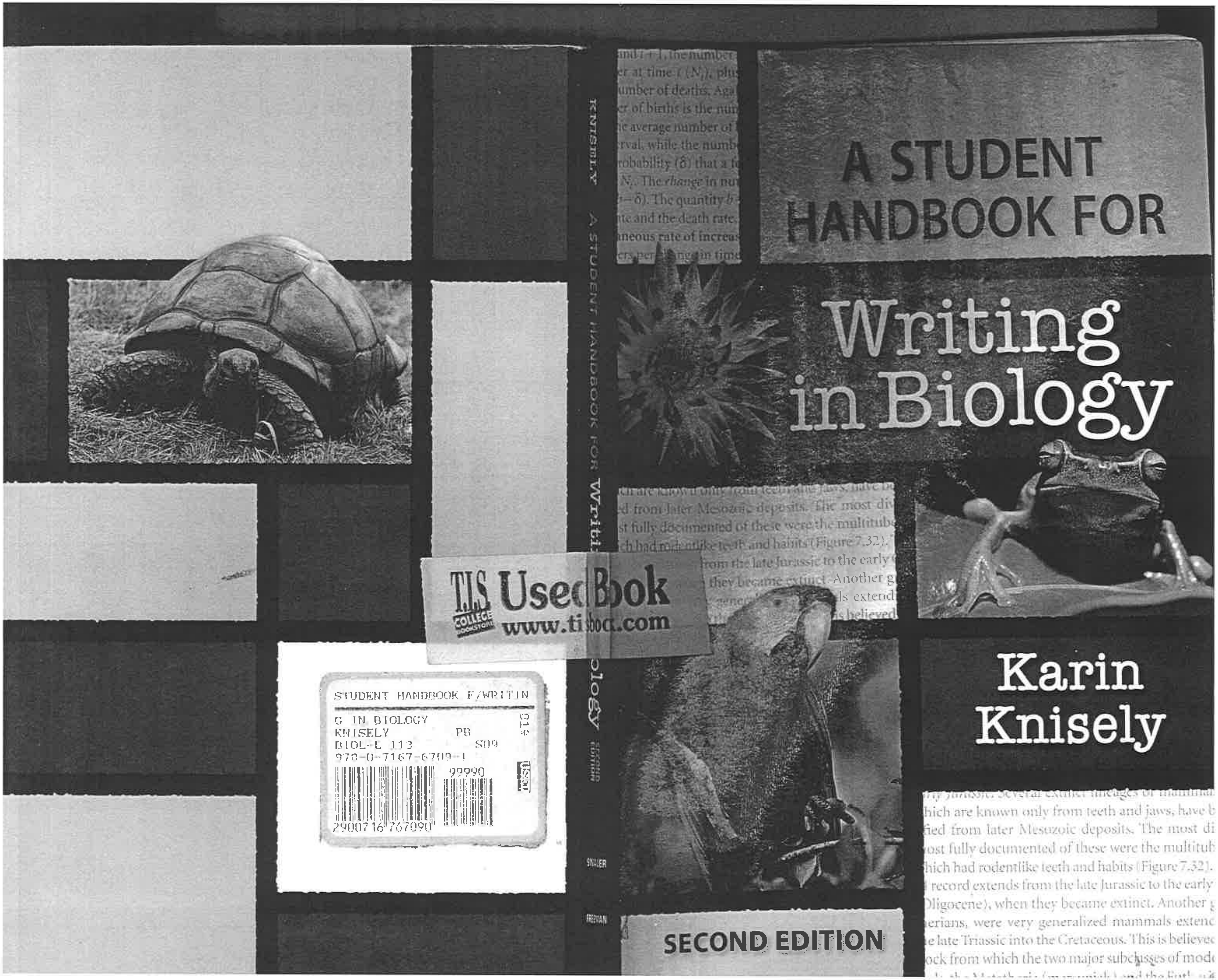
A STUDENT HANDBOOK FOR
Writing in Biology
Karin Knisely
SECOND EDITION
KNISELY A STUDENT HANDBOOK FOR Writing in Biology SECOND EDITION
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T.I.S. COLLEGE BOOKSTORE Used Book www.tisbook.com
STUDENT HANDBOOK F/WRITIN
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KNISELY PB
BIOL-L 113 S09
978-0-7167-6709-1
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TABLE 2.1 Identifying sponsors of sites on the World Wide Web

