Scientific Writing and Communication

PAPERS, PROPOSALS, AND PRESENTATIONS

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PREFACE

Communication plays a fundamental role in the sciences. It is the engine that propels virtually all scientific progress. Without good communication skills, scientists stand little chance of publishing their work, obtaining funds, receiving award, or attracting a wide audience when giving a talk. Even the most promising discovery means little if it cannot be communicated successfully. In fact, it is more often the case that advancements are limited not by their technical merit but by ineffective articulation. Thus, clear communication is a requirement, not an option, for a good scientist. Yet, most researchers are not formally trained in scientific writing, and thus have only a skeletal knowledge of basic scientific writing principles at best.

Scientific Writing and Communication: Papers, Proposals, and Presentations **serves as a comprehensive "one-stop" reference guide to scientific writing and communication for researchers in various scientific fields.** This book can be used as a textbook, a self-guided handbook, or as a general reference guide. It covers all areas of scientific communication a scientist needs to know and to master in order to successfully promote his or her research. The level of presentation is geared for those looking to improve their writing without having to read many different books on the subject. The handbook includes practical advice for writing coherent and succinct research papers, review articles, and grant proposals, as well as for organizing academic presentations and posters. Its discussion of the basic scientific writing principles also applies to theses and annual reports. This book shows you how to write clearly as a scientific author and how to recognize shortcomings in your own writing. It does so not only by providing crucial knowledge about the structure and delivery of written material but also by explaining how readers go about reading. In addition, it presents easy-to-understand and easy-to-remember principles and guidelines. Potential problem areas in

written and oral presentations are pointed out, and many guidelines and practical examples are provided for wording certain sections in research papers, grant proposals, or scientific talks. Examples range from student drafts to text passages of published works, including those of Nobel Prize papers edited by the author. The text contains numerous hallmark features, including:

Practical and conceptual organization. As a result of extensive class-testing, the text has been revised repeatedly to reflect the interests, concerns, and problems undergraduate and graduate students, postdoctoral fellows, and faculty encounter when communicating in their disciplines. The table of contents is divided into six distinctive parts. The first three parts of the text follow a logical progression from the basics of scientific writing style and composition, to planning and organizing the foundational precursor of a manuscript, to the specifics of how to write each major section of a research paper and review article. The last three parts focus on grant proposals, posters, and presentations, and job applications.

Broad-based appeal. This text is written for an audience ranging from upper-level undergraduate students to graduate students, from postdoctoral fellows and junior faculty to fully-fledged researchers. Although *Scientific Writing and Communication* can be used as a textbook, it is structured such that it is equally self-explanatory, allowing readers to understand how to write English publications or proposals and to present scientific talks without having to take a class.

Numerous real-world, relevant, and multi-disciplinary examples. The in-chapter examples are derived directly from real scientific documents and cover a broad range of disciplines, serving to accommodate the interest and need of scientists in the physical and biomedical fields, including medicine, molecular biology, ecology, chemistry, engineering, physics, and more.

Extensive exercise sets and end-of-chapter summaries. Chapter summaries reference the most important concepts in an easy-to-understand bulleted format. The end-of-chapter exercises and problems review style and composition principles and encourage readers to apply the presented principles and guidelines to their own writing. Answers to the exercises are provided in a separate appendix.

Writing guidelines and checklists for revisions. Straightforward writing principles and guidelines presented in the book provide the basis for writing scientific articles, proposals, and job applications and for creating clear posters and oral presentations. Explanations of these writing principles and guidelines are followed by common pitfall examples, as well as by suggestions and advice to revise one's work successfully. Furthermore, annotated examples of text passages bring to life the guidelines and principles presented throughout the chapter. Checklists at the end of each chapter aid readers in remembering and applying these rules when writing or revising a document.

Sample wording for scientific documents and presentations. Beginning scientific writer, non-native speaker, or those struggling with writer's block, will especially value the many tables with sample sentences that apply to different sections of a scientific paper, review article, or grant proposal. Anyone presenting

data at meetings and conferences will also find the sample phrases and advice on creating and delivering a talk or poster highly useful.

Special features for ESL students and researchers. *Scientific Writing and Communication* is written in an easy-to-follow style, appealing to both native and nonnative English speakers. In addition, given the broad international authorship (and readership) in science, special consideration is given to the unique problems international authors face. If you are an author whose native language is not English, you should, however, have a solid, basic knowledge of the language to maximize use of the book.

Scientific Writing and Communication: Papers, Proposals, and Presentations will not teach you how to write in the English language, *i.e.*, it is not a grammar book. You, the writer, must *practice* writing and thinking within this structure, and learn by example from the writings of others. 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. You will see improvement in your own writing skills by repeatedly practicing reading, writing, and critiquing of others' work.

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. 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

Without the contributions and advice of others, a book such as this would not have been possible. Thus, I would like to acknowledge my students, friends, and colleagues from the Max-Planck Institute, Indiana University, Fritz-Haber Institute, Humboldt University, University of Carabobo, University of Massachusetts at Worcester, and Yale University who have shared information and ideas across the sciences. I am particularly thankful to all those who were courageous enough to allow me to use draft sentences, paragraphs, or sections as examples or problems in this book as well as to those providing me with extensive and very specific samples: Kan Biao, Irene Bosch, Mark Bradford, Jaclyn Brown, Stephane Budel, Neeta Connally, Cindy Crusto, Alexey Federov, Alison Galvani, Roland Geerken, Daniela Grunow, Moshe Herzberg, Robert Homer, Jun Korenaga, Andres Franceschi Larrea, Stefanie Leacock, Patty Lee, Jin-Yu Lu, Rudolf Lurz, Richard Phillips, Hanna Richter, Michael Robek, Robert J. Schneider, Klaus von Schwarzenberg, Hong Tang, Jeffrey Townsend, and Jimin Wang. Without these samples the book would not be nearly as effective in exemplifying clear writing.

CHAPTER 1

Prelude

1.1 IMPORTANCE OF WRITING IN SCIENCE

Success in the professional scientific world hinges not only on good data but also on good communication. Without good communication, scientists stand little chance of publishing their work or moving up in their career path. Most colleges and universities, however, do not formally train their students, postdoctoral fellows, or faculty in technical writing but rather expect their students and staff to rely on undergraduate English composition classes and to pick up good composition and style by reading the publications of others. If you fall into one of these categories, you know that these approaches are usually not sufficient to provide the tools for authors in professional scientific fields. Not only the lack of these tools hinders your writing; most of the time you are also too close to your own writing to recognize any potential problems readers might have when trying to interpret what you have written.

Many readers think that science is generally hard to read because of the complexity of scientific concepts and topics. 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. To become an effective and successful author, you can and should strive to communicate clearly without oversimplifying scientific issues.

To understand how best to write clearly, you have to understand better 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 scientists the tools needed to become better writers.

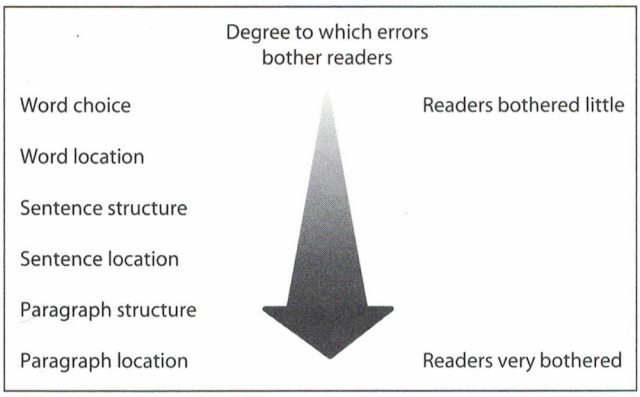

Figure 1.1 Degree to which errors in writing bother readers. Based on the perception of readers, it is more important to logically organize and present one's ideas than to worry about perfect grammatical form or word choice.

1.2 ABOUT READERS

Readers do not simply read—they interpret. Any sentence can be interpreted in many 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 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. Their interpretations are 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. They are bothered much more when a paragraph that clearly belongs in the Materials and Methods section appears in the Introduction of a manuscript than when a word is misspelled. In other words, the logical and structural organization of your document is much more important than using perfect grammatical form (see Figure 1.1).

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. The adage "form fits function" applies as much to writing as it does to the shape of a bird's wing or to the conformation of a protein.

1.3 ABOUT WRITERS

GUIDELINE:

Writing principles are the tools of professional writing.

Most of us can identify unclear writing by others, but we have a harder time recognizing our own. Scientists who write unclearly rarely think they do, much less intend to. Similarly, your own writing may appear

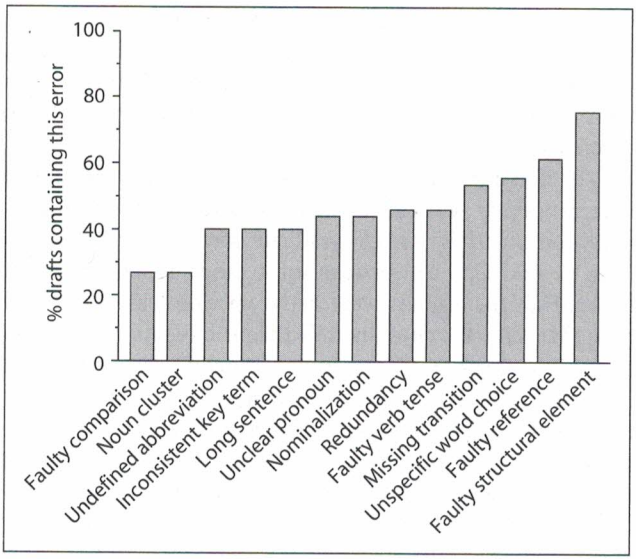

Figure 1.2 Commonness of writing errors among senior graduate students and postdoctoral fellows.

Explanation of elements:

Faulty comparison	Incomplete and ambiguous comparisons—comparing apples and oranges (Our findings are similar to Frater et al.)
Noun cluster	Two or more nouns in a row (water bath temperature variability results)
Undefined abbreviation	A nonstandard abbreviation is not defined in the text (CMMT)
Inconsistent key term	Different terms with the same meaning are used without being linked (nematode—worm—*C. elegans*)
Long sentence	Use of too many long sentences in document
Nominalization	Use of noun instead of more active and more interesting verb (measurement instead of to measure)
Redundancy	The same thing is said repeatedly in different ways, or unnecessarily long phrases are used instead of shorter versions ("the majority of" instead of "most")
Faulty verb tense	Present tense is used instead of past tense ("In our study, X crosses Y." instead of "In our study, X crossed Y.")
Unspecific word choice	Words are imprecise or unclear (The sample was incubated for several hours.)
Faulty reference	Reference is faultily placed in text, wrongly cited, inaccurate, or missing (It was reported (5) that x is the only element.)
Faulty structural element	Necessary component of a paper is missing, misplaced, or obscured (example: purpose of experiment is not stated, data are not interpreted, or conclusion is missing)

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 sound funny to most people outside these fields, "academese" sounds funny to most people outside the field of science.

To illustrate the commonness of errors in style and composition, I have randomly selected and analyzed 100 prepublication drafts, which were composed by senior graduate students and postdoctoral fellows from several U.S. universities for a range of biological and biomedical topics. Half the authors were native speakers, 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 drafts contained errors in style and composition, but each type of error was scored only once. For the most common grammatical, structural, and stylistic problems, the percentage of drafts containing these errors was calculated and is shown in Figure 1.2.

Interestingly, most drafts from these students and postdoctoral fellows contained faulty structural locations (76%). Faulty or missing references were the second most common error encountered (62%) followed 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 instructions.

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 to get their data onto paper. Others learn to imitate a particular style to fit into a field. Imitation is employed particularly by authors new in a field or unfamiliar with a topic. Some plump up their writing to impress readers, convinced that dense style sounds sophisticated and reflects deep thinking. The main reason for bad style and composition, however, is ignorance and lack of training. Scientific writers are 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 not of the writing principles that would benefit them as professionals.

To be successful scientists and professional writers, basic English composition is usually not enough. Particularly because you are often too close to your own writing to judge it, you need a set of writing principles to make you aware of how readers will interpret what has been written. The main goal of this book is to provide you with these principles 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.

1.4 ABOUT THIS BOOK

This book covers all elements of style and composition needed for writing a scientific document and for presenting a scientific talk. It explains choice of words, word location, sentence construction, and paragraph structure as well as the arrangement of these elements into the larger structures of a research paper, review article, or grant proposal. At the same time, the book emphasizes how the reader interprets what has been written. Special sections of the book have also been devoted to oral presentations and posters as well as to job applications.

