

GUIDELINES FOR WRITING LAB REPORTS

We ask you to write lab reports for a number of important reasons. First and foremost, it will help you improve your writing skills. Lab reports also introduce some of the basic conventions of scientific writing. Furthermore, writing lab reports requires mental processing of new information and ideas that reinforces key concepts and helps to illustrate how scientists themselves think about things.

In its essence, a lab report is similar to essays that you might write for a non-science course. All of the standard rules of grammar and sentence and paragraph structure apply. The major differences are that in a lab report ideas are organized according to a particular format, there is a stronger emphasis on precision and conciseness in sentence structure, and the passive voice is used in certain sections of the report.

Attention to the rules of composition is particularly important in scientific writing because of the need to convey ideas unambiguously. Clarity of meaning marks good scientific writing. Indeed, many of the most eminent scientists are superb writers as well--Edward O. Wilson, Stephen J. Gould, and Charles Darwin are as renowned for their ability to reveal nature in written prose as for their scientific contributions. In this course proficiency in the fundamentals of composition will facilitate your ability to communicate ideas in a lab report. Your grade will reflect your understanding of key concepts and your ability to convey this understanding in a coherent, well-written report.

Grading of Lab Reports

Your instructor will be asking the following questions while grading your lab report. You should review these questions while writing and proofreading your report.

- 1) Has the student read and followed the lab report guidelines?
- 2) Does the report follow the correct format? Is each section title clearly labeled?
- 3) Are information and ideas placed into the appropriate sections?
- 4) Be the report checked for grammar, punctuation; and speling?
- 5) Have sources of information been correctly cited and referenced?
- 6) Does the Background Information section present sufficient relevant background information?
- 7) Has the 3rd person passive voice been used consistently in the Procedures and Results sections?
- 8) Are the correct types of information placed in the "Description of Data" and "Explanation of Results" sections?
- 9) Have the results been thoroughly explained in the Discussion section?

GENERAL GUIDELINES FOR LAB REPORTS

1. All reports must be typed using a word processor on a microcomputer, such as those available in the computer labs in the Rickey Science Center. Use a 12pt font, 1" margins all around, and double-space your text.
2. Each student must write an independent lab report. Lab partners are encouraged to discuss the results of lab exercises, but each student must write a COMPLETELY INDEPENDENT report. Plagiarism may be rewarded with a failing grade (for the paper or the course), at the instructor's discretion.
3. Lab reports must follow the format outlined below and described on the following pages.

- Introduction
 - Background Information
 - Purpose
 - Hypothesis
- Procedures
- Results
 - Tables and Figures
 - Description of Data
- Discussion
 - Conclusions
 - Explanation of Results
 - Future Experiment
- Literature Citations

Introduction

The Introduction should include the following sections and should be **at least** two pages in length.

Background information. This section presents information that familiarizes the reader with the subject of the experiment. A well-written introduction should be THOROUGH, but only include information that is DIRECTLY RELEVANT to the experiment. For most lab exercises, this information can be found in the lab manual and textbook, although you may be instructed to use other sources as well. **Never directly copy or quote sentences from your sources.** Rather, ideas should be conveyed in your own words, and the source of this information should be cited and referenced (see description of Literature Citations below). Be sure to describe the variable tested and the nature of the control(s).

Purpose. In a few sentences explain why the experiment was performed--what was the scientific "problem" being studied and the objectives of the exercise. There are usually a number of purposes to the lab exercise. In the Ecosystem lab exercise, one purpose was to study the effects of different types of pollutants on an aquatic ecosystem. Some purposes are educational in nature, such as to learn about experimental design.

Hypothesis. Remember, a hypothesis is one possible explanation of observations or information. If you were asked to write a hypothesis before starting the exercise be sure to include it in your lab report. Whether your hypothesis is correct or not is irrelevant to your grade; frequently the best lab reports are those that clearly explain why the hypothesis is incorrect.

Procedures

The objective of the Procedures section is to describe the experimental procedure in sufficient detail for someone else to REPLICATE THE SAME EXPERIMENT. The steps of the procedures provided in the lab manual SHOULD NOT be copied verbatim. Rather, these procedures should be rewritten to provide the essential elements of the procedure, leaving out trivial details. For example, this sentence is unnecessarily detailed:

"Ten grams of NaCl were obtained from the front bench and dissolved in 250 ml of water in a glass beaker."

It is adequate to more simply state that:

"Ten g of NaCl were dissolved in 250 ml of water"

since the outcome of the experiment does not depend upon from where in the lab the NaCl was obtained nor the type of beaker used.

