Recommendations for Student Writing in Biology

Developed by the Sub-committee for Writing in Biology
Edited by M. Dornbush, D. Meinhardt, A. Wolf

University of Wisconsin-Green Bay

Departments of Human Biology and Natural and Applied Sciences

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General Introduction

This document was produced by the Biology faculty at the University of Wisconsin-Green Bay for use by students pursuing Biology and Human Biology majors and minors. Our primary goal is to help guide and improve scientific writing by our students. This document defines standards for writing style and manuscript format, complete with accompanying examples. In order to foster continuity and consistency in the development of student writing, we recommend that students follow the guidelines set by this document in all Biology courses, unless explicitly stated otherwise by the course instructor.

This document has three main sections. Chapter 1 (Effective writing practices) describes the use of correct and effective English style and form for scientific papers. Students should study this section in detail, as form and style for scientific manuscripts are quite different than form and style used in general English classes. Chapter 2 (Manuscript format for reporting experiments) provides a detailed description of the main sections of a standard scientific manuscript, a time-tested framework that is used by nearly all major scientific journals. The final chapter (Plagiarism) is taken from the University of Wisconsin-Green Bay's policy on plagiarism. This chapter defines plagiarism, provides examples of plagiarism, and explains why writers must cite sources.

Chapter 1: Effective writing practices

D. Meinhardt

Clarity and precision are extremely important for effective science writing. This section provides a brief overview of effective writing, as well as descriptions and examples of some common mistakes that detract from the clarity and precision of an author's writing. We provide abbreviations for specific mistakes (in parentheses) so that instructors can efficiently provide feedback on students' papers.

Section 1.1: A general strategy for effective writing

The clarity of a paper begins with its organization. The best way to begin organizing a paper is by making a detailed outline. By distilling the major parts of a paper into simplest terms, you can assess your understanding of the parts and their relationships to each other. Make an outline as soon as possible and then revise it as many times as necessary until it is perfectly clear. If you are having difficulty constructing a clear outline, you may need to reconsider the topic (e.g., limit or expand the focus of the paper).

Begin writing by following your outline closely. Each paragraph of a paper should present a single, coherent idea. The first sentence should clearly state the idea, and the following sentences should reinforce and support it. The final sentence of a paragraph should provide a transition to the next paragraph. If you are having trouble writing sentences that connect ideas you may need to go back to the outlining step and reassess your understanding of the material and the focus of your subject. When you are finished writing, reread the paper several times. It is very helpful to take a break from working on the paper (at least one day) before rereading it. Proofreading and editing a paper for clarity and precision is an **essential** part of writing an effective paper.

Section 1.2: Common writing problems

Economy (E)

Effective writers use as few words as possible to convey precisely their information or ideas. Wordy writing appears to be an attempt by the author to sound "smart." A good reader (possibly your professor) will not fall for this trick. Economy is particularly important in science writing, so keep it simple. Try to avoid phrases such as; *it has been indicated that, due to the fact that, as a result of the fact.* For example:

Instead of	*Manatees are endangered due to the fact that humans have degraded the animals' coastal habitat.*
Use	*Manatees are endangered because humans have degraded the animals' coastal habitat.*

Many words used for emphasis do not convey the precision needed in scientific writing. Words such as *extremely*, *very*, and *quite* are often unnecessary, or should be replaced with more specific information. For example:

Instead of	*African elephants are extremely large animals.*
Use	*African elephants are the largest living land animals.*

Comparative terms (CT)

Comparative terms are words and phrases such as, *bigger, smaller, more, less,* etc. Sentences that contain a comparative term without completing the comparison are meaningless. For example, the sentence, *"Honeybees are more social,"* is uninformative. The sentence, *"Honeybees are more social than mosquitoes,"* conveys specific information.

Dangling modifiers (DM)

Keep modifying phrases as close to the word they modify as possible to avoid confusion. For example:

Instead of	*Jumping into the water, a large boat caught my attention.*
Use	*Jumping into the water, I spotted a large boat.*

Dangling participles (DP)

Present participles are verbs ending in *-ing.* Dangling participles cause the same kind of confusion as dangling modifiers. For example:

Instead of	*Rushing to finish the paper, my computer caught fire.*
Use	*While I was rushing to finish the paper, my computer caught fire.*

Agreement (A)

The parts of a sentence should agree with each other. For native English speakers agreement is usually obvious. For example, *"I has a minute,"* should be, *"I have a minute."* Writers may have trouble when a plural noun is in front of a singular verb. For example, *"Any one of the articles are available,"* should be, *"Any one of the articles is available."* The subject of the sentence is *one* not *articles*, so the singular verb *is* should be used.

