

## BIOL 4800 – SPRING, 2005

### GUIDE TO WRITING SCIENTIFIC REPORTS

Scientific communication is one of the most important skills that you can learn at University. Yet effective writing is also a difficult skill to master, often taking years of practice. One of the problems for Biology students in particular is that there is often 'much writing to be done, but little time to focus on doing it well' (Pechenik, 2001). The aim of this guide is to provide you with some advice on the mechanics and pitfalls of scientific writing. My sources for this advice come from Pechenik (2001; this superb book is available upon request), a handout written by Gail Michener for her class in Animal Physiology, and from notes taken from a graduate course I taught at U of Alberta on Scientific Communication.

For students in 3<sup>rd</sup> or 4<sup>th</sup> yr University, poor reports usually stem from one (or a combination) of 4 problems. The first is that many of you have some training in writing 'essays' or 'opinion papers', and have difficulty in changing to the 'science' style. The aim of Scientific Writing is to be concise and clear, not verbose and flowery. Second, many students simply have poor writing skills. The simplest rules involving nouns, adverbs and clauses can go a long way to making your paper clear and easy-to-follow. Third, unclear writing usually stems from unclear thinking. Usually, if you are struggling with 'Writers Block', it means that you are not exactly clear in what you want to write about. Thus, one excellent way to truly 'learn' Biology, is to write about it. Lastly, it is my experience that many students do not take the task of writing seriously.

Your lab reports are to be written in a style typical of that required by scientific journals that report original research. The purpose of scientific writing is to convey information and ideas exactly, explicitly, and economically. If this is your first attempt at writing a formal report, you should pay particular attention to the instructions provided here.

#### **Title**

In a nutshell, the title should summarize what lies in the Introduction and Results sections. The aim is to grab the interest of potential readers, right from the start. Avoid non-informative titles such as 'Zooplankton of Tyrrell Lake', or 'Feeding preferences of fathead minnows'. Replace with something like 'Species composition of fall-collected zooplankton in a prairie lake' and 'Do fathead minnows, Pimephales promelas, select particular prey?' The title should be on a separate page, with your name (do not include your student ID), email, affiliation and date at the bottom.

#### **Abstract**

The aim here is to summarize in a few (5-8) sentences the major points of the study. You should write it last. As a first step, start with a sentence that covers the general problem/phenomenon being considered (e.g. 'The negative effects of parasites on host physiology, morphology and behaviour are well documented'). Next, shift to a mention of the system being studied (e.g. 'The effects of trematode infection on experimental populations of fathead minnows were studied ...'), then a brief mention of the

techniques used, then the most important findings. Always conclude with a general statement that covers the principal conclusions reached (e.g. These results show that light infections with encysting parasites decrease host growth rates, but only when hosts are poorly nourished). The abstract is always written in the passive voice. Also, be sure to make your abstract **informative**. For example, the phrase ‘Infection reduced host growth’ is probably true, but it is not informative. Try something like ‘Infection reduced the growth rates of minnows by 25.4 % compared to uninfected controls’.

The abstract is notoriously difficult to write. Often, it is the only part of your paper that your intended audience will read. Don’t leave it to the 5 minutes before your paper is due.

The abstract, together with the rest of your paper, should be double-spaced and written on one side of the page. Number all pages.

### **Introduction**

The aim is to orient the reader to the general nature of the problem under consideration. Because the experiments are designed to answer questions, the Introduction should inform the reader about what questions are being investigated and why those questions are of biological interest and importance. The Introduction is often the most difficult component of a paper to write properly. The problem is that to encourage a reader to keep going, you have to convince them early-on that you are an authority on the question of concern. This is not easy for young researchers, because it requires extensive background reading and clear understanding of the topic.

As one suggestion, aim to think in terms of paragraphs. For most papers that you will be writing for me, you will never need more than 3-4 paragraphs to get your message across. Try to think linearly; start with a general paragraph and work towards more and more specificity. For example, start with a general paragraph (e.g. general questions regarding galls, effects on hosts, biology of enemy/victim interactions), followed by a second one that introduces your specific system (Solidago and Eurosta and its enemies). Consider starting the 3<sup>rd</sup> paragraph with ... “The purpose of this experiment is to .....”.

Each of these paragraphs must contain authoritative references.

### **Materials and Methods**

The purpose of the methods is to inform the reader of important aspects of techniques, animals, equipment, and conditions such that the reader could repeat the experiment. You can skip trivial details, but you must include relevant aspects of methodology. In those cases where the experiment was set up for you, you will have to refer back to your notes or use Goater (personal communication) or use the lab manual (Goater, 2005). You can use subheadings if they make the section clearer (e.g. study site, collection methods, experimental design, analyses). The last paragraph should contain a section that describes the types of ‘analyses’ you used (correlations, ANOVA etc.).

## Results

The results section should describe to the reader what was discovered in the experiment and what you believe are the most important points. There should be two components: the presentation of data (with tables or figures) and corresponding text that focuses the reader on the main discoveries revealed by the data.

Data that do not warrant a table or figure can be reported with the text component of the results. When data are presented in a tabular or graphical format, each is numbered sequentially, starting with Table 1 and Fig. 1. By convention, the figures and tables should be covered in the text component in sequential order (i.e. cover the results from fig. 1 before fig. 2 and Table 2).