It is also important to include a clear description of how the data were collected, and how the raw data were mathematical manipulated. **For the Ecosystem lab, you should describe how the microorganisms were counted and the calculations that were performed, explaining the equation used.**

The passive voice is used in Procedures and Results sections

The sample sentences above illustrate use of the passive voice. The passive voice is used by convention in the Procedures and Results sections. This style of writing is used to convey that the researcher was impartial and objective when performing the experiment and collecting the data. Some scientists dispute this rationale and rightly argue that active voice ("I dissolved 10 g of NaCl in 250 ml of water") improves clarity and conciseness. Furthermore, scientists are rarely completely dispassionate in their pursuit of scientific knowledge. Nevertheless, since the passive voice is still the standard used in most scientific literature, you are asked to use it in your lab reports. Some examples of common errors in procedural sentences are presented below.

Example #1:

INCORRECT: "I added 5 ml of buffer to a 250 ml flask."

This sentence uses the active voice.

CORRECT: "**Five ml of buffer were added to a 250 ml flask.**"

This sentence uses the passive voice. Note also that a sentence should not begin with an arabic number (ie. "5").

Example #2:

INCORRECT: "Next, cover the flask with a piece of foil."

This sentence uses the imperative tense, instructing the reader what to do. This is the style used in the lab manual. However, the purpose of a Procedures section is to describe how **you** carried out the experiment. While it is not written as a set of instructions, it must be detailed enough to serve the same purpose for someone who wishes to repeat the experiment

CORRECT: "**Next, the flask was covered with foil.**"

Here, again, the passive voice is being used.

Example #3:

INCORRECT: "The three solutions were obtained and mixed together."

The phrase 'were obtained' is an example of tautology, stating what is explicit in the sentence--obviously the solutions 'were obtained,' otherwise they couldn't be mixed together. Be concise --don't waste words.

CORRECT: "**The three solutions were mixed together**"

Example #4:

INCORRECT: "This procedure sought to demonstrate the properties of ..."

Make sure that your sentences convey the meaning that you intend. 'Procedures' do not seek to do things, but they do have a purpose.

CORRECT: "**The purpose of this procedure was to demonstrate the properties of ...**"

Results

The scientific data is presented in this section. This includes both **qualitative** observations and **quantitative measurements**. **Numbers should never stand alone** –they must be accompanied by appropriate units (**eg. ml, cm, cm/sec, etc.**). You should include any observations that have bearing on the interpretation of the results (interpretation of the data are presented in the Discussion section). There are two sub-sections of the Results:

Figures and Tables. Whenever possible and practical, present your data in a table or a graph. All charts, graphs, drawings, photographs, etc. are collectively called **Figures** and should be referred to as figures in the text and numbered consecutively. A **table** is a presentation of textual or numeric data in rows and columns.

A correctly prepared graph should:

- 1) have the **independent** variable on the **x-axis**
- 2) be numbered (Figure 1, Figure 2, etc.)
- 3) have a descriptive title
- 4) possess clearly labeled axes
- 5) have data points that are clearly marked.

A correctly prepared table should:

- 1) be numbered (Table 1, Table 2, etc.)
- 2) have a descriptive title
- 3) have rows and columns clearly labeled.

Examples of a correctly prepared Chart and Table.

Figure 1. Oxygen uptake by barley seeds measured at different temperatures

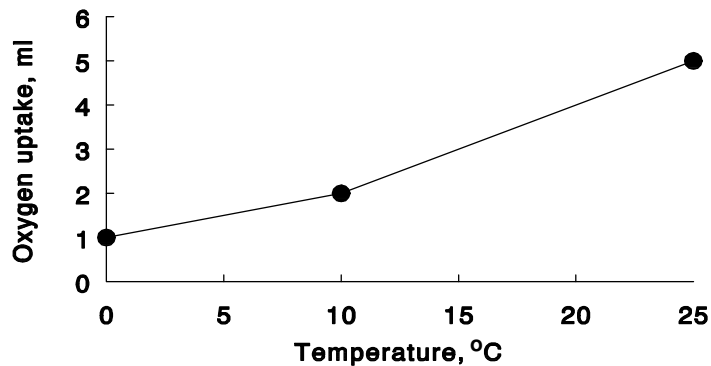


Table 1. Number of protozoa in ecosystems on week 1.

<u>Ecosystem</u>	<u>cells/ml</u>
control	20
pollutant 1	23
pollutant 2	3
pollutant 3	28
pollutant 4	19

Description of data. A table or graph presents data and allows trends in the data to be illustrated. However, you **must also describe the data**—in effect, narrate to the reader key features and trends that you perceive in the data. Use the third person passive voice.

For example, the data in Figure 1 above might be described as follows:

"One ml of O₂ was taken up by the barley seeds at 0°C. Oxygen uptake increased to 2.5 ml at 10°C and 5.5 ml at 25°C. Overall, there was a linear relationship between oxygen uptake and temperature."

