Writing Guidelines for the Biology Department
Section 1: Writing Laboratory Papers

Each paper is to be written in formal scientific style, which includes a title page, abstract, introduction, methods, results and discussion, and literature cited sections. Each of these sections should be indicated by providing the heading. The introduction and discussion sections must be thorough and MUST cite relevant primary literature sources.

Formatting Guidelines (in order of appearance):

1. **Title Page** – include a descriptive title, name of author(s), date. A descriptive title should state what the study is testing or the main result of the experiment, e.g., “Increased reading of guidelines elevates student performance on papers” or “Not reading the textbook is correlated with decreased student abilities to answer questions in class”. Also include the author(s) name(s), class designation (e.g. Bio 120), date, professor’s name and the Academic Honor Code statement. An example of a title that is not descriptive is “C. elegans worm project”.

2. **Abstract - 250 words or less.** The abstract is a short version of the paper, highlighting the question you were asking including a brief explanation of the study design, the most significant finding(s) of the study, and their implications. This is a vital part of a scientific paper as this is what the most people will read, and is essentially an advertisement for reading further. State what you did, why you did it, what you found, and the significance of your findings. **Do not try to recite all the results. Do not use citations here.** This section should be written last, once you have prepared all the other sections of the paper.

3. **Introduction** – generally 1-2 pages in length. This section is important because you describe what the state of research on the topic is and how you develop your question. It is where you describe why this study was done in the first place, as in “what great question will it answer” (because it was a class assignment is NOT an acceptable reason). **Cite relevant sources in this section of your report.** Make sure to cite anything that is not common knowledge. Use these citations to provide a brief summary to put this study into perspective of other similar studies. Introductions usually start by providing background information and describing something on a broad level and gradually become narrower in focus, eventually reaching the specific role that your study plays.

   The introduction is essentially divided into 3 sections and a finishing statement:
   I. Describe the current state of knowledge with respect to the broad topic.
   II. Describe more specific aspects of the topic that give a basis for your question.
   III. Set up your model system and describe your question/hypothesis.

   This is sometimes done as a series of separate paragraphs with more detail about the model system and what is known. Remember you must use the literature you cite to argue the validity of your hypothesis so a good background on the topic is required.
   IV. Finish the introduction by giving a brief synopsis of your question and the results of your experiment(s) in 1-2 sentences at the end.

4. **Methods** – Length depends on specific methods and analyses used. Do not give a list of supplies and equipment used. There are no separate “materials” and “methods” sections; they are integrated together. Explain the methods and techniques used to perform the experiments and analyze all data. This is essentially done in chronological order and usually has subheadings for individual sections (e.g., behavior recording, hormone assays, in situ hybridization, and statistical analysis). A goal here is to be concise in the methods, yet be able to communicate enough information to allow the reader to repeat the procedures. The **methods section differs**
from the rest of the paper in that it is always written in past tense using complete, declarative sentences (do not use commands).

You do not want to include every detail of the methods, and concentrations (either as molarity, X, or percent) are better than volumes. For example: do not write “we added 5 ml of magnesium chloride to a beaker and mixed it for 5 seconds and then added 100 µl of sodium chloride with a pipette and mixed it again” when you can state "sodium chloride was added to a final concentration of 5 mM in 0.1 mM magnesium chloride buffer”.

Making the connection to use a pipette or a beaker to hold these liquids is left up to the reader and should not be included in your writing (they may instead use a flask but get the same effect). Abbreviations also help make things concise, but do not overuse them.

If a very unique piece of equipment is used to get measurements or perform a process, some papers will mention the model and make of the instrument and any special settings used, usually within brackets and including the company and headquarters’ location. The way the data are analyzed is usually the last section of the methods and also the most overlooked by students. Be sure to include this section and details about how the data are handled (i.e., calculated mean and standard error or appropriate equations). Never give results in the method section.

5. **Results** - Length depends on the amount of data presented and number of experiments done. Give the results in a clear, concise manner using tables, figures, and prose. Be sure to include a descriptive title for all tables and a descriptive legend for all figures. For every table or figure included in your results, you should also have at least one sentence describing each in the text.

Make sure to reference the figures and tables in the text in parentheses. These sentences should tell the reader what to see in the figure or table. What pattern are you trying to show with the figure? For example, DO NOT simply say, “The change in duckweed numbers is shown in Figure 2” and instead say, “Duckweed growth increased with higher amounts of phosphate buffer (Figure 2).” It is necessary to describe to the reader the purpose of each figure and table in your results section. Prose describing your results should start with statements and phrases such as “In order to test..., we did ....” and briefly, summarize the purpose and method. Look at a published paper if you are unsure about how to write this section.

