DISSECTION OF A SCIENTIFIC PAPER

PURPOSE
Most of us think of scientists in the lab, shuffling test tubes, gel rigs, and mice. However, in reality, a large portion of a lab scientist's time is spent analyzing and presenting data to others. In fact, for every hour spent in the lab (or at a field study site) you can expect to spend another hour analyzing the data and still another hour preparing figures and text to accompany those results. Given the importance of the "post-lab" portion of a scientific experiment, we have designed this writing workshop to bring everyone up to speed on how to write a scientific paper.

Our goal main goal for this workshop is to expose you to the scientific paper format used in physiology journals. You will find that this format is similar to those you have followed in other lab courses. However, there are some differences between the format used in physiology and those used in chemistry, medicine, and even in other sub-fields of biology (e.g., genetics). Another objective of this workshop is to promote a concise writing style. Grammar, word choice, and paragraph structure may be terms that you associate with your English courses. However, good writing skills are equally as important in scientific communication. Most questions in biology are too broad to be answered by a single study. Therefore, developing a complete answer to any question takes many scientists, all working hard and sharing the results of their experiments. Thus, you owe it to your readers -- the scientists that hope to learn from your study and perhaps extend your work -- to present your ideas, methods, results, and conclusions in the clearest way possible. The bottom line ==> Good, solid research that is presented in an unclear and disorganized fashion will generally not make it past the lab bench.

BACKGROUND READING
Writing Papers in the Biological Sciences, McMillan, Chapters 3 and 4
-or-
A Student Handbook for Writing in Biology, Knisely, Chapter 3

PURPOSE
By this point in your college career you have undoubtedly read a number of primary science articles. It is unlikely, however, that you have really focused on the details of format and style. One of the best ways to develop your own writing skills is by studying other people's work. In this workshop you will examine three published papers: two from Physiological Zoology (which has recently changed its name to Physiological and Biochemical Zoology), and one from Journal of Comparative Physiology. Your job is to explore the features that are shared by all three papers. These are features that you will want to use in your own research papers.

GENERAL NOTE ABOUT FORMAT
Writing in the correct format does not guarantee that an article will be deemed worth of publication. However, the failure to follow the scientific paper format will result in automatic rejection of a submitted manuscript (even if the data is fabulous). Similarly, writing in the correct format will not guarantee you a good grade, but your professors will return your paper for you to rewrite if you do not follow the course guidelines!
STUDY PAPERS:


DISSECTION DIRECTIONS

- We want you to work through these papers in the same order that you should follow in writing your own research papers...
  Materials and Methods ==> Figures, tables, and results ==> Discussion ==> Introduction ==> Summary ==> Title

NOTE: YOU DO NOT HAVE TO READ THE PAPERS IN ORDER TO DO THIS LAB!!!!

- Please answer the items in italics in writing. The other items are primarily for thought and/or later discussion.

- You may work in groups of 1 - 3 people. You may answer questions as a team and turn in one set of answers.

- Completed workshops will be evaluated using the following scale: + = good effort, thoughtfully completed; √ = completed; - = not completed.

- Feel free to wear gloves.

A. MATERIALS and METHODS SECTION (= METHODS SECTION)

(i) List the main categories of information that are common to the Methods section of the three papers. By categories, we mean such elements as "animal care", "experimental directions", "recipes for solutions", "data analyses", etc.

(ii) You have probably noticed that the categories you have listed in (i) are presented in a similar order in the three papers. *Barring some exceptions, what is the general order of the categories?*

(iii) Bridges et al. and Packard et al. use many descriptive subheadings as "guideposts" within their methods section while Hosken and Withers only use two minimally descriptive subheadings. As a reader, which format works best for you? Why?

*Practice planting guideposts by adding some subheadings to the methods section of Hosken and Whither’s paper. Be sure to indicate where you would insert the subheadings as well as the precise words you would use.*
(iv) As a rule, any critical equations used in data analysis must be included in the Materials & Methods section (the exception are equations used in statistical tests). *Circle the equations given in Hosken and Withers.*

(v) In addition to pure methods, explanatory phrases are sometimes included in the Materials and Methods section to clarify why a particular step was taken. *Look through the Animal Capture and Maintenance and the Animal Restraint sub-sections in Bridges et al. and circle all the explanatory phrases that you find.* As a reader, do you think that you would have questioned the author’s rationale for a particular method if the explanatory phrase hadn’t been included?

### ADDITIONAL NOTE ABOUT MATERIAL AND METHODS SECTION

The recipes for any solutions used must also be included in the Materials and Methods section. For example:

"We homogenized the tissue in five volumes (w/w) of Extraction Medium A (75 mM Tris, 1 mM MgCl$_2$, 2 mM CaCl$_2$, pH 7.5 at 15 °C)."

