

Appendix 1: Handout on scientific writing and checklist of scientific manuscript components

Adapted from:

McMillan, V.E. 2001. *Writing papers in the biological sciences*. 3rd edition. Bedford/St. Martin's, Boston, Massachusetts.

Morgan, J.G., and M.E.B. Carter. 1999. Scientific writing. Pages 751-758 in J.E.B. Morgan and M.E.B. Carter, eds. *Investigating biology*. Benjamin/Cummings Publishing, Menlo Park, California.

Scientific Writing

In this course, each student is required to complete a paper using the format of a manuscript appearing in a peer-reviewed scientific journal. This semester your paper will be based on the laboratory experiment "Observing and Quantifying Predator-avoidance Behavior: Habitat Shifts by Snails in Response to Predator Cues." The paper should consist of at least five double-spaced, typed pages. Included here are guidelines for completing all sections of the paper.

Conducting a Literature Search

For your scientific paper, you need to find and **cite at least five references from the primary literature** that are relevant to the topic we studied. **At least three of these references must have been published between the years 2000 and 2005.** Primary sources of literature are reports of original findings and ideas. These generally take the form of research papers published in peer-reviewed scientific journals. Book chapters may also be a source of primary literature. Magazines and encyclopedias are poor sources of primary literature, and these sources should not be used.

Articles can be located using various literature search databases, including *Biological Abstracts* and *Cambridge Scientific Abstracts*. Your instructor will show you how to access one of these databases and perform a literature search. A "keyword" search is an excellent way of locating pertinent literature. Articles not found in our institution's library can be obtained through interlibrary loan. Additionally, some journal articles may be accessed via the Internet. **Include cover pages for five of your cited sources with your completed paper.**

Components of the Scientific Manuscript

Many professional biologists publish results from a research project as a manuscript in a peer-reviewed professional journal. Publishing research results in peer-reviewed scientific journals is important for several reasons. In particular, advances in science can only occur if research results are disseminated in an appropriate way to the scientific community. The peer review process subjects manuscripts to intense evaluation and revision. This typically involves review and evaluation of each submitted manuscript by a journal editor and two or more professional biologists. Manuscripts are rejected for many reasons, but poorly written manuscripts and manuscripts based on results from invalid experimental designs are almost always rejected. Inaccurate or misleading results from poorly-designed studies can inhibit the advancement of

science. Therefore, it is important to keep such results from becoming part of the mainstream literature.

Similarly to methods of valid experimental design, biologists must follow certain established rules when reporting research results in the form of a peer-reviewed scientific manuscript. Each manuscript is divided into sections, and each section contains specific components of the manuscript. **Your completed paper must contain each of the following sections. Use the “Checklist for a Scientific Manuscript” for further assistance.**

Title

The **title identifies the important components of the paper** and orients the reader by specifying the writer’s major findings or perspective. A good title is important if you want your paper to be read by others. For example, abstracting and indexing services rely heavily on titles for categorization purposes. Other scientists will use your title to determine if they want to obtain and read the paper or not. An inaccurate title may waste a reader’s time by suggesting, erroneously, that a paper contains certain information.

Organize your title around important words (key words) of the study (e.g., antipredator behavior, snails, molluscivorous fish). You want to ensure that your paper is noticed by readers interested in this subject. Therefore, avoid being too vague in your title, but also be concise.

Abstract

The **abstract is a short (approximately 250 word) passage that summarizes all major elements of the paper: introduction (including objectives), methods, results, and discussion (including major conclusions)**. It usually consists of a single paragraph, and a good abstract will stand on its own. In other words, readers should be able to understand what was done without having to refer to other sections of the paper. Several revisions are usually required to get an abstract into satisfactory shape. Be concise, but not too vague, so that readers can better decide if they want to read the paper. In most cases, this is the only section of your paper that readers will read. References are not cited in the abstract text.

Introduction

The **introduction is where you present your argument for why the study was done**. It **places your work in a broad conceptual context** and gives readers enough information to appreciate your objectives.

Proceed from the general to the specific, starting with a brief review of current knowledge of the topic and gradually narrowing to the specific question(s) you have addressed. For example: you could begin with “Interactions among predators and prey are important in structuring communities”, and end with, “Our specific objectives were to determine if physid snails detect predators through chemical cues, and subsequently move to habitats that provide refuges from these predators”. The **introduction usually concludes with your specific research question, objectives, and/or hypotheses**.

It is critical that you **document (cite) key references in this and all succeeding sections of the paper**. References used should be from the primary literature (e.g., peer-reviewed

scientific journals). Proper citation format in the text sections of the paper (including the introduction, methods, results, discussion) consists of listing the author(s) followed by the date of publication (e.g., Brown and Jones 1998). If there are more than two authors for an article, list the first author followed by "et al." (e.g., Brown et al. 1999).

Methods

The key point here is to **include enough information so that your study could be repeated**. This is also necessary so that the quality of the data can be assessed. Tell the reader where the study was conducted (do this first), then describe sampling devices, procedures, statistical analysis techniques used, etc. It is important to organize this section of the paper well. Subheadings may help in this regard. **Include only those procedures directly pertaining to the results you plan to present and discuss later** (e.g., you don't need to say that your instructor went to the store, purchased aquaria, etc.).