Scientific Writing and Communication is both a practical text with teaching exercises and a ready reference guide, which can be used long after class is over. In writing this book, my goal was to target as broad of a scientific audience as possible, ranging from both undergraduate and graduate students to postdoctoral fellows, junior faculty, and other scientists inside and outside the academic field. Considering the growing globalization, especially in science, I have also added suggestions for writers and readers for whom English is a second language.

Within each chapter, potential problem areas in scientific writing are pointed out in well-explained examples, and thorough instructions on how to avoid these problems are provided. It is important for readers and students to understand the writing principles presented and to learn how to apply them. To make examples and exercises directly applicable and more readily understandable to scientific writers, most examples were taken from prepublication drafts written by scientists in various fields and represent typical mistakes made when writing about science. I have collected most of the sample sentences and paragraphs over the years and also added a few of my own. Quite a few examples come from writers whose native language is not English and thus illustrate typical mistakes made by nonnative English writers. Other examples and exercises also present writings commonly encountered by scientific editors.

Aside from the examples, the book provides ample exercises to practice the discussed writing principles. I encourage you to work through these problems. The way you will learn and improve is by struggling with the problems, trying to apply the relevant writing principles yourself even if you miss the point in your answers. It is important to practice on paper because the only way to learn how to write is by writing. So 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, but rather try to think about the writing and to spend the time needed to understand these problems and their revisions. In this respect, although examples and exercises from many different areas of science are used in the book, it is not important from what scientific discipline examples or exercises arise; what is important is that you recognize mistakes of style and composition. You may disagree with some choices of answers. In fact, many exercises may have more than one possible answer, as there may be more

than one way to express an idea and to improve written passages. Some choices are better, some worse, and some just a matter of personal style. The goal is to improve the original statements such that they are clearer and more easily understandable by the reader.

1.5 DESIGN OF THIS BOOK

This book consists of six parts:

I. Scientific Writing Principles: 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

Part I presents 30 basic scientific writing principles of technical style and composition that every scientific writer should know. These principles range from principles on word choice to principles on sentence structure, sentence location, and paragraph construction. The importance of word location and details of grammar/technical style are particularly emphasized as is the interpretation by the reader. Many examples and their revised versions are used to illustrate the writing principles, and each chapter is followed by a variety of problems to practice the writing principles.

Part II deals with key elements necessary for preparing a manuscript. This part explains how to get started writing a manuscript and discusses authorship. It also explains how to collect, manage, and use references and how to avoid plagiarism. In addition, it provides the most important illustration principles for scientific authors in the biological, biomedical, and other scientific fields. It shows not only different types of figures but also explains the difference between figures constructed for a poster, an oral presentation, or a manuscript. Part II contains examples of good and bad graphs and reinforces guidelines and principles with practical problems.

In Part III authors learn to apply the writing principles 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 revisions. Here again, authors are encouraged to practice using the discussed guidelines on provided problems. In addition, Part III provides an overview of revising a manuscript and submitting it to a journal. It also explains the review process and gives advice on how to write a cover letter and how to respond to the editor and reviewer comments.

As garnering funding is an important part of the life of a scientist, a section on grant writing is included in Part IV. These chapters give information on federal and private funders, writing letters of inquiry, and the different sections of a grant proposal. Here, writing principles are applied

to putting together proposals. These chapters also contain sample sections of successful proposals and sample wordings for less frequently encountered proposal sections. In addition, Part IV also provides instructions on how to submit a proposal and how to communicate with the funder.

The ability to communicate findings orally is an important part of the scientific process. Part V instructs scientists on preparing and presenting an oral presentation or poster. In these chapters, the book provides not only real examples of slides and posters but also gives advice on the mechanism of speaking, combating stage fright, and fielding questions. It also presents basic guidelines to instruct speakers on visual aids and the content of a talk or poster.

To complete the series on scientific writing skills all scientists should have at their disposal, Part VI of this book provides information on job applications. This part includes advice on how to compose a CV and how to ask for or write a letter of recommendation. Examples of well-written research and teaching statements are also included in this chapter.

PART ONE

Scientific Writing Principles

STYLE AND COMPOSITION

CHAPTER 2

Individual Words

Word choice in scientific research papers is one of the primary concerns of scientists and editors alike. A few basic principles can provide a good guideline for the choice of words in scientific papers. These principles are the focus of this chapter.

Other parts of this chapter teach you to distinguish between words whose meanings are similar but not exactly the same. English is a particularly rich language. It encompasses about half a million words and has many synonyms and near synonyms. Over time, the meaning of words may change, making it even more difficult to 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.

2.1 THE CENTRAL PRINCIPLE

WRITING PRINCIPLE 1:

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. In the scientific fields, these 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 non-native speakers. Because of this diversity in readership, the burden of clarity rests on you, the author. You need to write clearly so that readers can follow your thinking and so that you achieve the highest possible impact. In other words, you need to write with the reader in mind.

To "write with the reader in mind" is the central principle of this book, and all other principles follow from it. 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. Good science does not excuse poor writing. Authors have an obligation to their readers to ensure that science is communicated well.

2.2 WORD CHOICE

Preciseness

WRITING PRINCIPLE 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 <u>several</u> hours.

b Nests were observed <u>frequently</u> for signs of predation.

c The carbonate layer was prepared <u>with</u> 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 the above example, the underlined words violate the same writing principle: 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. "Enhanced" is imprecise as well as the wrong word choice. "Increased" is the correct quantitative term for concentration. But how much was the increase? Writers should give a quantitative value such as "10%."

"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." Science is quantitative. A quantitative detail such as "every 12 hours" is much clearer than a qualitative term such as "frequently." Overall then, you should use precise terms and state the mean or a range when applicable.

Let us look at Example 2-1c more closely. The vague term underlined in this example is "with." "With" is one of the vaguest and most ambiguous terms in English. Because "with" can mean so many things, it is clearer to use a precise term whenever possible. If you do not use precise terms, 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

WRITING PRINCIPLE 3:

Use simple words.

Words in science should not only be precise, but they should also be as simple as possible. Consider the next 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. Admittedly, scientific writing has many technical terms. Therefore, 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.

Here is another example of pompous words that just cries out to be simplified:

Example 2-3

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.

Revised Example 2-3

Rattlesnakes come together when it gets cold in the fall.

ESL advice

Many English as a Second Language (ESL) authors convert vocabulary of their native language for use in English writing. In some cultures, pompous words are extensively used, and statements tend to be indirect. In Western cultures, however, statements are rather direct. Thus, these ESL authors need to pay special attention not to overuse pompous words and phrases. These authors also need to ensure that they do not use terms in English that they would use in their language.

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 has been 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; choose "use" rather than "utilize," for example (see also http://www.userlab.com/Downloads/SE.pdf for more details on using simplified English for an international audience, last accessed October, 2009).

2.3 WORD CHOICE—SPECIAL CASES

Misused Words

GUIDELINE:

Watch out for misused words.

ESL advice

Words are not always what they seem. Quite a few words and expressions in science are commonly 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. Consult a dictionary when you write so that people do not need to have one on hand when they read what you have written.

Commonly misused words fall into several categories including words with suffixes, verbs, adverbs and 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.
Nanoscience has a transformatizing impact on various technologies.

Revised Example 2-4 d **Individual** doses were calculated.
Nanoscience has a **transformative** impact on various technologies.

or even better:

Nanoscience transforms various technologies.

-ology

This ending means the study of something and is jargon when used in sentences such as these:

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 scientist who is a native speaker.

Example 2-5 a A picture was made.
A gel was made.
We made a graph.
We made the following experiments.

Revised Example 2-5 a A picture was **taken**.
A gel was **run**.
We **graphed** the data. OR
We **constructed** a graph.
We **performed** the following experiments.

affect, effect

"Affect" is usually used as a verb and means to act on or to influence.

Example 2-5 b The addition of KI-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.

"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).

Adverbs and Adjectives

ESL advice

overnext This word does not exist in English. What you probably mean is "The slide *after next.*"

Example 2-6 In the overnext 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.

Links

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 δ stopped increasing **since** being dampened by ψ.
The reaction rate decreased **because** 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, recovered.

Use "that" without commas for essential sentences. A phrase or clause introduced by "that" cannot be omitted without changing the meaning of the sentence. Such essential material should not be set off with commas.

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. We have seen some examples of such word pairs already: "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** together with their corresponding meanings.

Handling Language Sensitively

GUIDELINE:

Avoid sexism.

In recent years, people have become much more aware of the ways in which language affects our thinking. To avoid being accused of chauvinism and insensitivity, carefully consider what you write. If readers get offended, they are likely to stop reading.

Sexism includes any verbal or visual reference that presents men and women as unequal or excludes one group in favor of another. Although it may be unconscious and unintentional, sexism in writing can take many forms. Some forms are so subtle that authors might not even notice them unless they are pointed out. Consider this 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 host for this parasite.

Writing gets more complicated when we have to consider which pronoun to use for singular nouns that do not indicate gender 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

WRITING PRINCIPLE 4:

Omit unnecessary words and phrases.

Avoid any verbosity and wordiness by omitting unnecessary words and phrases and jargon.

Redundancies

Redundant words or phrases unnecessarily qualify other words and phrases. Many sentences in science appear complex because they contain redundancies. Writers should be as brief as possible consistent with clarity. However, if it takes more words to be clear, use more words.

Here are three examples of unnecessarily complex sentences:

Example 2-9 a The sample size was not quite sufficiently large enough.

b High pH values have been observed to occur in areas that have been determined to have few pine trees.

c Most galaxies with unusually luminous cores are highly asymmetric in shape.

Look at what can be cut out in the revision after unnecessary words and redundancies have been removed:

Revised Example 2-9 a The sample size was not **large** enough. OR: The sample size was too small.

b High pH values occur in areas with few pine trees.

c Most galaxies with unusually luminous cores are highly 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

Other warning words

Sometimes words that are perfectly good on their own can still indicate potential trouble. The following "warning words" often indicate that your thought has to be sharpened and your writing needs to be tightened. Most of the time, these warning words can be omitted:

area	character	conditions	field
level	nature	problem	process
situation	structure	system	

Unnecessary phrases

Many unnecessary words and phrases are used by both native and nonnative English speakers. We have already looked at commonly misused words. Let us now look at commonly misused phrases. Avoiding these phrases is a simple way 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 so that the facts are succinctly stated.

Example 2-10 It is well known that there are three subtypes of the KL-2 virus.

Revised Example 2-10 There are three subtypes of the KL-2 virus.

Example 2-11 In a previous study, it was demonstrated that "nanowire" devices with excellent sensing characteristics can be defined by TMAH etching.

Revised Example 2-11 "Nanowire" devices with excellent sensing characteristics can be defined by TMAH etching.

Example 2-12 Eddies have been shown to vary depending on the time of year.

Revised Example 2-12 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 was shown to...
it was observed that...
it is reasonable to assume that...
evidence has been presented that shows that...
it is speculated that...
it has been found that...
it has been demonstrated...
it has been reported that...
it has long been known that...

Phases that can be shortened include:

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

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 can also be pompous, and it is often not comprehensible 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"
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

WRITING PRINCIPLE 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 2-13 a MPTP is converted by MAOB to MPP, which reaches SNpc nerve cells via DA uptake systems.

b We assessed non-AGN galaxies, contained in the MUSYC survey in the ECDFS using HST for a target source.

The preceding examples may be perfectly intelligible to expert colleagues 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 the abstract. If you are using many abbreviations in a long scientific document, consider adding a list of abbreviations with definitions to go with 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

WRITING PRINCIPLE 6:

Use correct nomenclature and terminology.

In science, it is important to use correct vocabulary, nomenclature, 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.

This site contains definitions of more than 46,000 terms not only from medicine but also from biochemistry and plant biology.

http://thesaurus.reference.com/ Link to a visual Thesaurus that one can subscribe to.

http://www.bartleby.com/141/index.html

Stunk and White, the famous short but excellent style guide, is available in full online.

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://allserv.rug.ac.be/~rvdstich/eugloss/welcome.html

This system contains the electronic form of eight glossaries in which you can find 1,830 technical and popular medical terms in eight of the nine official European languages: English, Dutch, French, German, Italian, Spanish, Portuguese, and Danish.

http://www.glossarist.com/glossaries/science/life-sciences/biology.asp

This Comprehensive Directory of Biology serves as a dictionary and glossary and contains listings of biological terms and terminology.

http://infotree.library.ohiou.edu/byform:dictionaries/health-and-life-sciences/biology/

This good biological dictionary contains some 23,000 definitions, online glossaries, and acronym dictionaries in the field of biology.

http://www.biology-online.org/dictionary.asp

This online dictionary of biology terms introduces and combines various basic aspects of the biological and earth sciences.

http://www.userlab.com/Downloads/SE.pdf

This pdf file contains details on using simplified English for an international audience.

