A SHORT GUIDE TO WRITING ABOUT

BIOLOGY

SECOND EDITION

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A Short Guide to Writing about Biology

Second Edition

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Preface

Communicating through writing is an important part of the biologist's trade, and many of us wish we had more time to teach our students to do it well. Moreover, bad scientific writing often reflects fuzzy thinking, so that questioning the writing generally guides students toward a clearer understanding of the biology being written about. To improve students' writing in biology, half the battle is to persuade them to take the task seriously; the other half is to provide them with sufficient instructions to get them through the struggle successfully. In this book I address both halves of the battle, in a way that should not take up valuable class time.

The book is brief enough to be read by students along with other, more standard assignments, and straightforward enough to be understood without additional instruction. Although intended primarily for undergraduate use in typical lecture and laboratory courses, the book is also appropriate for undergraduate and graduate seminars.

ORGANIZATION

The benefits of learning to write well in biology are discussed in Chapter 1, where I also describe the sort of writing that professional biologists do, and review the key principles that characterize all sound scientific writing. This chapter also includes a section on the use of computers in preparing writing assignments. Chapter 2 gives detailed instruction in how to locate research articles using various printed and computerized indexing services, how to read the formal scientific literature, and how to take useful notes. Chapter 9 focuses on the process of revision and includes some exercises in proofreading and editing. Chapters 1, 2, and 9 should be read by all students early in the term before beginning any writing assignments; the other chapters cover the specific writing assignments typically encountered in the biology undergraduate curriculum and

can be assigned as appropriate, in any order. Chapter 3, on Writing Laboratory Reports, emphasizes that the result obtained in a study is often less important than the ability to discuss and interpret that result convincingly in the context of basic biological knowledge, and to demonstrate clear understanding of the purpose of the study. I emphasize the variability inherent in biological systems and how that variability is dealt with in presenting, interpreting, and discussing data. This chapter should also be useful for students preparing papers for publication. Chapter 4, Writing Essays and Term Papers, discusses the most profitable ways to decide on and explore a paper or essay topic.

Writing research proposals, critiques and summaries, and in-class essay examinations are discussed in separate chapters (Chapters 5, 6, and 10). To make the book more useful to all Biology majors, I have included chapters on how to give oral presentations (Chapter 7) and how to prepare applications for summer and permanent jobs in Biology and for graduate and professional schools (Chapter 8). There is also an appendix listing commonly used abbreviations for lengths, weights, volumes, and concentrations.

CHANGES MADE FOR THE SECOND EDITION

There is now a separate chapter on reading and notetaking (Chapter 2), emphasizing the struggle for understanding that must precede any concern with *how* something is said. Some of the material in this chapter was in Chapters 2 and 3 of the first edition, but much of it is new. In particular, I now discuss in detail how to read the graphs and tables—the data—found in the Results sections of research papers. Chapter 3 has been substantially reorganized, and I have added a section on keeping laboratory and field notebooks; I have also included more headings and subheadings to help students and instructors locate sections of particular concern in what is still the longest chapter in the book.

Throughout the book I have added and altered examples to broaden the range of biological areas represented. Nevertheless, the book remains fully accessible to students at even the earliest stages of their undergraduate training. I have also added material (for

example, the use of *Current Contents* and computerized literature searches; and how to prepare manuscripts for formal publication) of special interest to advanced undergraduates and graduate students. The new edition takes a kinder, but still cautionary, attitude toward student use of computers for graphing and revision. Finally, I now emphasize the importance of peer review in helping writers organize their material and helping them know whether they have really said what they intended to say; Chapter 9 (Revising) now includes a short section on how to be an effective reviewer of other people's writing, and how to interpret the criticism received.

