TOPIC 1
SCIENTIFIC WRITING

Objectives:
1. Learn the IMRaD format. Understand the purpose of each part of a scientific paper provided by your instructor and be able to explain what type of information is found in each section.

2. Understand how the parts of a paper correspond to the scientific method and the process of designing and performing an experiment.

3. Understand how to paraphrase and cite references to avoid plagiarism.

Introduction:
Laboratory and field-oriented courses in the Department of Biology at York College often entail exercises and experiments that require formal lab reports. Our department has developed a standard lab report format that you will use throughout the curriculum. It is based on the IMRAD format used in virtually all primary research articles in the biological literature. The acronym IMRAD refers to the following sections:

Introduction, Methods, Results And Discussion.

The complete order of sections should be title page, Abstract, Introduction, Methods, Results, Discussion, Literature Cited, tables, figure legends, and figures. Some instructors in the biology department may deviate slightly from this order. It is important that you determine this before you start to write.

Each section of the lab report plays an important and unique role. The following provides guidelines about the information in each section.

TITLE PAGE: Name of experiment or exercise, your name, name of lab partners, name of class, date experiment done, date report submitted. (separate sheet of paper)

ABSTRACT: This is a single, tightly-written paragraph that briefly summarizes the major elements of the lab report. A minimum of one sentence each should be devoted to your objectives, methods, results, and conclusion. Your job will be easier if you write the abstract after the rest of the report is complete. (separate sheet of paper)
INTRODUCTION: This section supplies background information and may also provide a theoretical basis and historical context for the work done in the lab. To do this, it may be necessary to cite information that has been published in research articles or books. A good Introduction indicates why the work was undertaken and why it is interesting. Toward the end of this section you should explicitly state your hypotheses or objectives and perhaps some predictions that fit the hypothesis.

MATERIALS AND METHODS: In this section you will describe the procedures that enabled you to collect your data. A simple listing of "materials" is inappropriate. Ideally, you should include the details that would permit someone to repeat your work based on their reading of this section. For most labs, the methods will come from a lab manual/handout. The degree to which your manual/handout may be used for citing methodology is up to your instructor. Avoid insignificant details such as the name of the company that made your pipette or the day of the week on which your lab occurred. The predominant verb tense in this section is past tense. This section is often the most straightforward to write and is therefore a good place to begin your report.

RESULTS: This is the core of the report in which you present your findings, usually in the form of numerical data. Sometimes raw data may be presented, but it is more common and useful to provide data that have been condensed to some degree. If you are presenting calculated means, don't forget to include some measure of data variability (e.g. standard deviations).

Tables may be needed to organize large groups of numbers. Figures (graphs) can be particularly useful to display trends in data. It is not enough, however, to simply refer readers to tables and figures. Results must be verbally expressed in the Results section. All of your data are not equally important. Draw the reader's attention to particularly noteworthy data or the presence of meaningful trends. If possible, support this with statistical analyses, keeping in mind that statistical significance may conflict with your sense of biological significance.

The text of the Results section should summarize the data, but stop short of interpreting their meaning or drawing major conclusions about their importance. Certain biology courses may require a differently-structured Results section -- see your instructor about appropriate modifications.
DISCUSSION: Interpret your data and evaluate the meaning of your results. Was your hypothesis, as stated in the Introduction, supported by the data? Don't be afraid to report "negative" data (e.g., lack of relationships among variables). In some cases, negative outcomes are more interesting and important than positive and predictable findings.

If your data seem anomalous or unreasonable, provide reasons that might help explain this. If possible, connect your findings with the results from published studies by using literature citations. Do your results contradict, reaffirm, or extend previously published findings? How do your results fit into the big picture?

Resist the temptation to discuss every aspect of your data and do not provide every conceivable explanation for the obtained results. Speculation should be limited and clearly identified as your own opinion. The last paragraph of this section should be a strong statement of the take-home message.