ESL Dictionaries and Other Sources

Konstantinidis, G. (2005). *Elsevier's dictionary of medicine and biology: In English, Greek, German, Italian, and Latin.* New York: Elsevier Science.

Longman dictionary of American English (2nd ed.). (1997). White Plains, NY: Longman.

Long, T. H. (Ed.). (1984). *Longman dictionary of English idioms* (Rev. ed.). Harlow, England: Longman.

The Oxford dictionary for scientific writers and editors. (1991). Oxford, England: Clarendon Press.

SUMMARY

WRITING PRINCIPLE 1: Write with the reader in mind.
WRITING PRINCIPLE 2: Use precise words.

WRITING PRINCIPLE 3: Use simple words.
WRITING PRINCIPLE 4: Omit unnecessary words and phrases.
WRITING PRINCIPLE 5: Avoid too many abbreviations.
WRITING PRINCIPLE 6: Use correct terminology and nomenclature.
ALSO: Watch out for misused words. Avoid sexism.

PROBLEMS

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 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 of the discovered exoplanets have an orbital period of less than 5 days.
4. In general, retinal explants treated with 0.5 μg/ml BSA exhibited increased growth rates compared with retinal explants treated with 0.5 μg/ml BSA.
5. We field ionized those atoms not ionized by the HCP and detected the electrons produced with the rapidly rising field ionization pulse shown in Fig. 2B.
6. Briefly, cells were incubated with Mytomycin C for 3.5 hours, harvested with trypsin, and frozen in aliquots.
7. To provide proof of concept for our hypothesis, we studied a virus in its host cells.
8. Apart from the discussed main band, weaker emissions were observed.
9. The current was dramatically affected when temperature was increased.
10. (Last sentence in an Introduction) The present paper reports on continuing experiments that were performed to clarify this surprising effect.
11. Only some of the region under study exhibits larger reddening.
12. Heating arises after recapture and subsequent equilibration following from the lowest $\bar{T} = 0{\cdot}04$, which is obtained by imaging the gas shortly after release from the trap.
13. A second calculated transition state that places the water molecule above the TFA ring is higher in energy than the first transition state.
14. The band showing vibrational splitting of 192/cm in Ne with the most intense peak at 444 nm can be identified with the A-> X transition of the dimer Ag_2.

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 are forced to divert energy from understanding the content of a text to unraveling its structure, which increases the possibility of misinterpretation or not understanding. Worse, if readers cannot unravel the structure, they will lose interest. Thus, authors need to pay close attention to word location and to the organizational structure of a text.

3.1 READERS' EXPECTATIONS

GUIDELINE:

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 writers, it is even more important to understand the importance of where in a sentence to place what information.

Consider the following example:

In this sentence, the word "mosquitoes" has been placed at the begin-

Example 3-1 a

Mosquitoes often carry parasites.

topic stress

ning 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 the following example:

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 the author is stressing this term. The author 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; the author 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

WRITING PRINCIPLE 7:
Establish importance.

To decide on the best placement of words within a sentence, it is crucial that authors decide what is important, what is less important, and what is not important before they 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. Authors need to recognize that the format and structure they use to present information will lead the reader to interpret it as important or less important.

In general, the end position in a sentence is more emphasized than the beginning position, and the main clause is 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 3-2

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.*

When one piece of news is in the main clause and another is at the end of the sentence or in the stress position, interpretation by the reader will vary. Most people will tend to emphasize the main clause more than the dependent clause, however. Even more, most people will tend to emphasize the information at the end of the sentence more than that at the beginning of the sentence. If readers were to vote on the impact of each sentence, the percent 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	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* as the strongest statement has the + information in both the main clause and the end position of the sentence. Thus, even in more complex sentences, word placement, if considered carefully, can help authors to guide and influence readers.

Although word placement is more important than word choice for 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 3-3 Although taking vitamin B6 may result in serious deformities or even death, 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 such as that of the stress position.

3.3 PLACEMENT OF WORDS

Complexity

WRITING PRINCIPLE 8:

Place old, familiar, and short information at the beginning of a sentence in the topic position.

WRITING PRINCIPLE 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. Above all, writing "flows" much better if the information is linked through word location. Readers get confused and misinterpret information when the author does not comprehend their structural needs. The general principle that authors should keep in mind is to provide context for their readers before asking these readers to consider anything new as can be seen in the next examples.

Example 3-4

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***.

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. Consequently, if the passage would continue, most people would expect to find information on "side effects" in any subsequent sentence or paragraph because "side effects" has been introduced in the stress position in the last sentence. When authors pay attention to word location as in the preceding example, their writing has good flow and continuity.

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 3-5:

Example 3-5 ***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 principles of word location as exclusively as shown in Examples 3-4 and 3-5. 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 principles about 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 3-6 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 3-6a because it starts with a long and complex subject. Example 3-6b, 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, authors need to also consider the length of terms or information when constructing sentences.

Here is another example whose revised version is much preferred by readers:

Example 3-7 The heavily disordered patterns characteristic of interference arising from multiple regions with different phase drops across the junction were eliminated by X (Fig. 2, B and C).

Revised Example 3-7 X eliminated the heavily disordered patterns characteristic of interference arising from multiple regions with different phase drops across the junction in some samples (Fig. 2, B and C).

Subject

WRITING PRINCIPLE 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.

In general, readers prefer to get to the subject/topic of the main sentence quickly. They understand a sentence more easily if the subject of it is readily available. When you open sentences with several words before its subject/topic, readers have a hard time understanding what the sentence is about. Thus, writers should 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 also prefer to see characters as their subjects. In fact, readers get confused if for no good reason authors do not make characters subjects. The central character is the subject of a series of sentences telling a story. Most readers prefer central characters to be live characters rather than abstract terms, but concepts can also serve as central characters if the corresponding verb describes an action. 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 another example:

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

Here, the topic "cells" is the subject. Any possible character such as a biochemist or a laboratory technician is not mentioned because it is 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 the most clear and direct if the subject is also the topic of the sentence (and paragraph). However, the subject of a sentence does not always state its topic as in the following example:

Example 3-11 **No one** could foresee these results

Subject ***topic***

If a subject is deleted entirely, 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 may know who is doing what, but the readers do not know and usually need more help than authors 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.

Verb Placement

WRITING PRINCIPLE 11:

Avoid interruptions between subject and verb and between verb and object.

ESL advice

Information is more easily interpreted if it is not obstructed. Often sentences are obstructed because the verb does not immediately follow the subject. Readers expect grammatical subjects to be followed immediately by the verb. Anything of length that intervenes between subject and verb is read as an interruption and therefore as something of lesser importance. Certain ESL authors should be especially aware of this principle. English sentences are better understood if their subject and verb are not interrupted.

Consider the following opening sentence of an introduction:

Example 3-13

Dengue virus, a Flavivirus belonging to the family *Flaviviridae*, which includes over 60 known human pathogens such those causing yellow fever, Japanese encephalitis, tick-borne encephalitis, Saint Louis encephalitis, and West Nile encephalitis, is classified into four different serotypes: Types 1, 2, 3, and 4.

This sentence obstructs the reader because the grammatical subject ("Dengue virus") is separated from its verb ("is classified") by 31 words. Without the verb, readers do not know what the subject is doing or what the sentence is all about. As a result, readers focus their attention on the arrival of the verb and resist recognizing anything in the interrupting material as being of primary importance. The longer the interruption lasts, the more likely it becomes that the "interruptive" material actually contains important information; but its structural location will continue to brand it as merely interruptive.

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 new

information in the sentence. At other times, the author should consider splitting the information into two sentences or even omitting the interrupting information altogether.

In Example 3-13, the relative importance of the intervening material is difficult to evaluate. The material may be important. In that case, the writer should have positioned it to reveal that importance. Here is one way to incorporate it:

Revised Example 3-13

Dengue virus is a *Flavivirus* belonging to the family *Flaviviridae*, which includes over 60 known human pathogens such as those causing yellow fever, Japanese encephalitis, tick-borne encephalitis, Saint Louis encephalitis, and West Nile encephalitis. **It is classified** into four different serotypes: Types 1, 2, 3, and 4.

On the other hand, the intervening material might be a mere aside that diverts attention from more important ideas. In that case, the writer should have deleted it, allowing the sentence to drive more directly toward its significant point:

Revised Example 3-13

Dengue virus is classified into four different serotypes: Types 1, 2, 3, and 4.

Only the author could tell us which of these revisions more accurately reflects her or his intentions.

Here is another example in which the subject is separated from its verb:

Example 3-14

Previous measurements, in which abrupt changes in the diffraction patterns produced by large fields were generally asymmetric and could only be eliminated by thermal cycling, are in sharp contrast to measurements we made on the cuprates.

A possible revision is shown next.

Revised Example 3-14

Previous measurements showed abrupt changes in the diffraction patterns produced by large fields, were generally asymmetric, and could only be eliminated by thermal cycling. **These experiments are in sharp contrast to measurements we made on the cuprates.**

ESL advice

Readers also like to get past the verb to the object of a sentence quickly. Therefore, authors 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 3-15 and 3-16.

Example 3-15

We quantitatively compared, using a model-based approximate Bayesian computation (ABC) method relying on computer simulations, the different introduction scenarios for the Western European WCR populations.

Revised Example 3-15

Using a model-based approximate Bayesian computation (ABC) method relying on computer simulations, we quantitatively compared the different introduction scenarios for the Western European WCR populations.

Example 3-16

We conclude, based on very simplified models of solar variability, that solar variability is insignificant.

Revised Example 3-16

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

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

WRITING PRINCIPLE 7: Establish importance.

WRITING PRINCIPLE 8: Place old, familiar, and short information at the beginning of a sentence in the topic position.

WRITING PRINCIPLE 9: Place new, complex, or long information at the end of a sentence in the stress position.

WRITING PRINCIPLE 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.

WRITING PRINCIPLE 11: Avoid interruptions between subject and verb and between verb and object.

CHAPTER 4

Technical Sentences

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, livelier, and 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. We discuss all these problems of grammar and technical style in detail in this chapter.

Note that this handbook is not a book of English grammar. The book captures only the mistakes that are most commonly made by scientific authors, particularly mistakes that tend to reduce the clarity of a scientific manuscript. For additional help with grammar and vocabulary, see, for example, Thurman (2002) 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

WRITING PRINCIPLE 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 separate parameters are important to describe the physical effects of an earthquake: seismic moment and radiated energy.

These sentences taken from two different Introductions 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 separate parameters are important to describe the physical effects of an earthquake: seismic moment and radiated energy.

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.

4.3 VOICE

WRITING PRINCIPLE 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 activity <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 activity.

Do not remove the passive voice completely, however; use the passive voice when readers do not need to know who performed the action. 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.

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

In addition, you can 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 Volcanic pipes are subterranean geological structures formed by the violent, supersonic eruption of deep-origin volcanoes. Volcanic pipes are composed of a deep, narrow cone (described as "carrot-shaped"). <u>Solidified magma usually fills the cone.</u> Volcanic pipes are made up of kimberlite or lamproite rock and are well known as the primary source of diamonds.

Revised Example 4-4 Volcanic pipes are subterranean geological structures formed by the violent, supersonic eruption of deep-origin volcanoes. Volcanic pipes are composed of a deep, narrow cone (described as "carrot-shaped"). **The cone is usually filled with solidified magma.** Volcanic pipes are made up of kimberlite or lamproite rock and are well known as the primary source of diamonds.

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.

4.4 TENSE

WRITING PRINCIPLE 14:

Use past tense for observations, completed actions, and specific conclusions.

WRITING PRINCIPLE 15:

Use the present tense for generalizations and statements of general validity.

ESL advice

The two main tenses that occur in scientific papers are present tense and past tense. 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, completed actions, and specific conclusions. For example, results described 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, as well as 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 generalizations and statements of general validity.

That is, results from already published papers should be described in the present tense as published results are generally assumed to be "facts." Thus, most of the Introduction describes previously established knowledge in 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.

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 Sultan **observed** that certain species of bacteria **respond** to light stimuli.

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

The Discussion relates your work to previously established knowledge. This section is the most difficult to write as it includes both past and present tense. Note that generally, 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 TXY addition **is shown** in Figure 5.