Users of the first edition will notice many other, smaller improvements throughout the book. The book has benefited from the advice and suggestions of the many people who took the time to read and comment on the first edition and on the manuscript for the second: Sylvan Barnet, Robert Chase, Maggie de Cuevas, George F. Edick, Louis F. Gainey, Jr., Sharon Hanks, Jared Haynes, Joseph Kelty, Martin Levin, John W. Munford, Peter Pederson, and Barbara Stewart. I have learned much about writing and teaching from letters and conversations with the many enthusiastic users of the first edition, and I welcome additional comments from readers of the present version. I also wish to thank George Ellmore, Mike Gable, and other colleagues who shared with me various laboratory handouts and student laboratory and field notebooks. I owe special thanks to Jay Shiro Tashiro for letting me try out and develop many of my ideas in some of his science education courses and workshops, and to my wife, Lindy Eyster, for her patience, understanding and advice.

Jan A. Pechenik

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Introduction and General Rules

The logical development of ideas and the clear, precise, and succinct communication of those ideas through writing are among the most difficult, but most important, skills that can be mastered in college. Effective writing is also one of the most difficult skills to teach. This is especially true in Biology classes, where there is often much writing to be done but little time to focus on doing it well. The chief message of this book is that developing your writing skills is worth every bit of effort it takes, and that Biology is a splendid field in which to pursue this goal.

WHAT DO BIOLOGISTS WRITE ABOUT, AND WHY?

The sort of writing that biologists do (lectures, letters of recommendation, grant proposals, research papers, and critiques of research papers and grant proposals written by other researchers) is similar in many respects to the sort of writing (essays, literature reviews, term papers, and laboratory reports) you are asked to do while enrolled in a typical Biology course. Basically, we must all prepare arguments.

Like a good term paper or essay, a lecture is an argument; it presents information in an orderly manner and seeks to convince the audience that this information fits sensibly into some much

larger story. Few students are aware of the time and effort required to write a coherent lecture, but the sad fact is that putting together a string of three or four lectures and then moving on to the next topic is the equivalent of preparing one 20- to 30-page term paper weekly.

In addition to preparing lectures, many of us spend quite a bit of time writing grant proposals, in the hope of obtaining the funding that will enable us to pursue our research programs (and possibly hire one of you for a summer in the process). A research proposal is unquestionably an argument; success depends on our ability to convince a panel of other biologists that what we wish to do is worth doing, that we are capable of doing it, that we are capable of correctly interpreting the results, and that the work cannot be done without the funds requested. Research money is not plentiful. Even well-written proposals have a difficult time; poorly written proposals generally don't stand a chance.

When we are not writing grant proposals or lectures, we are often preparing the results of our research for publication. Essentially, these articles are laboratory reports based on data collected over a much longer period of time than the typical laboratory session; in research articles, as in the preparation of laboratory reports, the goal is to present data clearly, and to interpret those data thoroughly and convincingly in the context of other work and basic biological principles. The preparation of research reports typically involves the following steps:

organizing the data;

preparing a first draft of the article (following the procedures outlined in Chapter 3 of this book);

revising and reprinting (or retyping) the paper;

asking one or several colleagues to read the paper critically;

revising the paper in accordance with the comments and suggestions of the readers;

reprinting (or retyping) and proofreading the paper;

and, finally, sending the paper to the editor of the journal in which we would most like to see our work published.

This is not the end of the story. The editor then sends the manuscript out to be reviewed by two or three other biologists. Their

comments, along with those of the editor, are then sent to the author, who must again rewrite the paper, often extensively. The editor may then accept the revised manuscript, or may request that it be rewritten again prior to publication.

Biologists obviously write about Biology, but they also write about other things. One of the other things college and university biologists write about is you; letters of recommendation are especially troublesome for us because they are so important to you. Like a good laboratory report, literature review, essay, or term paper, a letter of recommendation must be written clearly, developed logically, and proofread carefully if it is to argue convincingly on your behalf and help get you where you want to go.

And then there are the progress reports, committee reports, and internal memoranda. All this writing involves thinking, organizing, nailing down a convincing argument on paper, revising, retyping, and proofreading.

