

## **Writing Lab Reports and Scientific Papers**

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Verbal communication is temporal and easily forgotten, but written reports exist for long periods and yield long-term benefits for the author and others.

Scientific research is a group activity. Individual scientists perform experiments to test hypotheses about biological phenomena. After experiments are completed and duplicated, researchers attempt to persuade others to accept or reject their hypotheses by presenting the data and their interpretations. The lab report or the scientific paper is the vehicle of persuasion; when it is published, it is available to other scientists for review. If the results stand up to criticism, they become part of the accepted body of scientific knowledge unless later disproved.

In some cases, a report may not be persuasive in nature but instead is an archival record for future generations. For example, data on the distribution and frequency of rabid skunks in a certain year may be of use to future epidemiologists in deciding whether the incidence of rabies is increasing. Regardless of whether a report is persuasive or archival, the following guidelines apply.

### **Format**

A scientific report usually consists of the following:

1. Title
2. Abstract
3. Introduction
4. Materials and methods
5. Results
6. Discussion
7. Literature cited

There is general agreement among scientists that each section of the report should contain specific types of information.

### **Title**

The title should be less than ten words and should reflect the factual content of the paper. Scientific titles are not designed to catch the reader's fancy. A good title is straightforward and uses keywords that researchers in a particular field will recognize.

### **Abstract**

The purpose of an abstract is to allow the reader to judge whether it would serve his or her purposes to read the entire report. A good abstract is a concise (100 to 200 words) summary of the purpose of the report, the data presented, and the author's major conclusions.

### **Introduction**

The introduction defines the subject of the report. It must outline the scientific purpose(s) or objective(s) for the research performed and give the reader sufficient background to understand the rest of the report. Care should be

taken to limit the background to whatever is pertinent to the experiment. A good introduction will answer several questions, including the following:

*Why was this study performed?*

Answers to this question may be derived from observations of nature or from the literature.

*What knowledge already exists about this subject?*

The answer to this question must review the literature, showing the historical development of an idea and including the confirmations, conflicts, and gaps in existing knowledge.

*What is the specific purpose of the study?*

The specific hypotheses and experimental design pertinent to investigating the topic should be described.

## **Materials and Methods**

As the name implies, the materials and methods used in the experiments should be reported in this section. The difficulty in writing this section is to provide enough detail for the reader to understand the experiment without overwhelming him or her. When procedures from a lab book or another report are followed exactly, simply cite the work, noting that details can be found in that particular source. However, it is still necessary to describe special pieces of equipment and the general theory of the assays used. This can usually be done in a short paragraph, possibly along with a drawing of the experimental apparatus. Generally, this section attempts to answer the following questions:

*What materials were used?*

*How were they used?*

*Where and when was the work done? (This question is most important in field studies.)*

## **Results**

The results section should summarize the data from the experiments without discussing their implications. The data should be organized into tables, figures, graphs, photographs, and so on. But data included in a table should not be duplicated in a figure or graph.

All figures and tables should have descriptive titles and should include a legend explaining any symbols, abbreviations, or special methods used. Figures and tables should be numbered separately and should be referred to in the text by number, for example:

1. Figure 1 shows that the activity decreased after five minutes.
2. The activity decreased after five minutes (fig. 1).

Figures and tables should be self-explanatory; that is, the reader should be able to understand them without referring to the text. All columns and rows in tables and axes in figures should be labeled. See appendix B for graphing instructions.

This section of your report should concentrate on general trends and differences and not on trivial details. Many authors organize and write the results section before the rest of the report.

## **Discussion**

This section should not just be a restatement of the results but should emphasize interpretation of the data, relating them to existing theory and knowledge. Speculation is appropriate, if it is so identified. Suggestions for the improvement of techniques or experimental design may also be included here. In writing this section, you should

explain the logic that allows you to accept or reject your original hypotheses. You should also be able to suggest future experiments that might clarify areas of doubt in your results.

## Literature Cited

This section lists all articles or books cited in your report. It is not the same as a bibliography, which simply lists references regardless of whether they were cited in the paper. The listing should be alphabetized by the last names of the authors. Different journals require different formats for citing literature. The format that includes the most information is given in the following examples:

For articles:

Fox, J.W. 1988. Nest-building behavior of the catbird, *Dumetella carolinensis*. *Journal of Ecology* 47: 113-17.

For Books:

Bird, W.Z. 1990. *Ecological aspects of fox reproduction*. Berlin: Guttenberg Press.

For chapters in books:

Smith, C.J. 1989. Basal cell carcinomas. In *Histological aspects of cancer*, ed. C.D. Wilfred, pp. 278-91. Boston: Medical Press.

When citing references in the text, do not use footnotes; instead, refer to articles by the author's name and the date the paper was published. For example:

1. Fox in 1988 investigated the hormones on the nest-building behavior of catbirds.
2. Hormones are known to influence the nest-building behavior of catbirds (Fox, 1988).

When citing papers that have two authors, both names must be listed. When three or more authors are involved, the Latin *et al.* (*et alia*) meaning "and others" may be used. A paper by Smith, Lynch, Merrill, and Beam published in 1989 would be cited in the text as:

Smith et al. (1989) have shown that...

This short form is for text use only. In the Literature Cited, all names would be listed, usually last name preceding initials.

There are a number of style manuals that provide detailed directions for writing scientific papers. Some are listed in further readings at the end of this section.

## General Comments on Style

1. All scientific names (genus and species) must be italicized. (Underlining indicates italics in a typed paper.)
2. Use the metric system of measurements. Abbreviations of units are used without a following period.
3. Be aware that the word *data* is plural while *datum* is singular. This affects the choice of a correct verb. The word *species* is used both as a singular and as a plural.
4. Numbers should be written as numerals when they are greater than ten or when they are associated with measurements; for example, 6 mm or 2 g but *two* explanations of *six* factors. When one list includes numbers over and under ten, all numbers in the list may be expressed as numerals; for example, 17 sunfish, 13 bass, and 2 trout. Never start a sentence with numerals. Spell all numbers beginning sentences.
5. Be sure to divide paragraphs correctly and to use starting and ending sentences that indicate the purpose of the paragraph. A report or a section of a report should not be one long paragraph.
6. Every sentence must have a subject and a verb.

7. Avoid using the first person, I or we, in writing. Keep your writing impersonal, in the third person. Instead of saying, "We weighed the frogs and put them in a glass jar," write, "The frogs were weighed and put in a glass jar."
8. Avoid the use of slang and the overuse of contractions.
9. Be consistent in the use of tense throughout a paragraph--do not switch between past and present. It is best to use past tense.
10. Be sure that pronouns refer to antecedents. For example, in the statement, "Sometimes cecropia caterpillars are in cherry trees but they are hard to find," does "they" refer to caterpillars or trees?

After writing a report, read it over, watching especially for lack of precision and for ambiguity. Each sentence should present a clear message. The following examples illustrate lack of precision:

1. "The sample was incubated in mixture A minus B plus C." Does the mixture lack both B and C or lack B and contain C?
2. The title "Protection against Carcinogenesis by Antioxidants" leaves the reader wondering whether antioxidants protect from or cause cancer.

The only way to prevent such errors is to read and think about what you write. Learn to reread and edit your work.

### **Readings**

CBE Style Manual Committee. 1983. *CBE style manual: A guide for authors, editors, and publishers in the biological sciences*. 5th ed. Bethesda, Md.: Council of Biology Editors.

McMillan, V.E. 1988. *Writing papers in the biological sciences*. New York: St. Martin's Press, Inc.