TYPE OF WEB PAGE	PURPOSE	ENDING OF URL ADDRESS	EXAMPLES
Informational	To present factual information	.edu, .gov	Dictionaries, directories, information about a topic
Business/marketing	To sell a product	.com	Coca-Cola, Leica
Advocacy	To influence public opinion	.org	Democratic Party, Republican Party
News	To present very current information	.com	CNN, *USA Today*
Personal	To present information about an individual	Variety of endings, but has tilde (~) embedded in the URL	

Source: Widener University (<http://www2.widener.edu/Wolfgram-Memorial-Library/webevaluation/webeval.htm>), accessed 2004 Jan 28.

Websites are not considered primary references. When you write a laboratory report or research paper, make sure most of your references are part of the body of published literature, primarily journal articles. You may, however, supplement the literature cited with information retrieved from the Internet.

Chapter 3

Reading and Writing Scientific Papers

No matter whether you are a student or are already engaged in a profession, writing is a fact of life. There are many reasons for writing: to express your feelings, to entertain, to communicate information, and to persuade. When you write scientific papers, your primary reasons for writing are to communicate information and to persuade others of the validity of your findings.

Types of Scientific Writing

Scientific writing takes many forms. As an undergraduate biology major, you will be asked to write laboratory reports, answer essay questions on exams, write summaries of journal articles, and do literature surveys on topics of interest. Upperclass students may write a research proposal for honors work, and then complete their project by submitting an honors thesis. Graduate students typically write master's theses and doctoral dissertations and defend their written work with oral presentations. Professors write lectures, letters of recommendation for students, grant proposals, reviews of articles submitted for publication to scientific journals by their colleagues, and evaluations of grant proposals. In business and industry, scientific writing may take the form of progress reports, product descriptions, operating manuals, and sales and marketing material.

Hallmarks of Scientific Writing

What distinguishes scientific writing from other kinds of writing? One difference is the motive. Scientific writing aims to inform rather than to entertain the reader. The reader is typically a fellow scientist who intends to use this information, for example, to learn more about a process or to improve a product.

A second difference is the style. Brevity, a standard format, and proper use of grammar and punctuation are the hallmarks of well-written scientific papers. The authors have something important to communicate, and they want to make sure that others understand the significance of their work. Flowery language and "stream of consciousness" prose are not appropriate in scientific writing because they can obscure the writer's intended meaning.

A third difference between scientific and other types of writing is the tone. Scientific writing is factual and objective. The writer presents information without emotion and without editorializing.

Scientific Paper Format

Scientific papers are descriptions of how the scientific method was used to study a problem. They follow a standard format that allows the reader, first, to determine initial interest in the paper, second, to read a summary of the paper to learn more, and, finally, to read the paper itself for all the details. This format is very convenient, because it allows busy people to scan volumes of information in a relatively short time, then spend more time reading only those papers that truly provide the information they need.

Almost all scientific papers are organized as follows:

- Title
- List of Authors
- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- References

The **Title** is a **short, informative description of the essence of the paper.** It should contain the fewest number of words that accurately convey the content. Readers use the title to determine their initial interest in the paper.

Only the names of **people who played an active role** in designing the experiment, carrying it out, and analyzing the data appear in the **List of Authors.**

The **Abstract** is a **summary of the entire paper** in 250 words or less. It contains (1) an introduction (scope and purpose), (2) a short description of the methods, (3) results, and (4) conclusions. There are no literature citations or references to figures in the Abstract.

The **Introduction** concisely states what motivated the study, how it fits into the existing body of knowledge, and the objectives of the work. The Introduction consists of two primary parts:

1. **Background or historical perspective on the topic.** Primary journal articles and review articles, rather than secondary sources such as textbooks and newspaper articles, are cited to provide the reader with direct access to the original work. Inconsistencies, unanswered questions, or new questions that resulted from previous work set the stage for the present study.
2. **Statement of objectives of the work.** What were the goals of the present study?