I hope you are now convinced that effective writing is not irrelevant in a scientific career. When students in a Biology course receive criticisms of their writing, they often complain that "this is not an English course." These students do not understand that clear, concise, logical writing is an important tool of the biologist's trade, and that learning how to write well is at least as important as learning how to use a balance, extract a protein, use a taxonomic key, measure a nerve impulse, or run an electrophoretic gel. And, unlike these rather specialized laboratory techniques, mastering the art of effective writing will reward you regardless of the field in which you eventually find yourself. The fact that you may not become a biologist is no reason to cheat yourself out of the opportunity to become an effective writer; the difference between a well-crafted and poorly crafted letter of application is often the difference between getting the job you want or losing to another contender.

THE KEYS TO SUCCESS

There is no easy way to learn to write well in Biology. All good writing involves two struggles: the struggle for understanding and the struggle to communicate that understanding to a reader. Like the making of omelettes or crepes, the skill improves with

practice. However, being aware of certain key principles will ease the way considerably. Each of the following rules is discussed more fully in later chapters.

1. **Work to understand your sources.** When writing laboratory reports, spend time wrestling with your data until you are convinced you see the significance of what you have done. When taking notes from books or research articles, reread sentences you don't understand and look up the words that puzzle you. Too few students take this struggle for understanding seriously enough, but all good scientific writing begins with this first struggle. You can excel—in college and in life after college—by being one of the few who meet this challenge head on. If you don't commit yourself to winning the struggle for understanding, you will end up with nothing to say, or worse, what you do say will be wrong. In both cases you will produce nothing worth reading.
2. **Think about where you are going before you begin to write.** Much of the real work of writing is in the thinking that must precede each draft. Effective writing is like effective sailing; you must take the time to plot your course before getting too far from port. Your ideas about where you are going and how best to get there may very well change as you continue to work with and revise your paper, since the act of writing invariably clarifies your thinking and often brings entirely new ideas into focus. Nevertheless, you must have some plan in mind even when you first begin to write. This plan evolves from thoughtful consideration of your notes. Think first, then write; thoughtful revision follows. If, when you sit down to write that last draft of your paper, you still don't know where you are heading, you certainly won't get there smoothly, and you may well not get there at all. Almost certainly your readers will never get there.
3. **Write to illuminate, not to impress.** Use the simplest words and the simplest phrasing consistent with that goal. Define all specialized terminology. In general, if a term was recently new to you, it should be defined in

your writing. Don't try to impress the reader with big words and a technical vocabulary, but instead focus on getting your point across.

4. **Make a statement and back it up.** Remember, you are making an argument. In any argument, a statement of fact or opinion becomes convincing to the critical reader only when that statement is supported by evidence or explanation; provide it. You might, for instance, write, "Among the vertebrates, the development of sperm is triggered by the release of the hormone testosterone (Browder, 1984)." In this case, the statement is supported by reference to a book written by Leon Browder in 1984. In the following example, a statement is backed up by reference to the writer's own data: "Some wavelengths of light were more effective than others in promoting photosynthesis. For example, the rate of oxygen production at 650 nm* was nearly four times greater than that recorded for the same plants when using a wavelength of 550 nm (Figure 2)."

   References to papers or books written by two authors must include the names of both authors (e.g., Burns and Allen, 1946). When there are more than two authors, only the first author's name is written out (e.g., Fried et al., 1990). Note that an author's first name is never included in the citation. A statement made by your instructor should be cited as a personal communication (e.g., "R. A. Merz, personal communication"). Refer to a laboratory manual or handout by the author of the handout (e.g., R. Chase, 1992), or as follows: (Laboratory Manual, 1992).

5. **Always distinguish fact from possibility.** In the course of examining your data or reading your notes, you may form an opinion. This is splendid. But you must be careful not to state your opinion as though it were fact. "Species *X* lacks the ability to respond to sucrose" is a statement of fact, and should be supported with a refer-

*nm = nanometers; i.e., 10^{-9} meters.