A very common agreement problem occurs when two pronouns are used. For example, *"He wanted you and **I** for the team,"* should be, "*He wanted you and **me** for the team*." If you remove one of the pronouns the agreement of the other will be clearer. For example, few writers would make the mistake, *"He wanted I for the team,"* though many make the first mistake. Of course, if the pronouns are the subjects of the sentence, *he* and *I* are correct, as in, *"He and I want Tim on our team."* Spelling and grammar checkers commonly miss agreement mistakes, so be careful!

Passive voice (PV)

When writing a scientific article, writers should use active voice unless explicitly instructed otherwise by a journal or instructor. Active voice takes the form *"A does B."* Passive voice takes the form, *"B is done by A."* There are two major problems with passive voice. First, sentences full of passive voice construction tend to be overly wordy and clumsy. For example:

Instead of	*The blue car was washed and waxed by Tim.*
Use	*Tim washed and waxed the blue car.*

Another problem with passive voice is that it lets the writer avoid specifying a subject for the verb. Active voice usually provides more specific information. For example:

Instead of	*Specimens were measured with digital calipers.*
Use	*We measured the specimens with digital calipers.*

Long Words (LW)

Avoid using long words in an attempt to impress your reader. People commonly add syllables to words in an effort to sound more intelligent. For example don't write, *"We had to take a moment to get **orientated**,"* when you should write, *"We had to take a moment to get **oriented**."* Keep your writing simple. Use a shorter word if it conveys the same information as a longer one. For example:

Instead of	*"We utilized a capture-mark-recapture method to estimate population size."*
Use	*"We used a capture-mark-recapture method to estimate population size."*

Spelling Checkers (SC)

While spell checking features are useful, do not expect them to replace careful proofreading. For example, spell checkers won't tell you if **your** (should be **you're**) using the write (should be right) version of a homonym. **Two** (should be **too**) many people mix up the words two, too, and to, so be careful with these **to** (should be **too**). Again, their (should be **there**) our (should be **are**) to (should be **too**) many chances to make embarrassing mistakes with homonyms.

Split Infinitive (SI)

An infinitive is the form of a **verb** that comes after *to*, as in *to measure.* As a general rule, you should avoid splitting infinitives. For example:

Instead of	*"The chimpanzees seem to always forage in the same location."*
Use	*"The chimpanzees always seem to forage in the same location."*

Chapter 2: Manuscript format for reporting experiments

M. Dornbush and A. Wolf

This chapter outlines the general structure for reporting experimental results. Sections 2.1 through 2.6 describe the specific format within each of the six main sections of a scientific manuscript. Within your manuscript, each of these six sections should have an obvious heading: Abstract, Introduction, Methods, Results, Discussion, and Literature Cited. In general, sub-headings within each section are not necessary, but can be used sparingly to improve manuscript organization. Please realize that the main sections of a scientific paper were not chosen arbitrarily by the scientific community. Each section corresponds to a specific step, or to specific steps, in the scientific process. Thus, the format of a scientific manuscript mirrors the development of the research project from question conception to conclusions. The organization of the manuscript effectively navigates the reader through this process.

Section 2.1: Abstract

General Comments:

- This is the last section of the paper written, but it is the first section to appear in your manuscript.
- The abstract should summarize each main section of the manuscript in a sentence or two. The total length is general capped at around 250 words.
- The abstract should highlight your most important hypotheses, results, and conclusions.
- The other purpose of this section is to convince readers to read the whole manuscript; it's a sales pitch.
- The abstract does not contain citations or references to figures or tables.

Example Abstract:

The soil invertebrate community represents one of the most important, yet least understood, components of ecosystems[1]. Ecologists have established that fungal biomass increases with increasing soil carbon content, but we do not know how the density of Collembolan grazers alters this pattern[2]. Collembola are one of the few animals that heavily graze fungi, and they have previously been shown to reduce fungal biomass under controlled conditions[3]. We hypothesized that the density of Collembolan grazers will have a greater effect on fungal biomass than changes in soil carbon content[4]. We tested our hypothesis using a two-way factorial design where we doubled both soil carbon content and Collembolan density in an abandoned agricultural field in northeastern Wisconsin[5]. As hypothesized, fungal biomass was greatest in the high soil carbon treatment. However, Collembolan density affected fungal biomass only in the high soil carbon treatment, and Collembolan grazing did not completely eliminate the positive effect of soil carbon addition[6]. We conclude that Collembola densities can affect fungal biomass, but this effect is context dependent and does not override the effect of soil carbon content[7].
(*The above experiment and results are strictly hypothetical*)

Content:

- 1 - One sentence on background that address the bigger issue at hand.
- 2 - One sentence that highlights the specific area of uncertainty.

