FOURTH EDITION

SCIENTIFIC WRITING AND COMMUNICATION

PAPERS, PROPOSALS, AND PRESENTATIONS

Angelika H. Hofmann

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Scientific Writing and Communication

PAPERS, PROPOSALS, AND PRESENTATIONS

Fourth Edition

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PREFACE

Clear communication is a requirement, not an option, for a good scientist. Without such communication skills, scientists stand little chance of publishing their work, obtaining funds, or attracting a wide audience when giving a talk. Even the most promising discovery is worth little if it cannot be communicated successfully. *Scientific Writing and Communication: Papers, Proposals, and Presentations*, Fourth Edition, serves as a **comprehensive "one-stop" reference guide to scientific writing and communication**.

Despite the fundamental role of communication in the sciences, most researchers are not formally trained in scientific writing and thus have only a skeletal knowledge of basic scientific writing principles. Although most universities and colleges are aware of this problem, few of them offer formal training to their students and staff.

Scientific Writing and Communication: Papers, Proposals, and Presentations, Fourth Edition, shows you how to write clearly as a scientific author or technical writer and how to recognize shortcomings in your own writing and communication. The book targets a broad audience ranging from upper-level undergraduate students to graduate students, from postdoctoral fellows and faculty to fully fledged researchers and professional writers. Although *Papers, Proposals, and Presentations* can be used as a textbook, it is structured such that it is equally self-explanatory, allowing you to understand how to write English publications or proposals and to present scientific talks without having to take a class.

DESIGN OF THIS BOOK

This book consists of six main parts plus appendices:

I. Scientific Writing Basics: Style and Composition
II. Planning and Laying the Foundation
III. Manuscripts: Research Papers and Review Articles
IV. Grant Proposals
V. Posters and Presentations
VI. Job Applications
Appendices on Commonly Confused Terms, MS Word, Excel, and PowerPoint tips.

Part I provides an overview of scientific writing and presents 30 basic scientific writing rules of technical style and composition that every scientific writer should know, including word choice, sentence structure, sentence location, and paragraph construction. These rules are generally applicable to all scientific documents and emphasize such fundamental principles as word location, details of grammar/technical style, and reader interpretation. In addition to the rules, the reader will also find guidelines, which apply to specific sections of a scientific document or presentation or to scientific writing in general.

Part II describes the key steps that must be taken to prepare a well-written scientific document. It includes a section on how to start the writing process and discusses authorship. It also explains how to collect, successfully manage, and use references as well as how to avoid plagiarism. In addition, Part II outlines important guidelines for preparing figures and tables. In contrast to the basic scientific writing rules, guidelines—designated by ➤—apply to specific sections of a scientific document or presentation and may not be universally applicable, but rather situation-dependent.

In Part III, authors learn to apply the basic rules of Part I to writing and revising individual sections of a scientific research paper or review article. Authors are introduced to structural guidelines important for writing each section of an article and are given many examples of well-written sections as well as examples of sections that would benefit from revision. In addition, Part III provides an overview of how to revise a manuscript and how to submit it to a journal.

Part IV covers diverse sections on grant writing. These chapters provide information about federal and private funding organizations and guidelines for writing letters of inquiry and the different sections of a grant proposal. In addition, Part IV also provides instructions on how to submit a proposal and how to communicate with the funding agency.

Part V instructs scientists on how to prepare and present effective oral presentations and posters. In these chapters, real examples of slides and posters are provided, as is advice on effective speaking, combating stage fright, and fielding questions. To guide presentations, basic guidelines on visual aids and the content of a talk or poster are given.

Part VI of this book completes this series on scientific writing skills by providing information on job applications. This section includes advice on how to prepare a curriculum vitae (CV) and how to ask for and write letters of recommendation. Examples of well-written research and teaching statements are also included in Part VI.

The appendices round up the information on scientific writing and communication for those looking for a comprehensive list of commonly confused terms or technical tips on computer software, including MS Word, Excel, and PowerPoint, in composing scientific documents or presentations.

Throughout the book, readers will be guided by rules, guidelines, and annotations. Visually, these elements are designated as follows:

★ – Rules that are generally applicable to all scientific documents, emphasizing fundamental principles

➤ - Guidelines that apply to specific sections of a scientific document or presentation or to scientific writing in general

👍 - Good examples of writing and composition

👎 - Bad examples of writing and composition

HALLMARK FEATURES

Scientific Writing and Communication: Papers, Proposals, and Presentations has been used successfully for a number of years in courses on scientific writing at various universities and institutes worldwide. Like its predecessors, the fourth edition presents basic writing principles and applies these to composing research articles, review articles, proposals, job applications, posters, and oral presentations. Proven hallmark features include the following:

- **A practical presentation** carefully introduces basic writing mechanics before moving into manuscript planning and organizational strategies.
- **Relevant and multidisciplinary examples** are taken from real research papers and grant proposals by writers ranging from students to Nobel laureates. Good and bad examples, often annotated, are drawn from a broad range of scientific disciplines, including medicine, molecular biology, biochemistry, ecology, geology, chemistry, engineering, and physics.
- **Extensive end-of-chapter exercise sets** provide the opportunity to practice style and composition principles.
- **Writing guidelines and revision checklists** warn scientists against common pitfalls and equip them with the most successful techniques to revise a scientific paper, review article, or grant proposal.
- **Annotated text passages** bring the writing principles and guidelines to life by applying them to real-world, relevant, and multidisciplinary examples.
- **Many tables with sample sentences and phrases** are given that apply to different sections of a scientific paper, review article, or grant proposal for beginning scientific writers, non-native speakers, those struggling with writer's block, or those preparing to deliver a talk or poster at a conference.
- **Special features for ESL students and researchers** are presented in an easy-to-follow style, appealing to both native and non-native English speakers.

NEW TO THE FOURTH EDITION

Since the publication of the first, second, and third editions, I have heard from many professors and students that they found the text's comprehensive, practical, and hands-on approach to be of great value as they produced a wide range of scientific documents. Listening to their comments, I have revised the text with the goal of expanding these hallmark features and providing a few all-new resources. Specific updates and improvements in the fourth edition include the following:

- **A new section on "media literacy"** guides students and others in evaluating and verifying good versus bad sources.
- **A new section on scientific versus science writing** provides context and understanding of the difference of these genres.
- **A discussion of open access journals and electronic publishing** lays out these new and growing trends in scientific publishing.
- **An expanded section on scientific ethics** discusses the importance of these issues and provides guidance on key questions.

- **An updated section on basic statistical analysis** expands the fundamentals of reporting statistical data and analyses in a scientific context.
- **An expanded section on plagiarism** intends to guide students on avoiding this pitfall and makes them aware of important bioethical issues.
- **An expanded discussion of peer review and revision of draft papers** informs readers on what constitutes constructive comments and evaluations.
- **An updated chapter on job application** expands on the format and content of CVs and résumés.
- **New information on Google docs, sheets, and slides** informs about file sharing and options to work on the same document simultaneously.
- **Updated examples and exercises throughout the book** include current hot topics in the scientific field.
- **Expanded online resources** include an online instructional video guide for appropriate chapters, online solutions for homework assignments, online exercises, and updated online appendices on MS Word, Excel, and PowerPoint.
- **Updated PowerPoint slides** accompany the revisions of the fourth edition of *Scientific Writing and Communication: Papers, Proposals, and Presentations.*

Writing a clear research paper or grant proposal, and presenting an articulate talk, can be difficult for any scientist, but this difficulty is by no means insurmountable. You, the writer, must *practice* writing and thinking within this structure and learn by example from the writings of others. Ultimately, with guidance and practice, any scientist should be able to write a paper or proposal that sparkles with clarity and to deliver an engaging presentation. As you write your own papers or prepare your talks, you will recognize that every project has its unique challenges and that you will need practice and good judgment to apply all the writing and communication principles presented herein. In giving due attention to composition, style, and impact, your communication skills will improve significantly, and this book will have accomplished its purpose.

ACKNOWLEDGMENTS

Scientific Writing and Communication: Papers, Proposals, and Presentations, Fourth Edition, attempts to capture critical ideas in effective scientific writing in one location. As is the case for research papers and grant proposals, this book builds on previous works published on communicating in the sciences and beyond. These tremendously valuable resources are listed in the bibliography at the end of the book.

I would also like to acknowledge my students, friends, and colleagues from the Max-Planck Institute, the Fritz-Haber Institute, the Humboldt University, the University of Carabobo, the University of Massachusetts at Worcester, and Yale University who have shared information and ideas across the sciences. I am particularly thankful to all the students and scientists who were courageous enough to allow me to use draft sentences, paragraphs, or sections as examples or problems in this book. Without these samples the book would not be nearly as effective in exemplifying clear writing.

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PART ONE

Scientific Writing Basics

STYLE AND COMPOSITION

CHAPTER 1

Science and Communication

THIS CHAPTER PROVIDES AN OVERVIEW OF:

- The scientific method
- Scientific ethics
- The basic precept of writing
- Science writing versus scientific writing
- Expository writing versus technical writing
- The importance of practice

1.1 THE SCIENTIFIC METHOD

➤ Understand the scientific method

Science studies the natural world. It includes many different fields, from the life sciences to earth sciences to physical sciences; it also encompasses other specialized disciplines, such as anthropology and psychology. Through observational studies and experiments, scientists try to gather information and derive models to explain diverse phenomena. The series of steps involved in such studies have a similar pattern throughout the diverse scientific fields, although they are not rigid. These steps are collectively known as the scientific method and consist of

- Asking a question/making an observation
- Proposing a hypothesis
- Testing the predictions of a hypothesis through experiments or observations
- Analyzing and interpreting the data/drawing conclusions
- Communicating results

A scientific hypothesis is a highly probable proposition or explanation, based on observations and prior knowledge, that can be investigated further. It explains how or why a natural phenomenon occurs and makes at least one unique, testable prediction (e.g., hypothesis: the boiling temperature of water depends on altitude; prediction: water will boil at a lower temperature at an altitude of 5,000 ft than at sea level). If the hypothesis is wrong, scientists often come up with a new hypothesis. They then repeat the scientific steps to test it by experimentation or observation and publish their findings. If the hypothesis is widely accepted and broad enough in scope, it can turn into a theory and eventually into a law, on which scientists can build to advance research and knowledge further.

It is the last point of the scientific method, communicating results, with which this book is mainly concerned. Without clear communication, even the best results in science mean little. As a science student, it is therefore essential to be trained not only in observation, formulation of a hypothesis, and research methods but also in scientific communication. Learning how to communicate in science will prepare you well for the professional world. Without these skills, it will be difficult to succeed as your career will depend on publications, successful proposals, and clear presentations and posters. Communication in the professional scientific world includes

- Original scientific research articles—to communicate findings to other scientists and to the public
- Review articles—to glean and communicate in-depth interpretations of current topics published in research articles
- Grant proposals—to apply for funding of research
- Posters and oral presentations—to present your work visually and orally
- Science news articles, blogs, social media postings, or lectures—to communicate science effectively to the public, students, and so forth
- Evaluation of the work of others—for example, as a reviewer of a manuscript or a grant proposal
- Letters of recommendation
- Progress reports
- Cover letters
- Job applications

This book is meant to prepare you for these professional skills by teaching you how to research and use references, present and report on data, write research articles, compose reviews, draft grant proposals, and prepare presentations, posters, and even job applications. To generate such documents and presentations, you need a good foundation, including basic writing skills from the smallest units (words) to the larger ones (sentences, paragraphs, and full articles), all of which are covered in this book.

1.2 SCIENCE COMMUNICATION AND ETHICS

➤ Strive to communicate your findings clearly

Many readers think that scientific documents are generally hard to read because scientific concepts and topics are complex. However, this complexity does not need to result in difficult communication. It is important that readers accurately perceive what you as the author had in mind and that you avoid misunderstandings. To become an effective and successful author, you can and should strive to communicate clearly without oversimplifying scientific issues.

➤ Be ethical

Good science does not only need to be communicated well and effectively, it also has to pass scientific ethics, which apply to all scientists in their research and professional endeavors. Ethical norms cover a wide range of topics, from use of human subjects, such as fetal tissue, to fraud, sponsorship of research, and plagiarism (see also Chapter 8, Sections 8.5 and 8.6, and Chapter 12, Section 12.5), and are governed by standards in diverse scientific disciplines, law, and business. Such norms are important for the following reasons:

- To ensure accuracy and truth (and avoid fabrication, fraud, falsification, and misrepresentation of data)
- To ensure mutual respect, fairness, and trust (and thus make collaborations possible while protecting intellectual property rights, copyright, patenting rules, and authorship recognition)
- To hold scientists accountable (and avoid research misconduct, conflict of interests, human or animal harm)

Accordingly, codes of ethical conduct for scientists have been established by diverse professional organizations, journals, universities, institutes, and government agencies, such as the National Institutes of Health (NIH), the Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA). In medical research, key agreements include the Declaration of Helsinki, a set of ethical principles for research on human subjects developed by the World Medical Association (available at https://www.wma.net), and the Nuremberg Code, a set of ethical principles for experimentation on humans established after World War II (http://ohsr.od.nih.gov/guidelines/nuremberg.html).

Ethics in science also extends to scientific writing and communication. Scientific misconduct is federally defined as intended actions, such as fabrication and falsification of data and plagiarism. All researchers view these as unethical. Note, though, that human errors, sloppiness, miscalculations, bias, disparities of methods and interpretations, and even negligence are not classified as misconduct, although scientists strive to avoid them as well. Other deviations not defined as misconduct also are viewed as unethical by most scientists: stealing someone else's ideas or data, submitting or publishing the same papers in different journals, including someone who has not contributed to a project as an author on a paper, filing a patent without informing collaborators, asking sexual favors in exchange for authorship or a grade, exploiting students and postdocs, misrepresenting facts on a curriculum vitae (CV), not following protocols of animal care, and more. Although these offenses are considered serious, they do not fall within the official federal definition of scientific misconduct and are the subject of much ongoing discussions on this topic.

Most academic institutions offer, and even require, training in the responsible conduct of research and in research ethics in the hopes of reducing the rate of serious deviations. Such training allows researchers to understand ethical issues and challenges and informs them on how to handle situations and dilemmas they may encounter.