The **Materials and Methods** section describes, in full sentences and well-developed paragraphs, **how the experiment was done.** The author provides sufficient detail to allow another scientist to repeat the experiment. Volume, mass, concentration, growth conditions, temperature, pH, type of microscopy, statistical analyses, and sampling techniques are critical pieces of information that must be included. When and where the work was carried out is important if the study was done in the field (in nature), but is not included if the study was done in a laboratory. Conventional labware and laboratory techniques that are common knowledge (familiar to the audience) are not explained. In some instances, it is appropriate to use references to describe methods.

The **Results** section is **where the findings of the experiment are summarized**, without giving any explanations as to their significance (the "whys" are reserved for the Discussion section). A good Results section has two components:

- A *text*, which forms the body of this section
- Some form of *visual* that helps the reader comprehend the data and get the message faster than from reading a lengthy description

In the **Discussion** section, the **results are interpreted** and possible explanations are given. The author may:

- Summarize the results in a way that supports the conclusions
- Describe how the results relate to existing knowledge (literature sources)
- Describe inconsistencies in the data. This is preferable to concealing an anomalous result.
- Discuss possible sources of error
- Describe future extensions of the current work

References list the **outside sources** the authors consulted in preparing the paper. No one has time to return to a state of zero knowledge and rediscover known mechanisms and relationships. That is why scientists rely so heavily on information published by their colleagues. References are typically cited in the Introduction and Discussion sections of a scientific paper, and the procedures given in Materials and Methods are often modifications of those in previous work.

Styles for Documenting References

The Council of Science Editors (CBE Manual, 1994) recommends the following two formats for documenting references:

Citation-Sequence System. In the *text*, the source of the cited information is provided in an abbreviated form as a number in square brackets or parentheses. On the *references pages* that follow the Discussion section, the sources are listed in **numerical order** and include the full reference.

Name-Year System. In the *text*, the source is given in the form of author(s) and year. On the *references pages* that follow the Discussion section, the references are listed in **alphabetical order** according to the first author's last name.

The name-year system has the advantage that people working in the field will know the literature and, on seeing the authors' names, will understand the reference without having to check the reference list. This system is more commonly used and generally is preferred. With the citation-sequence system, for each reference the reader must turn to the reference list at the end of the paper to gain the same information.

Strategies for Reading Journal Articles

Papers in scientific journals are written by experts in the field. Because you are not yet an expert, you will probably find it difficult to read and understand journal articles. The following strategy may help.

Determine the topic. First, try to determine the topic of the article by reading the title and the abstract. Are the authors trying to answer a specific question, explain observations, present a theoretical model of a process, determine the relationship between one or more variables, or accomplish something else?

Acquire background information on the topic. Read about the topic in your textbook. Because textbook authors generally write for a student audience, not a group of experts, your textbook is likely to be easier to read. See "Strategies for Reading your Textbook" for some ways to read biology textbooks efficiently.

Read the Introduction. The introduction is usually easier to follow than the abstract. Skim the introduction with the following questions in mind:

- Why did the author(s) carry out this work?
- What are the main hypotheses?
- What was previously known about the topic or problem?
- What are the objectives of the current work?

Read the Results section selectively. Look at the figures and tables to determine what variables were studied. The independent variable (the one the investigator manipulated) is plotted on the *x*-axis, and the dependent variable(s) (the one that changes depending on the independent variable) is plotted on the *y*-axis. Also look for variables in column headings of tables.

There are two places to look for a qualitative description of each figure and table: the figure/table caption, and in the body of the Results section (text). The caption states the main idea of the visual. The topic sentence of the paragraph in the text does the same. Subsequent sentences in the paragraph provide details on what trends or findings the reader should notice in each visual. When you read about the results, ask yourself the following questions:

- What were the independent, dependent, and controlled variables?
- Was there a difference between the controls and the experimental groups?
- What were the main findings regarding the independent and dependent variables?

If necessary, reread the introduction to recall the main objectives and hypotheses of the work. Try to understand the big picture before concerning yourself with the details.

Read the Discussion section. The author typically presents his/her conclusions in this section and describes how the results of the study support these conclusions. This is where you can find out what was learned from the work. In particular:

- Were the hypotheses supported?

- What were the important findings?
- Were there any surprises?
- What further work is necessary or already in progress?
- How does this paper relate to your own work?