- 3 - One sentence justifying your *a priori* expectations.
- 4 - State your hypotheses.
- 5 - One to two sentences stating how you tested your hypothesis (very brief!).
- 6 - Small section on results that relate directly to your hypothesis. Include actual numbers when possible.
- 7 - One sentence on broader implications.

Section 2.2: Introduction

General Comments:

- Citations from the primary literature are absolutely required in this section.
- Do not turn this section into a literature review; it is not, and should remain concise and relevant to your hypotheses.

Content:

- One small summary paragraph placing your work into the larger context of the field.
- One or two small paragraphs laying out the specific area of uncertainty that you are addressing in this experiment.
- One final paragraph that very clearly states your objectives, the specific hypotheses that you are testing, and a very brief statement of how you tested you hypotheses.

Section 2.3: Methods

General Comments:

- The key to this section of the manuscript is organization, organization, organization.
- Provide enough information for the experiment to be critically evaluated by reviewers, as well as enough information so that other scientists can replicate the experiment.

Content:

- Highlight where you conducted your work (use GPS coordinates when describing field localities), general site characteristics, the climate, the organisms (*Quercus alba* L.) that you studied, etc.
- Describe the experimental design.
- Detail the methods used to test your hypotheses. Be sure that this section is organized in the same order that your hypotheses were stated in the introduction, and that it is very clear which methods relate to which hypotheses.
- Specific analytical equipment should be identified by manufacturer's name and home country. For example, "Soil respiration was measured twice monthly with a LI-COR 6400 portable photosynthesis system (LI-COR, Inc., Lincoln, NE, USA)."
- Discuss the statistical methods used to test your hypotheses. Again, be sure to clarify which statistical methods address which hypotheses. For example, "Addressing hypothesis one, among site differences in annual soil respiration rates were determined using one-way analysis of variance (ANOVA)."

Section 2.4: Results

General Comments:

- Presentation order should remain the same as the order in the introduction and methods and clearly identify which results address which hypotheses.
- Material should be presented in a manner that is simple and summarized for easy interpretation by the reader.
- Do not include discussion material. You should not discuss why the results were as they were, or what the results mean (interpretation). Simply present your results and relate them to your hypotheses.
- Avoid run-on results by being organized and making sure that you clearly describe why you are presenting the reader with value X and Y. If you relate your findings to your hypotheses, run-on-results shouldn't be a problem.
- Avoid direct references to tables and figures like "Results of the early spring experiments are found in Table 1..." Instead, summarize the key finding in a table or figure and provide the reference in parentheses. For example: "Early-spring monitoring supports the hypothesis that growth of ephemeral forbs reduces stream NO_3^- concentrations (Figure 1)."

Content:

- Present your results in the context of your initial hypotheses.
- The results section does not list all of the data collected, it only highlights the specific comparisons that you want the readers to see.
- When including data, provide specific numbers, relative comparisons (twice, half, etc), and cite figures and tables. For example, "Nitrogen-deficient plants were only half as tall as complete-nutrient plants by the fifth week (Figure 1)."
- When you present data or statistical results, present summary statistics (e.g. mean ± standard deviation or standard error) or test statistic values and their level of significance (e.g. $t = 1.2$, $P > 0.05$). For example, "*A. petiolata* biomass (2.3 ± 0.6 g m^{-2}) was significantly lower ($t = 4.8$, $P < 0.01$) when growing with *E. rugrosum*, than when in monoculture (45.3 ± 2.1 g m^{-2})."

Section 2.5: Discussion

General Comments:

- This is your chance to interpret your results, to include supporting literature, and to share your insights with the scientific community.
- Citations from the primary literature are absolutely required in this section.
- The biggest pitfall is to draw unwarranted implications from your work. Science works in small steps, and each study, no matter how proud you are of it, only contributes a tiny step forward.

Content:

- Address how your findings relate to your hypotheses, and again present them in the same order.
- Include a brief discussion of why you think you obtained these results, including relevant citations from the primary literature.

- If you have multiple hypotheses, follow this pattern for each hypothesis.
- Finally, end with a summary paragraph that includes a rehashing of your major conclusions, what your results mean for other work or larger scale issues, and future questions and directions based on your results. This is your last chance to make an impression with your work.