There sometimes is confusion about what to say about the data. In most journal articles, results are simply stated, and more important ones are given with probable and even possible mechanisms and explanations. However, discussion of how these data relate to the goals of the study and hypotheses are saved for the discussion section. The reason why you report the results only (with their interpretation in the discussion) is so that the reader does not get confused as to the difference between the actual results (facts) of the study and any interpretations (speculation) made about them. However, do not present raw, unanalyzed data. For example, the actual readings you get are not as interesting as the rate of the reaction.

Figures should not be redundant. For example, do not show 10 different graphs of a single rate; show one graph with 10 lines. Finally, tables and figures must be presented sequentially starting with number 1 and proceeding onward from that point (i.e. it is not appropriate to describe the results shown in Fig. 3 before you have discussed Fig. 1).

5A. **Tables** - Titles and captions go on the top. Tables should be numbered in the order in which they are cited in the text. In a table, be certain to state the appropriate units; only metric units
are acceptable. Tables must be able to stand-alone; *i.e.* your audience should be able to understand them in the absence of additional text (although they are introduced in the presentation of results). The titles must be descriptive, and all aspects of the table must be labeled, defined, and clearly described.

5B. **Figures** - Titles and captions go on the bottom. Figures containing images must be constructed using a graphics package, such as Powerpoint, Adobe Illustrator, or Photoshop, NOT Word (these programs can be found in the mac lab in Bush, the Olin Library, and the art department). Graphs can be made in Excel. Graphs must have axes labels with units and a series legend if multiple lines are shown. Graphs should not have titles at the top since they will have a complete figure legend below the graph. Once again, only metric units are acceptable, and figures must be able to stand-alone. Titles must be descriptive, and all aspects of the figure must be labeled, defined, and clearly described.

*Your figure legend should begin with “Figure #.” followed by a complete sentence (with both a subject and a verb) that describes the conclusion of the figure.* In other words, if someone could not see your figure or the rest of the figure legend, this sentence should state clearly what they should be able to take away about the experiment(s) if they could not see the figure. This sentence should be bolded. Figures should be numbered in the order in which they are cited in the text.

Below the title sentence of the figure legend should be a description of the experiment. In other words, how did you get to that conclusion? This should not repeat of the all the detail that is included in your materials and methods, but should at least state the specific technique used and any pertinent details. In a way, think of this as what you would tell someone if they asked you what you did in lab today. In answering that question, you would probably mention what you put into a chemical reaction, but you probably wouldn’t tell them the volumes. It should also clearly define every abbreviation within the figure, and if the figure contains multiple panels also define what each part represents. The figure legend for a single figure is typically 2 to 3 sentences.

**Common traps and pitfalls:**

A. Putting titles on graphs: the figure legend provides the conclusion so there is no need for a title.

B. The first sentence is not a sentence: Many students start their figure legend with “The effect of enzyme on substrate”. Not only does this not include a conclusion, but it also does not have a verb. Finally, it is not specific enough; which enzyme and substrate should be stated.

C. Placement of the legend: For tables, figure legends go above the table, but for figures, including graphs, figure legends go below the image.

D. Forgetting to label axes with units

E. Leaving the automatically generated series legend on a bar graph

F. Forgetting to include error bars or incorrectly plotting the standard deviations as their own points

G. Plotting raw data instead of averages with error bars.

6. **Discussion** – *Typically the longest and most variable section of a scientific paper.*

This section can be *difficult to write*, and it may be helpful to take a break of a day or so before starting to write this section. The discussion relates the results to the overall goals of the study.
and **assesses the hypothesis and whether it was supported.** It explains the relationships that exist between the dependent and independent variables and more importantly why those relationships were observed. The results from your study are compared to those from similar studies, and as a result **this section may often have citations** of other studies with a lot of overlap with studies cited in the introduction.

The **first paragraph is usually a summary of the overall experiment:** What was being done, and why? What was found, and what does it mean? This paragraph of the discussion is written **without giving specific results**, but only highlighting the most important broad patterns seen. The rest of the discussion follows up on specific observations and their interpretation. **It is important to present your work in a broader context here.** What does your study mean for the organism, habitat, or biochemical process that was studied?

Another aspect of the discussion is **addressing any limitations with the data or the experimental design** that may have impacted your results or their interpretation. Although you are encouraged to think critically about how your data were collected and analyzed, **do not dwell on “error analysis” in this section.** Although human error can be present and important, give yourself credit for conducting the experiment as was designed. If you were submitting this to a journal, they would not accept it if you say everything in your study is flawed. Typically **the error section, if necessary, is about a paragraph in length** and usually a small paragraph at that.