If a graph has a cumbersome amount of data, just the trends in the data should be described:

"As the temperature of incubation was increased from 0°C to 25°C, there was a linear increase in oxygen uptake from 1 ml to 5.5 ml."

Notice that this is a restatement of the data presented in figures and tables, interpretations of the data and conclusions are presented in the **Discussion** section.

Discussion

The Discussion should include the following sections:

Conclusions. In a sentence or two, state whether the hypothesis is supported by the results or not. Identify any other conclusions pertaining to the hypothesis based upon the results of the experiment.

Explanation of Results. In this section you should explain your results drawing upon information presented in the Background Information section and other literature sources. A cause/effect relationship or a correlation might be described here. For example, discussion pertaining to Table 1 (above) might include "The marked decrease in the number of protozoa in ecosystem 2 suggests that the pollutant added was a toxin." If your results did not support your hypothesis, then you should attempt to explain the discrepancy. Do not assume that your results are wrong, and then merely write about possible sources of error. As stated above, an incorrect hypothesis will not tarnish your lab report, so a thorough discussion of what your results tell you about the biological system you are studying is still the appropriate explanation of the results.

Future experiment. This section helps to show how well you understand the experiment and its results. In no more than two paragraphs, explain how another experiment might help to answer questions raised by the current experiment. Usually, the results of one experiment provide the basis for future related experiments, possibly in which other variables are studied. Be sure to state the PURPOSE of the future experiment, but do not include a lengthy description of procedures.

Literature Cited

It is essential that you identify ALL sources of information and ideas included in your report. Do not be misled into believing that citations are only required for direct quotes. As stated above, sources should not be directly quoted in a lab report. You must, however, cite the sources of information and ideas that you express in your own words. **Unless indicated otherwise by your instructor, the course textbook and lab manual, and web pages, are NOT acceptable sources of information. You must use the library.**

Citations

'Citations' within the text of the report point to the original source of information, and are most commonly used in the Background Information and Explanation of Results sections. Footnotes or subscripts ARE NOT used to cite sources in scientific writing. Although the format used for citations varies among disciplines, the Biology Department requires the following format for all assignments.

(Author, year of publication, page #) for example: (Smith, 1992, 97)

If the source has **three or more authors**, then the abbreviation 'et al.' can be used after the first author's name; for example:

(Smith et al., 1997, 184)

Proper Use of Citations

- 1) Citations must be accurate to the source of information – to the indicated article and page.
- 2) Do not cite from abstracts, cite only from the full text of an article.
- 3) Do not cite only at the end of paragraphs; citations should be included throughout a paragraph to prevent ambiguity as to the source of information.
- 4) For that matter, if a sentence contains information from more than one source (or your own conclusions and data from another source, cite the material in the clause in which it is used: In my experiment I found yeast respired best at 27° C, while Fredericks et al. (2005, 183) found the highest respiration at 28 ° C. –or- Optimal temperature for yeast respiration varies in the literature; in one experiment the yeast respired optimally at 27° C (Pitcairn, 2003, 1374), while Fredericks et al. (2005, 183) found the highest respiration at 28 ° C.
- 5) For a further discussion of citations, see the web page

<http://www.marietta.edu/~biol/library/citation.html>

References

Citations point to 'references' listed in the "Literature Citations" section of the lab report, where the sources of the information are listed alphabetically. Again, the specific format for references varies among disciplines, however, use the following formats for your lab reports:

Note; although 'et al.' can be used in citations, it should **never** be used in the full reference provided in the Literature Cited section.

Reference from a **book**:

McKinney M, Schoch R. 1998. Environmental science: systems and solutions. Sudbury (MA): Jones and Bartlett Publishers; 988p.

Chapter of an **edited book**:

Crabbé J, Barnola P. 1996. A new conceptual approach to bud dormancy on woody plants. In: Lang G., editor. Plant dormancy. Wallingford, Oxon (GB): CAB International; p. 83-113.

Marietta College Biology Department. 2003. Observation, ethograms and wall-seeking behavior. In: Introductory biology lab I manual. Marietta (OH): Marietta College; p. 1-19.

From a **journal** (1^o and 2^o sources):

Smith AB, Jones CD, Banks EF. 1994. Effects of absenteeism on student grades in biology. American Journal of Biology Class Attendance 123(4): 19-23.

From a **magazine** (3^o source) which does **not** use volume numbers (most DO):

Beckridge N. 1997. The parasitic wasp's secret weapon. Scientific American, November, 82- 85.

[Note that for tertiary sources, sometimes the month of publication substitutes for the journal volume number]

From **state or federal documents**:

Ohio EPA (Ohio Environmental Protection Agency). 1988. Biological criteria for the protection of aquatic life. Volume II, user's manual for biological field assessments of Ohio surface waters. Columbus (OH): Ohio EPA; 135p.

