mg/ml). However, *varying* concentrations

would be undefined and perhaps unmeasured (and changing) concentrations. Scientists would not be scientists if they used *varying* concentrations. *Vary* your language *variously* to distinguish between these two different words.

WHEREAS-WHILE

Both of these words are subordinating conjunctions, and they are often interchangeable. However, *while* has the connotation of time, whereas *whereas* has no obvious relation to time.

Nero fiddled *while* Rome burned.
Nero fiddled, *while* Day taught English.

The *while* is fine in the first example, but *whereas* would greatly improve the second one.

WHETHER-IF (See *if-whether*)

WHO'S-WHOSE

Who's is a contraction for "who is."

Who's in the lab?

Whose is the possessive form of *who*.

Whose gloves are these?

WHILE-ALTHOUGH (See *although-while*)

WILL (See *shall-will*)

> The difference between the right word and the almost right word is the difference between lightning and the lightning bug.
>
> —Mark Twain

APPENDIX 3

Words and Expressions to Avoid

Use no more words than are necessary to do the job. Superfluous words waste your time and official paper, tire your reader and obscure your meaning.

—Ernest Gowers

My advice to any young writer is: become an editor. You'll do less work, have less pressure, have more influence, make more money, and best of all: you get to tell others what to do instead of having to do all that rotten research and writing yourself.

—Bob Chieger

Avoid	**Use Instead**
a considerable amount of	much
a considerable number of	many
a great number of times	often
a majority of	most
a number of	some
a small number of	a few
absolutely essential	essential
accompany	go with
accounted for by the fact that	because
actual facts	facts
additionally	also
adjacent to	near
admonish	warn

(*continued*)

Avoid	Use Instead
afford an opportunity	let
afterwards	afterward
AIDS syndrome	AIDS (or Acquired Immune Deficiency Syndrome)
along the lines of	like
alternative choice	choice
an example of this is the fact that	for example
an order of magnitude faster	10 times faster
apparent	clear
approximately	about
are of the same opinion	agree
artificial prosthesis	prosthesis
as a consequence of	because
as a matter of fact	in fact (or leave out)
as a means of	to
as a result	(leave out)
as already stated	so
as is the case	as happens
as of this date	today
as to	about (or leave out)
as to whether	whether
ascertain	find out
assemble together	assemble
at a rapid rate	rapidly
at all times	always
at an early date	soon
at an earlier date	previously
at some future time	later
at the conclusion of	after
at the present time	now

Avoid	Use Instead
at the rate of	at
at this point in time	now
based on the fact that	because
be advised that	(leave out)
blend together	blend
brief in duration	brief
bring to a conclusion	end, conclude
by means of/by use of	by, with
capability	ability
causal factor	cause
caveat	warning
classify into groups	classify
collaborate together	collaborate
completely full	full
component	part
component parts	parts
compunction	regret
connected together	connected
consensus of opinion	consensus
considerable amount of	much
contiguous	touching
control groups	controls
deem	think
definitely proved	proved
desirable benefits	benefits
despite the fact that	although
disease process	disease
due to the fact that	because
during the course of	during, while

(*continued*)

Avoid	Use Instead
during the time that	while
earlier in time	earlier
echelons	levels
eliminate altogether	eliminate
elucidate	explain
employ	use
enclosed herewith	enclosed
encounter	meet
end result	result
endeavor	try
entirely eliminate	eliminate
equal to one another	equal
equivalent	equal
estimated at about	estimated at
etiology	cause
eventuate	happen
evidenced	showed
excess verbiage	verbiage (or excess words)
exhibit a tendency to	tend
extend an invitation	invite
fabricate	make
facilitate	ease, help
fatal outcome	death
fewer in number	fewer
field of microbiology	microbiology
finalize	end
first of all	first
firstly	first
following	after
for a period of	for

Avoid	**Use Instead**
for the purpose of	for
for the reason that/for this reason	since, because
from the point of view of	for
future plans	plans
give an account of	describe
give consideration to	consider
give rise to	cause
has been engaged in a study of	has studied
has the capability of	can
have the appearance of	look like
having regard to	about
higher in comparison to	higher than
HIV virus	HIV (or Human Immunodeficiency Virus)
impact (v.)	affect
important essentials	essentials
in a number of cases	some
in a position to	can, may
in a satisfactory manner	satisfactorily
in a timely manner	promptly
in a very real sense	in a sense (or leave out)
in all probability	probably
in almost all instances	nearly always
in an effort to	to
in case	if
in color/in length/in size	(leave out)
in close proximity to	close, near
in connection with	about, concerning
in lieu of	instead of
in light of	(leave out)
in many cases	often

