

WRITING A SCIENTIFIC ARTICLE

This outline is modified from the version many of you will have used in cell biology core class. It is a product of many different faculty contributions, and has been shaped to reflect my purpose. However, basically, there is no trick to writing a scientific report. It is formulaic. Here lies the formula.

The results of a laboratory study are written up as a formal report outside of class and turned in on or before the date given to you by your lab instructor. Remember that the purpose of such a report is to convey the results clearly and concisely to the reader, to give enough detail so that others can reproduce them. Then, in the Discussion/interpretation section you must explain the physiological phenomenon(s) that explain why the data outcome is as you observe, AND, discuss the significance of the data in light of current research in the field.

Intellectual Integrity in scientific writing

It is understood that your research paper (and any work you submit) is in your own words. Ideas, models, images etc. that are not your own must be properly credited with a citation. It is nearly impossible to cite too often, so if in doubt, cite the reference. The key – give credit where credit is due. We stand on the shoulders of those who come before us.

We expect that you will wrestle with the technical language of research publications. Part of the learning process is to read formats with which you are unfamiliar. Refrain from using direct quotes (unlike other disciplines, scientific papers rarely use this tradition). Use paraphrases, i.e. your own words, and follow with a citation.

If you have any doubts about what constitutes plagiarism, a serious intellectual offense, go to the Indiana University website, <http://education.indiana.edu/%7Efrick/plagiarism/item1.html> [accessed Aug 2005]

Credit will be given to original synthesis of ideas and concepts.

How to Write a Scientific Paper

Clear communication, both written and oral, is central to the work of scientists. The importance and impact of new research discoveries, novel clinical diagnoses, and exciting new hypotheses are lost to the world if they are not communicated clearly. *At this stage in your biology training you are expected to have had the basics in writing a scientific report and that you know how to use the resources in the Hatfield Library that are available to you as you work on your paper.*

Technical writing differs from other forms of writing because the goal is to express ideas clearly in as few words as possible. Scientists often make use of figures, photos, and tables as a means of simplifying complex ideas and data sets for the reader. There are a number of excellent books that can help the beginning technical writer. See Pointers at the end of this H/O.

I suggest that you visit the Writing Center before you begin your paper, and USE THIS AMAZING resource to better your writing skills.

FORMAT OF A SCIENTIFIC ARTICLE

Introduction.

The purpose of the introduction is to build an argument as to why you are investigating the topic. In other words, provide the rationale for the hypotheses you tested. This section is written after Methods, Results, and Discussion sections. The reason for this order of writing is because often when you are discussing the interpretation of your data unexpected data will be observed or a novel interpretation arise. If the unexpected data or interpretation is important you will need to prepare your reader for this in your introduction.

In a journal article, the introduction begins with an overall statement (s) of the significance of the particular area of research.

This can be followed by an *appropriate* review of the relevant work previously published on this topic. NOT an exhaustive review of everything in this field – rather, you should be strategic. Build an argument for why you are investigating the question of interest. Generally, there are two major argument styles used in scientific literature. 1) Here is what we know, here is what we don't know, and here is how this current study will contribute to the extension of our knowledge. If this argument is used then it pays for you to be heavy at the beginning on the broad significance of this area of research. 2) Present a conflict in the literature. By this I mean, you have noticed that some work suggests that X results from Y, others suggest the exact opposite, and you are proposing your research because you have a perfect model system to address this apparent paradox.

Then you would follow with your broad question or concept that you are investigating, and specific hypothesis to be tested, the relevance of which you will have made clear. Describe briefly the experimental approach you used to address the issue. It is appropriate to briefly describe the major conclusions from your study at this point.

Remember that a hypothesis is worded to include the measurements you are making. And example of question/concept and hypothesis:

We are interested in the notion that cannabinoids affect physiology and behavior in a context-dependent manner. This study used an *in vivo* frog heart preparation to test the hypothesis that cannabinoids affect heart rate and contractility in opposite ways depending on the state of stress that frog has experienced.

This and other sections that follow should contain properly referenced citations to the literature.

Materials and Methods. This section should be written in a clear, concise style. Describe the techniques used, the reagents (be sure to include concentrations), the instruments where applicable, and the procedures. It is acceptable to give a brief overall description of a method and then refer to a publication for the details e.g. as detailed in the Lab Manual (2000). Standard procedures and trivial details should not be included.

