General Format for Writing a Scientific Paper

Scientists have established the following format for "scientific papers". A complete paper is divided into sections, in this order...

- Title Page
- Abstract
- Introduction
- Materials and Methods
- Results
- Discussion
- References
- Acknowledgments

Although this format is not cast in stone, most scientific journals use it or some variation there of. By adhering to this format, researchers maintain a consistent and efficient means of communicating with the scientific community. This order is really quite logical and could apply to almost any report you might write. You can benefit from writing good scientific papers, even if you do not expect to go on in Biology. Preparing a scientific paper develops your ability to organize ideas logically, think clearly, and express yourself accurately and concisely. Mastery of these skills would be an asset for any career that you may pursue.

All papers should be typed, double-spaced (except the abstract), with at least one-inch margins on all sides. Any statements not original to you should be properly cited in the text using, and listed in the “References” section at the end of your paper using the style explained at the end of this appendix.

Title Page

The title page is the first page of the paper and should contain the following:

- An informative title
- Your full name or, if a group report, the full names of all group members
- Course number
- Instructor’s name
- Your lab day and time
- Due date for the paper

A good title is informative, i.e. it summarizes as specifically, accurately, and concisely as possible what the paper is about. For example, if you were investigating the effect of temperature on the feeding preferences of a certain type of caterpillar found on tobacco plants, acceptable titles might be “Effect of Temperature on the Feeding Preferences of the Tobacco Hornworm Larvae, Manduca sexta”, or “Does Temperature Influence which Diet the Tobacco Hornworm Larvae, Manduca sexta, will Select? The following titles would be uninformative and too general: “Effect of Temperature on Caterpillars”; “How Temperature Affects the Tobacco Hornworm Larvae, Manduca sexta”; “What is the Preferred Diet of the Tobacco Hornworm, Manduca sexta?”
Abstract
The second page of scientific paper begins with the Abstract. The Abstract states clearly and concisely what is dealt with in the paper. It is a concise statement of the questions, general procedure, basic findings, and main conclusions of the paper. This is a brief, all encompassing section summarizing what you discuss in the rest of the paper, and should be written last, after you know what you have said! The abstract should be written as one single-spaced paragraph (all other sections are double-spaced), and must not exceed 200-250 words.
A good “Abstract”...
- states the question investigated and the principal objectives of the investigation,
- specifies the scientific context of your experiment,
- summarizes what you did,
- summarizes your results, and
- states your major conclusions.

Introduction
The Introduction presents a background for the work you are doing and put it into an appropriate context (e.g. scientific principles, environmental issues, etc.). What questions are you asking in your study? What organisms or ideas were studied and why are they interesting or relevant? Identify the subject(s) and hypotheses of your work. Tell the reader why (s)he should keep reading and why what you are about to present is interesting. Briefly state your general approach or methods (e.g. experimental, observational, computer simulation, a combination of these, etc.) as a lead-in to the next section. Cite any references you used as sources for your background Information. Any statements not original to you should be properly cited in the text using the scientific citation style, and listed in the “References” section at the end of your paper.
This section should be written in the past tense when referring to this experiment. However, use the present tense when discussing another investigator’s published work. Why? Previously published work is considered part of the present body of knowledge.
A good “Introduction” will....
- include a clear statement of the problem or question addressed in the experiment,
- state the hypothesis or hypotheses that you tested in the study,
- put the question into some context by stating why this is an important question to be answered and/or why you found this to be a particularly interesting question,
- state the objectives of the research,
- address how the research helps to fill holes in our knowledge,
- include any background material that is particularly relevant to the question,
- give a brief overview of the method of the investigation. If deemed necessary, the reasons for the choice of a particular method should be stated, and
- state the principle results and conclusions of the investigation. Do not keep the reader in suspense. Let the reader follow the development of the evidence.