**Note:** Sometimes **results and discussion sections are combined.** The results are presented in a clear, concise manner, and their meaning to the big picture is immediately discussed. In science, this is often dictated by the particular journal. One advantage is this format may eliminate the difficulty many students have in limiting results to the “facts”, while reserving the discussion for interpretation and conclusions. Thus the combined results and discussion may feel more natural to some, in that **findings are explained as they are reported.** A disadvantage of this method is that if several parts of a study are alluding to the same general finding (e.g., multiple different experiments address the same hypothesis), the writing of this section may be convoluted, especially if there are many data to present. This method is most often seen in smaller papers with **fewer or less complex experiments** to discuss. If you chose to write this section as a combined section, you must indicate that you are doing so by providing the heading “Results and Discussion”.

7. **Literature Cited** – Cite relevant primary literature sources that were referenced in the text of your paper (see below). List the papers you've cited in the text in alphabetical order by author. Follow the formats shown in Section 2 of this guide or use the Cell format in Mendeley unless directed otherwise. **DO NOT** list references that are not cited in the text. **Cite ALL** references that are cited in the text, even if they are from textbooks, lab handouts, or other non-primary literature resources.
Section 2: Citing sources and the Literature Cited page
For lab papers, the number of sources required may vary, but in general, five peer-reviewed primary literature research articles are appropriate for a short paper, and ~15 articles should be used for a longer independent study. Textbooks, websites, review articles, and course laboratory protocols are NOT peer-reviewed primary literature. Although you are encouraged to use textbooks and review articles as sources of general information, these will not count toward the minimum number of peer-reviewed primary literature research articles. (Hint: A good, fast way to distinguish a review article from a primary literature article is to check if any original data are presented. If data from others are summarized but not presented, it’s a review article. If data are presented as individual figures or tables, it’s a primary literature article.)

Peer-reviewed scientific literature is found in scientific journals (e.g., Nature, Science, Cell, Ecology, Freshwater Biology, Aquatic Botany, Plant Cell). There are many ways for you to find excellent peer-reviewed sources. We recommend that you start by using the scientific databases that are available through the Olin Library website (e.g. Web of Science, Science Direct, and PubMed Central). Public websites are not peer-reviewed and are unsuitable for reference in your research paper. If you are uncertain whether a source is acceptable or not, please check with the instructor. Begin your library research early as it can take some time to track down appropriate papers for your report (the Olin Library may need to order articles for you through Interlibrary Loan).

Plagiarism will not be tolerated. Do not use direct quotes or footnotes (these are acceptable practices in other disciplines, but rarely used in biology).

Section 2a: Name/Year In-Text Citations
Biologists typically use the name/year format when citing a source in a paper. Cite each reference by giving the name(s) of the author(s) followed by the year in which the article was published.

Examples:

For papers with a single author:
A recent study showed that miRNA regulated development in zebrafish embryos (Walsh 2014).
-or-
Walsh (2014) found that miRNA regulates development in zebrafish embryos.

For papers with two authors:
Both ribonucleases and bifunctional nucleases are present in the pitcher fluid of the carnivorous plant genus Nepenthes (Stephenson and Hogan 2007).
-or-
Stephenson and Hogan (2007) showed the presence of ribonucleases and bifunctional nucleases in the pitcher fluid of the carnivorous plant genus Nepenthes.

For papers with more than two authors:
Cortisol levels are elevated in Anolis lizards exposed to stressful stimuli (Fokidis et al. 2014).
-or-
As discovered by Fokidis et al. (2014), cortisol levels are elevated in stressed anoles.

For an agency or website:
Since its introduction to the United States, West Nile virus has now spread to all southern states east of the Mississippi River (Center for Disease Control and Prevention, 2011).

Section 2b: the Literature Cited page
This section should be included as a separate page in your paper. References are listed alphabetically by first author’s last name. It is typical for scientific papers to have several authors. All authors’ names must be listed in this section (up to a maximum of 10). If there are more than ten authors list the first ten followed by “et al.”. The order of authorship on a paper is meaningful, typically representing the contribution of the authors to the work. Therefore, do NOT reorder the authors; each reference should start with the first author’s last name.

You are encouraged to use a reference manager such as Mendeley (www.mendeley.com) to organize and generate your bibliography. However, if you use this software or software like it, you should always double check that your reference format is in fact complete and correct.

Do not include a doi in your reference. That is APA style and incorrect for submission to the biology department.