Section 2.6: Literature Cited

- This section should contain a list of all external works specifically cited within the text of your manuscript.
- Citing of web pages is strongly discouraged; web pages are not peer reviewed and are ephemeral.
- There is no single accepted citation style for science writing, but rather citation style is dictated by each individual journal. In this document we follow the format required by the journal Ecology, published by the Ecological Society of America.

Citation format within the text of your manuscript:

- Nitrogen deficiency produces leaf chlorosis (Salisbury and Ross 1992).
- Salisbury and Ross (1992) found that nitrogen deficiency resulted in leaf chlorosis.
- The study area has not been harvested for at least 50 years (S. Smith *personal communication*). Note: this reference is not included in the literature cited section.

Citation format within the Literature Cited section:

Journal Article:

Evans, M.A., M. Esbenson, and C. Jaffe. 1981. Expect the unexpected when you care for a dying patient. Nursing 11:54-56.

Book:

McCaffery, M. 1979. Nursing management of the patient with pain. J.B. Lippencott, Co., Philadelphia, Pennsylvania. 211p.

Chapter or Article in an edited book:

Aerts, R. 2002. The role of various types of mycorrhizal fungi in nutrient cycling and plant competition. pp. 117-134 *IN* M.G.A. van der Heijden and I.R. Sanders (editors), Mycorrhizal Ecology. Springer, New York.

Section 2.7: Constructing tables and figures

General Comments:

- Tables and figures within a manuscript should not repeat the same information.
- Tables are used when the specific values are important to report. For example, tables are ideal for reporting statistical results, or for providing specific values that other researchers may want to use in a meta-analysis. Tables are also useful for presenting important information that is not the main focus of a study. For example, the soil properties of a research site are often summarized in a table.

- Figures are used when you want to highlight trends through time, the relationship between two or more variables (e.g. correlations), or to highlight differences among experimental treatments.

Content:

- Figures and tables do not have titles.
- Each figure axis should have both a label (e.g. Time) and units of measure (e.g. minutes).
- The scale of each axis should reflect the range of data that you are presenting. For example, if you data ranges from 0 to 60 minutes, then your axis might run from approximately 0 to 65 minutes, but clearly not 0 to 120 min (use some personal discretion).
- Figure legends are placed below figures, while table legends are placed above the table. In both cases legends should provide enough information for a reader to understand the figure/table without needing to refer back to the main text of the manuscript. This is very important, as figures/tables are often removed from their original manuscripts and inserted into textbooks and review papers. All figure/table legends should be written in complete and concise sentences. Legends should not include data interpretation, but they should include information such as species used, treatment descriptions, study location, sample size, etc.
- Tables should not have vertical lines within them. This only makes them visually busy, and does not improve organization or presentation. Use appropriate spacing between columns, rather than vertical lines, to organize your table. Tables should be constructed using a word processing program (e.g. Microsoft Word) by manually setting tabs.