Materials and Methods
The “Materials and Methods” section tells how the work was done. There should be enough detail that a competent worker can repeat the experiments. What procedures were followed? Are the treatments and controls clearly described? Does this section describe the sampling regime and sample sizes, including how individuals were assigned to treatments? What research materials were used: the organism, special chemicals, concentrations, instruments, etc.? Briefly explain the relevance of the methods to the questions you introduced above (e.g. "to determine if light limited algal growth, we measured..."). If applicable, include a description of the statistical methods you used in your analysis.
Careful writing of this section is important because the cornerstone of the scientific method requires that your results are reproducible, and for the results to be reproducible, you must provide the basis for the repetition of your experiments by others. Avoid lab manual or “cook book” type instructions. **This section should be written in the past tense.**

**Results**

The “Results” section presents in words the major results of the study. Your data should be presented succinctly in the body of the report and presented in detail as tables or graphs. However, do not present the same data in both tabular and graphical form in the same paper. Strive for clarity—the results should be short and sweet. Do not attempt to discuss the interpretation of your data—this should be done in the “Discussion” section.

The results section should be written so that any college student could read the text to learn what you have done. For example, you might use a paragraph to explain what is seen on a particular graph; “... When the enzyme as soaked in sulfuric acid, it produced no change in absorbance....” Do not make the common mistake of saying, “We performed the experiment, see figures 1-4.” That is too brief and does not convey to a novice what you have done. When stating your results in the body of the text, refer to your graphs and tables.

Tables and graphs alone do not make a Results section. In the text of this section describe your results (do not list actual numbers, but point out trends or important features). Refer to the figures and tables by number as well as any other relevant information. “See Figures” is not sufficient. Results are typically not discussed much more in this section unless brief discussion aids clarity. In referring to your results, avoid phrases like 'Table 1 shows the rate at which students fall asleep in class as a function of the time of day that class is taught.' Rather, write: "Students fall asleep in class twice as frequently during evening than day classes (Table 1)." The results section should avoid discussion and speculation. This is the place to tell the reader what you found out, not what it means.

*Each table and figure should be numbered sequentially* for easy reference in the text of the Results and Discussion sections. **Figures** (e.g. graphs and diagrams) are numbered consecutively as Figure 1 to Figure X. Be sure to label both axes of all graphs (e.g. growth rate, height, number of species, water consumed, etc.), include units (e.g. meters, liters, seconds, etc.), and define all treatments. Labels such as “treatments 1,2,3, and 4” are not sufficient. **Tables** are numbered separately from the figures as Table 1 to Table X. Label columns, including units of measure, and define all treatments.

Your reader should *NEVER* have to go back to the text to interpret the table or figure—thus you need to **provide a legend for each figure** and a **caption for each table**. A figure legend is freestanding text that goes *below* the figure. The first sentence of the legend (bold print in the example below) is typically a succinct statement that summarizes what the entire figure is about. The first sentence is then followed with particulars of the figure contents, as appropriate, including information about methods, how the data are expressed, or any abbreviations etc. An example of a legend...

**Figure 1. Light Micrograph of a Human Karyotype.** Fetal cells were obtained from Aimee Biophiliac in September 2008 by amniocentesis. The cells were cultured, metaphase chromosome spreads were prepared and the chromosomes stained and photographed as described in Materials and Methods. Individual chromosomes were cut out from the photograph and arranged in a karyotype. By virtue of the presence of two X-chromosomes, the karyotype indicates that the developing fetus is a female. Based on other information (data not presented), the fetus is expected to emerge March 19, 2009.
A table caption is freestanding text located above the table. It presents a succinct statement of the contents of the table. An example is...

**Table 1. Uptake of Various Electrolytes by Rhinoceros Cells in Culture.**

A caption must NOT include information about methods, how the data are expressed, or any abbreviations---if needed, those are included as footnotes to the table, with each footnote keyed to a footnote reference in the table by sequential, lettered superscripts.

**Discussion**

The discussion section is where you explain your results in detail, speculating on trends, possible causes, and conclusions. Try to present the principles, relationships, and generalizations shown by the Results. And bear in mind, in a good Discussion, you discuss—you do not recapitulate—the Results. Don't be shy; discuss the theoretical implications of your work, as well as any possible practical applications.

A good discussion section...

- states what conclusions can be drawn from the results (Present major findings first, then minor ones; Use specific numerical data to support these conclusions),
- compares your results with those of other workers and cites the references used for comparisons,
- puts your results in the context of the hypotheses and other material in your Introduction,
- indicates where your data fits into the big picture,
- addresses problems that arose in your study and how could they be avoided in the future,
- will attempt to explain why results might be inconsistent with the predictions you made (what you thought would happen before you did your study, based on a specific hypothesis or other background information),
- explains any exceptional aspects of your data or unexpected results,
- examines your results for possible errors or bias,
- recommends further work that could augment the results of the study you have presented, and
- states your major conclusions as clearly as possible, using specific examples from your data!!