LITERATURE CITED: All citations that appear in the body of your lab report must be listed in this section. We will use the author-year format to arrange the citations. List the papers in alphabetical order based on the first author's last name. Unfortunately, there are many ways of formatting citations. As a matter of convenience and consistency, we will arbitrarily adopt the following formats:

RESEARCH ARTICLES


BOOK


LAB MANUAL


EDITED VOLUME


WEB DOCUMENT

Author’s name(s). Date of publication. Title of page. Title of Site (if different from page) Available: web address. Accessed date of visit.


ELECTRONIC JOURNAL

Author’s name(s). Date of publication. Title of work. Title of serial [serial online] Volume number: pages. Available from: protocol, address, and path.

ELECTRONIC CORRESPONDENCE

Author’s name(s). Date of message. Title or subject line [type of medium]. Available from: protocol, address, and path.

Smith, J. 2007 February 13. Re: Scientific style [email to Keck, A.]. Available from: ajk001@alpha.morningside.edu

Doe, J. 1997 February 13. Citation formats [discussion online]. Available from: Bibliographic Instruction List BI-L via listserv@bingymb.cc.binghamton.edu

You are encouraged to cite appropriate literature in the Introduction, Methods, and Discussion sections of your lab report. Not surprisingly, there are some rules about how to do it correctly. Citations most commonly appear at the end of a sentence inside parentheses as illustrated in the following three examples:

Growth rates are positively correlated with rainfall (Jones 1993).

Growth rates are positively correlated with rainfall (Jones 1993, Roy and Smith 1988).

Growth rates are positively correlated with rainfall (Jones 1993, Roy and Smith 1988, Williams et al. 1937).

Note that "et al." was used for the last citation. This automatically informs you that Williams had two or more coauthors. All author's names should appear in the complete citation in the Literature Cited section of your report. The above format is preferred although some writers will explicitly insert the cited author's name(s) into a sentence:

Jones (1993) found that growth rates are positively correlated with rainfall.

A positive correlation between growth rates and rainfall was found by Jones (1993).
TABLES AND FIGURES

The Results section of a paper often presents data in the form of tables and figures. Your first consideration is deciding if visual aids are necessary. If you choose to include them, follow these guidelines.

TABLES

1) A table heading is a terse indication of table contents. It is usually a SINGLE sentence fragment and may, for example, lack a verb.

2) Restrict your use of horizontal lines and never use vertical lines.

3) Use superscripts and footnotes to provide additional information about the contents of the table.

4) Each table should be on its own piece of paper.

Table 1: Characteristics of Photosynthetic Pigments.

<table>
<thead>
<tr>
<th>Pigment</th>
<th>Color</th>
<th>Water Soluble?</th>
<th>Position on TLC strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phycobilins:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phycoerythrin</td>
<td>Red</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>phycocyanin</td>
<td>Blue</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>Carotenoids:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carotene</td>
<td>Orange</td>
<td>No</td>
<td>Very high</td>
</tr>
<tr>
<td>Xanthophylls</td>
<td>Yellow, orange</td>
<td>No</td>
<td>Moderate to low</td>
</tr>
<tr>
<td>Chlorophylls:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chlorophyll a</td>
<td>Bluish green</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>chlorophyll b</td>
<td>Yellow green</td>
<td>No</td>
<td>Slightly lower than chlorophyll a</td>
</tr>
<tr>
<td>chlorophyll c</td>
<td>Light green</td>
<td>No</td>
<td>Very low</td>
</tr>
</tbody>
</table>
FIGURES

1. Each figure should be centered on its own separate piece of paper.

2. Figures should be printed in portrait mode (not landscape).

3. The letters and numbers on the X (horizontal) and Y (vertical) axes should be LARGE. Other letters and numbers should be slightly smaller.

4. If the figure is complex, include a key to identify symbols, lines, or bars.

FIGURE LEGENDS

1. Every figure requires a separate figure legend.

2. Figure legends should provide enough information to allow the reader to interpret the figure. Unlike table headings, figure legends may consist of several sentences. The first sentence is often a sentence fragment (a conceptual title).