Tables are accompanied by a title placed above the table that briefly and clearly describes the contents. Each figure should be accompanied by a title placed below it. The text component **MUST** contain at least one reference to each table and figure. The idea is that if you are putting data in table or figure format, their associated results warrant specific comment. Thus, although the results in a figure might be obvious (to you), they may not be obvious to your reader. You will have a tendency to write a sentence something like “Table 1 provides results that show spatial variation in gall rates on Solidago”. Fight this urge! Instead, introduce the data in the table by a sentence such as “Gall rates were significantly higher in Population 1 than Population 2 (Table 1).”

Data should be presented only once within the results, either in a table, a figure or in the text. Where you describe the data is up to you. Raw data are rarely given in the Results. Instead, you should report means (always with some indication of error) and sample sizes. Statistical treatment of the data is reported in the Results. Whenever test statistics are reported (see below), the statistic (t, F, r), degrees of freedom, probability, and conclusion (accept or reject null hypothesis) must be provided. Do not include the step-by-step calculations.

Gone are the days when a ruler and graph paper are used. There are now plenty of graphics programs on the market, such as Cricket Graph and Sigma Plot. Your stats programs usually also come with crude graphics (e.g. JumpIn, SuperAnova, StatView) and these are sufficient for the purposes of your reports.

Tables and Figures should be on separate pages, and should follow the Literature Cited section at the back of the manuscript.

## Discussion

The purposes of the Discussion are to 1) interpret the data in context of other similar studies, 2) interpret the meaning and validity of the results, and 3) draw conclusions about the biological phenomenon under study. Other than purely descriptive studies, most biological experiments are conducted with a hypothesis in mind. If the data do not support the hypothesis, you should account for the discrepancy. Possibilities include poor experimental technique, to discovery of a previously unknown phenomenon. If

discussion of the results raises additional questions, the writer can briefly propose additional, follow-up experiments or refinements to the current experiment.

As for the Introduction, it is useful when first starting out to arrange your thoughts in terms of paragraphs. It is in the discussion where it is very useful to work from a well-considered outline. If you are truly struggling with 'writers block', aim to match every paragraph in the Results section, with a paragraph in the Discussion. It is unlikely that your discussion will stay this way, but it is often a good place to start.

Focus on the first paragraph of your discussion. It is here where you should cover the main results from the whole experiment, and place your results in context of other studies. The last sentence of this paragraph often summarizes the most significant part of the work. Subsequent paragraphs might start with 'An alternative explanation for these results, as suggested by Smith (1990) is .....'. It is towards the end of the discussion when editors usually allow some freedom with interpretation (i.e. speculation). If you have difficulty leaving your 'essay' roots behind, this is the only place where you might resurrect those tendencies.

### **Literature Cited**

The key here is to choose a conventional and appropriate style, and be consistent throughout the paper. Check a style used by the authors of one of your sources, then stick to it. Although learning where and when to use references is a practiced skill, there is no excuse for improper format. You should know as well that there is no answer to the question 'how many references do I need?'. In general, the types of reports that we deal with in my 3-4 yr classes tend to require between 10-25 references. However, I emphasize that this is a generalization and depends greatly on the type of experiment or study that you are doing.

### **Extra tips**

The advice described above will provide you with the necessary skills to complete a solid manuscript. But there are still some extra tips that you might consider in order to shift your paper from 'good' to 'great'.

1. A good reviewer will decide within the first 1-2 sentences of your introduction whether you are truly writing as an authority on a particular topic. They decide this by the content of your sentences and by your judicious use of references. In addition, reviewers can very quickly come to a conclusion on whether or not you really understand your data, and its' significance. Mastering these skills is the 'art' of scientific writing. You have to be seen as an authority (thus, you must know the literature cold), you have to write clearly, and you have to convince your peers that you have something to contribute. Your first step in this process is **practice**. The second is to spend some real time **thinking** about your data and about the organization and preparation of your paper. It is in this fuzzy area where most students lose their marks. Frankly, it is usually painfully easy to separate those students who have spent time thinking about their study, and their paper, from those who have put it together the night before the deadline.

2. Write to illuminate your information, not to impress. This is self-explanatory. It is another way of saying 'Too much fertilizer burns the petunias'. Be as simple as you can. My PhD supervisor used to pretend that his 14 yr old son was sitting in the room with him. As he wrote manuscripts, he would first explain a difficult concept to him, then write it down. If you are worried that you are being too flowery and verbose, go over your paper and remove every adverb. You will probably find that most are not needed. The same could probably be said for many of your adjectives.
3. Make a statement, then back it up. This is a good habit to get into. You can back up your statements with a good reference, or with an example, or both. 'Not all arthropods have reduced population sizes on heavily grazed short-grass prairie. For example, many species of grasshopper attained maximum population sizes on heavily grazed sites (Smith, 2003)'.
4. Don't plagiarize. I know that you will respond to this by 'Of course not'. But be sure you know what this statement means. **DO NOT PLAGIARIZE**. I have had to deal with too many instances of plagiarism in my upper-level courses. It is an humiliating offense to deal with. As you know, it can get you removed from the class, and even the University. Remember that quotations are used very rarely in Scientific writing, so virtually everything has to be in your own words.
5. Allow time for revision. This is hard to do, because we are all under time constraints. But you will be amazed at how taking a break from your paper, then doing a revision (really a re-vision!), will improve your paper.