

AP Biology Formal Lab Report Guidelines

Prepare a written report of your experiment which includes the section titles listed below. These section titles should be used to label each section of your report.

- I. Title
- II. Introduction
- III. Materials and Procedures
- IV. Results/Data Collection/Analysis
- V. Discussion/Conclusion
- VI. Literature Citation
- VII. Questions

The following information should be included in each section of the lab report.

- I. **Title** - Be as specific as possible and briefly denote primary topic dealt with during the experimentation. The title should be written in the appropriate box provided on the lab book formatted page.
- II. **Introduction** - In this section of the report you should include the following pieces of information:
 - a. Background information that will help them understand the experiment that you have conducted. Important terms should be defined in the section.
 - b. Purpose of the lab and should be clearly stated in the introduction.
 - c. Hypothesis – a testable hypothesis should be included, written in an if-then format.
- III. **Materials & Procedures** - A complete listing of the materials and supplies that were used to conduct the experiment should be included in this portion of the report. In this section of the report you should present the exact steps that were followed in your experiment. Clearly identify the control, variables and the measurement techniques used.
- IV. **Results/Data Collection/Analysis** - All of the data that was collected during the experiment should be presented in a data table or tables. Additionally, a graph of the data should be included in this section. Make sure that the graph is appropriately titled and axes labeled. Include a legend if necessary.
- V. **Discussion/Conclusions** - This portion of the report is used to clearly explain whether the results support or refute the hypothesis being tested. Explain what your findings mean and what conclusions you can draw from the data. Sources of error and suggestions for improvement should be included in this section.
- VI. **Literature Citation** – Given that some of the information included in your lab write up will have been taken from a published lab activity, you should include a citation of the source. The source(s) used should be cited within your lab write-up (especially in the introduction section) using scientific citation. Example: (College Board, 2001).

The following citation format will be appropriate for lab reports based on one of the 12 AP Biology labs:

Lab # ____ Title of Lab (College Board, 2001)
AP® Biology Lab Manual for Students (2001) New Jersey: College Board. p. ____-____.

- VII. **Questions** – The discussion questions found throughout the laboratory should be *written and answered* in this section.

FORMAL LAB REPORT FORMAT

The following is a guide for all formal lab reports in this course. You need not limit yourself to this outline. If additional information is warranted then please add it.

1. Title page and Introduction

- title, names of group members, class, teacher, date submitted
- important concepts essential to understand your experiment
- your choice of experimental model
- relevant and pertinent background of what is already known
- any knowledge that is not your own needs to be cited/ referenced
- indicate what you hope to learn (purpose)
- where applicable – independent variable, dependent variable, controls, etc.
- where applicable – hypothesis or hypotheses
- **caveat:** This introduction section will take some research. Do not “wing it” by making up info from your head!

2. Materials and Methods

- a description of the procedure – should be repeatable by another
- describe methods associated with controls
- describe methods for collecting the data
- describe any calculations (e.g., averages, rates, etc.)

3. Results & (Mathematical/ Statistical) Analysis

- construct data tables & graphs to present the data collected
- must include titles and labels for all tables, graphs, and figures
- NO RAW DATA; you do not need to show calculations – only the results
- must include verbal review of the results (in paragraphs) – i.e., tables, graphs, and figures by themselves will not suffice

4. Discussion & Conclusions

- state a valid conclusion & explain
- discuss the results of your experiment
- answer all questions from the lab manual in a well-written concise manner (i.e., paragraphs – not bulleted or numbered)
- explain any unexpected results & why those results may have been obtained
- evaluate the data to determine if it supports your hypothesis using specific reference to the data
- evaluate the procedure, making suggestions for improvement if needed
- identify weaknesses & state realistic improvements
- what did you learn from this lab?

SPELL CHECK!!! PEER-REVIEW!!! PROOFREAD!!!

Writing a Lab Report

FORMAT

A formal lab report should follow the general format used for a research report published in a scientific journal. Although different journals require different formats, all papers have a roughly similar outline. They reflect the basic scientific method of asking a question, formulating hypotheses, conducting experiments to test the hypotheses, and interpreting the results. You may want to go to the library to look at articles in journals such as *Bioscience*, *Proceedings of the national Academy of Sciences*, or *Limnology* to get an idea of how to write a scientific paper. (*Scientific American* is NOT considered a scientific journal because its purpose is not communication between research scientists engaged in related work.)