Present perfect tense is used when observations have been repeated or continue from the past to the present.

Example 4-9 X **has been** of interest for the past three decades.

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

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

4.5 SENTENCE LENGTH

WRITING PRINCIPLE 16:

Write short sentences. Aim for one main idea in a sentence.

Short sentences are easier to understand than long sentences. A paper full of long sentences is difficult to follow. The average sentence length in many scientific articles is over 30 words; in most newspapers, it is between 15 and 20 words (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. What scientific authors should be aiming for is 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 should 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 multi-clause 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 the following example:

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.

In the preceding example, the words in the sentence in 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 the following example:

Example 4-12 **Excessively long sentence**

Skin swabs were cultured at the time of the removal of the catheter from seven patients with catheter-related bloodstream infection and in five of these cases (71%), the culture yielded bacteria of the same species with a DNA fingerprint pattern similar to that of the isolates from the catheter and the blood, whereas a different organism grew from skin cultures in the other two patients (29%), suggesting that catheter infection may have originated from contamination of the catheter hub.

(79 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

Skin swabs were cultured at the time of the removal of the catheter from seven patients with catheter-related bloodstream infection. In five of these cases (71%), the culture yielded bacteria of the same species with a DNA fingerprint pattern similar to that of the isolates from the catheter and the blood. However, a different organism grew from skin cultures in the other two patients (29%). These observations suggest that catheter infection may have originated from contamination of the catheter hub.

(average of 20 words/sentence)

Whereas the original sentence was 79 (!) words long, the revised version has an average sentence length of 20 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

WRITING PRINCIPLE 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. If the action of a sentence is expressed by the main verb, the sentence is natural, direct, and easy to understand. If, instead, the action is expressed in a noun, the verb becomes buried and weak, and the sentence is dense and more difficult to understand.

ESL advice

Abstract nouns derived from verbs and adjectives are called nominalizations. Your readers will perceive your writing as dense especially 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
careful	care
centrifuge	centrifugation
compare	comparison
deduce	deduction
determine	determination
different	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

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	
was observed	caused	produced	make	get

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 An <u>increase</u> in temperature <u>occurred</u>.

In this example, the verb ("<u>occurred</u>") is not active but weak. The subject of the sentence ("<u>increase</u>") 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.**

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 another example:

Example 4-15 b This wavelength <u>caused a decrease</u> 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 With an increase in sperm concentration, the fertilization rate improved.

In this example, the action in the first part of the sentence is expressed in the nominalization "increase," which is the object of the preposition "with." The sentence is dense and difficult to read for two reasons: (a) "with" is imprecise: "when" would make the sentence clearer; and (b) the action is buried in the prepositional phrase without a verb.

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

Revised Example 4-15 c *When sperm concentration* ***was increased,*** the fertilization rate improved.

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.

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 principles presented, you will find your sentences not only more concrete, active, and concise but also more coherent and clearer for the reader.

4.7 NOUN CLUSTERS

WRITING PRINCIPLE 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 sparse matrix crystallization

b cultured rat tracheal endothelial cells

c When the strips were exposed to Leishmaniasis diseased patients' sera, we found the bands of 112 and 45 kDa.

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

Instead, 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 **crystallization *by* sparse matrix**

b **cultures *of* endothelial cells *from* the tracheas *of* rats**

c When the strips were exposed to **sera *of* patients *with* Leishmaniasis disease**, we found the bands of 112 and 45 kDa.

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

Note that not all sequences of nouns are noun clusters. Some noun pairs and clusters—such as "water bath," "cell wall," "egg receptor," and "sucrose density gradient"—are recognized as single words and accepted terms. When you untangle noun clusters, treat such terms as single words. Check a dictionary or other recent journal articles to determine which pairs of nouns are considered words if necessary.

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

WRITING PRINCIPLE 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 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	*Gram⁺ bacteria* do not respond to *these drugs*. Thus, they were of no interest to us.
Revised Example 4-19	Gram⁺ bacteria do not respond to *these drugs*. Thus, **these drugs** were of no interest to us. or **These drugs** were of no interest to us because Gram⁺ bacteria do not respond to ***them***.

Sometimes the noun 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

As human impacts on natural environments continue to increase, large species will become extinct faster than small species with similar biological characteristics. This can be illustrated with the use of our model predicting extinction risk from the level of external threat.

Here, "this" refers to an effect on the decline toward extinction. To avoid repeating so many words, we can use an *implied* term that encompasses the specific terms such as "trend." In the revision, "trend" is preceded by "this" to indicate that the trend was mentioned in the previous sentence.

Revised Example 4-21

As human impacts on natural environments continue to increase, large species will become extinct faster than in small species with similar biological characteristics. **This trend** can be illustrated with the use of our model predicting extinction risk from the level of external threat.

4.9 LISTS AND COMPARISONS

Parallel Ideas

WRITING PRINCIPLE 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*
but	**The more stable of the two states**	**expanded**	**twofold**
	the region of the metastable state	**decreased**	**10-fold.**

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.

Here 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*
Gene targeting in *P. patens* occurs both	**in**	**the laboratory**
and	**at**	**its natural habitat.**

Note that in Example 4-25, "in the laboratory" and "at its natural habitat" are in parallel form even though the specific prepositions ("in," "at") 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 that the child suffers from rheumatic disease.

In this sentence, the groups of words before and after "but" are not parallel, so it is not immediately obvious that the second half of the sentence is giving another possible reason for the illness. 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

GUIDELINE:

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.

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

4.10 FAULTY COMPARISONS

WRITING PRINCIPLE 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 very typical ambiguous comparison found in scientific papers:

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

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.

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.

Incomplete Comparisons

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

Example 4-29 This study tested 24 subjects compared to Menon's study.

Revised Example 4-29

A This study tested 24 subjects; Menon's study tested only 8 subjects.

B In this study, the number of subjects 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 more difficult.

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 **more difficult 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 more fertilized eggs in buffer A compared to buffer B.

Revised Example 4-31 We found **more** 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 compared to K_A.

Revised Example 4-32 K_D increased over time, **but K_A did not.**

4.11 COMMON ERRORS

WRITING PRINCIPLE 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. These errors can be avoided by carefully proofreading and double-checking the manuscript.

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.

ESL advice

The choice in spelling is sometimes between British and American versions of a word, which is especially confusing for ESL writers. Consult a dictionary to see whether one form is preferred to another or to check which version is British and which is American. Use a dictionary such as *the Dictionary of Contemporary English* that gives both British and American spellings, or search online dictionaries. Stick with one type of spelling or the other, but be consistent in your choice. Although generally written British English is more formal, this formality is not apparent in science writing. It is apparent much more in letter writing and other correspondences. North American English spelling is more common these days than British English spelling in scientific writing. However, it is usually a good idea to see what style your target journal has adopted. Many journals accept and use both British and American spelling if one of these spellings is used consistently throughout an article. Adjust your choice of punctuation rules accordingly as well. Grammar differences between the two language variations are few if any.

Most words that differ markedly between American English and British English are usually not used much in science, if at all. The most common differences in American and British English spelling are listed in Table 4.1 together with scientific words as examples.

Numbers versus Numerals

Various factors determine whether you need to spell out numbers or use numerals. These factors include different style guides, the size of the number, whether it is a scientific number with units, the context of the number, and what it is representing. For example, the APA style manual recommends spelling out single digit numbers (one through nine) and using numerals for 10 and above. However, *The Chicago Manual of Style* recommends spelling out whole numbers one through one hundred. Exceptions to these rules include:

1) Use numerals if scientific values are to be presented, i.e., for values with a unit (e.g., 6 days, 32 hr, 7.8 g) that do not begin a sentence.
2) Spell out any number used to begin a sentence (e.g., "Six hundred and three examinees participated in the experiment."). To avoid beginning a sentence with a number, reword the sentence so that it does not begin with the number (e.g., "Of these, 34 survived to adulthood.").
3) Large numbers, if rounded, are usually spelled out ("Three hundred animals frequented the water hole."); but, very large numbers (millions or more) are normally expressed with a mixture of numerals and spelled-out numbers ("The bird population was estimated to be 1.3 million.").
4) Although in informal writing you can use numerals and the "%" sign, as in "3% of the participants," in formal writing, you should spell out the percentage as, for example, in "5 percent of the participants."
5) For a series of mixed numbers greater and less than ten, use numerals as in "5, 10, and 15 hours."

Table 4.1 Differences between American and British spelling

AMERICAN SPELLING	BRITISH SPELLING	AMERICAN ENGLISH	BRITISH ENGLISH
-am	-amme	program	programme
-ay	-ey	gray	grey
-e-	-ae-, -oe-	edema, anesthesia, leukemia, pediatric	oedema, anaesthesia, leukaemia, paediatric
-er	-re	center, meter, fiber, liter	centre, metre, fibre, litre
-f-	-ph-	sulfur	sulphur
-ing, -able	-eing, -eable	aging, sizable	ageing, sizeable
im-, in-	em-, en-	imbed, insure	embed, ensure
-ize, yze	-ise, -yse	analyze, optimize, emphasize, realize	analyse, optimise, emphasise, realise
-l-	-ll-	signaling, labeling, modeling	signalling, labelling, modelling
-ll	-l	enroll, fulfill	enrol, fulfil
-og	-ogue	catalog	catalogue
-or	-our	tumor, flavor	tumour, flavour
-se	-ce	defense	defence
-um	-ium	aluminum	aluminium
-dg or -g	-dge or gu	aging, argument	ageing, arguement
-ed	-t	dreamed, learned	dreamt, learnt

Capitalization

Often authors are confused as to which words to capitalize. Here are some general guidelines:

1. **First word of a sentence**
   a. Begin every sentence or sentence equivalent with a capital letter.
   b. When you list items by points and the complete thought can be stated briefly, it is unnecessary to introduce the list with capitals:

Example 4-33 To start writing a research paper, scientists need

1. enough data,
2. valid references,
3. writing principles.

c. If the list cannot be stated briefly, introduce each subdivision with a capital letter and end it with a period.

2. Proper nouns

Capitalize all proper nouns within a sentence. Sometimes it may be difficult to distinguish between common and proper nouns. Common nouns do not require capitals within a sentence because they refer to everyday objects in a general sense. Proper nouns describe certain people, groups, or objects or are words derived from these sources. For this reason, the names of months and days are considered proper nouns because they are derived from names of gods and planets. These nouns are capitalized, whereas the seasons of the year are not capitalized (spring, fall). Proper nouns include the following categories:

a. names of persons and places (countries, regions, counties, cities, and other political and geographical divisions: Canada, Huntington's disease, Celsius)
b. names of months and days, languages, races, geological and historical periods and events, and documents (November, English, Friday, the Ice Age)
c. names of organized bodies and the distinguishing names substituted for them (American Chemical Society)
d. names of institutions, churches, schools, libraries, buildings, hotels, clubs, corporations, ships, and so forth (University of California, National Institutes of Health)
e. official titles of persons when used without their personal names (the Chief Scientist)

3. Quotations

Use a capital letter for the opening word of a quoted sentence but not for quoted phrases:

(Their report mentioned only "height, width, and breadth.")

4. Titles

Capitalize every important word in titles and literary titles. Prepositions, articles, and conjunctions are not capitalized unless one of them is the initial word in the title. (*Journal of Biochemistry, Handbook of Scientific Communication*). Note that some styles such as the *Publication Manual of the American Psychological Association* (APA) style capitalize all words in titles of 4 letters or more (e.g., "With").

5. Biological classification

The scientific name of a phylum, class, order, family, or genus is capitalized, but the name of a species or subspecies, or a common name, is not (*Olenellus thompsoni,* but arthropod and trilobite).

6. Parts of a book or report

Capitalize words followed by a number or letter to indicate the parts of a book or report that are used in text references (Appendix A, Chapter 2, Volume 12). Note that the sections of a research article are

also capitalized if a specific section is referred to (Materials and Methods, Results, Discussion), but these sections are not capitalized if they are discussed in a general sense (methods section, introduction, discussion.)

Italics

Certain words and phrases in science, generally Latin derivatives, are placed in *italics*. Aside from genus and species names, subheadings, foreign words, emphasized words, and titles of journals, books, and manuals, the following words are typically written in italics. Note that some styles such as APA style do not follow this rule.

in vivo *in vitro* *in organello*
de novo *in vacuo*

Punctuation

To avoid possible misinterpretation of your writing, pay attention to correct punctuation. In contemporary English, the trend is toward less punctuation and more simplicity.