Skim the Materials and Methods section. Scan the subheadings (if present) and the topic sentence of each paragraph to identify the basic approach. Do not be concerned with the details at this stage.

Read the article several times. Even experts must read journal articles several times before they understand the methodology and the implications of the findings. Take notes the first time you read the article, noting what is confusing. Consult your notes when you read the article again, and try to clarify what you didn't understand the first time through. Each time you read the article, you will understand a little more.

Strategies for Reading your Textbook

The following strategies are based on the proposition that you cannot read a chapter in a biology textbook just once and understand it completely. Repetition is a key ingredient in learning the material. Repetition not only provides you with multiple opportunities to be exposed to the material, but also gives you time to digest it. The basic approach is to read for organization and key concepts first, and then to fill in the details with each subsequent reading.

The two strategies described here work best with a chapter or section of text no longer than 25–30 pages. The first strategy is proposed by Counselling Services at the University of Victoria, Canada (Palmer-Stone, 2001).

1. Take no more than 25 minutes to:
   - Read the chapter title, introduction, and summary (at the end of the chapter, if present)
   - Read the headings and subheadings
   - Read the chapter title, introduction, summary, headings, and subheadings again
   - Skim the topic sentence of each paragraph (usually the first or second sentence)
   - Skim italicized or boldfaced words
2. Close your textbook. Take a full 30 minutes to:
   - Write down everything you can remember about what you read in the chapter (make a "mind map"). Each time you come to a dead end, use memory techniques such as associating ideas from your reading to lecture notes or other life experiences; visualizing pages, pictures, or graphs; staring out the window to daydream; letting your mind go blank.
   - Figure out how all this material is related. Organize it according to what makes sense in your mind, not necessarily according to how it is organized in the textbook. Write down questions and possible contradictions to check on later.
3. Open your textbook. Fill in the blanks in your mind map with a different colored pencil.
4. Read the chapter again, this time normally. Make another mind map.

A second strategy is:

1. Skim the chapter title, headings, and subheadings for an overview of the chapter content. Write down the headings and subheadings in the form of an outline.
2. Look at your outline and ask yourself the following questions:
   - What is the main topic of this chapter?
   - How do each of the headings relate to the topic?
   - How does each subheading relate to its heading?
3. Read each section, paying special attention to the topic sentence of each paragraph. At the end of each section, summarize the content in your own words. Answer the following questions:
   - What's the point?
   - What do I understand?
   - What is confusing?
4. If you read the assigned pages before the lecture, you can pay attention to the lecture content instead of just frantically taking notes. Check to see if there is a lecture notebook that accompanies your textbook. The lecture notebook contains the figures in black and white, and allows you to take notes during lecture directly on the figures.
5. After the lecture, while the information is still fresh in your mind, reread your notes on your reading. Ask yourself
   - What topics did the instructor emphasize in lecture? Fill in your lecture notes with details from your textbook.
   - What material do I understand better now?
   - What questions remain?
6. Remember that each time you read the material, you will learn a little more.

Study Groups

If you have read the material several times, taken notes, and listened attentively in lecture, but still have questions, talk about the material with your classmates. Small study groups are one reason why students who choose to major in the sciences persist in the sciences, rather than switching to a non-science major (Light, 2001).

What are some benefits of participating in small study groups? One benefit is the comfort level. You may be more likely to talk about problems when you are among your peers; after all, they are not the ones who assign your grade. Secondly, when a group is composed of peers with a similar knowledge base, group members speak the same language. Your instructor speaks a different language, because he or she has already struggled to master the material. When you communicate with your classmates, you verbalize your ideas at a level that is appropriate for your audience of peers. Finally, collaborative learning reflects the way scientists exchange information and share findings in the real world. A spirit of camaraderie develops when people work together toward a common goal. The prospect of learning difficult subject matter is no longer so daunting when you have support from a small group of like-minded individuals. The hard work may even be fun when there is good group chemistry.

Group study is not a substitute for studying alone, however. You must hold yourself accountable for reading the material, taking notes, and figuring out what you do not understand before you meet with your group. If you have not struggled to understand the material yourself, you are not in a position to help a classmate.