➤ Become media literate

At a time when sharing and accessing information is easier than ever and when it seems difficult to distinguish peer-reviewed from nonpeer-reviewed articles and valid scientific data and facts from unverified ones, clear and high-quality scientific communication has never been more important. It is therefore imperative that you verify information when you compose your documents. Do not rely on references in other articles, subjective opinions, policy-based evidence, unsupported facts, and nonpeer-reviewed reports or Web sources (see also Chapter 8, Section 8.2 and 8.10). Moreover, do not report your opinion as fact. Rather, clearly identify your opinion and conclusions (*Our findings indicate that* . . . ; *A possible model of X could be* . . .).

Valuing and respecting the scientific method and the peer-review process is essential when it comes to drafting, publishing, and reviewing manuscripts. Use respected, peer-reviewed journals (also known as primary sources) or peer-reviewed open access journals, rather than nonpeer-reviewed journals or websites. Learn how to distinguish peer-reviewed from nonpeer-reviewed articles. Reputable journals are typically found by searching online databases such as MEDLINE®, SCOPUS®, BIOSIS, and the Web of Science as well as on the Directory of Open Access Journals (see Chapter 8, Section 8.2). Reputable journals are also usually indexed in an academic database or search engine and have indicators such as impact factors.

If you are unsure about information you receive or find, make use of the scientific method: gather evidence, check sources, deduce, hypothesize, and synthesize conclusions yourself rather than relying on those of others. Knowing and using these practices will aid you and others in distinguishing reliable primary sources from those that are not.

1.3 ABOUT READERS

➤ Understand how readers go about reading

To understand how best to write clearly, it is important to understand how readers go about reading. Expectations and perceptions of readers have been widely studied in the fields of rhetoric, linguistics, and cognitive psychology. In this book, I provide an overview of these expectations and perceptions and apply them to a broad range of scientific fields, thus giving you the tools you need to become a better writer.

Readers immediately interpret what they read. Let me illustrate how readers go about reading on the example of one word:

Water!

Immediately, on reading this single word, you will have a picture in your mind. Some of you will think of water as in a dangerous flood or tsunami; others will think of going swimming on a hot day; yet others will think of getting water to drink when they are thirsty or the excitement they feel on finding water for which they have been drilling. In other words, different readers interpret this single word differently. Similarly, sentences can be interpreted in different ways, none of which may coincide with the interpretation intended by the author. Your goal as a writer should be to communicate the intended meaning of your writing clearly to as many readers as possible.

How do readers interpret what is written? There is no single answer to this question. When reading scientific papers, readers are affected not only by the content and format of a paper but also by its composition and style. Readers interpret documents based not only on words, sentences, and paragraphs but, above all, on the structural location of these elements. Thus, readers are bothered much more when a sentence is misplaced than when a word is imprecise. For example, they will find a Materials and Methods paragraph that appears in the Introduction of a manuscript more disruptive than a misspelled word. In other words, the logical and structural organization of scientific documents is much more important than perfect grammatical form (Figure 1.1).

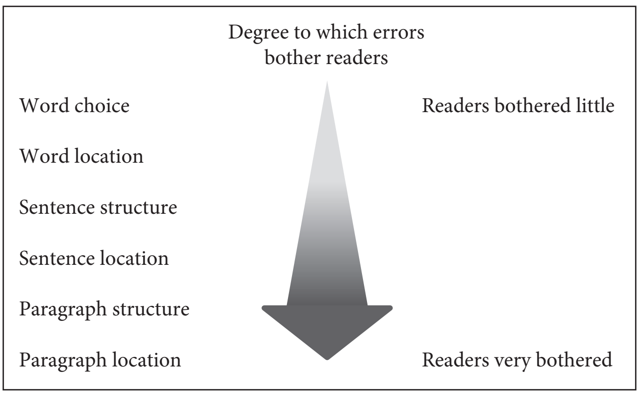

Figure 1.1 Degree to which errors in writing bother readers. Based on the perception of readers, it is more important to logically organize and present one's ideas than to worry about perfect grammatical form or word choice.

As an author, you need to be conscious of these elements when you write. Understanding the correlation of structure and function in a sentence, paragraph, or section is what underlies the science of scientific writing.

Aside from these elements of text composition, communication in science also depends on effective graphics depicting data or communicating complex biological phenomena to complement the writing. These visual elements are often key to providing the required evidence to convince readers of your data interpretations and to provide pictorial models that readers can remember. Understanding the needs of your audience in that respect is thus also important in becoming a successful writer.

Some topics are complicated by nature and can be hard to follow. Reading such science is work. A good writer, however, can make the work much easier.

1.4 ABOUT WRITERS

★ Write with the reader in mind

In the professional world, success in writing is determined by whether your readers understand what you are trying to say. You need to write clearly so that readers can follow your thinking and so that you achieve the greatest possible impact. To "write with the reader in mind" means to consider how the reader interprets what you have written. It requires you to construct your writing clearly, concisely, and at the right level, so that the reader can follow and understand what you want to say immediately. This rule should be viewed as the ***Basic Precept*** around which all other writing rules revolve.

Most of us can identify unclear writing by others, but we have a harder time recognizing our own mistakes. Scientists who write unclearly rarely think they do, much less intend to. Similarly, your own writing may appear clear to you, and it will come as a surprise when your readers say that it is not. The reason for this insensitivity is simple: Anyone who writes about something and understands its content is more likely to think the passage is clearly written than someone who knows less. However, we all know how difficult it is to understand "legalese" for anybody outside the legal field or "bureaucratese" for anyone other than a bureaucrat. In the same way that legalese and bureaucratese are difficult to understand for most people, "academese" is difficult to understand for most people outside the field of science.

To illustrate how frequent style and composition errors are in scientific writing, I randomly selected and analyzed writing error frequency in 100 prepublication scientific manuscripts by senior graduate students and postdoctoral fellows from several US universities covering a wide range of biological and biomedical topics. Half of the authors were native speakers and the other half were not—a ratio that reflects approximately the ratio of native to nonnative speakers among postdoctoral fellows in the United States today. All manuscripts contained errors

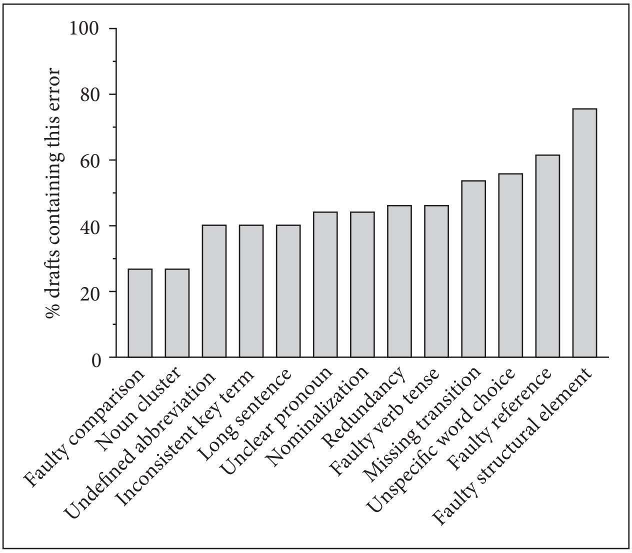

Figure 1.2 The most common grammatical, structural, and stylistic problems.

Explanation of elements:

Faulty comparison	Use of incomplete and ambiguous comparisons (*Example: "Our findings are similar to Frater et al."*)
Noun cluster	Use of two or more nouns in a row (*Example: "filament length variability"*)
Undefined abbreviation	A nonstandard abbreviation is not defined (*Example: "CMMT"*)
Inconsistent key term	Key terms are not repeated or linked (*Example: "nematode," "worm,"* "C. elegans")
Long sentences	Use of too many long sentences
Nominalization	Use of a noun instead of a more interesting verb (*Example: "measurement" instead of "to measure"*)
Redundancy	Ideas are repeated in different ways, or long phrases are used (*Example: "the majority of" instead of "most"*)
Faulty verb tense	Use of present tense instead of past tense
Unspecific word choice	Words are imprecise or unclear (*Example: "The sample was incubated for several hours."*)
Faulty reference	Reference is wrongly cited, inaccurate, missing, or has wrong placement in text (*Example: "It was reported (5) that x is the only element."*)
Faulty structural element	Key component of a paper is missing, misplaced, or obscured (*Example: The purpose of experiment is not stated.*)

in style and composition, but each type of error was scored only once. The percentage of the manuscripts containing the most common grammatical, structural, and stylistic problems is shown in Figure 1.2.

Interestingly, most manuscripts contained faulty structural locations (76%). Faulty or missing references were the second most common error encountered (62%), followed closely by unspecific word choice (56%) and missing transitions (54%). Other errors, such as faulty verb tense, use of redundancies, and nominalization, as well as unclear pronouns, also occurred relatively often (40%–46%). These results demonstrate the variety as well as the amazingly high frequency of writing problems scientists appear to have and show the importance and need for good scientific writing guidelines and instruction.

Why do these problems exist in scientific writing? Many writers simply want to unburden themselves of all the information they have collected and are happy just to get their data onto paper. Others, especially those new to a field or unfamiliar with a topic, learn to write by imitating a particular writing style characteristic of a field without clearly understanding the underlying structure. Some writers plump up their writing to impress readers, convinced that dense writing style sounds sophisticated and reflects deep thinking. The main reason for poor writing style and composition, however, is ignorance and lack of training. Scientific writers are often unaware of how to identify words, sentences, or paragraphs that may give readers a problem. Most are aware of certain "rules" taught to them in high school and undergraduate English composition classes but are not familiar with the basic rules that would benefit them as professionals in science.

To become a successful writer, you should have a firm grounding in basic English composition and an understanding of how readers interpret what has been written. The main goal of this book is to provide you with these basic rules (designated by ★: generally applicable to all scientific documents) and with guidelines (designated by ➤: apply to specific sections of a scientific document or presentation or to scientific writing in general) to ensure that your work has the highest possible impact and is clearly understood by the majority of readers, be they editors, students, or fellow scientists.

1.5 SCIENTIFIC WRITING VERSUS SCIENCE WRITING

➤ Distinguish between science writing and scientific writing

People often get confused about scientific writing versus science writing and mix up these terms. Yet the two are not synonymous. Most science writers are not scientific writers and vice versa. While the rest of this book deals with scientific writing, this brief section outlines the difference between scientific writing and science writing to help make the difference between the two more clear and to aid in guiding those seeking more information on the latter.

Scientific writing is a form of technical writing by scientists for other scientists. Unlike other styles of writing, this style of writing is not meant to be creative but fact-based and objective. It reports on studies, observations, and findings in a specific format. For example, peer-reviewed journal articles, which report on primary research and are published in scientific journals such as *Science* and *Nature*, fall into this category. Grant proposals, which seek funding, and literature review articles, which summarize and interpret published research, also belong to this genre. Example 1-1 is an example of scientific writing.

Example 1-1 Beta-thalassemia, an inherited morbid hemoglobinopathy, is caused by single-point mutations in the gene for beta-globin. Our long-term goal is to diagnose and treat hemoglobinopathies by using high-fidelity editing reagents, such as peptide nucleic acids, carried in targetable nanoparticles. To date, our group has optimized editing reagents using single-stranded DNA to correct the point mutation that causes beta-thalassemia.

Science writing, on the other hand, is nontechnical writing about science for a general audience. It is the form of journalism you find in *Scientific American, National Geographic,* or in articles on science published by *The New York Times.* (See also the website of the National Association of Science Writers at https://www.nasw.org/.)

Science writing is not a how-to manual or a review paper or research article. Science writers explain important and interesting topics in science and technology and lay out the broader social effects of these topics to a wide public audience. For example, a science writer may communicate the effects of climate change or describe an approach to stem the spread of the Zika virus. Science writers often are not trained scientists but humanists interested in science. They are mainly concerned with how to explain and interpret scientific concepts or processes in a way that is clear to a lay audience. They have to use nontechnical language to do so and define terms to ensure that their audience can understand what is being described. Their work may also be critical about scientific findings. Example 1-2 covers the same topic as Example 1-1, but this time in the style of science writing.

Example 1-2 Beta-thalassemia is an often fatal, inherited red blood cell disease, which is caused by a genetic mutation in the beta-globin gene. Scientists plan to repair mutations causing the disease by excising the mutated DNA and replacing it with DNA pieces containing the correct sequence. The correct DNA pieces will be carried into the cells on tiny particles the size of a few nanometers, which are able to cross the cell membrane.

Almost all elements of style found in scientific writing are also valid in science writing, but science writers need to pay particular attention to

- Selecting the key features of a work or process
- Providing background on a process or materials before labeling them

- Employing analogies and metaphors as well as examples of what something is not
- Using active voice and first person rather than passive voice and third person

1.6 MASTERING SCIENTIFIC WRITING

➤ Practice writing

To master the art of scientific writing, use the rules and guidelines of this book to help you grasp fully the necessary format expected for the respective scientific documents. Realize, though, that reading and hearing about these rules and guidelines is not enough. Familiarity with the nuances of these elements will be enhanced as you read scientific literature and pay attention to how professional scientists write about their work. Most important, however, is that you, as the writer, *practice* writing and thinking within this structure. Reading and editing the writing of others, as well as peer review, can also help you toward mastery. You will see improvement in your own writing skills by repeatedly practicing, reading, writing, and critiquing others' work.

This book includes writing exercises that allow you to practice the discussed rules and guidelines. Work through these exercises and give yourself the opportunity to make your own mistakes and achieve your own successes. Know that some of the problems are challenging and may be frustrating. Try not to get stuck in the scientific details of the exercises; what is important is that you recognize mistakes of style and composition and avoid misunderstandings and misinterpretations. You may disagree with some of the answers that have been provided, and many exercises will have more than one correct solution. Some solutions are better than others, and some just a matter of personal style. The goal is to improve the original text so that the material presented is clearer and more easily understood by the reader.