Here are a few important rules for punctuation:

ESL advice

1. Use simple punctuation.

The best approach to punctuation is usually the simplest. If you are confused over how to punctuate a particular sentence, readers will probably be confused as well. Rewrite the sentence in a form that requires only simple punctuation. Note that unlike some foreign languages, there are very few exclamation marks in English and essentially none in scientific writing.

2. Use a period to end a full sentence.

The trend in scientific writing is to eliminate semicolons and to use only periods (full stops) to end sentences.

Example 4-34 *Older style:* TS-25 was a heat inducible mutant; thus, it was given the prefix "TS."

Revised Example 4-34 *Newer style:* TS-25 was a heat-inducible **mutant. Thus**, it was given the prefix "TS."

3. Use semicolons to connect two independent sentences.

Place a semicolon between sentences that contain closely related ideas and are not linked by a coordinating conjunction such as "and," "or," and "but." However, remember that the trend in scientific writing is to eliminate semicolons.

Example 4-35 Some viruses are **deadly; others** are not.
or
Some viruses are **deadly. Others** are not.

4. Use commas for clarity and emphasis.

Check each sentence for reading errors. Then decide whether a phrase or sentence needs a comma or not. Consider the following example:

Example 4-36 Although samples were incubated at 37 °C for 24 hr we did not observe any change in the growth pattern.

This sentence has more than one possible interpretation depending on where the comma is placed:

Example 4-36 Interpretation A Although samples were incubated at 37 °C for 24 **hr, we** did not observe any change in the growth pattern.

Interpretation B Although samples were incubated at **37 °C, for** 24 hr we did not observe any change in the growth pattern.

It is important to place a comma at the correct location within the sentence to make the meaning of your writing clear. The comma's overall role is to add clarity or emphasis to a sentence.

Commas are needed under the following circumstances:

(a) Whenever a dependent clause or a long adverbial phrase comes before the main statement of the sentence, it needs a comma. Example 4-36 is an example of this rule.

(b) Transitional words and phrases are usually separated by a comma when they are used as an introductory phrase at the start of a sentence.

Example 4-37 Propanol, ethanol, and butanol are all organic alcohols. **However,** aerosol is not an organic alcohol. (or: Aerosol, **however,** is not an organic alcohol.)

However, commas are not placed after or in front of transition words if the flow of the sentence would be interrupted as in the following case:

Example 4-38 The cells absorbed the dye and were therefore blue.

(c) To determine whether to use commas for a clause that is within a sentence, read the sentence without the clause. Punctuation depends on whether the dependent clause within a sentence is essential or not. If the dependent clause is essential to the meaning, do not use commas. If the dependent clause is not essential for the meaning of the sentence, however, set it off by commas.

Example 4-39 a Some of the **cultures, which** came from Tennessee, were damaged.

b Of the cultures, 10% were damaged upon arrival. The cultures that were damaged were discarded.

Generally, commas are used with the word "which" but not with "that." See also Appendix on "Commonly Confused and Misused Words" for more information on "which" and "that."

Especially ESL writers are often confused about comma use elsewhere in the sentence. One particular comma placement that gets misused often is between the subject and the verb. Do not separate the subject and verb by a comma. If you disrupt the subject and verb by a dependent clause, use two commas, one before and one after the clause.

5. Place a comma between the items in a series as well as before the word *and*.

Commas should separate items in a series. In American scientific writing, a comma is also placed before the *and* in the series unlike in British English and unlike in American literary writing. Often this placement is important to the meaning of the sentence.

Example 4-40 a *E. coli* can produce septicemia, **meningitis, and** pneumonia.

b ARE-mRNAs can be rapidly stabilized upon exposure to certain signals including immune stimulation, UV and ionizing irradiation **(5), and** heat shock (10).

6. Use semicolons and/or numerals to punctuate complex series.

To separate independent but related clauses without using "and," "or," or "but," use a semicolon, but remember the trend in English is to eliminate this use when possible.

Use semicolons and numerals to separate the items within the sentence when items in a series are unusually long and especially when they contain their own punctuation. Use a colon to introduce the list or series.

Example 4-41 Antibiotic-resistant pathogens often cause infections and are an important source of mortality for patients hospitalized in an ICU. Of concern are especially gram-negative bacilli, such as Klebsiella and Enterobacter, producing extended-spectrum ß-lactamases, multiple drug-resistant *M. tuberculosis,* and fluconazole-resistant Candida spp., especially *Candida krusei, Candida glabrata,* and *Candida albicans* in HIV patients.

Revised Example 4-41 Antibiotic-resistant pathogens often cause infections and are an important source of mortality for patients hospitalized in an ICU. Of concern are especially: **(1)** gram-negative bacilli, such as Klebsiella and Enterobacter,

producing extended-spectrum **ß-lactamases; (2)** multiple drug-resistant ***M. tuberculosis;* and (3)** fluconazole-resistant Candida spp., especially *Candida krusei*, *Candida glabrata*, and *Candida albicans* in HIV patients.

7. Avoid weak connectors.

Scientists are extremely fond of coupling pairs of independent sentences. However, the words "and," "but," "for," "or," and "nor" are weak connectors. If weak connectors cannot be avoided, they should be set off by commas. For stronger writing, consider making each statement a separate sentence.

An example of weak writing is given next.

Example 4-42

The amplitude of the potential pattern in the electrolyte decreases with increasing distance from the electrode and expands parallel to the electrode at the same time (Figure 6a, top), and this expansion is also felt at the electrode/electrolyte interface in the form of changed migration current densities, indicating that the migration coupling encompasses a wide range of the electrodes, sometimes even all of the interface.

Revised Example 4-42

The amplitude of the potential pattern in the electrolyte decreases with increasing distance from the electrode and expands parallel to the electrode at the same time (Figure 6a, top). This expansion is also felt at the electrode/electrolyte interface in the form of changed migration current densities. Thus, the migration coupling encompasses a wide range of the electrodes, sometimes even all of the interface.

8. Avoid quotation marks.

Whenever you copy another writer's or speaker's exact words, enclose the material in standard (double) quotation marks (although this happens rarely in scientific writing). Use single quotation marks for a quote within a quote. Remember to cite the source of the material, including the page number on which it appears.

When the name of an article or book chapter is cited in the text, enclose it in double quotation marks. Sometimes titles can also be placed in italics.

Example 4-43

An article, "Structure of the 30S Ribosomal Subunit," recently appeared in *Cell*.

In journals, quotation marks are often used around new technical terms, old terms used in an unusual way, or simply to draw attention to a word. (In books, italics or boldface are often used instead.)

9. Avoid hyphenation.

Avoid hyphens if possible. Write "cooperation" and "rearranged," but hyphenate two (or more) word clusters such as "English-speaking," "high-pressure," and terms that contain a capital letter or a number and a noun such as "N-terminal" and "100-fold."

10. Abbreviations.

In scientific English, abbreviations for a single word are spelled with a period as in "Prof.," and "fig." Note that in British English, titles do not have a final period if the last letter of the abbreviation corresponds to the last letter of the word itself (Dr, Mr, Mrs, Ms), whereas American English prefers the period after these abbreviations (Dr., Mr., Mrs., Ms.). Units of measure are usually lowercase without a period (kg, min), even when they are acronyms (ppm [parts per million]). Other acronyms not referring to units of measure are usually capitalized without periods (DNA) but can also be a mixture of lowercase and uppercase letters (iRNA, ssDNA.) Units of measure named after people are capitalized without period (C [Celsius], F [Fahrenheit]).

Subject-Verb Correspondence

The subject and verb of a sentence must agree. A singular subject must have a singular verb, and a plural subject must have a plural verb.

Example 4-44 The *blood, urine, and stool* of each patient was examined.

The subject of the sentence is "blood, urine, and stool," not "patient." Because the subject is plural, the verb must be plural as well.

Revised Example 4-44 The *blood, urine, and stool* of each patient **were** examined.

Many scientific authors are confused about such words as "data," "spectra," and "media." "Data," "spectra," and "media" are the plural forms of "datum," "spectrum," and "medium" and thus should be treated as plural nouns. (Note that some dictionaries do accept use of both singular and plural verbs for these words.)

Example 4-45 Our data **suggest** that Klein's hypothesis is correct.

Other singular and plural forms of words commonly used in the biomedical sciences are shown in Table 4.2.

Table 4.2 Singular and plural nouns forms

SINGULAR	PLURAL
alga	algae
analysis	analyses
bacterium	bacteria
criterion	criteria
datum	data
flagellum	flagella
genus	genera
hypothesis	hypotheses
larva	larvae
matrix	matrices
medium	media
nucleus	nuclei
phenomenon	phenomena
serum	sera
spectrum	spectra
stimulus	stimuli

Subjects and verbs should not only agree, they should also make sense together.

Example 4-46 The *concentration* of the protein was measured.

Unlike temperature or amounts, concentration cannot be measured. It has to be calculated or determined.

Revised Example 4-46 The *concentration* of the protein was **determined**.

Unclear Modifiers

Unclear modifiers, such as dangling modifiers or misplaced modifiers, are words or phrases that modify an element of a sentence in an ambiguous manner because they could either be modifying the subject or the object of the clause. Avoid dangling or misplaced modifiers.

In general, you should place modifiers near the word or words they modify, especially when a reader might think that they modify something different in the sentence.

Dangling modifiers most frequently occur at the beginning of sentences (often as introductory clauses or phrases) but can also appear at the end. They often have an -ing word (gerund) or an infinitive phrase near the start of the sentence. To revise a sentence that contains a dangling modifier, name the appropriate or logical doer of the action as the subject of the main clause or change the phrase that dangles into a

complete introductory clause by naming the doer of the action *in that clause.*

Example 4-47 Having tested positive for HIV, we disqualified the patients for participation in the study.

This modifier is unclear because it modifies "we." It sounds as if "we" tested positive for HIV.

Revised Example 4-47 Having tested positive for HIV, **the patients** were disqualified for participation in the study.
or
Patients that tested positive for HIV were disqualified for participation in the study.

Following is another example:

Example 4-48 While incubating at 30°C, we added another 10 ml of buffer K to the samples.

"While incubating at 30°C" appears to modify "we." Because "we" were not incubating, this modifier is an unclear modifier.

Revised Example 4-48 **While the samples were incubating at 30°C**, we added another 10 ml of buffer K to them.
or
We added another 10 ml of buffer K to the samples **while they were incubating** at 30°C.

SUMMARY

WRITING PRINCIPLE 12: Use the first person.
WRITING PRINCIPLE 13: Use the active voice.
WRITING PRINCIPLE 14: Use past tense for observations, completed actions, and specific conclusions.
WRITING PRINCIPLE 15: Use the present tense for generalizations and statements of general validity.
WRITING PRINCIPLE 16: Write short sentences. Aim for one main idea in a sentence.
WRITING PRINCIPLE 17: Use active verbs.
WRITING PRINCIPLE 18: Avoid noun clusters.
WRITING PRINCIPLE 19: Use clear pronouns.
WRITING PRINCIPLE 20: Use correct parallel form. If possible, arrange ideas in a list to read from shorter to longer.
WRITING PRINCIPLE 21: Avoid faulty comparisons.
WRITING PRINCIPLE 22: Avoid errors in spelling, punctuation, and grammar.

CHAPTER 6

From Sentences to Paragraphs

6.1 PARAGRAPH STRUCTURE

Aside from paying attention to words and sentences, authors need to construct paragraphs carefully. If paragraphs are not clearly constructed, a paper that has perfect word choice, word location, and sentence structure can be difficult to understand. Let us look at a paragraph in which the author has not paid much attention to the needs of the reader:

Example 6-1

1Volcanic ash adsorption poses a great environmental hazard. **2**The deposition of this ash and the subsequent draining of its volatiles is a rapid route by which elements and ions are delivered to the ground (3–5). **3**Due to similar magma types, there appears to be some similarity in the compositions of leachates derived from volcanoes in the same regions. **4**The greatest hazard to the environment is posed by magmas with relatively high halogen content, and many hazardous leachate fluoride concentrations are found in volcanoes with high F/SO_4^{2-} ratios. **5**Finer particle sizes, <2 mm across, appear to experience enhanced adsorption, with the implication that leachate hazards may be high even where ashfall is limited (7, 8). **6**Enhanced growth of sulphuric acid droplets in high humidity conditions can increase gas accumulation, which increases the probability of contact with ash particles (12). **7**The measuring and reporting of leachate results should be standardized.