**References (or References Cited)**

The References section is a complete list of all references that you cited within your paper. The references are listed in alphabetical order by last name of the first author of each publication. Include only those references that you have actually read and that you specifically mention in your paper. If a laboratory handout was used it is only a beginning and must be cited.

When researching for information for the Introduction and Discussion sections or the paper, seek out original sources that are written by experts in the field (e.g. articles found in scientific journals such as Science, Nature, Proceedings of the National Academy of Sciences, New England Journal of Medicine, etc.) or authoritative magazines (e.g. Scientific American) and books written by well respected scientists. Textbooks, although acceptable in this class as a last resort, are rarely cited in the scientific papers since information in textbooks is less reliable than from the original sources.
In-Text Citations

Citation formats are often discipline specific. Footnotes or endnotes are not normally used in scientific writing as they are in humanities and the social sciences. Because natural scientists most often use the Name-Year System, we will use this system in this course. All citations occur in the text in parentheses, with the author(s) and date of publication. For example: Bush (2003) found that the suspected possession of weapons of mass destruction is sufficient justification for the military invasion of another country. Alternatively: The suspected possession of weapons of mass destruction is sufficient justification for the military invasion of another country (Bush 2003). It’s as easy as that! If there is more than one author of a source, simply use the first author's last name, followed by et al., Latin for “and others”. For example, (Bush et al. 2003). The complete list of authors will appear in the full citation at the end of your paper.

The format of the References section varies slightly from one scientific journal to another. Every scientific journal provides an “Instructions to Authors” that describes the format for the References section and all other requirements for papers they will accept. Use the following as examples for citing various kinds of sources in for this course....

Citing Journal and Magazine Articles

- **Format**

- **Examples**


Citing Journal and Magazine Articles with no Identifiable Author

- **Format**

- **Example**

Citing Books

- **Format**
  Author(s). Publication year. *Book Title*, edition if known. Publisher, Place of publication, number of pages.

- **Example**
Citing Book Chapters

- **Format**
  Author(s). Publication year. Chapter title. In: Book title (Author(s)/editors, first name first) Place of publication, pages.

- **Example**

Citing Newspaper Articles

- **Format**
  Author(s). Date (Year/Month/Day). Article title. Newspaper title Section: Page: Column.

- **Examples**


Citing Newspaper Articles with no Identifiable Author

- **Format**

- **Example**

Citing Sites on the Internet

The complete web address should be presented so that anyone else could easily visit the same website. Attempt to include the following elements (not all elements appear on all Web pages):

1. author(s) (last name, first initial)
2. date created or updated
3. title of the page
4. title of the complete web site (if different from the page)
5. URL (full web address)
6. the date accessed.

- **Format**
  Author's last name, First initial. (date created or updated). Title of the page. Title of the complete site. [Online]. Available: http://full.web.address. [Date accessed].

- **Example**
Citing a Lecture

- **Format**
  Lecturer’s last name, First initial. Lecture Location of Lecture, Date, Room number.

- **Example**
  Greengrove, C. Lecture. UW-Tacoma, 8 January 1997, TLS490sc.

Citing a Video

- **Format**
  *Title of video* (videocassette). editor or director. Producer’s name, producer. [Location of Production]: Organization responsible for production, Year.

- **Example**

Citing a Thesis or Dissertation

- **Format**
  Author. Publication year. *Title*[dissertation]. Publisher: Place of publication, number of pages. Available from: University Microfilms, Ann Arbor, MI; DAI number.

- **Example**

Government report

- **Format**
  Author/Agency (if no author). Publication year. Title. Publisher, Place of publication, number of pages.

- **Example**

Acknowledgments

In this section you should thank anyone who has helped you in any aspect of this project. (e.g. "I thank William Gates for assisting with the computer code used to analyze the temperature data, Spike Lee for reading my pH meter, Barack Obama for the economic stimulus package the underlies the funding of this project, Dewey, Cheetham, and Howe for valuable discussions of the ideas underlying the analysis of the data and my mother for assisting in the formatting of the figures, tables and chemical equations and for changing my diapers when I was a baby.")