Avoid Plagiarism: Paraphrase What You Read

One of the best ways to know whether or not you understand an author's work is to summarize the key findings in your own words. Do not make the mistake of simply copying the text word for word from the textbook or journal article, just because you think that you could not have said it better yourself. Get into the habit of paraphrasing the information in the source document, and carefully noting the source (see "Documenting Sources" in Chapter 4). By convention, direct quotations are not used in scientific writing.

Plagiarism is taking someone else's ideas and passing them off as your own. This includes citing the source but still copying the words verbatim. Usually plagiarism is unintentional and is the result of not having a clear understanding of the material. If you can state in your

own words what you think the author meant, then you probably understood it. If not, you may have to read the paper a few more times or ask for help from your instructor or a fellow student.

To avoid plagiarism when taking notes, follow this collective advice of Lannon (2000), McMillan (1997), Pechenik (2004), and other authorities on scientific writing:

- Don't take notes until you have read the source text at least twice. You have to understand it before you can summarize it.
- Retain key words.
- Don't use full sentences.
- Use your own words and write in your own style.
- Distinguish your own ideas and questions from those of the source text (e.g., "Me: Confusing!").
- Don't cite out of context. Preserve the author's original meaning.
- Fully document the source for later listing under References.

The Benefits of Learning to Write Scientific Papers

Why is it valuable to learn how to write scientific papers? First, scientific writing is a systematic approach to describing a problem. By writing what you know (and what you do not know) about the problem, it is often possible to identify gaps in your own knowledge.

Secondly, scientific writing aims to persuade the reader of the validity of the procedures, results, and conclusions described in the paper. Improving your reasoning abilities in laboratory reports may have a positive effect on other areas of your life as well.

Third, when you learn to write lab reports, you are investing in your future. Publications in the sciences are affirmation from your colleagues that your work has merit; you have been accepted into the community of experts in your field. Even if your career path is not in the sciences, scientific writing is very logical and organized, characteristics appreciated by busy people everywhere.

Credibility and Reputation

The credibility and reputation of scientists are established primarily by their ability to communicate effectively through their written reports. Poorly written papers, regardless of the importance of the content, may not get published if the reviewers do not understand what the writer intended to say.

You should think about your reputation even as a student. When you write your laboratory reports in an accepted, concise, and accurate manner, your instructor knows that you are serious about your work. Your instructor appreciates not only the time and effort required to understand the subject matter, but also your willingness to write according to the standards of the profession.

Model Papers

Before writing your first laboratory report, go to the library and take a look at some biology journals such as *American Journal of Botany, Ecology, The EMBO Journal, Journal of Biological Chemistry, Journal of Molecular Biology*, and *Marine Biology*. Photocopy one or two journal articles that interest you so you can refer to them for format questions.

Almost all journals devote one page or more to "Instructions to Authors," in which specific information is conveyed regarding length of the manuscript, general format, figures, conventions, references, and so on. Skim this section to get an idea of what journal editors expect from scientists who wish to have their work published.

Because most beginning biology students find journal articles hard to read, a sample student laboratory report is given in Chapter 6. Read the comments in the left margin as you peruse the report to familiarize yourself with the basics of scientific paper format and content, as well as purpose, audience, and tone.

Chapter 4

Step-by-Step Instructions for Preparing a Laboratory Report or Scientific Paper

In order to prepare a well-written laboratory report according to accepted conventions, the following skills are required:

- A solid command of the English language
- An understanding of the scientific method
- An understanding of scientific concepts and terminology
- Advanced word processing skills
- Knowledge of computer graphing software
- The ability to read and evaluate journal articles
- The ability to search the primary literature efficiently
- The ability to evaluate the reliability of Internet sources.

If you are a first- or second-year college student, it is unlikely that you possess all of these skills when you are asked to write your first laboratory report. Don't worry. The instructions in this chapter will guide you through the steps involved in preparing the first draft of a laboratory report. Revision is addressed in the next chapter, and the Appendices will help you with word processing and graphing tasks.

Timetable

Preparing a laboratory report or scientific paper is hard work. It will take much more time than you expect. Writing the first draft is only the first step. You must also allow time for proofreading and revision. If you work on your paper in stages, the final product will be much better than if you try to do everything at the last minute.