For example, "a ten-fold serial dilution was carried out" is sufficient rather than something of this sort: "With a one mL pipette, withdraw 0.5 mL of the bacterial culture using a pipetting bulb; add this to 4.5 mL of sterile broth and mix thoroughly with a vortex mixer. Remove 0.5 mL of the resulting suspension and add it to another tube containing 4.5 mL of sterile broth and mix as before. Repeat this procedure four more times." One must, however, describe modifications of standard procedures.

This section may be subdivided into logical subsections to cover different aspects of the experiment for clarity. Note that there is **not** a separate materials list, but instead specific materials used are incorporated into the narrative text.

Results. Here one describes the results obtained in words, with references to supporting figures and/or tables. For example "mRNA was isolated and screened for induced gene expression during myelin synthesis (Fig. 7)" or "Figure 7 shows that specific mRNAs were induced during..."

The results are presented with a brief explanation for the rationale of the experiment and the specific question you are trying to answer. Briefly describe the results. A brief conclusion based on the results may be made but no extended interpretation is included here. That's reserved for the Discussion section. Statistical analysis, if appropriate, should also be included in this section. Only include Tables or Figures that are specifically referred to in the text.

Tables and Figures of your data should be presented on separate pages. They must be accompanied with a descriptive legend which begins with Table 1. or Figure 1., a brief title and is followed by a detailed but succinct description of the table or figure. This is placed above tables (though additional descriptions go below the table) but below figures. Tables are usually numerical data presented in rows and columns; figures are graphs, schematics, photos etc. See examples:

Example of a graph:

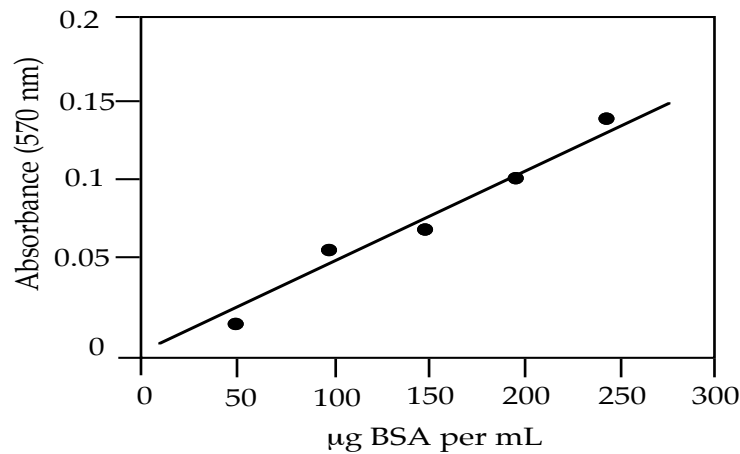


Figure 1. Absorbance in response to increasing concentrations of bovine serum albumin (BSA). The indicated concentrations of BSA (x-axis) were plotted against the absorbance at wavelength 570 nm (y-axis).

Example of a table:

Table 3. Total chlorophyll contents and ratios of chlorophyll a to chlorophyll b in freshly isolated or cultured guard cell protoplasts of *Nicotiana glauca* (Graham).

Preparation	Total Chl (pg cell ⁻¹)	Chl a/Chl b
Freshly isolated GCP	0.43 ± 0.01	3.7 ± 0.6
Type II (1 wk @ 32°C)	ND	ND
Type III (1 wk @ 38°C)	0.63 ± 0.14	5.2 ± 0.9
Type IV (1 wk @ 38° C in 0.1 μM ABA)	0.23 ± 0.03*	3.5 ± 0.1

Contents were adjusted based on the assumption that 75% of cultured cells survived. Values are means ± SE from three separate experiments. Mean chlorophyll contents of Type III and Type IV cells were not significantly different from those of freshly-isolated GCP but were significantly different from each other (*unpaired t-test, 0.05 level of significance). Chl a/Chl b ratios were not significantly different in any two-way comparison. ND = not determined.

Discussion. In many ways, this is the most important section of a report because it is here that one discusses the meaning of the results. It is in this section, that one states the major conclusions drawn from the results, whether these results are consistent with your original hypotheses, and how those results compare to those in the literature.