If you catch yourself reading this paragraph more than once, you are not alone. You may think that you have not paid enough attention and start reading it over. Some readers may even consider themselves not smart

enough to understand the topic. The individual sentences are intelligently composed and free of grammatical errors. The sentences are also not overly long or complex. The vocabulary is professional but not beyond the scope of the educated general reader. Nonetheless, most of you arrive at the end of the paragraph without fully understanding what the author is saying. The problem lies not with you but with the author because the author has not composed the paragraph with the reader in mind.

When you take a closer look at this paragraph, you can see that the paragraph has not been organized properly. It is neither coherent nor cohesive or consistent. In fact, important information, such as transitions and logical connections, seem to have been left out. Even more, sentences seem to be put together at random and not in any logical order. For readers to follow the logic of a paragraph, its sentences have to be organized. Let us look at the revised version of Example 6-1:

Revised Example 6-1 A

1Volcanic ash adsorption poses a great environmental hazard. **2**The deposition of this ash and the subsequent leaching of its volatiles is a rapid route by which elements and ions are delivered to the ground (3-5). **3′***Adsorption can be influenced by magma type, particle size, and humidity conditions (7).* **3***For example,* there appears to be some similarity in the compositions of leachates derived from volcanoes in the same regions due to similar magma types. **4***In fact,* the greatest hazard to the environment is posed by magmas with relatively high halogen content, and many hazardous leachate fluoride concentrations are found in volcanoes with high F/SO_4^{2-} ratios. **5***Aside from magma type,* finer particle sizes, <2 mm across, appear to experience enhanced adsorption, with the implication that leachate hazards may be high even where *ash deposition* is limited (7, 8). **6***Furthermore,* enhanced growth of sulphuric acid droplets in high humidity conditions can increase *adsorption,* which increases the probability of contact with ash particles (12). **7***Ideally,* the measuring and reporting of leachate results should be standardized.

After looking at this revision, you may now recognize the lack of organization and links in the original paragraph. You can see that an important missing link was sentence 3′. It ties sentences 3 through 6 together and links them to the beginning of the paragraph. Adding the transitions "for example," "in fact," "aside from," "furthermore," and "ideally" logically connects the ideas in the paragraph. All these connections were left unarticulated in the original paragraph. Replacing "ashfall" with "ash deposition" and "gas accumulation" with "adsorption" helps to keep the reader focused on the topic because terms are used more consistently throughout the paragraph. We can see that most of our difficulty in understanding the original paragraph was due not to any deficiency in our reading skills but rather to the author's lack of knowledge and understanding of our needs as readers.

Although the revision greatly improved the paragraph, we could revise it even more:

Revised Example 6-1 B

1′Volcanic ash adsorption poses a great environmental hazard *because adsorbed volatiles can be rapidly deposited and subsequently leached into the ground.* **2′***Adsorption can be influenced by magma type, particle size, and humidity conditions (7).* **3***For example,* similar magma types derived from volcanoes in the same regions exhibit similar compositions of leachates. **4***In fact,* the greatest hazard to the environment is posed by magmas with a relatively high halogen content and by magmas with high F/SO_4^{2-} ratios in which many hazardous leachate fluoride concentrations are found. **5***Aside from magma type,* finer particle sizes, <2 mm across, appear to experience enhanced adsorption, with the implication that leachate hazards may be high even where *ash deposition* is limited (7, 8). **6***Furthermore,* high humidity results in enhanced growth of sulphuric acid droplets, which increases adsorption by increasing the probability of contact with ash particles (12). **7′***Unfortunately, the use of different leachate analysis techniques currently prevents useful comparison between data.* **8***Ideally,* the measuring and reporting of leachate results should be standardized.

The flow of the paragraph has been further improved in Revised Example 6-1B. Sentence 1 and 2 have been combined into sentence 1′, making their relationship clearer through the use of "because." Another link, sentence 7′, has been placed before the last sentence to more logically connect it to the rest of the paragraph. If these additions and transitions truly reflect what the author had in mind is only known to the author himself or herself, however.

To construct a paragraph clearly, each paragraph needs to be written such that it tells a story. Readers should be able to follow the story of each paragraph regardless of whether they understand the science. A well-constructed paragraph must not only be organized, it must also be coherent. In addition, important ideas should be emphasized, and subtopics should be signaled.

6.2 PARAGRAPH ORGANIZATION

WRITING PRINCIPLE 23:
Organize your paragraphs.

A paragraph is a group of sentences on a single topic. The sentences within a paragraph are not put together randomly, however. In a well-written paragraph, the sentences need to be logically organized and positioned.

Sentence Positions

Every paragraph contains two important power positions: the first sentence and the last sentence. Usually, the first sentence introduces the topic of the paragraph, whereas the last sentence may be used to summarize, draw a conclusion, or emphasize something of importance.

These power positions are not equal. The first position in a paragraph is considered more powerful than the last position because it gives the reader a direction of where the paragraph is going. Within the first and the last sentence of the paragraph, the psychological geography of the sentence structure is particularly important. The beginning of the sentences should describe familiar information, whereas the stress position within these sentences should highlight significant words to be emphasized (see also Chapter 3).

Topic Sentence

WRITING PRINCIPLE 24:

Use a topic sentence to provide an overview of the paragraph.

Generally, a well written paragraph gives an overview first and then goes into detail. Note that most of the time, it is clearest to have only one message per paragraph. The overview is usually provided by the first sentence, the so-called topic sentence. The topic sentence states the central topic or message of the paragraph and guides the reader into the paragraph. The end or stress position of the topic sentence highlights the topics that the author wants readers to follow in the rest of the paragraph. The paragraph then develops that message by using examples, definitions, justifications, contradictions, or by analyzing and solving a problem.

Although a topic sentence may appear anywhere in the paragraph, it is usually the first sentence, that is, the first power position. The first sentence of a paragraph may also contain a transition from the previous paragraph or section. Some paragraphs may even contain more than one topic sentence. If a topic sentence is placed at the end of a paragraph, it receives extra emphasis. This sentence may introduce the topic of the next paragraph(s). It can also serve as a summary or conclusion. In a well-written paper in which all the topic sentences are in the first power position, a reader can simply scan the topic sentences alone and know what the paper is about without having read it entirely.

The Middle of the Paragraph

GUIDELINE:

Arrange the details in the remaining sentences.

Details within the paragraph are organized depending on the purpose of the information contained in the paragraph. The pattern of the

organization may be listing details from most to least important, least to most important, in an announced order, or chronologically. Other paragraphs may be written in a compare-and-contrast pattern or in a problem-and-solution pattern.

The following examples both begin with a topic sentence. The details found in the remaining sentences are organized logically and consistently to explain the message provided by the topic sentence.

Example 6-2

Volatile organic compounds (VOCs) are emitted from a variety of manmade and natural sources. Manmade sources include motor vehicles, chemical plants, refineries, factories, consumer and commercial products, and other industrial sources. Natural sources responsible for biogenic VOC emissions include oak, citrus, eucalyptus, pine, spruce, maple, hickory, fir, and cottonwood. The overall relative contributions of manmade versus natural sources of VOCs have not been clearly established, but the relative contributions of these source groups vary depending on geography.

The topic of the preceding paragraph is "VOCs." The pattern of organization, that is, the order of the remaining sentences, is not random but proceeds in the order the items are listed: *manmade* first, then *natural*.

Consider another example:

Example 6-3

For the preparation of postmitochondrial fractions, placentas were obtained after delivery. Their membranes were removed, and the organs were washed extensively at 4 °C with buffer A (10 mM Tris-HCl, pH 7.5, 20 mm $Mg(acetate)_2$, 100 mM K(acetate), 0.4 mM EDTA). The organs were then shock frozen in liquid nitrogen as 20 g aliquots and subsequently stored at –80 °C. For postmitochondrial preparation, 20 g of frozen tissue was suspended in 20 ml of buffer A containing 200 mM sucrose through homogenization in a blender. To separate cell debris and nuclei, the homogenate was centrifuged at 1,500 × *g* for 2 min at 4 °C. To obtain the postmitochondrial fraction, the supernatant was then recentrifuged at 20,000 × *g* for 20 min.

Example 6-3, which is from a Materials and Methods section of a prepublication journal article, also has a topic sentence ("For the preparation of postmitochondrial fractions ..."). The remaining sentences of the paragraph are organized in a chronological pattern in which the reader can follow step by step how the fractions were prepared from the original tissue. The subjects of the sentences in the preceding example are all tissue or fraction related. The paragraph begins with a goal ("For the

preparation of ...") and ends with a statement that indicates "mission accomplished."

Aside from the general organization of the paragraph, the author also needs to pay attention to word location and to keeping a consistent order of topics and a consistent point of view. These points are addressed in more detail in the next sections.

Topic Order

WRITING PRINCIPLE 25:
Use consistent order.

Although parallel form is most often used at the sentence level (see Chapter 4), in scientific papers, it can also be used in a larger context. Parallelism helps locate information in paragraphs, sections, chapters, and so forth. Good parallel form puts related ideas together in the same grammatical form and style and thus provides consistency throughout the paper.

If you list items in a topic sentence and then describe them in the remaining sentences of a paragraph, you should not only use parallel form but also keep the same order. For example, if the items in the topic sentence are "dogs," "cats," and "birds," the remaining sentences of the paragraph should explain first "dogs," then "cats," and last "birds." This way the reader's expectation is fulfilled. Make sure you include all the items mentioned in the topic sentence. Avoid interrupting the order of your items by filling in with other information. Also, do not add any items *not* mentioned in the topic sentence.

An example of a paragraph in which consistent order is used is Example 6-4.

Example 6-4

1In response to a foreign macromolecule, five different immunoglobulins can be synthesized: IgG, IgM, IgA, IgE, or IgD. **2**IgG is the main immunoglobulin in serum. **3**IgM is the first class to appear following exposure to an antigen. **4**IgA is the major class in external secretions such as saliva, tears, and mucus. **5**Thus, IgA serves as a first line of defense against bacterial and viral antigens. **6**IgA is transported across epithelial cells from the blood side to the extracellular side by a specific receptor. **7**IgE protects against parasites. **8**The role of IgD is not known.

In this example, the topic sentence lists five items. The remaining sentences of the paragraph explain these items in the same order as they are introduced in the topic sentence and use exactly the same key terms (IgG, IgM, IgA, IgE, and IgD). Note that other information has been filled in between sentences 4 and 7. Interruption such as that can make paragraphs

difficult to read because reading about the last items is delayed. If such an interruption is longer, consider placing the additional information into a separate paragraph.

Point of View and Person

WRITING PRINCIPLE 26:
Use consistent point of view.

ESL advice

Be consistent in your point of view and person. Switching from one style (point of view or person) to another within a document disorients the reader. ESL authors should pay special attention to this principle, as many tend to switch the point of view within paragraphs for no apparent reason.

The point of view is consistent when the same term, or the same category term, is the *subject* of successive sentences that deal with the same topic. The point of view is inconsistent when the topic is the same, but the subjects of the sentences are different or when the person is switched (e.g., from third to second person). An inconsistent point of view makes similarities and differences difficult to see for the reader.

Here is an example.

Example 6-5

1This study suggests that *patients* with a prolonged febrile illness should always be a consideration for tuberculosis, especially if family members have been born in a country where tuberculosis is endemic. **2**Tuberculosis presents not only as fever, **3**but you may also have lymphadenopathy and arthritis. **4***Patients* with disseminated tuberculosis usually have evidence of pulmonary or hepatic disease.

The subjects of sentence 1 and 4 are "patients." However, in sentences 2 and 3, the point of view is not consistent: Neither the first nor the second subject of the sentence is *patients*. The first subject of the sentence is *tuberculosis*. For the second subject, there is a switch in person to *you*. Switches like this are very disruptive to the paragraph and disorienting for the reader.

Revised Example 6-5

1This study suggests that *patients* with a prolonged febrile illness should always be a consideration for tuberculosis, especially if family members have been born in a country where tuberculosis is endemic. **2Patients** with tuberculosis present not only with fever, **3**but may also have lymphadenopathy and arthritis. **4***Patients* with disseminated tuberculosis usually have evidence of pulmonary or hepatic disease.

6.3 PARAGRAPH COHERENCE

Cohesion and Word Location

WRITING PRINCIPLE 27:

Make your sentences cohesive.

Within a paragraph, the sentences not only need to be logically organized, they also need to be cohesive. Sentences are cohesive if they fit neatly and logically together. When authors arrange sentences to be cohesive, they consider word location. Good word location creates good "flow" of a paragraph.

Example 6-6

1Important pathogens can be found in the genus

Yersinia. 2***Yersinia*** contains several **species**. 3**One species**,

Y. pestis, is the cause of bubonic **plague**. 4The **plague** bacillus infects lymph nodes near the site of infection to produce buboes.