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**B. RESULTS SECTION**

1. **Figures**

Refer to the following:

Hosken and Withers, Figure 7
Bridges et al., Figure 3
Packard et al., Figure 3

Examine these figures carefully. Now think back to various figures included in biology or chemistry lab reports. You’ll probably realize that there is at least one striking difference between the layout of the "lab report figure" and the "research paper figure"; **in a formal research paper, there is no centered title above the figure.** This feature (or lack there of) does not mean that there is no title ....

(i) Read the first sentence of each figure legend. *What does each of these accomplish?*

(ii) Read the following sentences in each figure legend. *List the type of general information that is contained in these sentences?* What do these sentences accomplish? What would the [figure+legend]-unit lack if these sentences were omitted?

The bottom line for figure legends is that they should **always contain** ...

- the title (= a sentence which precisely describes what the figure shows)
- a summary of the results
- a key for any symbols used

... so that the [Figure+Legend]-unit can stand alone.
In addition to the above three elements, figure legends may also contain...
- a summary of the methods used to obtain the data shown
- statistical results
- references

(iii) Which of the figures show processed data and which show raw data? Why do you think an author would choose to include raw data as opposed to processed data in a published paper? In other words, what information can an author only convey with raw data and what type of information can an author only convey with processed data?

2. Tables

Refer to the following:
- Bridges et al., Table 1
- Packard et al., Table 2

(iv) What information is contained within the text at the top of each of these tables?
What information is contained within the text at the bottom of each of these tables? *Based on these observations, how do Table Legends differ from Figure Legends in the journal Physiological Zoology?*

(v) Specific point about Bridges et al., Table 1.
Notice how Bridges et al. makes use of a tabular format to compare their data to published work. Pretty neat, huh?! You can do this, too.

3. Results Text

(i) Beginning Biology 334 students typically write results sections that are WAY too short. Begin your examination of the results section by determining how long a typical results section in a published physiology paper is. *Pick one of the papers and count the number of paragraphs within the results section. How does this number compare to the number of figures and tables? How many pages is the text of the results section? What fraction of the entire paper is this?*

(ii) It is common for biology students to think that only numbers makes up "real" data. However, behavioral data is an extremely important aspect of many of the studies that you will be doing in Animal Physiology and we would like you to include behavioral data whenever possible and important. For example, if you were reporting on the heart rate of resting crayfish, your readers need to know how the crayfish were behaving in order to interpret your numerical data. Behavioral data are also helpful for someone trying to duplicate your experiment.

*Read the first paragraph of the Results section in Hosken and Withers. Underline the behavioral data that the author's have included.* The wording of these sentences is an excellent example of how to report behavior that may influence numerical results.

(iii) Pick one figure and find the corresponding portion of the results text. *How does the presentation of the results differ between that given in the [figure+figure legend]*
and that presented in the text? Is there any information that is presented in both the legend and in the text? Is there any information that is presented in only the legend or in the text? If yes, explain what type of information is redundant.

4. Statistical Results
Skim the results section of each paper looking specifically for the statistical results. Notice that the authors (almost) never use an entire sentence to relay statistical results. Instead, the authors emphasize the biological results in complete sentences and relegate the statistical results to small parenthetical statements [e.g., (Student's T-test; p < 0.05)].

GENERAL NOTE ABOUT STATISTICAL RESULTS
Make sure that you understand the distinction between statistical results and biological results. In this class we are primarily interested in the biological results ... the statistical results are necessary but always take a back seat.

(i) In non-technical terms, explain what "p < 0.05" means. By non-technical, we mean without terms such as "null hypothesis" and the like.

(ii) Suppose that you have just completed an analysis of your own data collected during a four hour animal physiology lab and you have found a p-value of 0.08. Should you completely reject your hypothesis? Why or why not? Would your answer be different if your p-value was 0.18?

C. DISCUSSION

(i) In the first paragraph of a discussion section, an author typically restates his/her hypothesis or central question of the study (the reader will have already encountered this information in the introduction) and says whether or not the results of the experiment agree with the predictions. Assuming that the these authors have followed this convention, you should be able to write down the central question of the study, simply based on the first (and occasionally the second) paragraph of the discussion. Put this idea to the test on the next page.

a) What is the central question of Bridges et al.'s study?
b) What is the central question of Hosken and Wither's study?
c) What is the central question of Packard et al.'s study? Try not to get bogged down in the technical terms used)

Note: you should be able to do this even though you have not yet read the introduction. If you cannot, there may well be a flaw in the paper.