Generally, the way to organize a discussion is based entirely on the major findings. This means that you must be crystal clear on what your findings are, then organize them in a logical order, include every major point. This is essentially your outline. Often if I have four figures, then those four figures break down to four main sections of my discussion. For each section I will state the major finding. Then explain the physiological interpretation of that finding. State whether this is consistent or inconsistent with our hypothesis. Then examine whether this is consistent with other peoples studies (literature).

Again the discussion is not an exhaustive literature review. You only use literature to support your interpretations, or show how anomalous your data is. Always discuss this in terms of the physiology of your system.

Literature Cited. You must include references to primary literature sources (this does not include the lab manual or your textbook). Outside sources that were used are listed in this section. Only show those sources actually cited in the text. Note that there is no one correct style; what is important is that proper credit is given and that sufficient bibliographic material is included so the reader can find the source. While there may not be a correct style, there is an acceptable style. The editorial board of each journal sets its own style to which authors must adhere. You will use the following guidelines.

In biology (other disciplines have their own formats), you will be using the Name-Year System from Scientific Style and Format: the CBE manual for authors, editors, and publishers (REF T11 S386 1994). Below are examples of proper citations:

Journal article - one to ten authors

Last Name Initial(s), Last Name Initial(s), ... Last Name Initial(s). Year. Article title. Journal title Volume number(issue number):beginning page-ending page.

Example reference: Che YS, Gloer JB, Scott JA, Malloch D. 2004. Communiols A-D: new mono- and bis-tetrahydrofuran derivatives from the coprophilous fungus *Podospora communis*. *Tetrahedr Let* 45(37):6891-4.

Example Citation (what appears in the text of your paper or report):

(Smith 2004) - One author

(Smith and Jones 2004) - Two authors

(Che et al. 2004) - Three or more authors

Journal article -eleven or more authors

Last Name Initial(s), Last Name Initial(s), ... Last Name Initial(s), et al. Year. Article title. Journal title Volume number(issue number):beginning page-ending page.

Example reference: Edmunds W, Pebody R, Aggerback H, Baron S, Berbers G, Conyn-Van Spendonck M, Hallander H, Olander R, Maple P, De Melker H, et al. 2000. The sero-epidemiology of diphtheria in Western Europe. *Epidemiol Infect* 125(1):113-25.

Example citation: (Edmunds et al. 2000)

Article Title All words are lowercase in the article title, except for first letter of the first word and for proper nouns.

Journal Titles First letters of each word are capitalized in journal titles. Journal titles are abbreviated, with the exception of single word titles and acronyms. Write out the entire name of one-word journal titles. Use the BIOSIS *List of Serials* or *Biological Abstracts* for the accepted, standard abbreviations of multiple-word journal titles or look at the literature cited section in a journal article for some examples.

Multiple Authors The first 10 authors are listed. If there are 11 or more authors, the first 10 authors are listed followed by "et al."

Book - one author

Last Name Initial. Year. Title. Place of Publication: Publisher. Number of pages.

Example reference: Djerassi C. 1992. *The pill, pygmy chimps, and Degas' Horse*. New York: BasicBooks. 319 p.

Example citation: (Djerassi 1992)

Book - by editor

Last Name Initial, editor(s). Year. Title. Edition (if not the 1st). Place of Publication: Publisher. Number of pages.

Example reference: Herndl CG, Brown SC, editors. 1996. Green culture: Environmental rhetoric in contemporary America. Madison, WI: University of Wisconsin Press. 315 p.

Example citation: (Herndl and Brown 1996)

Chapter or article in edited book

Last Name Initials (author of the chapter). Year. Chapter or section title. In Last name Initials. Title of the book. Place of Publication: Publisher. Pages of the chapter.

Example reference: Cantrill J. 1996. Gold, Yellowstone, and the search for a rhetorical identity. In Herndl C, Brown S, editors. Green culture: Environmental rhetoric in contemporary America. Madison, WI: University of Wisconsin Press. p 166-194.

Example citation: (Cantrill 1996)

Web Page: Author/Editor Last name Initial. Year. Title, [Type of medium]. Available: URL [Access date].

Example reference: Maddux L. 1999. Biology Page, [Online] Available: <http://library.willamette.edu/webstation/subject/bio.htm/> [1999, March 7].

Example citation: (Maddux 1999)