(*continued*)

Avoid	Use Instead
in my opinion it is not an unjustifiable assumption that	I think
in order to/in such a manner as to	to
in relation to	toward, to
in respect to	about
in some cases	sometimes
in spite of the fact that	although
in terms of	about
in the absence of	without
in the amount of	for
in the course of	during
in the direction of	toward
in the event that	if
in the first place	first
in the not-too-distant future	soon
in the possession of	has, have
in the vast majority of cases	usually
in this day and age	now
in view of the fact that	because, since
inasmuch as	because
inception	start
incline to the view	think
including but not limited to	including
incumbent upon	must
initiate	begin, start
interface	boundary
introduced a new/introduced for the first time	introduced
involves the use of	uses
is defined as	is
is designed to be	is

Avoid	**Use Instead**
is knowledgeable of	knows
it can be seen that	thus, so
it goes without saying that I	I
it has been reported by Smith	Smith reported
it has long been known that	(I haven't bothered to look up the reference)
it is apparent that	apparently
it is believed that	I think
it is clear that	clearly
it is clear that much additional work will be required before a complete understanding	(I don't understand it)
it is doubtful that	possibly
it is evident that *a* produced *b*	*a* produced *b*
it is generally believed	many think
it is important to note that	(leave out)
it is my understanding that	I understand that
it is of interest to note that	(leave out)
it is often the case that	often
it is recommended that consideration be given to	we recommend
it is worth pointing out in this context that	note that
it may be that	I think
it may, however, be noted that	but
it should be noted that	note that (or leave out)
it was observed in the course of	we observed
it will be necessary to these experiments that	you must
join together	join
lacked the ability to	could not
LCD display	LCD (or liquid crystal display)
liase with	coordinate with

(*continued*)

Avoid	Use Instead
majority of	most
make an assumption that	assume
make preparations for	prepare
make reference to	refer to
may possibly	may
merge together	merge
methodology	method
militate against	prohibit
mix together	mix
month of	(leave out)
mutually interdependent	interdependent
needless to say	(leave out, and consider leaving out whatever follows it)
new initiatives	initiatives
not later than	by
now pending	pending
of considerable magnitude	large
of great theoretical and practical importance	useful
of insufficient magnitude	too small
of long standing	old
of the opinion that	think that
on a daily basis	daily
on account of	because
on behalf of	for
on no occasion	never
on the basis of	by
on the grounds that	since, because
on the part of	by, among, for
optimum	best

Avoid	Use Instead
our attention has been called to the fact that	we belatedly discovered
owing to the fact that	since, because
parameters	limits
penultimate	next to last
perform	do
permit	let
place a major emphasis on	stress
pooled together	pooled
practicable	practical
present time	present
presents a picture similar to	resembles
previous to/prior to	before
prioritize	rank
protein determinations were performed	proteins were determined
provide assistance with	help
provided that	if
qualified expert	expert
quantify	measure
quite	(leave out)
quite a large quantity of	much
quite unique	unique
rather interesting	interesting
referred to as	called
relative to	about
remuneration	pay, payment
rendered completely inoperative	broken
repeat again	repeat
reported in the literature	reported
resultant effect	result

(*continued*)

Avoid	Use Instead
revert back	revert
root cause	cause
serious crisis	crisis
serves the function of being	is
shortfall	shortage
single unit	unit
so as to	to
spliced together	spliced
subject matter	subject
subsequent to	after
sufficient	enough
sufficient enough quantity of	enough
sum total	total
surreptitiously	secretly
take into consideration	consider
terminate	end
the great majority of	most
the opinion is advanced that	I think
the predominant number of	most
the question as to whether	whether
the reason is because	because
the vast majority of	most
there is reason to believe	I think
this result would seem to indicate	this result indicates
through the use of	by, with
time period	time, period (not both)
to the extent that	if
to the fullest possible extent	fully
towards	toward
transmit	send

Avoid	**Use Instead**
ultimate	last
unanimity of opinion	agreement
until such time as	until
utilize	use
validate	confirm
very necessary	necessary
very unique	unique
was of the opinion that	believed
ways and means	ways, means (not both)
we have insufficient knowledge	we do not know
we wish to thank	we thank
what is the explanation of	why
whether or not	whether
with a view to	to
with reference to	about
with regard to	concerning, about
with respect to	about
with the aid of	with
with the possible exception of	except
with the result that	so that
within the realm of possibility	possible
witnessed	saw

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