(ii) From a reader's perspective, give two reasons why it is helpful to have the author of a paper restate the central question at the start of the discussion. In other words, what would you, as a reader, be forced to do if the author did not restate the central question.
(iii) Using the same paper that you selected in part B3(i) count the number of paragraphs in the discussion. *How does the discussion length compare to that of the results section? What portion of the whole paper is it?*

(iv) Compare the sub-headings of the Results and Discussion sections in Packard et al.’s paper. Do the same with Bridges et al. *How have these author’s used the subheadings to organize the flow of these two sections?*

**GENERAL NOTES ON SUBHEADINGS:**
We highly encourage the use of subheadings in the Materials & Methods, Results, and Discussion sections of the research papers you write for Animal Physiology for two important reasons:

(a) Subheadings help the reader stay focused and organized.
(b) Subheadings help the author organize and write the paper.

**GENERAL NOTES ON RESULTS AND DISCUSSION SECTIONS**
Do not be intimidated by the length of these sections in the study papers. These scientists have been working for at least a year on their studies; you will have four hours to four weeks. **** Thus, we do not expect you to have as much material to graph, analyze, and discuss as you see in these papers ***

**D. INTRODUCTION**
Effective scientific paper introductions do three fundamental things:
1. Establish the context for the work by describing our current state of knowledge
2. Reveal what uncertainties still remain
3. Explain how the study being presented will fill this gap in knowledge

#1 is accomplished by introducing the general topic and using outside literature to explain what we already know about this.

#2 should lead to the inescapable conclusion that there is a real gap in our understanding and that this gap needs to be filled. In other words, the context should make it clear why it is important to fill this gap.

#3 should be clear about how the study being presented is different in some ways from previous studies.

(i) *Draw a box around the part(s) of the introduction for the paper you previously selected (in parts B3(i) & C(iii)) that establishes our current state of knowledge. Label this box “current state of knowledge”.*

(ii) *How many outside sources does the author use to establish our current state of knowledge?*

(iii) *Draw a box around the part(s) of the introduction that reveals the current gap in knowledge. Label this box “gap in knowledge”.*
(iv) **Draw a box around the part of the introduction that explains how the study will fill this gap in knowledge and how it differs from what has been done in the past. Box this part and label it “current study”. This is essentially the purpose of the study.**

(v) **Pick another of the study papers and repeat steps (i) through (iv). Do the two papers present the information (state of knowledge/gap in knowledge/current study) in the same order?**

How long should an introduction be? The flip answer is “as long as it needs to be”. This is not too helpful, though. To get an idea of the length of an introduction, measure the length of the introduction for the paper you have chosen.

(vi) **Approximately what fraction of the paper is the Introduction?**

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**WRITER BEWARE!**

Many beginning Biology 334 students write mediocre introductions for the first paper. By far the most common mistake made by these students is that they fail to write an introduction for the study that they actually performed; instead, the introduction introduces a study that the student thought he/she was going undertake. The best way to avoid making this mistake is to write the introduction only after you have completed the methods, results and discussion sections.

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**E. ABSTRACT AND TITLE**

(i) Glance at the abstract from each paper. Notice that each is only one paragraph long. With only rare exceptions, abstracts in all biological journals are kept to one paragraph. Physiological Zoology has a limit of 200 words in the abstract.

(ii) **Pick one of the abstracts and draw a line between the portions of the text which provide each of the following information: introductory, methods, results, interpretations of the results. How many sentences are devoted to each type of information? How well does the number of sentences dedicated to each type of information relate to the length of the corresponding section in the whole paper?**

(iii) A good title lets the reader know what the paper is all about. In other words, a good title would convey the central question addressed by the paper. Look at the titles for the three papers. **How well do each of the titles convey this information? Do you think that any of the titles does a poor job at informing the reader? If so, can you rewrite the title so it provides a better description of the paper's subject?**

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**F. VOICE: ACTIVE versus PASSIVE**

(i) Read through the Introduction of Packard et al.'s paper. **How many sentences are written in the passive voice?**

(ii) Read through the Materials and Methods section. You'll notice that although the passive voice is used more in this section than in the Introduction, Packard and co-workers still makes considerable use of the active voice.
(iii) In general terms, how much does Packard et al. use the active voice in his Results and Discussion sections ("hardly at all", "sometimes", "about half the time", "quite a bit", "exclusively")?

(iv) Is Packard et al.'s extensive use of the active voice unusual? Answer this question by looking through the other two papers.

**GENERAL NOTES ON PASSIVE AND ACTIVE VOICE**

Active versus passive voice is largely a personal choice these days in scientific writing, although some journals actually require 100% passive voice. However, I prefer a mixture of active and passive voice for the following reasons:

(a) YOU did the experiment, YOU should take credit for it.
(b) It is much more interesting to read something that has varied sentence structure.