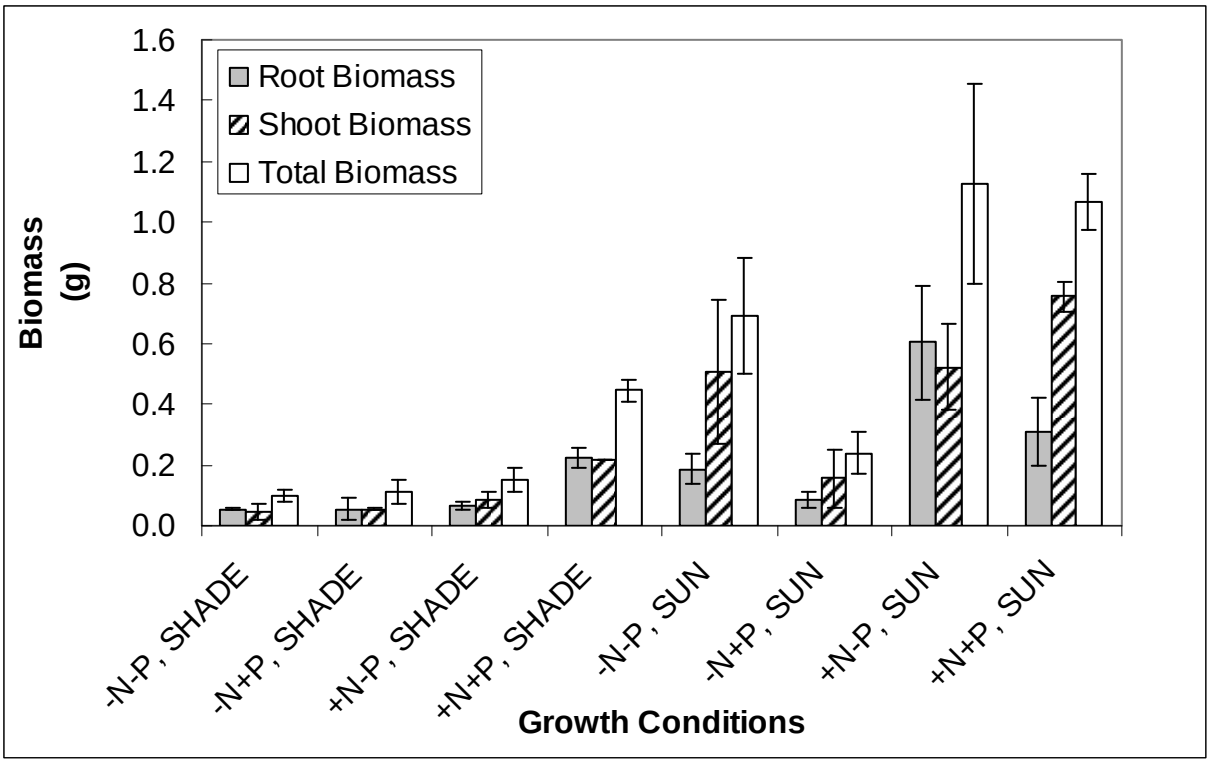

Figure 1. Effects of light environment and nutrient availability on biomass allocation in green house grown soy beans (*Glycine max*). All plants were grown in the Laboratory Sciences greenhouse on the University of Wisconsin-Green Bay campus. SUN plants were grown under full ambient sunlight, while SHADE plants received only 50% of ambient light. +/-N, and +/-P plants either received or did not receive supplemental nitrogen or phosphorous, respectively. Error bars are ± 1 standard error of the mean.

Table 1. Comparison of vascular plant richness and land area among the entire state of Wisconsin, USA, and two Costa Rican national parks. Carara National Park is centrally located along the Pacific coast of Costa Rica within the transition zone between tropical wet and dry forests. Santa Rosa National Park supports a tropical dry forest, and is located in northwestern Costa Rica along the Pacific coast.

Location	Area (ha)	Species Richness	Species Density (#/1000 ha)
Wisconsin, USA	16,965,199	2,572	0.15
Wisconsin (native)		(1,889)	(0.11)
Wisconsin (exotic)		(683)	(0.04)
Carara National Park, Costa Rica	5,300	1,075	202.83
Santa Rosa National Park, Costa Rica	49,515	1,119	23.07

Chapter 3: University of Wisconsin-Green Bay Policy on Plagiarism

Section 3.1: What is plagiarism?

Plagiarism is the accidental or deliberate presentation of someone else's words, ideas, or information as your own. In a university, it is considered a serious form of academic dishonesty. Penalties for plagiarism can range from a lowered grade on the paper to expulsion from school.

Section 3.2: What are some examples of plagiarism?

Plagiarism occurs when

- you buy a term paper and hand it in as your own, or you have someone else write the paper for you;
- you copy portions of someone else's essay (whether from a classmate, a periodical article, or a web site) and pass them off as your own;
- you forget to put quotation marks around a passage you copied word for word from another source;
- your borrow ideas or statistics from another source and put them in your own words, but fail to make clear that you got the ideas or statistics from the source.

Section 3.3: Why do we credit sources?

Academic writers give credit to sources for several reasons:

- Because academic readers often want to know how the ideas of the person they're reading agree with, disagree with, or modify the views of published experts in the field. An academic reader can often learn a lot about your thinking by knowing whom you've read, and whom you agree and disagree with. Professors often use phrases like "situate your views within the ongoing published conversation in the discipline" to describe this idea.
- Because academic readers sometimes want to know more about the subject. By citing your sources and listing them at the end of your paper, you allow a curious reader to look them up in a library or on the Internet.
- Because claims in academic writing are always subject to tests and proof. By listing the author of a quotation and providing a page number, you're telling the reader, "If you don't believe that this person really wrote this, you can look it up for yourself."
- Most of all, because it's the honest thing to do. If you copy word for word from an article by a professional writer but you don't give credit to that writer, you're claiming you yourself produced this professional-level writing. If you use the ideas of an expert on a subject but don't mention that you got the ideas from this expert, you're claiming that you yourself came up with these expert-level ideas. That's wrong.

Section 3.4: How do I credit sources?

- See section 2.6 for proper format for crediting sources.