Just like any other skill, mastering the skill of scientific writing and communication takes time—usually years. Ultimately, with guidance and practice, any scientist should be able to write a paper or proposal that sparkles with clarity and to deliver an engaging presentation. As you write your own papers or prepare your talks, you will recognize that every project has its unique challenges and that you will need practice and good judgment to apply all the writing and communication principles presented herein. In giving due attention to composition, style, and impact, your communication skills will receive the necessary foundation and evolve into those needed for professional writing, and this book will have accomplished its purpose.

SUMMARY

Chapter 1
Video Guide

BASIC PRECEPT: Write with the reader in mind.

BASIC SCIENTIFIC WRITING GUIDELINES

- Understand the scientific method.
- Strive to communicate your findings clearly.
- Be ethical.
- Become media literate
- Understand how readers go about reading.
- Distinguish between science writing and scientific writing.
- Practice writing.

CHAPTER 2

Individual Words

Word choice in scientific research papers is one of the primary concerns of scientists and editors alike. This chapter provides basic guidelines for the choice of words in scientific papers.

Choosing the best words to write about science is not easy. Over time, the meaning of words may even change, making it even more difficult to select and distinguish between words in English. Authors need to be aware of the exact meaning of words to convey their messages clearly to as many readers as possible.

THIS CHAPTER TEACHES YOU THE FOLLOWING PRINCIPLES AND RULES:

- The central writing principle
- Basic rules of word choice for clarity
- Words and phrases to avoid or omit
- General terminology and nomenclature

2.1 THE CENTRAL PRINCIPLE

★ (1) Write with the reader in mind

Many scientists think that the primary goal in science is to obtain great results, but good science alone will not bring you success. Your collection of data cannot speak for itself—it needs to be communicated and communicated well. Authors have an obligation to their readers to ensure that science is communicated clearly.

In the scientific fields, readers may be reviewers of a paper or proposals, editors, students, Nobel laureates, scientists from a different discipline, or readers whose native language is not English; in fact, probably most of them will be nonnative speakers, as English is being adopted as the global scientific language. Because of this diversity in readership, the burden of clarity rests on you, the author. Your readers need to be able to follow your thinking, so write with your readers in mind. This basic precept is the central principle of this book, and all other writing rules follow from it.

2.2 WORD CHOICE

Precision

★ (2) Use precise words

The problem of many sentences in science is not grammar but word choice. Consider the following three examples.

Example 2-1	**a**	The current remained increased for several hours.
	b	Nests were observed frequently for signs of predation.
	c	The carbonate layer was prepared with sodium carbonate.

Although the words underlined in these examples can be found frequently in research papers, these word choices are problematic and disliked by editors and reviewers. In each of the three sentences of this example, the underlined words violate the same basic rule: these words are not precise.

You can improve these sample sentences by revising the word choices.

Revised Example 2-1	**a**	The current remained increased for **6 hours**.
	b	Nests were observed **every 12 hours** for signs of predation.
	c	The carbonate layer was prepared **using** sodium carbonate. or:
		The carbonate layer was prepared **in the presence of** sodium carbonate.

Why are the revised sentences better than those in Examples 2-1a to 2-1c? The revised sentences convey more precisely what the writer is describing. “Several” is imprecise. How many is “several”? Writers should give a quantitative value such as “6 hours.” Note also that if you use imprecise words, other scientists may not be able to follow your experiment or thinking.

“Frequently” is also imprecise. How often is frequently? Use a quantitative term such as “every 12 hours,” or “at 6 AM and at 6 PM.” A quantitative detail such as “every 12 hours” is much clearer than a qualitative term such as “frequently.”

Let us look at Example 2-1c more closely. The vague term underlined in this example is “with.” This word is one of the vaguest and most ambiguous terms in English. Because “with” can mean so many things, you should use a more precise term whenever possible. Otherwise, the reader has to guess what you mean. Note that “with” does have legitimate uses, such as “in the company of," as in "I went to school with Brian." Another standard meaning is "by the means of," as in "We washed the dishes with soap." "With" can also be used as an attribute, as in "patients with diabetes." Furthermore, some verbs are followed by "with" such as "compared with." However, scientific writers often use "with" instead of a more precise term and thus confuse readers. In the preceding example, it is much more accurate to write "using" or "in the presence of" instead of "with."

Level of Sophistication

★ (3) Use simple words

Words in science should not only be precise, they should also be as simple as possible. Consider the following examples.

Example 2-2

a Fractions of 0.8 ml were collected, <u>reduced to dryness</u>, and dissolved in 3.75% methanol (v/v) prior to being sequenced.

b Our results <u>reflect deviations</u> from thermal equilibrium during desorption.

These sentences are written in a style that appears heavy and dense to the reader and can even be considered portentous. Admittedly, scientific writing has many technical terms. To keep your writing from being too heavy, choose simple words for the rest of the sentence. "Reduced to dryness" can be expressed much simpler by writing "dried" and "reflect deviations" by "deviate."

Revised Example 2-2

a Fractions of 0.8 ml were collected, **dried**, and dissolved in 3.75% methanol (v/v) prior to being sequenced.

b Our results **deviate** from thermal equilibrium during desorption.

The revised sentences are more easily understood by readers because their word choice is much simpler.

Often, young scientists try to mimic more experienced researchers and then write in a style they think experienced researchers would use. However, this can come off as pompous. Here is another such example that needs to be simplified.

Example 2-3

<u>There is a large body of experimental evidence that clearly shows that members of the genus *Crotalus* congregate simultaneously in cases of prolonged decreased temperature conditions in the later part of the year.</u>

Revised Example 2-3

Rattlesnakes come together when it gets cold in the fall.

Many English as a second language (ESL) authors convert vocabulary of their native language for use in English writing. In other cultures, flowery language is extensively used. In professional English, however, you need to use correct terminology and avoid the grandiose words or phrases. In professional English, statements are rather direct (see Chapter 5 for more on ESL differences). Thus, authors need to pay special attention to avoiding flowery words or unnecessarily complicated phrases.

Regardless of your native language, remember that most of your readers are probably nonnative English speakers. You have to ensure that these readers can understand what you have written. Use simple words. That is, aside from the technical terms, choose a level of words that you would use when talking about your work to a friend; for example, choose "girl" rather than "female child" (see also http://www.userlab.com/Downloads/SE.pdf for more details on using simplified English for an international audience).

2.3 WORD CHOICE: SPECIAL CASES

Misused Words

➤ Watch out for misused words

ESL advice

Words are not always what they seem. Often, words and expressions in science are misused and confused, especially by ESL authors. Some of the words are used incorrectly so often that they sound right even when they are not. Watch out for these misused and confused scientific terms. Use a dictionary if needed or look up definitions on the Internet.

Commonly misused words fall into several categories, including words with suffixes, verbs, adverbs, adjectives, and links.

Suffixes

-ability Be aware of *-ability* words. Often, the sentence should be rewritten using a stronger verb preceded by the verb *can*.

👎	**Example 2-4**	**a**	Changeability of *X* occurs when *Y* is added.
👍	**Revised Example 2-4**	**a**	*X* **can change** when *Y* is added.

-ization Challenge *-ization* nouns. Many writers tend to invent nouns by adding the ending *-ation* or *-ization* onto the verb.

👎	**Example 2-4**	**b**	Metabolization of phosphates was different than expected.
👍	**Revised Example 2-4**	**b**	Phosphates were **metabolized** differently than expected.

-ize Often, nouns or adjectives are wrongly changed to verbs by adding *-ize* to a word.

Example 2-4	**c**	Older patients were prioritized.
Revised Example 2-4	**c**	Older patients were **given priority**.

-ized/-izing You should also challenge *-ized* or *-izing* adjectives and search for simpler substitutions.

Example 2-4	**d**	Individualized doses were calculated. Quantum materials have a transformatizing impact on various technologies.
Revised Example 2-4	**d**	**Individual** doses were calculated. Quantum materials have a **transformative** impact on various technologies. or, even better: Quantum materials transform various technologies.

-ology This ending means the study of something and is jargon when used in sentences such as the following.

Example 2-4	**e**	No pathology was found. Cytology was normal. Symptomology was severe. Serology was negative.
Revised Example 2-4	**e**	No **pathologic condition** was found. **Cytologic findings** were normal. **Symptoms** were severe. **Serologic findings** were normal.

Verbs

ESL advice

make Like "to do," "to make" is often overused by ESL writers. Be sure to use the correct terms in context instead of simply substituting "to make" for any unknown term. If you are not sure about the correct terminology, consult an English textbook, journal, or a scientist who is a native speaker.

Example 2-5	**a**	A picture was <u>made</u>. We <u>made</u> a graph.
Revised Example 2-5	**a**	A picture was **taken**. We **graphed** the data. or: We **constructed** a graph.

affect, effect “Affect” is usually used as a verb and means to act on or to influence.

Example 2-5	**b**	The addition of Kl-3 to MZ1 cells affected their growth rate. [i.e., it could have increased or decreased or induced something else]

More rare, “affect” can also be a noun with a specialized meaning in medicine and psychology: an emotion.

Example 2-5	**c**	People can experience a positive or negative **affect** as a result of their thoughts. She showed a normal reaction and affect.

“Effect” is usually used as a noun meaning a result or resultant condition.

Example 2-5	**d**	We examined the **effect** of Kl-3 on MZ1 cells.

When used as a verb (rarely), “effect” means to cause or bring about.

Example 2-5	**e**	The addition of Kl-3 to MZ1 cells **effected** a change in their growth rate. [i.e., it caused or brought about change]

ESL advice

Adverbs and Adjectives

overnext This word does not exist in English. What you probably mean is “the one *after the next*.”

Example 2-6	In the <u>overnext</u> slide, we will see . . .
Revised Example 2-6	In the **slide after next**, we will see . . .

significant(ly) Use only when you are talking about statistical significance and give a *p*-value. Otherwise, use “important,” “substantial,” “markedly,” “meaningful,” or “notable.”

Linking words

since, because Use "since" only in its temporal sense, not as a substitute for "because." If you want to indicate causality, use "because."

Example 2-7 a Growth stopped **since** the temperature fell below freezing.
The reaction rate decreased **because** the temperature dropped.

which, that Sometimes these words can be used interchangeably. More often, they cannot. Use "which" with commas for nondefining (nonessential) sentences.

Example 2-7 b Dogs, which have been domesticated for millennia, are our best friends.

Use "that" without commas for essential sentences. If the section of a sentence introduced by "that" is omitted, the meaning of the sentence is changed or may not be apparent.

Example 2-7 c Dogs that were treated with the antidote recovered.

Be especially careful about words that are easily confused by writers and about words that look similar but mean different things. Examples include those previously described ("affect" and "effect," "since" and "because," and "which" and "that"). More commonly confused words, including *as/like*, *while/whereas*, *principle/principal*, and *quantitate/quantify*, are listed in **Appendix A** together with their corresponding meanings.

Handling Language Sensitively

➤ Avoid sexism

Contemporary society prefers gender-neutral (unisex) language to convey inclusion and equality of all sexes. To avoid being accused of chauvinism and insensitivity, carefully consider what you write. If readers get offended, they are likely to stop reading.

Sexism refers to any form of stereotypic attitude, exclusion, or discrimination based on gender. Sexism can be both verbal and visual. It is often unintentionally introduced. Some forms are so subtle that authors might not even notice them unless they are pointed out. Consider the following example.

Example 2-8	**a**	Man is not the only host for this parasite.

The easiest solution to avoid sexism is to use “unisex” terms.

Revised Example 2-8	**a**	**Humans** are not the only hosts for this parasite.

Writing gets more complicated when we have to consider which pronoun to use for singular nouns that do not indicate gender or sexual orientation such as faculty, staff, teacher, scientist, student, and doctor. Although more formal language requires a singular pronoun (its, his, her), it raises the problem of biased language. The change in the English language is toward using a plural “they,” and plural verbs for these cases as shown in the next example.

Example 2-8	**b**	A nurse should double-check her IV settings.
Revised Example 2-8	**b**	**Nurses** should double-check **their** IV settings.

2.4 REDUNDANCIES AND JARGON

★ (4) Omit unnecessary words and phrases

Many sentences in science appear complex because they contain redundancies. Redundant words or phrases unnecessarily qualify other words and phrases. Writers should be as brief as possible and should avoid any verbosity by omitting unnecessary words and phrases and jargon (see also Chapter 6, Section 6.4 on condensing). However, if it takes more words to be clear, use more words.

The following are two examples of unnecessarily complex sentences.

Example 2-9	**a**	High pH values have been observed to occur in areas that have been determined to have few pine trees.
	b	Most galaxies with unusually luminous cores are quite asymmetric in shape.

By cutting out unnecessary words and redundancies, these sentences can be revised to the following.

Revised Example 2-9	**a**	High pH values occur in areas with few pine trees.
	b	Most galaxies with unusually luminous cores are asymmetric.

Unnecessary Words

The following individual words can and should be omitted because they add nothing to a text:

actually	basically	essentially	fairly	much	really
practically	quite	rather	several	very	virtually

Other Examples of Redundancies

In the next list, all the words in parentheses are redundant and can be omitted:

(already) existing	at (the) present (time)
(basic) fundamentals	blue (in color)
cold (temperature)	(completely) eliminate
(currently) underway	each (individual)
each and every [choose one]	(end) result
estimated (roughly) at	(final) outcome
first (and foremost)	(future) plans
(main) essentials	never (before)
period (of time)	reason is (because)
(still) persists	(true) facts

Unnecessary Phrases

Many unnecessary words and phrases are used by both native and non-native English speakers. Like commonly misused words, commonly misused phrases can often be avoided to make your writing shorter and clearer.

Certain phrases are often unnecessarily used to introduce previous studies or results. These phrases can almost always be deleted to state the facts more succinctly.

Example 2-10	In a previous study, it was demonstrated that heavy metals can be removed from aqueous solution by sawdust adsorption.
Revised Example 2-10	Heavy metals can be removed from aqueous solution by sawdust adsorption.

Example 2-11	Eddies have been shown to vary depending on the time of year.
Revised Example 2-11	Eddies **vary** depending on the time of year.