3. Figure legends precede the figures and should be stacked consecutively on a single sheet of paper. Alternatively, figure legends can be placed BELOW the graph itself. See the example on the next page.
Figure 1-Typical time course of the cold acclimation and vernalization responses in *Arabidopsis thaliana*. The acquisition of freezing tolerance occurs within days, whereas vernalization requires several weeks of cold exposure.

from:

PLAGIARISM & PARAPHRASING IN SCIENCE WRITING

Scientists and science students are expected to be intellectually honest. A key aspect of this honesty is the careful giving of credit when discussing published data and ideas. To not give appropriate written credit by citing the published work of others is an act of plagiarism.

Webster’s 7th New Collegiate Dictionary defines ‘plagiarize’ in the following ways:

1) To steal and pass off as one’s own (the ideas or words of another)
2) To present as one’s own an idea or product derived from an existing source

Plagiarism is easily avoided through the practice of literature citation. When in doubt, cite. Does this mean that every sentence that is not 100% original must have a citation? No, it means that you must use some common sense. If, for example, it takes three sentences to express an idea or discuss data from a published source, you do not have to cite the source in all three sentences. Once may be enough. Sometimes it works best to cite the source in the first sentence, other times it seems better in the third sentence. If a paraphrased section is long, it may be best to cite the source in both the first and last paraphrased sentence. Use good judgment and seek the opinion of your instructor or mentor.

Literature citations, while absolutely essential, do not necessarily mean you have appropriately used your sources. Citing a source does not free you to use the wording found in the cited text. This brings us to the gray area of paraphrasing. While plagiarism is clearly intellectual dishonesty, poor paraphrasing comes closer to intellectual laziness. Unacceptable paraphrasing would be tinkering with the order of words in the original passage or simply changing a couple of insignificant words. Strong paraphrasing involves a total digestion and rewriting of a cited passage. Your goal when extracting information from a cited source is to capture the author’s meaning but express it in your own words. This takes some effort, but the end result is always worthwhile.

Is it OK to just avoid paraphrasing by using quotation marks around the cited passage?

No, quoting passages from a cited source is rarely used in science writing.
LEARN TO PARAPHRASE:

The following examples illustrate inadequate and acceptable paraphrasing.

_Exact wording of a passage from Whitehouse and Jaffe (1996, Animal Behavior 51:1207):

We found that the combat strategy followed by _A. laevigata_ depends upon the specific threat. _Atta laevigata_ mainly recruited soldiers in response to a mechanical disturbance (simulated vertebrate threat), but recruited predominantly small ants in response to a conspecific threat.

_Inadequate paraphrasing:

The combat strategy used by _A. laevigata_ depends upon the exact threat. _Atta laevigata_ primarily recruits soldiers in response to a physical disturbance (such as a vertebrate), but recruited predominantly small ants in response to a conspecific threat (Whitehouse and Jaffe 1996).

_Acceptable paraphrasing:

_Atta laevigata_ adjusts its recruitment to match the nature of the threat. Mechanical disturbances induce a recruitment of mostly soldiers whereas conspecific threats elicit the recruitment of mostly small ants (Whitehouse and Jaffe 1996).
Another more general example of paraphrasing. Remember that quotations are discouraged in scientific writing.

_The original passage:_

Students frequently overuse direct quotation in taking notes, and as a result they overuse quotations in the final [research] paper. Probably only about 10% of your final manuscript should appear as directly quoted matter. Therefore, you should strive to limit the amount of exact transcribing of source materials while taking notes. Lester, James D. _Writing Research Papers_. 2nd ed. (1976): 46-47.

_A legitimate paraphrase:_

In research papers students often quote excessively, failing to keep quoted material down to a desirable level. Since the problem usually originates during note taking, it is essential to minimize the material recorded verbatim (Lester 46-47).

_An acceptable summary:_

Students should take just a few notes in direct quotation from sources to help minimize the amount of quoted material in a research paper (Lester 46-47).

_A plagiarized version:_

Students often use too many direct quotations when they take notes, resulting in too many of them in the final research paper. In fact, probably only about 10% of the final copy should consist of directly quoted material. So it is important to limit the amount of source material copied while taking notes.