Although not all journals require authors to divide their papers into clearly labeled sections, this practice will help you develop good habits in reporting your findings. Therefore, you are asked to label clearly each section in your paper except for the title.

Title

The title should consist of a few well-chosen words indicating the subject of the report. "Well-chosen" means that the title reflects the scope of your report accurately; do not call your paper "Effects of Chemicals on Animals" if you really studied how feeding dietary supplements of vitamins A and D affected the appearance of the fur of three white rats.

Abstract

The abstract is a short paragraph of 150 words or less that summarizes your experiment, including pertinent information about your experimental subjects, materials and methods, results, and conclusions. This is the part of the paper scientists read to decide whether they are interested in looking at the rest of the paper. Thus the information the abstract contains should help people decide whether your research sheds any useful light on what they are studying.

Introduction

The introduction gives the background of the experiment. It should include an explanation of background of the general problem or area being investigated, telling why this problem is of interest and outlining what information is already known about the problem.

The problem does not necessarily have to be relevant to the health and welfare of human beings or of immediate economic importance to be of interest. Students often attempt to force a human perspective on a problem that is of interest because it is related to broad underlying principles of the structure or functioning of living things. In building up this part of your report you may want to consult outside references or at the very least, reread the relevant parts of your text. But be sure to keep tract of where you get this information and list all references used, including your textbook and laboratory guide, in a reference list at the end of the paper.

The introduction should also present the question you are trying to answer or the hypotheses you are testing. You should include what outcome you expect, and how it would help support or refute your hypothesis or answer your question.

Materials and Methods

This action should include a concise description of the materials, procedures, and equipment used. There should be enough detail so that someone else could repeat your work. Therefore, brand names of equipment, concentrations and amounts of solutions, species, size of age, sex, and other information about the experimental subjects should be included. If you follow directions from a book or paper, just say so. You need not repeat them in your paper.

If, however, you change the procedure, you should explain why you did so and exactly what you did differently.

Do not include the rationale for your work in this section. Also, be sure to report your procedure as a past event rather than writing this section as a set of directions to your reader. You do not need to report

attempts at the experiment with techniques that failed unless these techniques are very likely to be tried by other people in the future.

Results

Present your findings in a logical, not chronological order. Give the results that you found, not what you think you should have found. The organism is always right! You may have to do some thinking, however, to find out why the results came out as they did. Do not explain your results in this section.

Results can often be reported more effectively in the form of one or more tables or graphs or drawings. These should have clear labels and captions. Be sure to indicate whether the data reported are single readings or averages. Statistical analyses of your data should also be included here if appropriate. In addition, a written description should summarize the results illustrated in the graph or figures. This should point out trends or inconsistencies but not include explanations or opinions.

Discussion (Analysis)

Here you should give your interpretations of the data and relate them to the questions you posed in the introduction. Be careful to avoid making this section just a repetition of the introduction. If you have any data to explain away, do it here or make a new hypothesis as to why the results came out in a way you did not expect. Did the results answer your question? Did they support or disprove your hypothesis? Draw some conclusions, supporting them with your data. What is the significance of your results in the general area you studied? What are the main principles demonstrated by your results?

What further experiments should be performed to clear up discrepancies or ambiguities in your results? How might your work best be continued or extended?

Conclusion

this should be a separate section only if you have a lot of conclusions. Otherwise you should simply round off your discussion section with the conclusions that you can draw from your experiments.

Conclusion

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References

You must refer to all the sources of information that you used in your paper. Failure to do so is a serious offense, *plagiarism*, and will result in rejection of your laboratory report or worse. All of the sources in the reference list must be cited in the paper and vice versa.

There are several possible systems for organizing your references. You may choose to list the references in the order in which you cite them in the text. In this case you place a number in your paper after a comment from the reference; for example, "The Loch Ness monster is a big work (1)," and then list the reference from which you obtained this information as number 1 in your references list. Alternatively, you may alphabetize your list of references and the number of the list when you have finished preparing your report. In that case you can use either the number or the author's last name(s) to refer to the source.