Other commonly used unnecessary phrases that can usually be deleted include the following:

there are many papers stating . . .	it is speculated that . . .
it was shown to . . .	it has been found that . . .
it was observed that . . .	it has been demonstrated . . .
it is reasonable to assume that . . .	it has been reported that . . .
evidence has been presented that shows that . . .	it has long been known that . . .

Phrases that can be shortened include:

Avoid	**Better**	**Avoid**	**Better**
A considerable number of	many	in the absence of	without
an adequate amount of	enough	in view of the fact that	because, as
an example of this is the fact that	for example	in the event that	if
as a consequence of	because	it is of interest to note that	note that
at no time	never	it is often the case that	often
based on the fact that	because	majority of	most
by means of	by	no later than	by
considerable amount of	much	number of	many
despite the fact that	although	on the basis of	by
due to the fact that	due to	prior to	before
during the time that	while, when	referred to as	called
first of all	first	regardless of the fact that	even though
for the purpose of	to	so as to	to
has the capability of	can, is able	utilization	use
in light of the fact that	because	with reference/regard to	about (or omit)
in many cases	often	with respect to	about
in order to	to	with the exception of	except
in some cases	sometimes		

A more extensive list of redundancies can be found in Day (1998) and O'Connor (1975).

Jargon

Jargon is the use of terms specific to a technical or professional group. Jargon is often incomprehensible for "outsiders." In science, jargon often includes "laboratory slang" as in the following examples.

Examples of jargon that should be avoided:

Southern blotted This is laboratory jargon. The correct use is ". . . analyzed by Southern blot . . ."

Western blotted	Similar to “Southern blotted,” “Western blotted” is laboratory slang. The correct use is “. . . subjected to Western blot analysis” or “. . . analyzed by Western blot.”
electrophorized	the correct usage is “analyzed by or subjected to electrophoresis”
bugs	meaning bacteria, never used in scientific writing
lab	use “laboratory”
prep	use “prepare” or “preparation”
vet	the correct term to use is “veterinarian”
evidenced	use the noun “evidence” instead
vortexed	“vortex” exists only as a noun; use “was mixed by vortex” instead

2.5 ABBREVIATIONS

★ (5) Avoid too many abbreviations

A special type of word choice to consider is the use of abbreviations. Too many abbreviations can be confusing to the reader and should therefore be kept to a minimum. Similarly, nonstandard abbreviations need to be limited or the reader will get lost. Use International System (SI) units when you use standard abbreviations such as kg or m. Standard abbreviations are widely accepted. Check also that you have not used too many abbreviations, even those approved by your target journal. You can legitimately use abbreviations to replace lengthy terms that appear more than about 10 times in a 10-page manuscript or that appear several times in quick succession, but do not use more than four or five such abbreviations in a single paper. Additionally, avoid making sentences indigestible by using too many abbreviations in a short space.

Example 2-12 AI, an important technology for economic activities, is largely focused on ICT and RT, whereas our new BI model is not.

The preceding example may be perfectly intelligible to expert colleagues in the artificial intelligence field but will be unintelligible to most readers.

Define essential abbreviations at their first appearance, in a footnote at the beginning of the paper, or in both places, according to the journal’s requirements. Once you have defined an abbreviation, use it whenever you need it—do not switch back to using the full term unless many pages have elapsed since its previous appearance—then you may remind the reader, once, what the abbreviation means. If you use—and define—an abbreviation in the title of a paper (although this is not recommended), redefine it in the text. Do the same for abbreviations used (and defined) in an abstract. If you are using many abbreviations in a long scientific document, consider adding a list of abbreviations with definitions to the document.

Special Abbreviations

Certain Latin-derived abbreviations are used often in science. Note that although the following are Latin derivatives, they are often used without italics:

e.g. = *exempli gratia*—for example
et al. = *et alia*—and others
i.e. = *id est*—that is

2.6 NOMENCLATURE AND TERMINOLOGY

★ (6) Use correct nomenclature and terminology

In science, it is important to use correct vocabulary, nomenclature (taxonomy), and terminology to avoid being misunderstood and to avoid confusing the reader. If you are not sure about a term, do not guess. Rather, take the time to look it up in a dictionary, thesaurus, or other reference book. Dictionaries for the biological, medical, and other scientific fields as well as online dictionaries are listed in Section 2.7.

Common Terminology

In science, all organisms are given a name, consisting of two Latin-derived parts: the genus and the species. This nomenclature is also known as binomial, binominal, or binary nomenclature. The genus name is written first and starts with a capital letter. The species name follows the genus name and starts with a lowercase letter. On first mention, genus names should be written out completely, but in subsequent mentions, the genus name can be abbreviated. For example, *Homo sapiens* can be written *H. sapiens*. Note that scientific names are traditionally written in italics. The names of higher taxa such as families or orders are capitalized but not italicized.

Examples of binominal nomenclature include:

	Genus	***species***
humans	*Homo*	*sapiens*
dog	*Canis*	*lupus*
mouse	*Mus*	*musculus*
apple	*Malus*	*domestica*

Aside from genus and species, genes and proteins of several organisms have also been named on the relevant model organism websites and in scientific journals using formal guidelines. When new information becomes available, scientists often work together to revise the nomenclature as needed. However, alternate names frequently exist and can pose a challenge to effective organization and exchange of biological information.

The most common scientific nomenclature includes the following:

Species and all Latin derivates are in *italics* (*in vivo, Physcomitrella patens,* etc.)
Human genes: all caps and *italics* (*ADH3, HBA1*)
Human proteins: caps, no italics (ADH3, HBA1)
Mouse genes: first letter capitalized, the rest lowercased, *italics* (*Sta, Shh, Glra1*)
Mouse proteins: like genes but no italics (Sta, Shh, Glra1)
Bacterial genes: three lowercase, italicized letters, followed by uppercase letter for different alleles (*rpoB*).
Bacterial proteins: not italicized, first letter capitalized (RpoB).
***Arabidopsis* genes**: three letters, *italics*, lowercase for mutants (*abc*), capital letters for wild type (*ABC*)
***Arabidopsis* protein**: capitalized, no italics (ABC)
***Arabidopsis* phenotypes**: first letter capitalized, rest lowercase, no italics (Abc^+ for wild type, Abc^- for mutant)
Yeast gene: same as for Arabidopsis
Yeast protein: first letter capitalized, rest lowercase, plus number for wild type (Icp1, Icp1p), plus number dash number for mutant (Icp1-1, Icp1-1p)

To distinguish the species of origin for homologous genes with the same gene symbol, an abbreviation of the species name is added as a prefix to the gene symbol. For example, human loci (HSA)*G6PD* where HSA = *Homo sapiens* and homologous mouse loci (MMU)*G6pd* where MMU = *Mus musculus*.

2.7 DICTIONARIES

Dictionaries—Biological and Medical Sciences

Biological Sciences (General)

Hine, R., & Martin, E. (2004). *A dictionary of biology*. New York: Oxford University Press.
Martin, E., & Hine, R. (Eds). (2015). *A dictionary of biology* (7th ed.). New York: Oxford University Press.
McGraw-Hill dictionary of bioscience (2nd ed.). (2003). New York: McGraw-Hill Book Company and Sybil P. Parker.
McGraw-Hill dictionary of scientific and technical terms (6th ed.). (2002). New York: Sybil P. Parker.

Biochemistry

Cammack, R., Atwood, T., Campbell, P., Parish, H., Smith, T., Vella, F., et al. (2006). *The Oxford dictionary of biochemistry and molecular biology*. New York: Oxford University Press.
International Union of Biochemistry. (1992). *Biochemical nomenclature and related documents*. London: Portland Press.

Biotechnology

Bains, W. (2004). *Biotechnology from A to Z.* New York: Oxford University Press.

Sengar, R. S., & Chaudhary, R. (2015). *Dictionary of biotechnology.* New Delhi, India: CBS Publishers.

Cell Biology

Lackie, J. M. (2013). *The dictionary of cell and molecular biology* (5th ed.). New York: Academic Press.

Genetics

King, R. C., Stansfield, W. D., & Mulligan, P. K. (2012). *Dictionary of genetics* (8th ed.). New York: Oxford University Press.

Immunology

Cruse, J. M., & Lewis, R. E. (2009). *Illustrated dictionary of immunology* (3rd ed.). Boca Raton, FL: CRC Press.

Herbert, W. J., Wilkinson, P. C., & Stott, D. I. (1995). *Dictionary of immunology*. New York: Academic.

Playfair, J. H. L., & Chain, B. M. (2009). *Immunology at a glance*. Oxford, UK: Blackwell.

Medical Sciences

Merriam-Webster's medical dictionary. (2016). Springfield, MA: Merriam-Webster

Miller, B. F., Keanne, C. B., & O'Toole, M. T. (Eds.). (2005). *Miller-Keanne encyclopedia and dictionary of medicine, nursing, and allied health*. Philadelphia: Saunders.

Mosby's dictionary of medicine, nursing, and health professions. (2016). St. Louis, MO: C. V. Mosby.

Stedman's word books series. (2001–2004). Philadelphia: Lippincott.

Microbiology

Garrity, G. M. (2005). *Bergey's manual of systematic bacteriology,* Vol. 2 (Parts A, B, and C). New York: Springer.

Gillespie, S. H., & Bamford, K. B. (2012). *Medical microbiology and infection at a glance*. Malden, MA: Blackwell.

Singleton, P., & Sainsbury, D. (2006). *Dictionary of microbiology and molecular biology*. New York: Wiley.

Molecular Biology

Cammack, R., Atwood, T., Campbell, P., Parish, H., Smith, T., Vella, F., et al. (2006). *The Oxford dictionary of biochemistry and molecular biology.* New York: Oxford University Press.

Singleton, P., & Sainsbury, D. (2006). *Dictionary of microbiology and molecular biology*. New York: Wiley.

Plant Biology

Allaby, M. (2012). *A dictionary of plant sciences* (3rd ed.). New York: Oxford University Press.

Beentje, H., & Williamson, J. (2016). *The Kew plant glossary: An illustrated dictionary of plant terms* (2nd ed.). Richmond, UK: Royal Botanic Gardens, Kew.

Mabberley, D. J. (2017). *The plant-book: A portable dictionary of the higher plants*. New York: Cambridge University Press.

Macura, P. (2002). *Elsevier's dictionary of botany*. New York: Elsevier Science.

Virology

Hull, R., Brown, F., & Payne, C. (1989). *Virology: Directory & dictionary of animal, bacterial and plant viruses.* London: Macmillan.

Mahy, B. W. J. (2011). *A dictionary of virology (3rd ed.).* New York: Academic Press.

Dictionaries—Other Scientific Fields

Astronomy

Mitton, J. (2008). *Cambridge illustrated dictionary of astronomy*. Cambridge, UK: Cambridge University Press.

Ridpath, I. (2012). *A dictionary of astronomy* (2nd ed.). New York: Oxford University Press.

Chemistry

Connelly, N. G., Hartshorn, R. M., Damhus, T., & Hutton, A. T. (Eds.). (2005). *Nomenclature of inorganic chemistry*: *IUPAC recommendations*. London: Royal Society of Chemistry.

Hellwinkel, D. (2010). *Systematic nomenclature of organic chemistry*: *A directory to comprehension and application of its basic principles*. New York: Springer.

Law, J., & Rennie, R. (Eds.) (2016). *A dictionary of chemistry* (7th ed.). New York: Oxford University Press.

McGraw-Hill dictionary of chemistry (2nd ed.) (2003). New York: McGraw-Hill.

The Merck index: An encyclopedia of chemicals, drugs, and biologicals (15th ed.). (2013). Whitehouse Station, NY: Merck.

Chemical Engineering

Schaschke, C. (2014). *A dictionary of chemical engineering.* New York: Oxford University Press.

Computer Science

Butterfield, A., Ngondi, G. E., & Kerr, A. (Eds.). (2016). *A dictionary of computer science* (7th ed.). New York: Oxford University Press.

Downing, D., Covington, M., & Covington, M. (2017). *Dictionary of computer and Internet terms* (12th ed.). Hauppauge, NY: Barron's Business Dictionaries.

Laplante, P. A. (Ed.). (2000). *Dictionary of computer science, engineering, and technology*. Boca Raton, FL: CRC Press.

Ecology and Evolutionary Biology

Allaby, M. (2010). *A dictionary of ecology* (4th ed.). New York: Oxford University Press.

Daintith, J. (2003). *Dictionary of evolutionary biology.* New York: Facts on File.

Lincoln, R. J., Boxshall, G. A., & Clark, P. F. (1998). *A Dictionary of ecology, evolution, and systematics* (2nd ed.). Cambridge, UK: Cambridge University Press.

Geology

Allaby, M. (2013). *A dictionary of geology and earth sciences* (4th ed.). New York: Oxford University Press.

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http://www.medbioworld.com
The largest medical and bioscience resource directory on the Internet
http://www.visualthesaurus.com
Link to a visual thesaurus
http://thesaurus.reference.com/ (or thesaurus.com)
Another visual thesaurus; this site also contains a link to a highly rated iTunes app, Thesaurus Rex by Dictionary.com
http://www.bartleby.com/141/index.html
Stunk and White, the famous short but excellent style guide

http://www.nlm.nih.gov/medlineplus/mplusdictionary.html
National Library of Medicine
http://www.medicinenet.com/script/main/hp.asp
Webster's new world medical dictionary authored by MedicineNet
http://www.biology-online.org/dictionary.asp
Online dictionary of biology terms for the biological and earth sciences
http://www.userlab.com/Downloads/SE.pdf
Contains details on using simplified English for an international audience

Apps

The newest science apps, including dictionaries, may be acquired through, for example,

https://www.bestcollegesonline.com/blog/40-most-awesome-ipad-apps-for-science-students/
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SUMMARY

Chapter 2 Video Guide

BASIC RULES—STYLE

- ★ Write with the reader in mind.
- ★ Use precise words.
- ★ Use simple words.
- ★ Omit unnecessary words and phrases.
- ★ Avoid too many abbreviations.
- ★ Use correct nomenclature and terminology.

ALSO: Watch out for misused words. Avoid sexism.

