WRITING ACROSS THE CURRICULUM

Writing in the Biological Sciences

Science is a collective field to study, and its growth depends on the exchange of data and information, including certain fundamentals of history, mathematics, and communication. It is a common misconception that students taking a biology class do not need to be good writers. In fact, biologists must be able to effectively impart their research, explain a hypothesis, record data, and provide conclusions. While there are a few celebrated scientific writers, such as Lewis Thomas and Stephen Jay Gould, the majority of biologists are rarely given credit for the breadth of their writing tasks.

Because the purpose of scientific writing is to offer empirical evidence that is both observable and verifiable, it is important to write with precision. Readers expect precise descriptions of procedures and findings, free of personal biases. The presentation of data is the core of scientific reporting, and, therefore, it is essential to communicate in a straightforward manner since scientists expect to be able to **replicate**—repeat step-by-step—the experiment or process that the researcher carried out.

USING SOURCES

While researching your topic, be aware that there are two types of sources: **primary** and **secondary.** Good scientific writing will include a mixture of both.

Primary Sources

Primary sources are materials written or recorded by people who were directly involved in the events under examination as witnesses or participants. Examples include conference papers, dissertations, technical reports, and scholarly journals that include specialized research papers. Primary sources can also include tables and figures that present the results of experiments or data collection.

Secondary Sources

Offering interpretation and commentary on primary sources, secondary sources are written for both scientists and non-scientists. These texts are helpful as they inform us of the ways in which professional historians, philosophers, science writers, etc., have understood biological data. Even though these sources are of great value, biology papers, when possible, should not be comprised entirely of secondary sources. Instead, it is beneficial to study a variety of data to get a better grasp of the information that shapes a hypothesis. The bibliographies of secondary sources can often suggest further reading of primary sources. Both primary and secondary sources include digital and print formats.

TYPES OF ASSIGNMENTS

The Lab Report

A lab report is a presentation of original findings categorized into multiple sections following a format that reflects the rationality of a scientific hypothesis. The report should have a specific, informative title, usually followed by a one-paragraph summary of the paper that will follow. The author then states the purpose of the experiment, placing the work in a broader scientific context. A progressive listing of procedures is described, and the findings are outlined and interpreted. Last, the author lists the references that were cited. When writing for publication, biologists often follow this format.

Because scientific writing depends largely on objective observation rather than subjective comments, scientists generally avoid using the first person (I, our, we) in their writing. The sciences focus on the experiment rather than on the person doing the experimenting. Therefore, in lab reports verbs often take the passive form: "A sample of zinc oxide was prepared by heating a solution of zinc, iodine, and acidified water until all the water had boiled away."

Title

Titles identify the important contents of a paper and orient readers by making clear the writer's major findings. If you are having trouble with developing a title, try adding it after you have already written at least one draft of the paper and have a better understanding of the subject.

- Make the title informative and specific.
- Be concise.
- Include appropriate classifying information.
- Avoid specialized terminology, coined words, and abbreviations.

A good title, for example, might be "An Experimentally Determined Formula for the Buoyant Force of Water."

Abstract

The abstract is a summary (usually 250 words or less), which appears just after the title and author's name, briefly and clearly explaining the major elements of the paper and, therefore, of the experiment performed: the purpose of the lab experiment or assignment, the methodology employed, the results obtained, the conclusion reached. Written as a single paragraph, abstracts help scientists assess the relevance of a paper to their own research.

While writing an abstract, be sure to avoid general, descriptive statements that only hint at your results or serve as a basic table of contents. Consider every sentence, every word.

- Summarize the major points of the paper.
- Be specific and concise.
- Make sure the abstract can stand on its own and still make sense to the reader.

Introduction

The introduction serves to present your objectives for your scientific argument. It relays to the reader sufficient information needed to fully appreciate your conjecture, while stating why this problem is worth investigating. A good introduction hooks its readers, interesting them in the study.

- Orient the reader by summarizing pertinent literature in your field.
- Explain the rationale for the study and your major objectives.

Methodology

Your methodology provides appropriate criteria for evaluating the collected data. How measurements were made, which controls were used, which variables were or were not considered—all of these elements are necessary to construct your interpretation of the results. The credibility of your scientific argument largely depends on how clearly and precisely you have outlined and justified your procedures.