Whichever system you use, you may sometimes want to cite the author and date of the source in your text. This has the advantage of letting your reader know something about the authority and how recent your information is without flipping to the end of the report all the time. For example, you could say, "The Loch Ness monster is a giant worm (Smith, 1970)," or "Smith (1970) has found that the Loch Ness monster is a huge worm," or "In 1970, Smith found that the Loch Ness monster is a large worm." With three or more authors, name them all the first time that you cite them and then use "Smith et al." subsequently (et al. means "and other"). You do not need to repeat the date each time unless you have more than one reference from the same author.

SUGGESTED FORMAT FOR REFERENCE LIST ENTRIES

Here are examples of three types of entries that you might make in your reference list. You may also use the format used by a prominent scientific journal or one suggested by your instructor. Once you have decided on the format, use it consistently for all of your references.

A book reference might read as follows:

Vince, Prae, D. *Photoperiodism in Plants* New York:
McGraw-Hill, 1975. pp.104 and 194

A reference to a journal article:

Raymond, J. A., and A. L. DeVries. (1977)
"Adsorption inhibition as a mechanism of freezing
resistance in polar fishes." Proc. Nat. Acad. Sci.,
U.S.A. 74: 2589-2593.

A reference to an article that appeared in a book.
Rehn, A. "Chemical defense of ant acacias." In J.
Pearson, ed. *Phytochemistry*. New York. Academic
Press, 1973.

Writing Tips

Your report will be easier to read and understand if you follow these tips and try to conform to the accepted style of scientific writing that is required for scientific papers. Conformity can be a good thing if it increases communication!

1. Write in the past tense, not present or future:
"Two rats were anesthetized and..."
2. Use metric units (gram, meter, litre, second) and the Celsius temperature scale.
3. Use correct abbreviations **without** periods:

10 millitres	=	10mL
12 litres	=	12 L
3 micrograms	=	3 μ g
7 grams	=	7 g
24 kilograms	=	24kg
663 nanometers	=	663 nm
8 micrometers	=	8 μ m
21 centimeters	=	21 cm
9 meters	=	9 m
52 kilometers	=	52 km
37 degrees Celsius	=	37°(37°C)

4. If you start a sentence with a number, write out the number: "Twelve grams of minced toad brain were..."
5. For solutions, use molarity rather than normality:

5 molar	=	5 M
.005 molar	=	5 x 10 ⁻³ M or 5 mM
.000005 molar	=	5 x 10 ⁻⁶ M or 5 μ M

If the solution is given as a percent solution, indicate whether it was made up on the basis of weight or volume:

5 g glycerol + 95 g H₂O = 5% glycerol (w/w)
5mL glycerol + 95 mL H₂O = 5% glycerol (v/v) 5 g
glycerol brought up to 100mL with H₂O = 5%
glycerol (w/v)

6. Refer to animals and plants by their scientific names. (This is not necessary when referring to humans and common laboratory animals.) Always underline or *italicize* the genus and species names of organisms, for example, *Stentor coeruleus*. Be specific as you can in naming the organism, but when the name is not known completely (as in your Pond Ecosystem report), write sp. after the generic name, for example, *Oscillatoria* sp.
7. Avoid boring the reader with copies verbiage and excessively formal writing. It is perfectly all right to sound excited about your work if you have worked carefully and have interesting results to report.

When in doubt, ask your instructor or try to find an example in a recent journal.

Writing a Lab Report

Although this outline should prove useful to you in writing a research paper, you should also refer to scientific periodicals (journals) in order to develop a format and writing style appropriate for the area of study.

1. Title

Choose a title that briefly conveys to the reader the purpose of the paper. Many readers scan journal article titles and decide whether or not to pursue an article based on the information in the title. Generally, the title should convey three things:

- primary factors manipulated or studied
- outcome of the manipulation (the response of the effects)
- organisms studied, if relevant

Example: the Effect of Varying Serotonin Concentration on CA Release at Synaptic Membranes in Motoneurons of *Aplysia*.