PROBLEMS

Chapter 2 Self-Assessment

PROBLEM 2-1 Precise Words

Find the nonspecific terms in the following sentences. Replace the nonspecific choices with more precise terms or phrases. Note that it is generally not necessary to change the sentence structure; just replace the individual words. Guess or invent something if you have to.

1. All OVE mutants showed enhanced iP concentrations.
2. Plants were kept in the cold overnight.
3. Some exoplanets orbit multiple stars.
4. Apart from the discussed main band, weaker emissions were observed.
5. (Last sentence in an Introduction) The present paper reports on continuing experiments that were performed to clarify this surprising effect.
6. The current was greatly affected when temperature was increased.
7. To provide proof of concept for our hypothesis, we studied a virus in its host cells.
8. Only some of the region under study exhibits larger reddening.
9. The first transition state is a little lower in energy than the second transition state.
10. Heating arises after recapture and subsequent equilibration following from the lowest $T^{-} = 0.04$, which is obtained by imaging the gas shortly after release from the trap.
11. The band showing vibrational splitting of 192/cm in Ne with the most intense peak at 444 nm can be identified with the $A \rightarrow X$ transition of the dimer Ag_2.
12. The afterglow of the blast wave was markedly brighter than we expected.

PROBLEM 2-2 Simple Words

Improve the word choice in the following examples by replacing the underlined terms or phrases with simpler word choices. Again, do not change the sentence structure; just change the words.

1. These data substantiate our hypothesis.
2. We utilized UV light to induce *Arabidopsis* for mutations.
3. The differences in our results compared to those of Retter et al. (2015) can be accounted for by the fact that different algorithms were used.
4. For the purpose of examining cell migration, we dissected mouse brains.
5. Our results are in accordance with Seuter et al. (1988) who measured iP in the culture medium of *Physcomitrella* transformed with the agrobacterial isopentenyltransferase gene.

6. We performed a systematic study of the vibrational spectrum of CO_2 using various isotopomers.
7. An example of this is the fact that quantum materials differ substantially.
8. In Swaziland, the number of HIV-infected children increased by an order of magnitude in the past decade.

PROBLEM 2-3 Commonly Confused/Misused Words

Consider the pairs of confused and misused word choices provided for the following sentences. Be sure you understand the difference in word choice. Using the provided word choices, fill in the correct words. It is okay to use Appendix A of this book or a dictionary.

1. **like, as:**
   Plasmids were isolated ________ described by Beates (17).
   Carbon dioxide, neon, helium, methane, krypton, and hydrogen are gaseous components of dry air, ________ argon.
2. **while, whereas:**
   The first enzyme was added ________ the DNA mixtures were incubating at 37°C.
   In weathered soils, little P is available for biological uptake, ________ in young soils little N is available for uptake.
3. **varying, various:**
   ________ water levels in a pond are often the result of climate conditions.
   Each student received ________ concentrations of NaCl solution for the experiment.
   Electrodes can be of ________ sizes.
4. **effect, affect:**
   Nutrition concentration was the most important factor ________ population size.
   Ozone causes cellular damage inside leaves that adversely ________ plant production.
5. **that, which:**
   Fish ________ live in caves show many adaptations to living in darkness.
   The value of the standard electrode potential is zero, ________ forms the basis for calculating cell potentials.
   It is still a challenge to produce layered black phosphorus nanosheets, ________ have shown promising applications in electronics.
6. **include, consist of:**
   Her research interests ________ all areas of biochemistry and structural biology.
   Components of Hyperion's crust ________ solid H_2O and CO_2.

7. **represents, is:**
   25 mg of ketamine _________ an overdose of anesthetic for mice.
   The Schrödinger equation _________ a fundamental equation in quantum mechanics.
8. **infers, implies:**
   Both curves are of an identical shape, which _________ a constant front profile as well as a constant velocity.
   The Intergovernmental Panel on Climate Change has been criticized for _________ that climate-envelope models are more precise than they actually are.
9. **can, may:**
   It _________ appear that Table 1 contains an essentially complete summary of patterns that occur in electrochemical systems.
   Huge numbers of species _________ be at risk of extinction from climate change.

PROBLEM 2-4 Redundancies and Jargon

Edit the phrases shown; change any redundancies to a shorter and better expression.

absolutely essential	along the lines of
a large number of	as a consequence of
despite the fact that	for the purpose of
in a position to	in close proximity to
in connection with	in order to
in the event that	in view of the fact that
the majority of	it is worth pointing out that

PROBLEM 2-5 Redundancies and Jargon

Improve the word choice of the underlined words in the following examples by removing any redundancies, jargon, and unnecessary words and phrases. Do not change the sentence structure.

1. The doubling rate appeared to be <u>quite short</u>.
2. The data of the analysis on cell cycle parameters <u>are shown</u> in Fig. 1. They have revealed that the cell cycle is controlled by factor X.
3. After 2 hr of <u>incubation</u> of CO_2 on an Ag(110) surface, we ended the incubation procedure.
4. The effect of temperature on conductivity <u>was examined and found not to</u> change dramatically.
5. Often, jewel weed <u>can be found to grow in close proximity to</u> poison ivy. (Two corrections needed.)
6. After infecting a host cell, a herpes viral DNA genome enters the nucleus where it is <u>transcribed from DNA to RNA</u> to both messenger RNAs (mRNAs) and noncoding RNAs (ncRNAs).

7. Transduction efficiencies *in vivo* were much higher than <u>transduction efficiencies</u> *in vitro*.
8. Although transition metals <u>have the capability of</u> forming bonds with six shared electron pairs, only quadruply bonded compounds can be isolated as stable species at room temperature.
9. Upon heat activation, filament size increased, and the number of buds decreased. Both <u>the increase in filament length and the decrease in the number of buds</u> were only seen for cytokinin mutants.
10. Larger mammals are more likely to get extinct than smaller ones <u>due to the fact that</u> larger animals are fewer in number and are disproportionately exploited by humans.

PROBLEM 2-6 Redundancies and Jargon

Identify and remove the jargon and other redundancies in the following sentences.

1. It is also worth pointing out that collagen synthesis returned to normal 3 days post injury.
2. In spite of the fact that our present knowledge on the subject at this point is far from complete, this macromolecular structure can aid in the design of new antibiotics.
3. A substantial proportion of HIV patients also develops tuberculosis.
4. After 3 hr, the old medium was dumped, and the same amount of fresh medium was added.
5. The data in Table 1 are very consistent with Brokl's (1999) model.
6. This appears to indicate that factor A possibly may have a tendency to interact with factor B.
7. In a considerable number of cases, degradation leads to topsoil loss and a reduction in soil fertility.
8. We analyzed helium content in steam escaping from fractures and thermal features of Yellowstone National Park for the purpose of determining the proportions of helium-3 and helium-4 in gas emissions by the super volcano.

PROBLEM 2-7 Abbreviations

Identify the basic writing rule that is violated for the underlined word choices in the following paragraph by describing as best as you can what the general mistake is.

We used the <u>SVWN</u> (Slater, Vosko, Wilk, Nusair) functional as a local-density model and the Becke-Lee-Yang-Parr (<u>B-LYP</u>) exchange-correlation functional for our analysis. All calculations were done in triplicate and adjusted based on the Becke-Perdew (<u>BP</u>) and <u>PW91</u> functionals. We also included the Becke-Lee-Yang-Parr <u>B-LYP</u> functional to overcome the limitations of the <u>BP</u> and <u>PW91</u> functionals. The nonlocal <u>B-LYP</u> functional includes a zero-point energy (ZPE) correction. Configuration-interaction methods (CI) or density-functional theory (DFT) describe the exchange and correlation effects. This is the first report on DFT plane-wave calculations and the SVWN functional for Z. We found that the Z bond is 2.73 Angstroms for PW91 and B-LYP.

PROBLEM 2-8 Mixed Word Choice

Improve the word choice in these examples.

1. A typical scientist spends many long hours, even on the weekend, in his laboratory.
2. We studied the affect of erythromycin on 5 male and 3 female children in three different essays.
3. A graph displaying this data is shown in the overnext slide.
4. We made a picture of the gel we made.
5. We observed a change in cluster size after several minutes.
6. Isolatability of the Nnkla-1 protein was more difficult than expected.
7. Absorbance was measured at varying time points.
8. To make perfect slides of DNA nicks, an electron microscope is absolutely essential.
9. The hiring of new faculty is traditionally overseen by the chairman of a department.
10. To reduce the amount of data points, we tossed out every alternative test point.
11. It has been reported that thiophene was discovered as a contaminant of benzene.

PROBLEM 2-9 Mixed Word Choice

Edit the following passage. Pay attention to word choice. Use precise and simple words. Check for misused and confused terms. Avoid sexism and redundancies.

Sulfonamides were among the first manmade agents used successfully to treat diseases. On account of their broad antibacterial activity, these drugs were in earlier times used almost exclusively in the treatment of a wide assortment of diseases. It is most fortunate that other drugs have supplanted sulfonamides as antimicrobial agents because all pathogenic bacteria are capable of developing resistance to sulfonamides. Sulfonamides prevent the synthesis of folic acid that is a coenzyme important in amino acid metabolism. Although sulfonamides are for the most part readily tolerated, it has been observed that they do have some side affects.

CHAPTER 3

Word Location

Although word choice is important for the interpretation of a sentence, readers take the greatest percentage of clues for interpretation not from word choice but from the *location* of words within a sentence. That is, readers expect a certain format in each sentence.

If this format is not met, readers get confused and start paying attention to the organization rather than to the content of a sentence, which increases the possibility of misinterpretation or not understanding. Worse, if readers cannot follow the format, they will lose interest. Thus, you need to pay close attention to word location and to the organizational structure of a text.

THIS CHAPTER EXPLAINS:

- How readers interpret sentences
- How to create good flow
- How to establish importance within sentences

3.1 READERS' EXPECTATIONS

➤ The location of words within a sentence is important for its interpretation

Your task as an author is not only to choose the right words but also the most effective location for your words. You will have to convince most of your readers to interpret your sentences as you intended. There is always a minority, however, who interpret sentences differently from the majority. For this minority of readers, it is even more important to understand the importance of where in a sentence to place what information.

Consider Example 3-1a.

Example 3-1 **a** Mosquitoes often carry parasites.

topic *stress*

In this sentence, the word "mosquitoes" has been placed at the beginning of the sentence in the topic position, and the word "parasites" has been placed at the end of the sentence in the stress position. This positioning tells the reader that "mosquitoes" are the topic of the sentence and that "parasites" is to be emphasized. To most readers, the format of this sentence implies that the author has talked about mosquitoes before and is about to introduce a new topic, "parasites." Another version of the same sentence presents a different emphasis, as can be seen in Example 3-1b.

Example 3-1 **b** Parasites are often carried by mosquitoes.

topic *stress*

Although the sentence in Example 3-1b uses the same words as the sentence in Example 3-1a, the word locations have been altered. In Example 3-1b, the familiar topic now appears to be "parasites" at the beginning of the sentence, and the emphasized word is "mosquitoes" at the end or stress position of the sentence. Placing "mosquitoes" at the end of the sentence indicates to the reader that you are stressing this term. You may want to stress the term to ensure that the reader immediately understands that the stress is on "mosquitoes" and not on fleas or rats; you may also want to stress the term to ensure that the reader does not miss the introduction of a new topic. Placing "mosquitoes" in the stress position of the sentence guides the reader's attention.

3.2 COMPETITION FOR EMPHASIS

★ (7) Establish importance

To decide on the best placement of words within a sentence, it is crucial that you decide what is important, what is less important, and what is not important before you start writing or revising. When you write, important information can then be stressed, less important information can be subordinated, and unimportant information can be omitted. For example, when reporting on the results of a study conducted by an author in a given year, beginning writers often put the year or author at the start of the sentence as shown in the next example.

Example 3-2	**a**	In 2018, Smith reported that XXX leads to YYY.
	b	Smith (2018) reported that XXX leads to YYY.

These sentences emphasize the year (Example 3-2a) or author (Example 3-2b) in the topic position, but that is typically not what these writers intended. An alternate version of this sentence would be the following one.

Revised Example 3-2	XXX leads to YYY (Smith, 2018).

In the revised example, the findings are now emphasized, and the author and year information, which is less important than the actual findings, is subordinated in parenthesis.

You need to recognize that the format and structure you use to present information will lead the reader to interpret it as more important or less important. In general, readers see the beginning and end position in a sentence as being emphasized, whereby the end position is more emphasized than the beginning position. Furthermore, the main clause is seen as more emphasized than the dependent clause. Thus, a main clause, a clause that is independent and can stand alone as a complete sentence, carries more weight than a dependent clause, which depends on the rest of the sentence for its meaning.

Consider the following four versions of a sentence. In each of these examples, the main clause has been italicized.

Example 3-3	**a**	Although vitamin B6 seems to reduce the risk of macular degeneration, *it may have some side effects.*
	b	*Vitamin B6 reduces the risk of macular degeneration*, but it may have some side effects.
	c	*Taking vitamin B6 may have some side effects*, but vitamin B6 also reduces macular degeneration.
	d	Although taking vitamin B6 has some side effects, *vitamin B6 reduces macular degeneration.*

For most readers, information in the main clause carries more weight than that in the dependent clause. Furthermore, most people perceive information at the end of the sentence as more important than that at the beginning of the sentence.

In the given example, if readers were to vote on the impact of each sentence, the percentage of readers that would recommend taking vitamin B6 would be highest in version D and lowest in version A. A more detailed analysis shows the following:

Sentence version	News in main clause	News in end position	Perception of vitamin B6 recommendation (%)
A	– negative	– negative	30
B	+ positive	(–) negative (dep. clause)	40
C	– negative	(+) positive (dep. clause)	60
D	+ positive	+ positive	70

Based on these percentages, readers (e.g., physicians) are most likely to recommend taking vitamin B6 after reading sentence D and least likely to recommend it after reading sentence A. The reason for this is that the strongest statement has the positive (+) information in both the main clause and at the end position of the sentence, while the weakest statement contains the negative (–) information both in the main clause and at the end position of the sentence. Thus, even in more complex sentences, word placement, if considered carefully, can help guide and influence readers.

