

Writing Scientific Papers

For any scientific research, the job is not done until the findings have been communicated to others. Consequently, it is essential that all scientists be able to compose concise, intelligible reports about their research. This ability requires both a sound understanding of the form of a scientific paper and a clear, compact writing style.

Scientific papers generally include the following sections:

- *Title*
- *Abstract*
- *Introduction*
- *Methods*
- *Results*
- *Discussion*
- *Literature Cited*

Not all journals follow this format, but most do, and that makes it easier for you to find the parts that interest you. You should write your lab reports for this class in the format of a standard scientific paper. The best way to learn how to write a scientific paper is by using published papers as examples to emulate. For this class, your papers should follow the format of the journal *Ecology*. The following is a brief description of what you should include in each section.

Title

The title should be informative: it should allow the reader to determine what the paper is about. It may contain information on the question, the system, and the organisms studied. It should not be “cutesy” and it should not be inane. For example, “*Lab Write-up #1*” is not an acceptable title, nor is “*All washed up: life in the intertidal zone*”.

Abstract (summary)

This section is a concise summary of the question, the general approach (methods) used to answer it, the results, conclusions, and implications. Abstracts vary in length, but you should try to keep yours to less than 150 words. Most scientists read the abstract of a paper first, and from that they often decide whether to read the paper or not. If the abstract isn't interesting and well written, then the rest of the paper might not be read.

Introduction (“Why?”)

The introduction is where you familiarize the reader with the general topic of your paper. In this section you should state what general question(s) you are addressing, and what specific hypotheses you will test. First, you should state the general issue of interest and then briefly summarize previous work that has been done on this subject. Next, explain how your research relates to those studies. Then describe how your research will clarify any unresolved problems or ambiguities. Finally, state the specific questions or hypotheses your work tests.

To write a good Introduction (and Discussion) you will need to be familiar with (and cite) the scientific literature on the topic of your study. This requires “library” research, much of which can now be done online with database searches.

Methods (“Where, When, and How?”)

In this section you tell the reader how you went about testing your hypotheses, explaining in detail how the research was done. You should give a brief description of your study area (including its location and any pertinent physical and biological features), note when you did your study, and describe what kinds of data you collected, how you collected them, and what types of analyses you performed. Enough detail should be given that someone who wanted to repeat your study could do so. This section (and all parts describing your study) should be written in the *past tense* because you are describing work that has already been completed.

Results (“What?”)

This is the part of the paper where you present your data and the results of your analyses using tables and figures. The data should be organized into a coherent sequence, and presented in the form of tables, graphs, or other sorts of figures. Include only those data that are relevant to the hypotheses being tested. In the body of the paper you should give a written description of the important patterns and trends in the data (referring the reader appropriate tables and figures), and explain what the data tell you in relation to your hypotheses. Do not interpret your data in light of the larger issues raised in the Introduction or give conclusions in this section – leave that for the Discussion. Label tables in order as Table 1, Table 2, etc., and all graphs and drawings as Figure 1, Figure 2, etc. With each table and figure you must also include a short, written title (tables) or legend (figures) describing the data. As a general rule, if data can be presented as either a figure or a table, a figure is better – it has more impact and is normally easier to decipher. Don’t duplicate data by placing the same data in both a table and a figure.

Discussion (“So what?”)

This is the section where you interpret your data in light of your hypotheses and questions and make conclusions about the implications of your findings. Do this by comparing your results to those from other published studies, discussing any similarities and differences between them, and describe how these similarities and differences relate to general theory in your field of study. This section is the place for some creativity in evaluating of your results. You should generate and describe sets of alternative hypotheses that could explain your findings. You should acknowledge weaknesses and limitations of your study, but do not make the common mistake that inexperienced scientists make of over emphasizing the weaknesses of their study. Even the best studies have weaknesses. You may discuss better ways to study the question(s) that motivated your study, and you may suggest other interesting questions for future studies, but don’t overdo it. End with a brief bit (no more than a few sentences) summarizing the most important findings and implications of your study.

In this section you should:

1. Reach conclusions about your initial hypotheses
2. Compare these conclusions to those of other researchers
3. Identify sources of error and inadequacies of the techniques used and suggest improvements
4. Identify the next steps needed in research on the problem
5. Speculate on the broader meaning (implications) of your work

Literature cited

In this part of your paper you should list (alphabetically by author) all of the papers that you cited in your paper. You should include the author's name(s), date of publication, title of the article, and the journal's name, volume number, and page numbers of the article. For papers in edited books, in addition to the author's name, date, and title, give the title of the book, name of the editor, and name of the publishing company.

When citing a paper in the text of your manuscript, use standard format, e.g., “Connell (1961) found that the lower limit of the distribution of the barnacle *Chthamalus stellatus* was set by competition with another barnacle.” Refer to published papers for other examples.

Examples:

For a journal article (one author):

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54:187-211.

For an article/chapter in a book:

Chesson, P.L. and T.J. Case. 1986. Nonequilibrium community theories: chance, variability, history, and coexistence. Pp 229-239 in J. Diamond and T.J. Case, editors. *Community ecology*. Harper and Row, New York, New York.

General comments

Your papers must be typed, lines should be *double-spaced*, and the margins should be wide enough (at least 1”) for written comments. All pages should be numbered. Scientific names should be *italicized*.

Refer to all tables and figures with parenthetical citations. For example, “the barnacle *Chthamalus dalli* reached its highest density in the high intertidal zone (Fig. 1; Table 2).” *Do not* write a weak sentence like “Table 2 contains the data on barnacle distributions.”

When you finish your paper, proofread it carefully to eliminate any grammatical, typographical, and spelling errors. Make use of software that checks spelling and grammar, but don't rely on these to catch all your errors. Study each sentence to see if you can make it more concise, without sacrificing clarity. Although you are striving for a compact style, a longer but clearer sentence is better than a short but confusing one. A short but clear sentence is best. Try to critique your own paper as you would one from a scientific journal. Although you are always limited by the quality of the data, when you turn in your paper, you should feel confident that you did a good job of presenting your findings in the context of their importance to the field of study.