Introduction

The introduction provides the reader with the context needed to understand your work and its significance. The introduction explains the “why” of your paper, and provides background information on the history of scientific investigation that led to our present understanding of the phenomenon being studied. Introductions define key terms and specify the problem and the general investigative approach.

The reader, after reading your introduction, should know precisely the importance of the problem being addressed. Be sure to properly cite any historical background referred to in the introduction.

2. Materials and Methods

This section should describe what you did to get your data, but should not present the data itself. The description of your work needs to be specific that someone else can duplicate it with the expectation of getting the same result, assuming that the person was knowledgeable of the techniques involved.

Carefully outline the procedure and the techniques you used. Generally, techniques and procedures that are already published in lab manuals and other sources need not be fully described, merely briefly outlined and referenced. Describe any deviations from standard procedures so that others can appraise the new procedures or attempt to reproduce the new procedures themselves.

Graphically outline complicated procedures. Besides procedures, this section should also include models of equipment used, source of chemicals (if relevant), number and types (may include sex/strain) of organisms used, sample sizes, number of times the experimental procedure was performed, and any other pertinent factors.

3. Results & Analysis

This section refers back to the question asked by the study and to the hypothesis. State what you found out and whether or not that data supported the hypothesis. Then present the summarized data to support this conclusion.

It is crucial that you clearly organize and present the outcomes of your experiments. This is best accomplished by presenting data in clearly labeled graphs and charts, consistently labeled and cited in the text. Graphs and tables should be clear without reference to the text. Number graphs and tables in the order in which they are mentioned in the text (i.e. Table 1, Table 2 and so on).

The results section gives just the facts. You can interpret and discuss in the next section.

4. Discussion & Conclusions

The significance and interpretation of the study should be explained in this section. Discuss specific points made in the Results section in light of previous studies or hypotheses.

Some of the questions to be answered in this section are:

- Why do you think the data did (or didn't) support the hypothesis?
- What previously unsuspected data phenomenon does this suggest?
- How might your experimental procedures be improved?
- Are some of your results due to artifacts? How do you know?

- What variables might you have overlooked?
- What other studies should be done on the basis of your results?
- How does this work affect the field you are working in?

The most important part of the Discussion section is establishing what the results indicate, both for the ongoing study and future studies. Here is where you analyze your results and draw conclusions. You may also add opinions here (and only here), but keep your opinions brief.

This section follows the discussion section and allows you to comment on your experiment. How could you improve your experiment? What were some sources of error? How could you modify your experiment or test another related hypothesis? What does the future hold for your work?

5. Literature Cited

This is similar to a bibliography, but contains only the books, articles, and personal communication cited in the text of your research paper. Cite all sources of fact or theory in your paper that were not generated by you. This will primarily include research articles, but may include review articles and texts as well.

Alphabetically list, by the last name of the author, all sources cited in your paper. If more than one publication by the same author is cited, draw a line instead of repeating the author's name.

The order in which information is presented should be as follows:

last name of principle author, first name or initials, date, title of book or article, name of journal or city of book publication, volume and number of journal or book publisher's name.

Here are some examples, including the correct punctuation:

Aacon, A. A. 1989. On the Road Again. Chicago: Transcontinental Press.

Aardvark, Alan. 1986. Basic techniques in ant farming. El Paso: Hilltop Press.

Abbott, B. and Jenkins, C. In inquiry into the habitation of ants. New York: Permanent Press.

Anonymous. 1952. Atomic energy and the ant population. Washington: U.S. Printing Office.

_____. 1995. More ant tales. New York: Second Chance Books.

Foster, Walter. 1988. Ant proteins. Anthropology Tomorrow Vol. 1, No. 53.

Internal Citations:

Ideas or facts that you did not conceive independently must be attributed to their sources. Use internal citations to cite references in text of your report. You may do this in one of two ways:

- Belly-to-back skin transplants lead to misdirected wiping responses in *Rana pipiens* (Heidemann, 1977)
or
- Heidemann (1977) found that bell-to-back skin transplants lead to misdirected wiping responses in *Rana pipiens*.