Although word placement is more important than word choice for sentence interpretation by the reader, if a word is strong or extreme enough it can dominate the reader's attention. Let us replace "side effects" with an extreme phrase in the strongest positive sentence above and look at the effect.

Example 3-4 Although taking vitamin B6 may result in <u>serious deformities or even death</u>, vitamin B6 reduces macular degeneration.

In this example, no matter where you put the extreme "serious deformities or even death," it overpowers the structural location of everything else, including that of the stress position.

3.3 PLACEMENT OF WORDS

Complexity

★ (8) Place old, familiar, and short information at the beginning of a sentence in the topic position

★ (9) Place new, complex, or long information at the end of a sentence in the stress position

If information is placed where most readers expect to find it, it is interpreted more easily and more uniformly. Readers expect to see old information that links backward at the beginning of a sentence (or paragraph) and new information at the end of a sentence (or paragraph) where it is emphasized more.

Once sentences are ordered into paragraphs, the importance of word location becomes even more obvious, as writing "flows" much better if the information is linked through word location. Consider the following example.

Example 3-5

Macular degeneration is affected by ***diet***. ***One of the diet components*** that influences the progression of macular degeneration is ***vitamin B6***. Although ***vitamin B6*** seems to reduce the risk of macular degeneration, it may have some **side effects**.

If the passage were to continue, most people would expect to find information on "side effects" in any subsequent sentence or paragraph. Readers will get confused and misinterpret passages when they do not find the information they are expecting. But why do readers expect to read about side effects next?

Note how the information at the end position of a sentence in the preceding example is placed at the beginning, or topic position, of the next sentence, leading to "jumping word location." In each of these sentences, the new information in the stress position of one sentence becomes old, familiar information in any subsequent sentence and is therefore placed at the topic position in the sentence that follows. The human brain looks for patterns and recognizes that this paragraph is organized by "jumping word location." Because "side effects" has been introduced in the stress position in the last sentence, most people would therefore expect to find information on "side effects" in any subsequent sentence or paragraph.

When you pay attention to word location, as in the preceding example, your writing is perceived to have good flow and continuity. When you do not comprehend the structural needs of readers, readers get confused.

Another way to achieve good flow or continuity is to write a whole paragraph from the point of view of the old information as in Example 3-6.

Example 3-6

Depression in the elderly is thought to affect more than 6.5 million of the 35 million Americans who are 65 years of age and older. ***It*** is considered to be a disorder that is commonly underdiagnosed, undertreated, and mismanaged by pharmacotherapy both in community dwelling seniors and in those residing in nursing facilities. ***Depression*** in the elderly has also been closely associated with dependency and disability that presents in both emotional and physical symptoms, thus amplifying the difficulty in diagnosis. ***Major depression***, dysthymic disorder, and subsyndromal depression tend to be higher in persons over 65 who live in a long-term care facility.

Note how in this example, the topic "depression" is consistently placed in the topic position of each sentence, providing a link back for the reader. In each of the sentences in the preceding example, new information is always placed at the end of each sentence. Thus, every sentence provides new information, although the writer does not expand on it. If passages are consistently written from the same point of view as in the preceding example, good flow is also achieved.

Not all paragraphs will follow these basic rules of word location as exclusively as shown in Examples 3-5 and 3-6. Many paragraphs display a mixture of the word locations shown in these examples (see also Chapter 6 on paragraph construction). That is okay. What is not okay is to jump back and forth between one point of view and another for no apparent reason.

If we apply these basic rules for old and new information to writing and revising, we quickly realize that although some sentences are easy to write or revise, others are not. It is particularly hard to begin sentences well, especially if they are long and complex.

Which of these two sentences do you prefer?

Example 3-7	**a**	Outbreaks of limb deformities in natural populations of amphibians across the United States and Canada, especially in wetland associated with agricultural fields, were evaluated in this study.
	b	We evaluated outbreaks of limb deformities that occurred in natural populations of amphibians across the United States and Canada, especially in wetland associated with agricultural fields.

Most readers dislike Example 3-7a because it starts with a long and complex subject. Example 3-7b, on the other hand, begins simply and moves toward complexity. Readers prefer to see short information at the beginning of a sentence and long information at the end of a sentence. Thus, you need to consider the length of terms or information when constructing sentences.

Subject

★ (10) Get to the subject of the main sentence quickly, and make it short and specific. If possible, use central characters and topics as subjects

Readers prefer not only to see short information at the beginning of a sentence but also to get to the subject/topic of the main sentence quickly. They understand a sentence more easily if the subject is readily available. When you open sentences with several words before their subject/topic, readers have a hard time understanding what the sentence is about. Thus, avoid long introductory phrases and long subjects.

Example 3-8	Due to the nonlinear and hence complex nature of ocean currents, modeling these currents in the tropical Pacific is difficult.
Revised Example 3-8	**Modeling ocean currents in the tropical Pacific** is difficult due to their nonlinear and hence complex nature.

The subject in Example 3-8 arrives after the first 11 words, whereas the subject in the revised sentence is immediately available, making the revised sentence more easily understandable.

Readers like to see characters as their subjects. In fact, readers get confused if for no good reason you do not make characters subjects. Consider the following example and its revision.

Example 3-9	The reason for rejection on the part of the biochemists was that the focus of the paper was too broad.
Revised Example 3-9	The biochemists rejected the paper because it was too broad.

For Example 3-9, most readers consider the revised sentence to be much clearer than the original one because the central characters (biochemists) are the subject of the verb. In the revised version, the subject is also short and specific and much more concise.

Let us look at yet another example.

Example 3-10	The cells were incubated at room temperature for two days.

Here, the topic "cells" is also the subject of the sentence. Any possible character such as a biochemist or a laboratory technician is not made the subject because they are not the topic of interest. Instead, "cells" take the place of the live character. This choice is actually preferred in certain sections of a research paper (or grant proposal), such as in the Materials and Methods section. To the reader, sentences appear clearer and more direct if the subject is also the topic of the sentence (and paragraph).

The subject of a sentence does not always state its topic, however, as in the following example.

Example 3-11	**No one** could foresee these results. *Subject* ... *Topic*

If a subject is deleted entirely, as in the next example, writers create the biggest problem for readers.

Example 3-12	A decision was made in favor of the use of dyes, nitrofurans, and amidines as disinfectants.

The author of this sentence may know who is doing what, but the readers do not know and usually need more help than you think. The sentence in Example 3-12 has different interpretations.

Revised Example 3-12	We decided to use dyes, nitrofurans, and amidines as disinfectants. or: They/Researchers decided to use dyes, nitrofurans, and amidines as disinfectants.

For additional discussions about the subject and verb of a sentence, also see Chapter 4, Sections 4.2 and 4.11.

Verb Placement

★ (11) Avoid interruptions between subject and verb and between verb and object Information

General sentence structure in English consists of Subject–Verb–Object/Completer. The verb, or action word, follows the subject (the entity that is doing something) directly, and the object (the entity that is acted upon) immediately follows the verb. Often, sentences are obstructed if the verb does not immediately follow the subject. When readers see the subject of a sentence, they immediately start looking for the verb and pay little attention to any interrupting text between the two. Native and nonnative speakers need to be aware of this rule. English sentences are better understood if their subject and verb are not interrupted, and information is more easily interpreted if it is not obstructed.

ESL advice

Consider the following opening sentence of an introduction.

Example 3-13	<u>Rhinovirus</u>, an Enterovirus belonging to the family *Picornaviridae*, which consists of 37 species grouped into 17 genera including pathogens such as Poliovirus, Saffold virus, Coxsackie A virus, and Hepatitis A virus, <u>causes</u> 10–40% of the common cold.

This sentence is obstructed because the grammatical subject ("Rhinovirus") is separated from its verb ("causes") by 30 words. The more words are placed between subject and verb, the more confusion they cause, making the reader sway between finding the verb of the main clause and focusing on the interrupting material. To guide the reader through a sentence, make the sentence flow by placing the verb immediately after the subject and moving the intervening material elsewhere.

Often, an interruption can be moved to the beginning or to the end of a sentence, depending on whether it is connected to old or to new information in the sentence. At other times, you need to consider splitting the information into two sentences or even omitting the interrupting information altogether.

In Example 3-13, it is unclear how important the interrupting material is. If the material is important, the sentence could, for example, be split into two sentences, as shown in the following revision, which allows the important material to be highlighted appropriately.

👍	**Revised Example 3-13**	**Rhinovirus** is an Enterovirus belonging to the family *Picornaviridae*, which consists of 37 species grouped into 17 genera including pathogens such as Poliovirus, Saffold virus, Coxsackie A virus, and Hepatitis A virus. **It causes** 10–40% of the common cold.

If the interrupting material is not important and just reflects an interesting side fact, it should be omitted to allow the reader to focus on the main statement, as shown in the following.

👍	**Revised Example 3-13**	**Rhinovirus causes** 10–40% of the common cold.

ESL advice

Readers also like to get past the verb to the object of a sentence quickly. Therefore, you should avoid any interruptions between verb and object by placing interrupting passages either at the beginning or at the end of the sentence. In some languages other than English, sentences tend to be complex, and information gets repeatedly interrupted. If English is not your native language, resist the temptation to apply the principles of writing in your native language to writing in English. Avoid interruptions between the verb and its object, as shown in Example 3-14.

👎	**Example 3-14**	We conclude, based on very simplified models of solar variability, that solar variability is insignificant.
👍	**Revised Example 3-14**	We conclude that solar variability is insignificant **based on very simplified models of solar variability.** or: **Based on very simplified models of solar variability,** we conclude that solar variability is insignificant.

SUMMARY

Chapter 3
Video Guide

BASIC RULES—STYLE

- ★ Establish importance.
- ★ Place old, familiar, and short information at the beginning of a sentence in the topic position.
- ★ Place new, complex, or long information at the end of a sentence in the stress position.
- ★ Get to the subject of the main sentence quickly, and make it short and specific. If possible, use central characters and topics as subjects.
- ★ Avoid interruptions between subject and verb and between verb and object.

PROBLEMS

Chapter 3 Self-Assessment

PROBLEM 3-1 Sentence Interpretation

When scientists submit papers for publication, they often dread the response of reviewers. Here are four sentences that could have been written in different structural arrangements by reviewers to deliver the same news. Which statement is the one most likely resulting in the paper being accepted, and which is most likely the one resulting in rejection? Explain why.

1. Overall, although this manuscript is of interest for structural biologists, a more detailed analysis of ABC should be provided.
2. Although a more detailed analysis of ABC should be provided, this manuscript is of interest for structural biologists.
3. This manuscript is of interest for structural biologists, but a more detailed analysis of ABC should be provided.
4. A more detailed analysis of ABC should be provided, but overall, this manuscript is of interest for structural biologists.

PROBLEM 3-2 Word Placement and Flow

Rewrite one of the following paragraphs. Place words such that the reader can easily follow the logic flow of the message.

(a) Rainwater often picks up carbon dioxide, resulting in a weak solution of carbonic acid. A cave is formed when such rainwater trickles into the ground in areas with a high limestone content. Carbonic acid slowly dissolves the limestone. As more and more limestone dissolves, the cave grows underground. When a cave's ceiling gets eroded and collapses, a sinkhole forms.

(b) A quantum dot is a tiny semiconductor nanostructure. It is made of silicon, cadmium selenide, cadmium sulfide, or indium arsenide. A small number (on the order of 1–100) of conduction band electrons, valence band holes, or excitons are contained in a quantum dot. Colloidal semiconductor nanocrystals are small quantum dots, which can be as small as 2 to 10 nanometers, corresponding to 10 to 50 atoms in diameter.

PROBLEM 3-3 Word Placement and Flow

Write a paragraph using the list of facts provided. To create good flow, place words carefully at the beginning and end positions of sentences.

- fleas transmit plague *bacillus* to humans
- *bacilli* migrate from bite site to lymph nodes
- name “bubonic plague” arises because buboes = enlarged nodes

PROBLEM 3-4 Word Placement and Flow

1. **Construct a paragraph about thermophiles using the list of facts provided. Create good flow of the message through word placement.**
   - microorganisms
   - temperature range for growth between 45°C and 70°C
   - found in hot sulfur springs
   - cannot grow at body temperature
   - not involved in infectious diseases of humans
   - mechanism to resist elevated temperature unclear
2. **What does the reader expect to read next after having read the last sentence of your paragraph?**

PROBLEM 3-5 Subject–Verb–Object Placement

Rewrite the following sentences such that the subject is followed immediately by the verb and interruptions between verb and object are avoided. Place the subject early in the sentence if possible.

1. To date, more than 1,000 exoplanets, some of them with orbits of just a few hours, others with orbits of more than 1,000 years, have been confirmed.
2. Onchocerciasis, with approximately 18 million infected cases worldwide and 80 million more people at risk of infection, is now recognized as one of the major public health and socioeconomic problems in many tropical countries (Murdoch et al., 1996; OEPA, 1998).

3. Aside from protein X, protein Y, with a sequence very similar to a DNA-binding kinase, has been found to be able to bind RNA.
4. Early experiments revealed, as demonstrated by a strong suppression of the transition temperature with impurities (4), the extreme fragility of the superconductivity in the ruthenate superconductor Sr_2RuO_4 (SRO).
5. Earth's primordial atmosphere, consisting of high levels of helium and neon, which are now only present in high quantities in the innermost mantle and core of the Earth, was blown off several times after catastrophic impacts with other space bodies.
6. Recent reports show that digital disease detection systems, which use *big data* sources for information and can lead to early predictions of disease outbreaks, health behavior, and attitudes (4, 7, 8), heavily draw on mobile devices and online sharing platforms.

CHAPTER 4

Technical Sentences

Although this handbook is not an English grammar guide, the book captures the mistakes that are most commonly made by scientific authors, particularly mistakes that tend to reduce the clarity of a scientific manuscript.