Your methodology can be divided into two sections, as outlined below:

- **Materials**

Give complete categorical information about the organisms that you are writing about: names of the genus and species as well as subspecies, strains, etc. Specify how they were obtained, and include any other information relevant to the study: age, gender, size, physiological state, rearing conditions, etc. If human subjects were used, biologists must demonstrate proof that the subjects have agreed to be involved in the study.

Be sure to describe any tools, sampling devices, and any other testing apparatus used during the experiment.

- **Methods**

Describe the steps employed to carry out the experiment in detail. Be sure to include statistical measurements as necessary to make particular assessments. If, however, you used a method that has already been described in a scientific journal, cite the reference rather than repeating the information in your report. However, if the reference is hard to obtain or if the method used was in any way altered, supply the full information.

- Organize your material logically.
- Use specific, informative language.

Results

The Results section *summarizes* the data, *emphasizes* important patterns or trends, and **illustrates and supports** your generalizations with explanatory details, statistics, examples of representative cases, and tables and/or figures. In order to convey the results unambiguously, your writing must be clearly organized.

If this section is long and includes many different topics, consider using subheadings to make the text easier for the reader to grasp. This section should be a straightforward report of the data. Do not compare your findings with those of other researchers, and do not discuss why your results were or were not consistent with your predictions.

- Do not interpret the data or draw major conclusions.
- Integrate quantitative data with the text.
- Omit peripheral information and unnecessary details.

Conclusion

This section serves to inform readers of the outcomes that can be drawn from the experiment. In this section, it is important to refer to facts and cite tables or figures as needed and, in particular, to use these materials as evidence to support or deny your hypothesis. Some important questions to ask are:

- Does the data support your original hypothesis? Why or why not?
- Are your findings consistent with other researchers? Why or why not?

In addition, keep in mind the following guidelines:

- Interpret your results and support your conclusions with evidence.
- Do not try to account for every conceivable explanation.
- Recognize the importance of "negative" results.
- Write with confidence.
- Use coherent, logical organization.

Documentation

Under the heading "References" you should list only the references cited in the text of your report. Do not list any other sources, even if they proved to be useful background reading. Since citation formats can and do vary from one academic field to another, the following guidelines are based on recommendations by the Council of Biology Editors. The CBE recommends two systems of documentation: the first uses name-year parenthetical citations in the text of the paper together with a references list that gives full bibliographic information for each source. The second system uses a numerical listing of sources corresponding to the sequence in which they are mentioned in the paper. CBE documentation style is widely used in the biological sciences, although APA Style is acceptable; be sure to check with your instructor.

Using Graphs and Tables

Clear graphs and concise, intelligible tables are as important as clear, concise writing. Any data showing a trend should be graphed. If there is no trend, or if the exact numbers are more important, use a table.

The type of graph you draw will depend on the kinds of data you have collected. Continuous data (showing relationships) need a line graph. Discrete and/or classified data (raw facts) must be drawn as a table.

Science Review

A **science review** synthesizes published information on a scientific issue or topic. Review papers are important as they help biologists keep informed of current knowledge and research and learn about topics that are unfamiliar to them. In such reviews, the writer must present evidence to persuade readers that new interpretations are valid.

Though review papers can cover quite different areas of biology, all such papers follow a specific format: abstract, introduction, body paragraphs, conclusion, and references cited.
When writing a review, be sure to limit your topic to an issue that is currently being researched.

Similarly, use sources that are up to date—the more recently published, the better. Remember to paraphrase and/or summarize your material and to document your sources; your aim is to inform, but also to evaluate and interpret. If your review is longer than two or three pages, use subject headings to help your reader follow and understand your organization and idea progression.

Research Paper

Unless instructed otherwise, the biology **research paper** adheres to the designated sections of the lab report—although it goes into much more detail. Unlike a lab report, which consists mainly of the primary information gathered during your own experiment, a research paper may detail someone else's work in a particular field. For example, your professor may ask you write about a specific procedure used in a study of the longevity of Rhesus monkeys in relation to caloric restriction. In this case, instead of forming a hypothesis around what you think will happen, a thesis statement—a central, organizing idea—would be more appropriate. In addition, strict attention must be paid to documenting your sources.

As the research paper is written under the assumption that it will be read by fellow scientists, attention to detail, specific use of appropriate terminology, accuracy of description, and clear and direct writing are required. Note also that the structure of lab reports and research papers creates a definitive organizing pattern, and the writer plugs information into the appropriate subject headings. Refer to the earlier section of this handout for a basic outline for your paper.