Results

The results section should **summarize important data and statistics graphically and narratively** so that interpretations and conclusions you will make in the discussion section of the paper are supported. Use figures and/or tables to summarize data, number figures and tables in the order they are presented, and cite figures and tables as (Fig. 1) or (Table 1) in the text. For example, means and variance measures could be summarized using bar charts (a figure). Key results from statistical analyses must also be provided (e.g., t statistics, critical t values, degrees of freedom) in tables or parenthetically in the manuscript text. See the example of a peer-reviewed journal article that your instructor has provided for assistance in reporting statistical analysis results. Additionally, narrative summaries of key results in figures and tables must be provided in the text.

The results section should be a straightforward narrative and diagrammatic report of the data. **Save narrative comparisons of your results to those of other researchers, speculations of why or why results did not support hypotheses, etc., for the discussion**. Only results that are important in supporting or refuting hypotheses, or in meeting objectives should be reported here. However, you should reveal whether or not hypotheses presented in the introduction are supported.

Discussion

The discussion is where you **tell the reader what you think your findings mean, and why they are important**. Do the results support the original hypotheses? Why or why not? Compare your results to those of other researchers. Additionally, discuss how your results fit into the bigger picture. In other words, what contributions does your study make to the advancement of science?

In contrast to the introduction section, proceed from the specific to the general level in the discussion. You can begin with a brief summary of your key results, then state why you think these results were found, and compare/contrast your results with those from other studies. Last, how do your results contribute to an improved understanding of the broad problem you studied?

References

In this section, list all references cited in previous sections of the paper. References should be listed in alphabetical order. Use the following examples for proper formats.

Journal articles:

Auerbach, S., F.C. Zhou, and B.L. Jacobs. 1994. Serotonin turnover in raphe neurons transplanted into rat hippocampus. *Neuroscience Letters* 61:147-152.

Lee, T.D., and F.A. Bazzaz. 1982. Regulation of fruit and seed production in an annual legume, *Cassia fasciculata*. *Ecology* 63:1363-1373.

Low, M.G. 1988. Structural and functional roles of various protein anchors. *Science* 239:269-275.

Books:

McMillan, V.E. 2001. *Writing Papers in the Biological Sciences*. Bedford Books, Boston, Massachusetts.

Book chapters:

Lowe, R.L. 1996. Periphyton patterns in lakes. Pages 57-76 in R.J. Stevenson, M.L. Bothwell, and R.L. Lowe. eds. *Algal Ecology*. Academic Press, New York, New York.

Checklist for a Scientific Manuscript

Use the following checklist to assist in constructing your scientific manuscript. When your paper is finished, you should be able to answer "yes" to each question. Note that **I will use this checklist as a guide when evaluating your manuscript.**

Title

Is the title sufficiently informative? _____

Is the title concise? _____

Abstract

Does the abstract summarize all major sections of the paper, including the introduction, methods, results, and discussion? _____

Does the abstract consist of a single paragraph? _____

Is the abstract sufficiently informative, yet concise? _____

Are citations of references absent, as they should be? _____

Introduction

Does the introduction begin with a review of current knowledge of the general topic to be studied? _____

Are appropriate references cited to support your statements? _____

Are references cited in the proper format? _____

Are your research questions or objectives explicitly stated? _____

Are hypotheses explicitly stated? _____

Does the introduction gradually narrow in focus and conclude with specific questions, objectives, and hypotheses to be addressed in your study? _____

Methods

Are subheadings used to help organize this section?_____

Is the study site sufficiently described? If the study was conducted in the laboratory, has this been made clear?_____

Is the experimental design sufficiently described so that the study can be evaluated and repeated? Are independent and dependent variables identified and described? Has information been provided regarding the number of treatments, the number of replicates per treatment, and statistical analysis techniques used?_____

Is the discussion of procedures restricted to those directly affecting the study results?_____

Are appropriate references cited to support your statements?_____

Are references cited in the proper format?_____

Results

Are tables and/or figures used to summarize the important results?_____

Are tables and figures properly labeled with captions and axes labels?_____

Are tables and figures referenced properly in the manuscript text?_____

Are key results from statistical analyses (e.g., t statistics, critical t values) presented in tables or parenthetically in the manuscript text?_____

Are key results in tables and figures summarized in the manuscript text?_____

Did you indicate if hypotheses were or were not supported by statistical analysis results?_____

Did you correctly refrain from interpreting results, comparing your results of other researchers, and speculating as to why results did or did not support hypotheses, etc.?_____

Discussion

Does the discussion begin with a brief summary of key results?_____

Are all key results interpreted and discussed in light of whether they did or did not support hypotheses?_____

Are key results compared and contrasted with results from other studies?_____

Are appropriate references cited to support your statements?_____

Are references cited in the proper format?_____

Does the discussion gradually broaden in focus and conclude by addressing the broader significance of this research project to advancement of science?_____

References

Are at least five peer-reviewed references cited in the text of the paper?_____

Were at least three of these references published between 2000 and the present year?_____

Are cover pages of at least five cited sources included with your manuscript?_____

Are all sources cited in the text listed in the references section and vice versa?_____

Are sources cited using the proper format?_____