IN THIS CHAPTER YOU WILL FIND:

- General advice on style in science
- Issues of grammar and style
- Basics of technical style
- Discussions of first and third person, active and passive voice, past and present tense, sentence length, verbs and action, noun clusters, pronouns, lists, and comparisons
- A list of common errors, including American versus British spelling, numbers versus numerals, capitalization, italics, punctuation, and common grammatical errors

4.1 GRAMMAR AND TECHNICAL STYLE

A paper full of grammatical errors discourages readers as well as reviewers and editors. It may also result in misinterpretation of what has been written. Although logically ordered and clearly expressed ideas are more important than perfect grammatical form, editors, reviewers, and readers will all be grateful if you write not only clearly and concisely but also correctly. Know that editors do not expect perfect English from ESL authors, nor do they expect the ultimate levels of literacy from native English speakers. If you use good technical style and avoid grammatical errors, however, your paper will be clearer and livelier, and you will reach a wider audience.

Many authors (especially native English speakers) are surprised to find certain phrases and sentences of their writing marked by editors because of bad style. A trained writer, however, will be able to recognize common style and grammar problems. Excessive use of third person, passive voice, nominalization, noun clusters, redundancies, and jargon are common causes of wordiness and bad style. Unclear use of tense, pronouns, prepositions, and articles can also confuse readers. All these problems of grammar and technical style are discussed in detail in this chapter.

For additional help with grammar and vocabulary, see, for example, Thurman (2012) or Perelman et al. (1997), which are listed in the references section. A glossary of grammatical terms can be found at the end of this book as well.

4.2 PERSON

➤ (12) Use the first person

Use the first person ("I" or "we") for describing what you did—but do not overuse it; do not use it if the journal (or your supervisor) has banned it or if the focus of the sentence should be on the organism or another topic.

It was once fashionable to avoid using "I" or "we" in scientific research papers because these terms were considered to be subjective, whereas the aim in science is to be objective. However, science is not purely objective. Writing from the point of view of "I" or "we" is appropriate in a scientific research paper wherever judgment comes in as the following examples illustrate.

Example 4-1	**a**	To determine the mechanism for the direct effect of contrast media on heart muscle mechanics, the study on heart muscles isolated from cats was carried out.
	b	The authors show here that two main causes exist for avalanches: snow pack and external stress on the snow pack.

These sentences taken from two different Introduction sections would be more accurate and more vigorous if the first person "we" were used for the subject instead of the third person: "the study" in Example 4-1a or "the authors" in 4-1b. The advantage of using the first person is that using "we" generally forces the author to use the active voice, which is lively.

Revised Example 4-1	**a**	To determine the mechanism for the direct effect of contrast media on heart muscle mechanics, **we carried out** the study on heart muscles isolated from cats.
	b	**We** show here that two main causes exist for avalanches: snow pack and external stress on the snow pack.

Although in most of the sections of a scientific document the use of first person is preferred, this use is more controversial in the Materials and Methods section. There, the first person "we" is not usually the topic. Instead, materials, methods, or organisms are usually the topic. In addition, it often may not have been the author(s) who performed a certain experiment but rather a technician or hired helper. Therefore, in the Materials and Methods section, use of third person is usually preferred. In certain fields such as in ecology, however, many journals require the use of first person and active voice, even in the Materials and Methods section.

In some scientific disciplines or as outlined by specific journals, third person continues to be used or even required. In these cases, you may have to go with what is expected, but know that, given a choice, your readers prefer first person.

Rarely is scientific research conducted or a paper authored by only one person. When you have a choice between first person singular ("I") and first person plural ("we"), it generally is better to choose plural for publications ("Here we report . . ."). Not only does it give recognition to the work of others—if indirectly—your reviewers and readers also will not perceive you as working in isolation. In contrast to publications, in grant proposals that clearly involve only you as a researcher, you should feel free to use first person singular.

4.3 VOICE

★ (13) Use the active voice

Use the active voice rather than the passive voice. If the passive voice is used excessively, writing becomes very dull and dense, as in the following examples.

Example 4-2	**a**	Cats <u>are hated</u> by dogs.
	b	No change in conductivity <u>was observed</u>.

These sentences are much livelier and more interesting when active voice is used.

Revised Example 4-2	**a**	Dogs **hate** cats.
	b	We **observed** no change in conductivity.

Do not remove the passive voice completely, however; use the passive voice when readers do not need to know who performed the action (e.g., in the Materials and Methods section; see Chapter 12, Section 12.4). You may also have to use the passive voice when the emphasis should be on a specific topic or when word location needs to be considered (see Example 4-4).

Example 4-3 Viral DNA **was isolated** 24 hours after inoculation.

In addition, you should use the passive voice if this allows you to replace a long subject with a short one, gives you a more consistent point of view (i.e., lets you use the same subject in consecutive sentences), or lets you put emphasis on the terms you want to have emphasized.

Example 4-4 Most of the world's diamonds are found in cooled volcanic lava tubes. The stones originally form at great depth under high pressure and temperature. Molten magma that rises up through lava tubes and volcanic pipes often transports them, and thus brings them closer to the surface of the Earth's mantle and crust where they can be mined.

Revised Example 4-4 Most of the world's diamonds are found in cooled volcanic lava tubes. The stones originally form at great depth under high pressure and temperature. **They are often transported by molten magma that rises through lava tubes and volcanic pipes, and thus brought** closer to the surface of the Earth's mantle and crust where they can be mined.

The passive voice is needed in the preceding revision to keep the focus on the cone rather than shifting to new information. In the revision, word location has been considered. Although the revision leads to use of passive voice, this choice is preferable here to ensure good flow. In general, considering word location (jumping word location or consistent point of view; see Chapter 6, Section 6.3) is more important than use of active voice.

4.4 TENSE

★ (14) Use past tense for observations and specific conclusions

★ (15) Use present tense for general rules and established knowledge

ESL advice

The two main tenses that occur in scientific papers are present tense and past tense. In proposals, future tense is also widely used. Many scientific authors, especially ESL authors, seem to be confused about when to use past tense and present tense. Many are also unsure if past tense and present tense can be mixed in the same sentence or paragraph. Generally, you should use the past tense for observations and specific conclusions. For example, results presented in your paper should be described in past tense because you have done these experiments and your results are not yet accepted "facts." Therefore, the Abstract, Materials and Methods, and Results sections should employ past tense as they refer primarily to your own work.

Example 4-5 **a** Higher temperatures **resulted** in less bud formation.

b The three images **were taken** about 90 minutes apart.

You should use the present tense for general rules, accepted facts, and established knowledge. Thus, results from already published papers should be described in the present tense as published results are generally assumed to be "facts." Similarly, if something is a general rule or fact that is still true in the present, use present tense.

Example 4-6 **a** The newly discovered planet **is** at least as big as Pluto.

b Most regions where this problem **arises belong** to category X.

c Fields like public health **explore** the predictive power of Big Data.

If you use past tense for describing results of already published work, you are implying to the reader that you do not consider these results to be "facts" but observations.

Can tense be mixed in the same sentence or paragraph? Certainly, as is apparent in the next example.

Example 4-7 Brown **reported** that the bacteria *Brucella* **cause** abortion in livestock.

This example describes an experiment that has been completed. "Reported" is therefore written in past tense. "Cause," however, is present tense because this part of the sentence is still true and is considered established knowledge once published.

Like the Introduction section, the Discussion section of a research article can include both past and present tense, depending on whether you are reporting an observation or one-time occurrence or whether you are describing a general rule that continues to hold true. Note that, usually, remarks about the presentation of data should be in present tense, and descriptions of assumptions and theory should also be described in present tense in your paper.

Example 4-8 The effect of temperature on the microbiome **is shown** in Figure 5.

For findings and events that have been started in the past and are ongoing or have present consequences, use present perfect tense.

Example 4-9 The number of people addicted to painkillers **has been** growing for the past three decades.

Only experiments that you plan to do in the future should be written in the future tense. Future experiments are usually not included in research articles but are described in grant proposals.

👍	**Example 4-10**	We **will examine** if parallel universes exit.

4.5 SENTENCE LENGTH

★ (16) Write short sentences. Aim for one main idea in a sentence

Short sentences are easier to understand than long sentences. Generally, the longer a sentence, the more difficult it is to grasp. The average sentence length in many scientific articles is over 30 words per sentence; in most newspapers, it is between 15 and 20 words per sentence (one of the reasons that newspaper articles are easier to understand). Many scientific papers could be strengthened by shorter sentences, although not every sentence should be short. Using *only* short sentences does not result in strong writing but leads to choppy, hard-to-follow passages. Some sentences need to be long to communicate complex ideas. Scientific authors should aim for an average sentence length of about 20 to 22 words. This means that some sentences will be longer and some shorter, but the average number of words per sentence overall will be around 20 to 22.

Short, simple sentences tend to emphasize the idea contained in them. The longer a sentence gets, the more difficult it is for the reader to identify what is of primary importance. Therefore, single-clause sentences have more weight, and thus more importance, than multiclause sentences. Writing a short sentence that highlights the main topic is particularly important at the beginning of a section or paragraph. It ensures that you have the attention of the reader from the outset and lets the reader focus on the main idea.

Similarly, readers assign more importance to sentences that stand on their own (independent sentences) than to a clause that depends on the presence of another clause. Thus, independent sentences have more weight than dependent sentences, which in turn have more weight than phrases. Consider Example 4-11.

Example 4-11	**a**	Rheumatic fever is an autoimmune disease.
	b	*It is generally accepted in the field of medicine that* rheumatic fever is an autoimmune disease.

The words in the sentence of Example 4-11a, “Rheumatic fever is an autoimmune disease,” tend to weigh more when they are in their own sentence than when they appear in some longer sentence such as the sentence in Example 4-11b. In addition, in the sentence in Example 4-11b, the same words appear in a dependent clause, which makes the reader perceive them as less important. For both of these reasons, most readers perceive the sentence in Example 4-11a as "weighing more" than the sentence in Example 4-11b.

Many sentences in scientific papers are needlessly complex. As a general guideline, do not present too many ideas in a single sentence. Instead, make sure your sentences do not contain more than one main idea and that they do not wander. The first step to ensure that your sentences do not contain too many ideas is to decide which details in a sentence are important. Only when you have assigned importance will you be able to subordinate less important information and omit unimportant information. Often, you can consider breaking subordinate sentences into separate sentences.

ESL advice

In certain cultures, people write in very complex, indirect ways. If you have this background, be particularly aware that English sentences that are concise and direct are better understood than sentences that are long and contain many different ideas.

It is a good idea to imagine yourself sitting across from an important reader. Write your paper as if you were *telling* this reader about your work. Remember that the purpose of a scientific paper is to inform, not to impress.

Consider Example 4-12.

Example 4-12 **Excessively long sentence**

When central venous IV lines were removed, skin samples from patients with IV line–related bloodstream infections were collected and in 80% of these samples, bacteria with high DNA identity to those found in the bloodstream and IV lines were identified, whereas in 20% of the patients isolated bacteria had no or low DNA identity, suggesting that most bloodstream infections in patients with central venous IV lines arise from contamination of IV lines or needles during insertion.

(76 words/sentence)

In this example, the first idea ends before "and." The second idea ends before "whereas" and the third idea before "suggesting." All of these ideas should be written in separate sentences.

Revised Example 4-12

When central venous IV lines were removed, skin samples from patients with IV line–related bloodstream infections were collected. In 80% of these samples, bacteria with high DNA identity to those found in the bloodstream and IV lines were identified. However, in 20% of the patients isolated bacteria had no or low DNA identity. These observations suggest that most bloodstream infections in patients with central venous IV lines arise from contamination of IV lines or needles during insertion.

(average of 19 words/sentence)

Whereas the original sentence was 76 (!) words long, the revised version has an average sentence length of 19 words. Therefore, the revised version is much easier to understand. The reason is not that the sentences are shorter, but mainly that the ideas are separated into different sentences.

4.6 VERBS AND ACTION

★ (17) Use active verbs

Verbs are perhaps the most important part of an English sentence. With strong and active verbs, your writing enlivens and energizes. Verbs make sentences direct and easy to follow. If you hide verbs by using nominalizations, that is, abstract nouns derived from verbs and adjectives, you will make your writing heavy and much harder to comprehend for readers.

ESL advice

Your readers will perceive your writing as particularly dense when you use many abstract nouns. “Academese” tends to be full of nominalizations. Many nonnative-speaking scientists also excessively use nouns in their native language, which they then translate and apply in English. For better scientific style, avoid nominalizations—use active verbs instead.

Active verb	**Buried verb/nominalization**
assess	assessment
decide	made the decision
depends on	is dependent on
exist	existence
follows	is following
form	formation
inhibit	inhibition
measure	measurement
remove	removal

In the following example, the action is not in the verb but in the noun.

Example 4-13 Their suggestion for us was a different analysis of the data.

In the revision, the actions are all verbs, resulting in a much clearer and less dense style.

Revised Example 4-13 They **suggested** that we **analyze** the data differently.

Other examples of verbs and adjectives and their nominalizations include the following.

Verb	**Nominalization**
analyze	analysis
attempt	attempt
centrifuge	centrifugation
compare	comparison
determine	determination
differ	difference
discover	discovery
discuss	discussion
dissect	dissection
evaluate	evaluation
elute	elution
explain	explanation
fail	failure
hypothesize	hypothesis
increase	increase
isolate	isolation
move	movement
need	need
react	reaction
separate	separation
speculate	speculation

Here, too, use the active verb instead of the nominalization. Note that some nominalizations and verbs are identical, such as graph (verb) and graph (noun).

Science is more interesting particularly if the actions of animals and cells are described in active verbs.

Example 4-14 Earthworms react to light.
Muscles contract.
Blood flows.

Avoid writing with weak verbs. Weak verbs seem abstract and impersonal and result in boring writing. Examples of weak verbs include the following:

occurred	was seen	was noted	was done	get
was observed	caused	produced	make	

When you find yourself writing using one of these verbs, stop and check if you can use an active verb instead.

Example 4-15 **a** A 10% increase in temperature occurred.

In this example, the verb ("occurred") is not active but weak. The subject of the sentence ("increase") expresses the action. This noun is also a nominalization of the verb "increase." As a result of the nominalization, the sentence is complicated and indirect. To revise a sentence whose action is buried in a noun, replace the weak verb with the action of the noun.

Revised Example 4-15 **a** Temperature **increased** 10%.