The reader conceives these sentences as cohesive because the information provided at the beginning of sentences 2, 3, and 4 relates to the one at the end position of the sentences directly preceding them (see also Chapter 3 on word location.)

If more and more new information is added before the relationship between the two sentences is clear, the continuity of a paragraph is broken. Consider the following example:

Example 6-7 a *Yersinia* contains several **species**. The cause of bubonic plague, also known as the "black death," is one **species**, *Y. pestis*.

b *Yersinia* contains several **species**. **One species**, *Y. pestis*, is the cause of bubonic plague, also known as the "black death."

The flow of Example 6-7a is not as smooth as that of Example 6-7b because new information ("bubonic plague," "black death") is introduced before the information of the previous sentence ("*Yesinia*," "species") is repeated. Example 6-7b is much more direct, and the continuity between the sentences much smoother due to the word location of the key term "species." In this example, the information of the previous sentence has been placed at the beginning of the new sentence due to jumping word location.

Placing information provided at the end of a sentence at the beginning of the next sentence is not the only way to provide paragraph cohesion.

Cohesion can also be created by providing a consistent point of view as in the next example.

Example 6-8

Rhubarb is a frequently used Chinese herbal medicine. **It** is used to treat various ailments including constipation, inflammation, and cancer.[1,2] As a drug, **rhubarb** is made up of the roots and rhizomes of three members of the *Polygonaceae* family, *Rheum officinale, R. palmatum,* and *R. tanguticum*. Different **rhubarb** species show substantial differences in purgative effects and chemical compositions. However, **they** are similar in physical appearance and thus difficult to distinguish.

Here information in the topic position of each sentence refers back to the topic position of the first (or topic) sentence. In other words, a consistent point of view is kept—the subject in each sentence is the same term or category term.

Many, if not most, paragraphs contain a mixture of these two types of word placement. For some sentences, information in the topic position may refer back to the end position of the previous sentence. For other sentences, information may be written from the point of view of the old information and refer back to the topic position of the topic sentence or subtopic sentence. An example of such a "mixed" paragraph is shown next.

Example 6-9

The **prophylactic** administration of drugs can sometimes be detrimental to patients, especially if prophylaxis is **continued** for several days. **Continued** exposure of the host's microbial flora to antibiotics often leads to resistant strains, and this can lead to **superinfection**. **Superinfection** can be avoided, however, by prophylactically using probiotics together with the antibiotics to restore normal flora. **Prophylaxis** is recommended when the host is subjected to a **treatment**, not involving antibiotics, that can lead to serious disease. One such **treatment** is **surgical procedure**. In **surgical procedures, prophylaxis** is usually directed at preventing staphylococcal infection. In **surgical procedures** that are considered "clean," antibiotics are not recommended.

This paragraph flows well. Notice that every sentence in the paragraph has at least one link to a previous or subsequent sentence. Some sentences will have both, a link to the previous sentence and one to a sentence following,

and in a few instances there may be three links, such as when a sentence introduces a subtopic.

Constructing paragraphs in which mixed word locations occur is okay—as long as the links do not get too muddled to risk losing the reader as in the next example:

Example 6-10

Animals, particularly domestic animals, are important reservoirs and sources of disease to humans. *Salmonella* species are normally found in the intestinal tract of animals such as poultry and cattle. When humans ingest contaminated food, the salmonellae can cause disease called Salmonellosis. In terms of animal disease transmission, humans often represent a dead end because the disease cannot be transferred from human to human. Salmonellosis may be acquired from animals, but the infected human can also serve as a source of disease to other humans.

In this example, old and new information has been misplaced and is therefore not linked clearly. As a result, there are too many links between sentences. Readers get confused, as they no longer can distinguish between what is the topic and what is the stress in each sentence or in the paragraph as a whole. As a result of such misplaced information, the paragraph is not very cohesive and does not "flow" well. By checking your own writing for what has been placed in the topic and stress positions in your sentences, you can perceive where potential problems exist and then improve your writing to better meet the reader's expectations.

Misplacement of old and new information, as seen in the preceding example, is one of the main problems in professional writing. Information is usually misplaced because most writers want to capture any important new thought before it escapes. As most writers write linearly, new information is wrongly placed at the beginning of the sentence and old information ends up at the end of a sentence. Only during the revision stage are logical links between sentences considered but may not be caught if the author does not revise or not revise sufficiently enough. Authors who misplace information are attending more to their own need for unburdening

themselves of their information than to the reader's need for interpreting what is written.

Another extreme in paragraph construction occurs when an author creates no links between sentences. Links are most often ignored when an author assumes that the reader is familiar with the topic or that logical jumps are clear. Missing links may not be obvious to the author but usually confuse and frustrate readers as in the following example:

Example 6-11

1A range of giant mammals, birds and reptiles lived on Earth during the Pleistocene Epoch. **2**These creatures included the woolly mammoth, sabre-toothed cat and giant deer in the Northern Hemisphere, and giant marsupials like *Diprotodon* in Australia. **3**Palaeontologists are very interested in ice age mammals. **4**The part played by **humans** in the extinction of the megafauna is very unclear. **5**Many researchers believe that the migration of **humans** into various parts of the world contributed to the extinction of many large animals. **6**Environmental changes were also associated with the onset of the last glacial cycle.

In the preceding example, either no links or no clear logical links have been established between sentences 2, 3, and 4, nor between sentences 5 and 6. Here, word location has not been considered, and sentences cannot be linked because critical terms, and thus critical information, are missing. Are giant mammals the same as ice age mammals? Is the Pleistocene epoch meant by megafauna? Does this epoch correspond to the last ice age? The connection between these terms is not clearly established, maybe because the author assumes that readers are familiar with this terminology. Instead, readers are left guessing at the missing connections between sentences.

Coherence and Continuity

Cohesive flow is the first of two steps toward creating continuity for your readers. The other step is to make your paragraphs and passages coherent. A coherent paragraph consists of a series of sentences that lead logically from one to the next, thus creating continuity. The ideas in a sentence need to be linked such that the story flows smoothly from sentence to sentence (and paragraph to paragraph). Readers consider a paragraph to be coherent if they can quickly find the topic of each sentence and if they see how the topics are a related set of ideas.

Along with topic sentences and word location, *key terms* and *transitions* are the main techniques used to create the logical framework, and

thus coherence, of a paragraph and of a paper. Repeating and linking key terms ensures that the topic of the work cannot be missed and that relationships between topics are clear. In addition, transitions create continuity by indicating the logical relationship between sentences and/or paragraphs, particularly for sentences that cannot be linked by word location.

Key Terms

WRITING PRINCIPLE 28:

Use key terms to create continuity.
Repeat them exactly and early, and link them.

Key terms are words or short phrases used to identify important ideas in a sentence, a paragraph, and the paper as a whole. Usually, key terms are used to identify your main points in the topic sentence. Key terms should be clearly defined and identical throughout the paragraph (and the document). They can be technical terms, such as "kinase" or "HIV-1," or nontechnical terms such as "mechanism" or "decrease."

Key terms should not be changed but should be kept the same consistently. If you deliberately repeat key terms, your main points are emphasized and you create continuity. For clear continuity, repeat key terms *exactly.* If a key term is not repeated exactly and another term is used instead, it may be difficult to see the relationship between the two terms. Although readers within the field may be familiar with the relationship, readers outside the field may not be.

Example 6-12

To assess original conditions of crystal nucleation and growth in metamorphic rocks, it is necessary to analyze crystal distribution quantitatively. Density could potentially provide insight into the time scale of mineral growth following the thermal peak of metamorphism.

How does "density" relate to the previous sentence? Readers unfamiliar with this particular topic may not know that "crystal distribution" and "density" here mean the same thing. Readers may be confused when two different terms are used. To avoid confusing readers, write with the nonspecialist in mind. Do not change key terms.

Revised Example 6-12

To assess original conditions of crystal nucleation and growth in metamorphic rocks, it is necessary to analyze crystal distribution quantitatively. **Crystal distribution** could potentially provide insight into the time scale of mineral growth following the thermal peak of metamorphism.

In the revised example, "crystal distribution" is the main key term that holds the paragraph together. Because it is repeated exactly, the

relationship between the two sentences is clear, and even readers outside the field of protein chromatography will understand the passage.

Linking Key Terms

When you need to shift from a category term to a more specific term or the other way around, key terms should be linked so continuity is not lost and the paragraph stays coherent. To link key terms, use the category term to define the specific term.

Example 6-13

Infectious diseases that arise due to travel may be caused by gram-positive organisms. **One such organism,** *Staphylococcus aureus,* can cause cellulitis, purulent arthritis, and suppurative lymphadenitis.

If key terms are not linked, as in the next example, readers stumble and get lost.

Example 6-14

So far, we have only looked at electrode reactions that are connected to an N-shaped I/φ_{DL} characteristic whereby φ_{DL} is the autocatalytic variable. The S-shaped, current-potential characteristic has a negative differential resistance but shows an opposing behavior with respect to pattern formation.

A key term or category term has to be included in the second sentence to create a link between the sentences. The term "I/ϕ_{DL} characteristic" is the key term in the first sentence. "The S-shaped, current-potential characteristic" described in sentence 2 is actually another type of the "I/ϕ_{DL} characteristic." Although this relationship may be clear to the author, readers may not know how these terms are linked. Linking these key terms by a suppressed "which is..." clause will make the relationship clear to the reader.

Revised Example 6-14

So far we have only looked at electrode reactions that are connected to an N-shaped I/ϕ_{DL} characteristic whereby φ_{DL} is the autocatalytic variable. **Another type of I/ϕ_{DL},** the S-shaped, current-potential characteristic, has a negative differential resistance but shows an opposing behavior with respect to pattern formation.

The term "which is" could be included: "Another type of I/ϕ_{DL}, which is the S-shaped, current-potential characteristic,..." However, because the definition is clear without "which is," it can be omitted. Leaving out the "which is" creates an appositive, a very useful way to define a scientific term while conserving words.

The definition should not be written as a separate sentence because this separation would break the continuity. To maintain continuity, it is important to include the definition as a part of an existing sentence. When key terms are linked and repeated consistently and early, good word location almost always falls right into place.

Transitions

WRITING PRINCIPLE 29:
Use transitions to indicate logical relationships bewteen sentences.

To ensure continuity within a paragraph, a writer must use key terms and also make use of other techniques such as transitions. Transitions ensure that the reader understands what each sentence says and indicate how the sentences and paragraphs are logically related to each other and to the story. Transitions should be placed at the beginning of a sentence for strongest continuity, usually set off by a comma.

If transitions are missing, the logical relationship between sentences can be unclear and may even be nonexistent. The importance of adding transitions is shown in Example 6-15 and its revisions.

Example 6-15

To determine the effects of solid-solution ratio on K12 adsorption at fixed pH 7, K12 adsorption isotherm experiments were conducted. _____ aqueous carbonate concentrations were measured.

The logical relationship between the first and second sentence of this example is not immediately obvious to the reader. Possible transitions that one could fill in between these two sentences include the following:

Revised Example 6-15

To determine the effects of solid-solution ratio on K12 adsorption at fixed pH 7, K12 adsorption isotherm experiments were conducted. **In addition,** aqueous carbonate concentrations were measured.

To determine the effects of solid-solution ratio on K12 adsorption at fixed pH 7, K12 adsorption isotherm experiments were conducted. **For this purpose,** aqueous carbonate concentrations were measured.

To determine the effects of solid-solution ratio on K12 adsorption at fixed pH 7, K12 adsorption isotherm experiments were conducted. **First,** aqueous carbonate concentrations were measured.

To determine the effects of solid-solution ratio on K12 adsorption at fixed pH 7, K12 adsorption isotherm experiments were conducted. **Subsequently,** aqueous carbonate concentrations were measured.

When the transition is missing between these two sentences, most readers may guess that the intended relationship is "in addition," but readers should not be guessing.
Here is another example:

Example 6-16 We determined whether the increased endotoxin susceptibility of *AUF1*$^{-/-}$ mice is due to deregulation of proinflammatory cytokine expression. We measured the serum TNFα level in *AUF1*$^{-/-}$ mice after LPS challenge.

In Example 6-16, the logical relationship between the first and second sentence is also not clear because a transition is missing. Once the transition is added in, the relationship between the two sentences becomes obvious.

Revised Example 6-16 We determined whether the increased endotoxin susceptibility of *AUF1*$^{-/-}$ mice is due to deregulation of proinflammatory cytokine expression. **For this purpose,** we measured the serum TNFα level in *AUF1*$^{-/-}$ mice after LPS challenge.