Smith RD, Ammann A, Bartoldus C, Brinson MM. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands and functional indices. Wetlands Research Program Technical Report WRP-DE-9. Vicksburg (MS): US Army Corps of Engineers Waterways Experiment Station; 88p.

USDHHS (US Department of Health and Human Services), Center for Disease Control and Prevention. 1993. Fluoridation census, 1992. Atlanta (GA): CDC; 686p.

For more information on citations see this web page:

<http://www.marietta.edu/~biol/library/citation.html>

or consult the sample lab report at:

<http://marietta.edu/~biol/introlab/samprep.pdf>

If you cannot find an example of how to handle a particular reference, consult a RECENT edition of the Ohio Journal of Science, or the CSE manual:

Council of Science Editors, Style Manual Committee. 2006. Scientific style and format: the CSE manual for authors, editors, and publishers, 7th ed. Reston (VA): The Council; 658p.

The CSE manual is in the reference section of the library; we are using the N-Y system mentioned in the manual.

References to web pages (i.e. HTML) are *not* allowed in lab reports or term papers. Web pages are notoriously short-lived, and a reference to a specific URL today is likely to not work (or no longer provided the referenced material) in the near future.

If you are asked to do literature research, **on-line articles in pdf format can be used.**

However, online articles that are in HTML format are not acceptable for the reason given above and because the original format and page numbering of the published article are not preserved. In general, if you print up an online article and a URL is included at the top of the page, and/or the page numbers begin at '1' even though the article reference gives a different first page number, and/or there are hyperlinks to the figures and tables, then you are looking at an HTML version of the article.

References to web pages (only allowed for special assignments)

For some assignments you may be asked to search for information on the internet. A reference for such information must include, as a minimum, this information in following order:

1. Author of the web page or 'anonymous' if author is not identified.
2. Title of the web page from which the information was obtained. Follow title with [Internet].
3. Name of organization that prepared the web page, and, when present, the name of the company, government agency, or university that sponsors that organization. Sometimes this can only be found by inspecting the URL.
4. Date of page creation or last update: date cited [in brackets] i.e. [created 2008 May 15; cited 2008 Sep 14]. Sometimes this can be obtained directly from the page or through the 'View, Page Source' option on the pull-down menu.
5. URL (in parentheses) of the page.

URL, title and other information can be copied from browser to your document using the 'cut' and 'paste' functions.

Examples:

Franchesca P, Kjeldsen K, Hughey K. Algae: the forgotten treasure of tidepools. [Internet] Department of Biology at Sonoma State. [modified 1997 May 23; cited 1998 Oct 5] (<http://www.sonoma.edu/biology/algae/algae.html>).

Matthews HS, Lave LB. Price setting for green design. [Internet] The Green Initiative. Carnegie Mellon University. [no date given: cited 2008 Jun 18] (<http://gdi.ce.cmu.edu/gd/Research/price.html>).

Anonymous. Algal bioassays (nutrient testing). [Internet] Bureau of Laboratories, Florida Department of Environmental Protection. [modified 2005 Feb 1; cited 2007 Aug 9] (<http://www.dep.state.fl.us/biology/biol/aalimnut.htm>).

A note on 'et al.'

Adv. 1. et al. - used as an abbreviation of 'et alii' (masculine plural) or 'et aliae' (feminine plural) or 'et alia' (neutral plural) when referring to a number of people
[and others, et al](#)

(Source: <http://www.thefreedictionary.com/et%20al.>)

As you can see, et al. is an abbreviation for a Latin term of art. Loosely translated it means "and others". It is used in citing a reference when there are 3 or more authors on a single paper. It is not used when there are only 2 authors because then it would be "and other" and et al. means "and others". You can use et al. if there are 3 or more authors, although some use a convention of listing out all of the authors the first time a paper is cited and et al. after that. Either way, spell it right – et al.

NEVER, EVER, EVER use ET AL. in the Literature Cited section. List out ALL the authors there.

Name: _____

Be sure to read the section on writing procedures, before doing this exercise. Rewrite each sentence so that they express the ideas clearly, grammatically, and using the passive voice.

1. Obtain a test tube and put it in the water bath.
2. I began the experiment by grinding up 3 g of spinach leaves.
3. I measured pH of 3 solutions after blowing air through them.
4. Place iodine on the slide, stain the sample for 1 minute.
5. This procedure sought to count the number of algae in the sample.
6. The samples each I put into two test tubes and put them into an ice bucket.
7. 2 samples should be taken from each ecosystem.
8. I counted 12 squares and then added together the number of cells.