In the revised sentence, when the verb is active and strong, the sentence is simpler, more direct, and more efficient than when the action is nominalized.

Consider Example 4-15b.

Example 4-15 **b** This wavelength caused a decrease in the molar absorption coefficient.

This example contains the weak verb "caused." In the sample sentence, the action is buried in the object ("decrease"), and the true object ("molar absorption coefficient") is sidetracked into a prepositional phrase ("in the molar absorption coefficient").

Revised Example 4-15 **b** This wavelength **decreased** the molar absorption coefficient.

Whereas the original sentence just sits, the revised sentence moves because the verb is strong and active.

Sometimes writers express action in the object of a preposition instead of in the verb. (Prepositions are words such as "of," "for," "on," "in," "to," and "with.")

Example 4-15 **c** Upon early inflammation of organ transplantation, allografts are rejected.

The sentence in this example is heavy and hard to follow because instead of an active verb, the noun "inflammation" is used in conjunction with the preposition "upon."

To make this sentence easier to read, turn the prepositional phrase into a dependent sentence and use a verb instead of the nominalization. Using an active verb makes this sentence much livelier and easier to understand.

Revised Example 4-15 **c** *When organ transplants* ***become inflamed*** *early,* allografts are rejected.

Although most nominalizations in scientific writing can and should be turned into verbs, there are exceptions. Keep a nominalization if it refers to a previous sentence or if it names the object of the verb.

Example 4-16

a **This observation** led us to conclude . . .

b An example of this theory is provided by **a delay** in the reaction.

Analysis and Revision

To find and revise sentences that may confuse your readers, analyze your sentences:

1. Underline the first 8 to 10 words in the main sentence, ignoring introductory phrases.
2. For the underlined words, identify the central *character* of the sentence or paragraph.
3. Make the *character* the subject.
4. Look for the action.
5. If the actions are nominalizations, change them into verbs and make the relevant characters their subject.
6. Replace weak verbs with strong, active verbs if necessary.
7. Rewrite the sentence using conjunctions such as “because,” “if,” “when,” “although,” “that,” or “whether.” If necessary, turn a prepositional phrase into a dependent clause.
8. Avoid other nominalizations and abstract nouns in the remainder of the sentence as well—change them to verbs.

Example 4-17 Despite the identification of the AIDS virus by *researchers, there has been a* failure to develop a vaccine for the immunization of those at risk.

Example 4-17 Analysis and Revision

1. The central character of the sentence is *researchers.*
2. Here the nominalization among the first 8 to 10 words is “failure.” (Other nominalizations are “identification” and “immunization.”)
3. Change the nominalization to a verb: failure > fail (identification > identify, immunization > immunize).
4. Make the character the new subject of the verb, and turn the prepositional phrase into a dependent clause, leading to the following:

Revised Example 4-17 Although *researchers* **identified** the AIDS virus, *they* **failed** to develop a vaccine to immunize those at risk.

If you revise your sentences using the suggestions and basic rules presented, you will find your sentences not only more concrete, active, and concise but also more coherent and clearer for the reader.

4.7 CLUSTERS OF NOUNS

★ (18) Avoid noun clusters

Noun clusters are nouns that are strung together to form one term. In English, nouns (and adjectives) can be used to modify other nouns. However, when nouns appear one right after the other, it can be difficult to tell how they relate to each other and what the real meaning of the cluster is. When you add more than one modifier in front of a single noun or place additional modifying nouns and/or adjectives in front of an existing noun pair, you may end up with confusing noun clusters. Avoid clusters of nouns, especially if there are more than two or three nouns in the cluster. These noun clusters are awkward and sometimes downright incomprehensible.

Example 4-18

a porcine tracheal fluid samples

b Peter Carri is a condensed matter and quantum many-body theoretical physicist.

Instead, work your way from the back to the front and use prepositions to link the nouns. The prepositions add clarity to the phrase—they show more fully how the nouns relate to one another—and the meaning of your words becomes clearer.

Revised Example 4-18

a fluid samples *from* the trachea *of* pigs

b Peter Carri is a **theoretical physicist studying condensed matter and quantum many-body physics**.

Note that certain noun pairs and clusters—such as "water bath," "cell wall," "egg receptor," and "sucrose density gradient"—are accepted terms. Do not break such terms apart. If you are unsure if a term is accepted as a single word, look it up in a dictionary, a recent journal article, or online.

If a technical name is a noun cluster (example: pyrophosphate dependent phosphofructo-1-kinase apo form structure), there are three ways to help your reader:

1. Use hyphens to show the relationship between the words (pyrophosphate-dependent phosphofructo-1-kinase apo-form structure).
2. Explain the name (the structure of the apo-form of pyrophosphate-dependent phosphofructo-1-kinase).

3. Explain to the reader that you will use a shorter name (the apo-form structure of pyrophosphate-dependent phosphofructo-1-kinase, short PPi-PFK apo-form).

Hyphens in noun clusters are most often used for

- Two-word terms that are used together (high-pressure chamber, ATP-dependent)
- Adjectives that consist of three or more words (four-to-one ratio)
- Terms that contain a capital letter or a number and a noun (C-terminal end, 10-fold increase)

4.8 PRONOUNS

★ (19) Use clear pronouns

Pronouns are words that take the place of nouns.

Examples	it, none, they, these, those, their, them, this, that, which, who, whose

It is essential that you use clear pronouns. Unclear pronouns are one of the most common problems in scientific writing. If the pronoun that refers to a noun is unclear, the reader may have trouble understanding the sentence. An author always knows which term she or he is referring to. A reader is not so lucky. Be sure that the pronouns you use refer clearly to a noun or antecedent in the current or previous sentence. If there are too many possible nouns the pronoun can refer to, repeat the reference noun after the pronoun.

Example 4-19	*Anaerobic organisms* typically live in the *intestines*. Thus, they are of interest to us.
Revised Example 4-19	*Anaerobic organisms* typically live in the *intestines*. Thus, **intestines** are of interest to us. or: **Intestines** are of interest to us because ***they*** typically contain anaerobic organisms.

Sometimes the noun or antecedent that a pronoun refers to has been implied but not stated. To clarify the reference, explicitly state the implied noun after the pronoun as in the next example.

Example 4-20	If a specimen is frozen in a bath containing dry ice and acetone, the water of the cell can be removed by sublimation to prevent damage to the cell. This is commonly used for preservation of cultures.

Revised Example 4-20

If a specimen is frozen in a bath containing dry ice and acetone, the water of the cell can be removed by sublimation to prevent damage to the cell. **This technique** is commonly used for preservation of cultures.

Consider another example.

Example 4-21

The impact and proliferation of humans are considered the main cause for the rate of mass extinction today. As this rate increases, life in oceans will be affected more dramatically than species on land. This can be shown by our model, which calculates extinction rate.

Here, "this" refers to an effect on the rate of mass extinction. To clarify the pronoun, you can use an *implied term* such as "trend" that refers to the idea in the sentence before. Using such terms is especially helpful when the implied term is much shorter than expressing the idea to which it refers.

Revised Example 4-21

The impact and proliferation of humans are considered the main cause for the rate of mass extinction today. As this rate increases, life in oceans will be affected more dramatically than species on land. **This trend** can be shown by our model, which calculates extinction risk.

4.9 LISTS AND COMPARISONS

Parallel Ideas

★ (20) Use correct parallel form

Lists and ideas that are joined by "and," "or," or "but" are of equal importance in a sentence, and so are ideas that are being compared. These ideas should be treated equally by writing them in parallel form. To write ideas in parallel form, the same grammatical structures are used. These grammatical structures can be single words, prepositional phrases, infinitive phrases, or clauses. If parallel ideas are written in parallel form, the reader does not get distracted by the form but can concentrate on the idea.

The next few examples are sentences that contain parallel ideas joined by "and," "or," or "but," which are written in parallel form.

Example 4-22

	Subject	*Verb*	*Adverb*
For rice,	**molybdenum concentrations**	**were**	**twice as high,**
but	**selenium concentrations**	**were**	**three times lower**
than for wheat.			

In the preceding example, the same parallel form is used for the two ideas that are being compared, namely, the group of words after "but" is in the same grammatical structure as the group of words before "but"—in this case, subject, verb, adverb.

Following are a few more examples.

Example 4-23

	Direct Object	*Preposition*	*Object of Preposition*
Based on our hypothesis, we expected to see	**a decrease**	**in**	**the infection rate**
and	**an increase**	**in**	**survival of patients.**

Example 4-24

	Subject	*Verb*
	***S. franciscanus* sperm**	**can fertilize**
S. purpuratus eggs, but	***L. pictus* sperm**	**cannot.**

Example 4-25

	Preposition	*Object of Preposition*
Brown bears were observed	**at**	**the zoo**
and	**in**	**their natural habitats.**

Note that in Example 4-25, "at the zoo" and "in their natural habitats" are in parallel form even though the specific prepositions ("at," "in") are different. For parallel form, it is only important that both terms are prepositions.

Do not confuse the reader by obscuring the logical relationship of parallel ideas.

Example 4-26 Prolonged febrile illness together with subcutaneous nodules in a child could be due to an infection with a Gram+ organism, but it could also be <u>that the child suffers from rheumatic disease</u>.

In this sentence, two equal ideas are connected by "but." However, these parallel ideas are not instantly apparent because the grammatical form of the first part of the sentence is not parallel to that of the second part. Because the second half of the sentence is equal in logic and importance, it should be written in parallel form.

Revised Example 4-26 Prolonged febrile illness together with subcutaneous nodules in a child could be due to an infection with a Gram+ organism, but it could also be **due to rheumatic disease**.

This sentence can be further simplified.

Revised Example 4-26	Prolonged febrile illness together with subcutaneous nodules in a child could be due to an infection with a Gram+ organism or due to rheumatic disease.

Coordination

➤ Arrange ideas in a list to read from shorter to longer

If a sentence lists two or more ideas, these ideas should not only be in parallel form but they should also be coordinated. Careful writers coordinate ideas that are both grammatically and logically parallel. For good coordination, ideas should be arranged to read from shorter to longer in terms of the number of words contained in the idea. Coordinating ideas in this way makes a sentence more graceful.

Consider the following two sentences.

Example 4-27	**a**	Loss of coral reefs will affect organisms, such as turtles and sea birds that depend on specific habitats for reproduction, and beaches.
	b	Loss of coral reefs will affect **beaches and organisms** such as turtles and sea birds that depend on specific habitats for reproduction.

Example 4-27a seems to end too abruptly with “beaches.” Example 4-27b has much better flow because here the two parallel ideas have been arranged from shorter to longer.

4.10 FAULTY COMPARISONS

★ (21) Avoid faulty comparisons

Aside from maintaining parallelism in your comparisons, you should avoid grammatical and logical problems when writing comparisons. These problems result in faulty comparisons, one of the most common problems in scientific writing. Faulty comparisons can arise because of ambiguous comparisons and incomplete comparisons. Faulty comparisons may also be due to the overuse of “compared to.” Examples for all of these scenarios are shown in the following sections.

Ambiguous Comparisons

The following example is a typical ambiguous comparison found in scientific papers.

Example 4-28	Our conclusions are consistent with Tamseela et al. (2013).

Comparisons such as this are confusing for the reader as they compare unlike things. To avoid such ambiguous comparisons, make sure that you are comparing like items.

Revised Example 4-28	**a**	Our conclusions are consistent with **the conclusions of** Tamseela et al. (2013).

This sentence can be written even simpler by using a pronoun to avoid repetition.

Revised Example 4-28	**b**	Our conclusions are consistent with **those of** Tamseela et al. (2013).

Incomplete Comparisons

Absolute statements should not be written as comparisons. Information being compared and that with which it is being compared need to be listed completely and in parallel.

Example 4-29		This study tested 24 networks compared to Menon's study.
Revised Example 4-29	**a**	This study tested 24 networks; Menon's study tested only 8 networks.
	b	In this study, the number of networks tested (24 subjects) was three times that of Menon's study (8 subjects).

ESL advice

Such incomplete comparisons may confuse readers because their intended meaning is unclear. In certain foreign languages, incomplete comparisons occur often. Avoid these when writing in English.

Here is another example.

Example 4-30	RNA isolation is <u>more difficult</u>.

The question the reader naturally asks when reading this sentence is: More difficult than what? To complete the comparison, you need to include the item that RNA isolation is compared with as shown in the revised example.

Revised Example 4-30	RNA isolation is **<u>more difficult</u> than DNA isolation**.

"Compared to"

Use "than" not "compared to" for comparative terms such as "smaller," "higher," "lower," "fewer," "greater," "more," and so forth.

Example 4-31	We found <u>more</u> fertilized eggs in buffer A <u>compared to</u> buffer B.
Revised Example 4-31	We found <u>more</u> fertilized eggs in buffer A **than in** buffer B.

Note that "in" is repeated in the revised example to keep parallel form.

Avoid using "compared to" with the words "decreased" or "increased" because the meaning is ambiguous.

Example 4-32	K_D increased over time <u>compared to</u> K_A.
Revised Example 4-32	K_D increased over time, **but K_A did not.**

4.11 COMMON ERRORS

★ (22) Avoid errors in spelling, punctuation, and grammar

In any type of writing, errors should be avoided. Common errors include (a) spelling, (b) punctuation, (c) words that are omitted, (d) a subject and verb that do not make sense together, (e) a subject and verb that do not agree, and (f) unclear modifiers. When one of these errors appears, the reader is slowed down and may even need to reread the sentence to figure out the intended meaning (see also Chapter 2, Section 2.3). These errors can be avoided by carefully proofreading and double-checking the manuscript. You may choose the grammar and spell checker of MS Word to help do so or consult Grammarly online (https://www.grammarly.com).

Spelling

If you use a computer to prepare your manuscript, make use of a spell checker to avoid some common errors. Such a program will not find all the mistakes, however. For example, the program will not point out words that are wrong but correctly spelled ("from" when you meant "form" or "to" instead of "two").

A spell checker program also will not point out if you spelled the same word in the same way throughout. Compile a word list: Every time you make a decision on spelling, record it, and check your second draft for conformity to the list.