Some transitions that are used in more casual conversation should be avoided in scientific writing:

besides (but not besides X . . .)		additionally	as a matter of fact	
suddenly	admittedly	basically	ergo	at once

Use transitions and conjugations, but only where appropriate. Note that logical relationships can also be clear without transitions. It is not necessary to place a transition or conjugation in every sentence, as logical relationships are often apparent from the word location within sentences.

ESL advice

Use transitions to link ideas, but do not overuse them. In addition, ensure that you are using the correct transitions, especially when you are an ESL author. ESL writers are prone to using transitions whose meaning is quite different from the one they intend. Check a dictionary rather than guessing when using transitions. Do not trust a thesaurus, however. Certain transitions are considered outdated. Rather, consult a scientific editor, current peer-reviewed articles published by native English speakers in well-respected journals, or a book on scientific style to check whether a transition is still in use in contemporary scientific writing. Avoid outdated terms such as the following:

hitherto	aforementioned	henceforth	
notwithstanding	firstly (use "first" instead)	secondly	lastly

Common transitions include words, phrases, or even sentences. Whereas transition words are standard terms that indicate logical relationships between sentences, transition phrases are either infinitive or

Table 6.1 Transition words, phrases, and sentences

USE	EXAMPLE		
	TRANSITION WORDS	TRANSITION PHRASE	TRANSITION SENTENCE
Addition	again, also, further, furthermore, in addition, moreover	In addition to X, we... Besides X,...	Further experiments showed that...
Concession	clearly, evidently, obviously, undeniably		Granted that X is...
Comparison	also, likewise, similarly, etc.	As seen in... In the same way,	When A is compared with B... As reported by... When compared to...
Contrast	but, however, nevertheless, nonetheless, still, yet	In contrast to A... On one hand; on the other hand... Despite X... Unlike X,... On the contrary,...	One difference is that... Although X differed...
Example	for example, specifically	To illustrate X...	An example of X is that..., That is,...
Explanation	here, therefore, in short	Because of X... In this experiment...	One reason is that... Because X is...
Purpose	for this purpose,	For the purpose of... To this end,... To determine XYZ, we...	The purpose of X was to...
Result	consequently, generally, hence, therefore, thus	As a result of...	Evidence for XYZ was that... Analysis of ABC showed that...
Sequence/ time	after, finally, first, later, last, meanwhile, next,	After careful analysis of X...	After X was completed,...
	now, second, then, while, subsequently	During centrifugation,...	When we determined X...
Summary	in brief, in conclusion, in fact, in short, in summary	To summarize (our results),...	As a summary of our results shows,...
Strength of transition			

prepositional phrases. A transition sentence uses a subject and verb. The subject in the transition sentence, and the object in a transition phrase, usually repeat a key term. Note that transition sentences are stronger than transition phrases, which in turn are stronger than transition words. The farther away from the main point of a paragraph or section, the stronger the transition should be to link back to the main point (see Table 6.1).

6.4 CONDENSING

WRITING PRINCIPLE 30:

Make your writing concise.

A well-written paragraph needs not only to be organized, coherent, and consistent, but it also needs to be concise. Wordiness is a common problem in scientific writing. Many journals limit the number of words in various parts of an article or in the article as a whole.

If you need to condense a paragraph (or paper), do not despair. A wide range of methods is available to make a paragraph more concise without having to remove important material from a paper. Be aware, however, that clarity is always more important than brevity.

Condensing often needs to be done in combination with other techniques:

1. Emphasizing important information
2. De-emphasizing or omitting less important information
3. Replacing or omitting words and phrases

Establishing Importance

GUIDELINE:

Establish importance.

In many scientific papers, important information is outweighed by unimportant information. Because of this imbalance, it is often difficult for the reader to find the real "meat" of the paper. De-emphasizing or omitting less important information is probably the most important technique in condensing.

As a first step in condensing, you need to decide what is important, what is less important, and what is unimportant information in your manuscript. The next steps are to emphasize the important information and to de-emphasize the less important information. Unimportant information adds nothing but clutter and distracts the reader. It should be omitted.

To emphasize your important information, either place it in a power position or signal it directly by using statements such as "Most important, ..." or "The key finding of this study was...." Less important information can be de-emphasized by subordinating it. This can be done,

for example, by placing it in a subordinate clause as shown in the next examples.

Example 6-17 Information about the relation between WBC count and hospital case fatality rates is limited. A link between WBC count and increased long-term mortality after acute myocardial infarction may exist.

Revised Example 6-17 *Although information about the relation between WBC count and hospital case fatality rates is limited,* a link between WBC count and increased long-term mortality after acute myocardial infarction may exist.

Example 6-18 The Hainan aborigines are an ethnic group living at the entrance route to Southeast Asia and have been influenced little by relocation and migrations of other ethnic groups.

Revised Example 6-18 The Hainan aborigines, *an ethnic group living at the entrance route to Southeast Asia,* have been influenced little by relocation and migrations of other ethnic groups.

When less important information has been reduced or omitted, and important information has been emphasized, the reader will be able to see the forest for the trees.

Words and Phrases That Can Be Omitted

GUIDELINE:

Omit "overview" words, phrases, and sentences.

ESL advice

Another important technique in condensing is to replace or to omit unnecessary words and phrases. Aside from redundancies and jargon, all of which are discussed in Chapter 2, other words and phrases can be omitted to condense a document. Certain ESL writers whose native language uses many flowery phrases should be particularly aware of what words and phrases can be omitted in a scientific document.

Scrutinize your paper for pointless words and phrases ruthlessly. Dissect every sentence. As a rule, when equivalent alternatives exist, choose the shortest one. In scientific writing, every word should count.

Verbs to Omit

Omit verbs such as

describes	noted	was done	reported
noticed	observed	occurred	seen

Just state the facts.

Example 6-19 Jones et al. reported that intracellular calcium is released when adipocytes are stimulated with insulin.
(15 words)

Revised Example 6-19 Intracellular calcium is released when adipocytes are stimulated with insulin (Jones et al., 1996.)
(10 words)

Phrases to Omit

Omit phrases and sentences that tell your reader what a sentence/paragraph is about.

Example 6-20 Products were verified by gel electrophoresis. The results are presented in Figure 1.
(13 words)

Revised Example 6-20 Products were verified by gel electrophoresis (Fig. 1).
(6 words)

Example 6-21 To assess the purity of the gene product, many techniques were employed.
(12 words)

Revised Example 6-21 (Omit)
(0 words)

Other expressions to omit:

This section describes...
In regard to...
As far as X is concerned...
The experiment was done by...
Figure 6 shows that...

"It...That" Phrases

Aside from jargon and other redundancies, you should replace or omit "It...that" phrases. Most of these phrases are pointless fillers and can be omitted entirely. If the idea in the phrase is essential, replace the phrase with a shorter version.

Examples of "It...that" phrases:

It is interesting to note that...	**omit**
In light of the fact that...	**replace (because)**
It is possible that...	**reword (... may..., perhaps, possibly)**
It has been reported that...	**omit or replace (Taylor reported that...; or [reference])**

Positive Versus Negative Expressions

GUIDELINE:

Aviod writing in the negative.

Changing negative expressions to positive expressions usually results in shorter sentences. Moreover, readers prefer to read positive things, not negative things. Avoid writing in the negative. Write instead in the positive. Above all, avoid double negatives, which can easily confuse readers.

Examples of changing from negative to positive:

negative	**positive**
do not overlook	note
not different	similar
not infrequently	frequently
not many	few
not the same	different
not unimportant	important

Excessive Detail

GUIDELINE:

Omit excessive detail

Detail that can be inferred or is unimportant should be omitted.

Example 6-22

a Using a 1 ml tip, we removed 750 µl of the aliquot into a new Eppendorf tube.

b Resuspended cells were transferred to a 0.4 cm cuvette (Bio-Rad) and electroporated using a Bio-Rad Gene Pulser.

Revised Example 6-22

a We removed 750 µl of the aliquot.

b Resuspended cells were electroporated using a Bio-Rad Gene Pulser.

Intensifiers and Hedges

GUIDELINE:

Do not overuse intensifiers or hedges

Intensifiers are adjectives, adverbs, or verbs that are used to strengthen nouns or verbs such as the following:

always	basic	central	certainly	clearly
crucial	prove	quite	show	very

Hedges are cautious adjectives, adverbs, or verbs such as the following:

actually	appear	could	essentially	indicate	many	
may	most	often	perhaps	possibly	seem	some
suggest	usually					

ESL advice

Intensifiers and hedges are often overused, especially by ESL writers. Aside from making a sentence wordy, you will sound arrogant and too aggressive if you overuse intensifiers and too cautious or timid if you overuse hedges. Omitting intensifiers and hedges will not only avoid these appearances but also shorten sentences.

Example 6-23	Our results may indicate that siRNA dublex possibly caused an RNA interference effect.
Revised Example 6-23	Our results **suggest** that siRNA dublex causes an RNA interference effect. **or** siRNA dublex **may** cause an RNA interference effect.

Example 6-24	Figure 5 clearly shows that the protein was absent in the fraction.
Revised Example 6-24	Figure 5 shows that the protein was absent in the fraction.

Figure Legends

Figure legends in particular can often be condensed. Many journals prefer telegram-style figure legends. Usually, articles can be omitted and prepositional phrases can be shortened or omitted not only in figure titles but also in their explanatory notes.

Example 6-25	Figure 3. Shown here are tangential sections as seen through a barrel cortex of a trimmed mouse. A-C show the ipsilateral barrel cortex; D-F depict the contralateral barrel cortex. The scale bar is 0.2 mm.
Revised Example 6-25	Figure 3. Tangential sections through a barrel cortex of a trimmed mouse. A-C, Ipsilateral barrel cortex; D-F, Contralateral barrel cortex. Scale bar, 0.2 mm.

SUMMARY

WRITING PRINCIPLE 23: Organize your paragraphs.
WRITING PRINCIPLE 24: Use a topic sentence to provide an overview of the paragraph.
Arrange the details in the remaining sentences.
WRITING PRINCIPLE 25: Use consistent order.
WRITING PRINCIPLE 26: Use consistent point of view (same subject for different sentences within a paragraph).
WRITING PRINCIPLE 27: Make your sentences cohesive.
WRITING PRINCIPLE 28: Use key terms to create continuity. Repeat key terms exactly and early, and link them.

WRITING PRINCIPLE 29: Use transitions to indicate logical relationships between sentences.

WRITING PRINCIPLE 30: Make your writing concise.

- Establish importance
- Omit overview words, phrases, and sentences
- Avoid writing in the negative
- Omit excessive detail
- Do not overuse intensifiers and hedges

PROBLEMS

Problem 6-1 Paragraph Organization

The following paragraph is about the two phases of *P. infestans* infection. Although the first sentence of the paragraph introduces the potato pathogen, the second sentence of the paragraph does not logically link back to the first sentence nor does it clearly introduce the two phases. Rewrite the second sentence to link it to the first sentence and to lead into the description of the two phases. Put parallel ideas into parallel form.

Phytophthora infestans, which precipitated the Irish potato famines in the mid-19th century, remains the most economically important potato pathogen. Up to 36 hr postinoculation, *P. infestans* forms haustoria and requires living plant tissue. After this biotrophic phase of the infection, a necrotrophic phase ensues in which infected host tissue becomes necrotic (1).

Problem 6-2 Paragraph Organization

The following paragraph is about types of glutamate receptors. Although the paragraph has a topic sentence, the remaining sentences of the paragraph do not follow logically from the topic sentence. Add a sentence after the topic sentence to fulfill the expectations of the reader. (What does the reader expect to read about after reading the topic sentence?) Reorganize sentence 2 to make it parallel to sentence 3.

1Ionotropic glutamate receptors fall into two general categories (7, 8). 2When NMDA receptors are activated by N-methyl-D-aspartate (NMDA), ion channels are opened, allowing ions to rush into the cell and thus cause an excitatory postsynaptic potential. 3non-NMDA receptors like PCP bind to kainate and quisqualate only and prevent ion flow and an excitatory postsynaptic potential, even in the presence of NMDA.

Problem 6-3 Paragraph Organization

The following paragraph is about the features characterizing copper oxide superconductors. Although sentences 2 and 3 describe the two features of the copper oxide superconductors, the paragraph does not have a topic sentence. Write a clear topic sentence for this paragraph. The topic sentence should state the message of the paragraph (the features of copper oxide superconductors). In your topic sentence, try to make the topic the subject of the sentence.