Examples:

For journal articles, use the Cell format:

For an article from an internet only journal:

For lab manual or handout:

For websites:

For books:

Note: Almost all the articles you will find will be on the internet. However, that does not mean that they should be cited as websites. For example, see the image on the next page. The appropriate citation for this particular review article is
Section 3: Writing Research (Review) Papers

A library research paper (Review Paper) is similar in general format to a lab paper, but it does not contain a materials and methods, results, or discussion section because its purpose is not to report new experimental work but to summarize the existing research that has been conducted in a given field. Review papers are useful to scientists because they provide researchers with a summary of the state of research in a given area and any significant advancements that have been made recently. They also indicate avenues of research that still need to be pursued.

Review papers typically summarize dozens (sometimes more than 100) of research papers related to the topic. A typical undergraduate research paper should have at least 10-15 primary literature articles as sources.

General Format:

Title Page: (same as with a lab paper)
Abstract: A 250 word (maximum) summary of the review. This should briefly summarize the topic of the review and significant recent discoveries.

Introduction: This section is typically short (one to two pages at most). It should provide historical detail, describe previous work on the topic and tell the reader what aspects of the topic will be addressed and how the review is organized.

Body of the paper: The review should be organized with logical subheadings that frame the information from your references around major ideas/topics that you want to discuss. Look for common topics and areas of investigation among your sources. You should NOT present a series of stand-alone “book reports” on each of your sources. For each subheading, you must have more than one paragraph.

Conclusions: This section should summarize the entire paper and draw conclusions about the topic. It is here that particular points can be made about directions for future research.
Section 4: Style

Scientific papers should only be difficult to read because a certain amount of background knowledge is needed, *not because the writing is confusing, convoluted, redundant, or official sounding*. Writing style counts here too, and the best papers are those that read like a “story about a discovery”. Below are some tips.

- Use the **active voice** (*we*) instead of the passive voice; **first person is OK**.
- Write in **past tense** when describing your own results and materials and methods. You typically write in the **present tense** when describing established knowledge from previous studies. Your abstract, materials and methods, and results are typically written in past tense whereas much of the introduction and discussion will be in present tense because you will be citing established knowledge.

Examples:

In the **Introduction**: The reproductive success of yellow-bellied marmots (*Marmota flaviventris*) is strongly influenced by the availability of food and burrows (Anderson et al. 1976).

**In the Materials and Methods**: We placed the inoculated plants in a high-humidity environment for 100 hours.

- Short clear sentences are preferable to long wordy ones.
- Spell check.
- Proofread your paper. Then have someone else proofread it again before you hand it in.
- Use **topic sentences** for each paragraph (e.g., “To investigate how testosterone affects sports playing, we …”)
- **Ask the biology and/or writing tutors at TJs** to read your paper before you submit it. This free resource is available to you and should give you significant support to boost your grade for your first draft.
- Number your pages.

**Brief Style Points**
- Effect is a noun. Affect is a verb.

  - Scientific names are italicized, with the genus capitalized and species lowercase. For example, *E. coli* and *C. elegans* are two great model systems. (As an aside, zebrafish is one word.)

  - There is rarely a reason to use the phrase “due to”. It is a cumbersome phrase that means nothing more than "because".

  - You must have a leading zero before a decimal place. (i.e. **0.5** NOT **.5**)

  - When writing numerals with units, always insert a space between the number and the unit.

Correct: **0.05 mL**
Incorrect: **0.05mL**
- Never start a sentence with a numeral.

Correct: We combined 5% substrate solution with the enzyme.
Incorrect: 5% substrate solution was combined with the enzyme.

- When using an abbreviated name for a molecule (chemical, protein, etc.), write the complete name of the molecule first and place its abbreviated name in parentheses immediately after. You can then use the abbreviated term throughout the rest of the paper.

  Correct: We used 2, 6-dichlorophenolindophenol (DCPIP) to act as an indicator...
  Incorrect: We used DCPIP (2, 6-dichlorophenolindophenol) to act as an indicator...

- We do not use the word prove in science. You can say support, suggest, demonstrate, or is consistent with.

Identifying Passive and Active Voice (with Zombies!)
-Avoid using passive voice in your writing. Still confused about what’s the difference between passive and active voice? Rebecca Johnson, a professor of culture and ethics at USMC, has the best advice ever.
  According to Professor Johnson, if you can add the phrase “by zombies” after the verb and the sentence still makes sense, then your sentence has passive voice.

For example:

Passive Voice = She was chased [by zombies].

Active Voice = Zombies chased [by zombies] her.

And voila! It’s a simple and fun way to identify when you’re using passive voice.