Scientific and Technical Writing:

A Guide for University of Mount Union Environmental Science and Biology Students

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M:/BI/mcclauca/handout/ScientificWriting.doc

Scientific and Technical Writing: A Guide for University of Mount Union Science Students

A research project is not complete until the findings of the study are communicated to other professionals. This usually takes the form of a paper published in a professional journal. Indeed, in the biological sciences, as well as in many other fields, one of the most commonly used measures of a person's professional achievement is the number and quality of journal articles that one has authored. After all, what value is there in discovering new information unless it is made available for others to use?

One of the requirements of the laboratory portions of many science courses at the University of Mount Union is to write a scientific report of the results that you obtain in laboratory and field experiments or in individual research projects. The editors of nearly every biological journal require that authors follow a rather standard format when preparing their papers for publication. In addition, there are numerous style conventions in the biological sciences that are generally accepted and which help readers follow the paper. The most thorough and appropriate style reference for the biological and environmental sciences is *Scientific style and format :The CSE manual for authors, editors, and publishers. 8th ed.* (Council of Science Editors, 2014). This reference is available on campus at www.scientificstyleandformat.org and at the DWOC Studio in the KHIC. See the references at the end of this guide for a complete citation.

You are strongly encouraged to examine a recent issue of a biological journal to see how a published scientific paper is organized and to get a taste of the style of current scientific writing. There are many recent issues of scientific journals in the current periodicals collection at the KHIC – Library. Many scientific journals conform to CSE (2012) guidelines. You should NOT consider the journals *Science, Nature* or any newsletters to be typical of the style and format described here.

Overall organization.

A scientific research paper almost always has a very specific organization. Your papers (unless otherwise directed by your instructor) should use the following format and section headings:

- Title page
- Abstract *
- Introduction
- Materials and Methods
- Results
- Discussion
- Acknowledgments*
- References

*the abstract and acknowledgments may be omitted in certain types of papers.

Title Page

The first page of the paper is called the title page. The information given on the title page is not part of the body of the paper, but appears at the top of the first page of the published paper, preceding the formal introductory section. The title page contains the name of the paper, the name(s) of the

author(s), their address(es), as well as any other information pertinent to the paper as specified by the editor. On the title page of papers written in this department you should give:

- the name of the paper
- your name
- the name of the course for which you are writing the paper
- the date when you finished writing the paper.

The title should be descriptive, informative and brief. It may be a statement or a question. If a statement, it should start with the most important words or terms with the following words appearing in descending order of importance.

Abstract

The abstract is a brief summary of the main points of the paper including methods, findings and conclusions. Journals differ in the allowable length; for our department, abstracts may not exceed one typed, double-spaced page (250 words) in length. The abstract does not include details, bibliographic citations, tables, figures, or abbreviations (except those widely recognized such as pH or DNA).

Introduction

The introduction sets the stage for the paper. It briefly describes the state of knowledge that gave rise to the question or hypothesis that was the focus of the research. The introduction provides the rationale for your experiment and it provides the reader with a roadmap of what will be presented in the paper. A good introduction will provide answers to the following types of questions:

- What was the status of the field before you obtained your new information?
- What important information was lacking that prompted you to conduct the experiments?
- What scientific purpose has been served by your doing the experiment?
- What model or hypothesis was tested?
- What was the approach to the study?

Although your research reports as an undergraduate may not represent significant advances in science, they should represent significant advances in your understanding of a scientific issue. Your introduction should reflect that.

Materials and Methods

This section describes the materials and procedures used in your study. If the work was done in the field, a site description will be included in this section. The procedures should be sufficient to allow another scientist to repeat the experiment you conducted. On the other hand, you do not need to describe common procedures such as measuring pH or temperature, unless some novel or unique approach was used. If you used a technique that was previously described in the literature, you

should give credit to the originator of the technique by providing an appropriate citation to their work (the appropriate way to cite references will be described below). The methods should be described in a narrative style as opposed to a cookbook style or a list.

The questions to be answered in this section are:

- How did you perform your experiment?
- What reagents, chemicals, unique equipment, subjects, organisms, field location, etc. did you use?

Common Errors:

1 Writing in imperative mood. Imperative mood is the use of commands.
Example: Measure the length of the tibia.

2 Using laundry lists.

Note: Some instructors and a few editors expect scientific writing to be in third person. The trend however is for increased use of first person (Alley 1996)

Results

The results section describes, in detail, the findings of your study. It does not contain a discussion of the implications or significance of your results. This type of material is reserved for the Discussion section. The Results section also does not contain extensive reporting of raw data. Rather, it does contain summaries of raw data that make clear the final results of the experiments.

The presentation of results if enhanced through the use of graphs and pictures (called figures) and tables. These allow the reader to more quickly see the nature of your data and to highlight the main results. However, it is not just a collection of data: it must contain descriptive text as well. In other words, you could think of tables and figures as illustrations of what you say in your text.

Tables and figures are presented in scientific journal articles in a standardized format. Tables are numbered consecutively in order of their appearance in the paper and they are referred to in the body of the text by number. For example, an author might state: "As shown in Table 1, the number of students in each lab section is quite consistent."

Each table must have a number, a fully descriptive title, and each column must have a heading. Three full width horizontal lines separate the major sections of a table: The first is between the table number and title and the column headings, the second is between the headings and the field (where the data goes) and the third below the field and above any footnotes. The example on page 8 illustrates a properly formatted table and a corresponding table used to illustrate the terms associated with tables. These examples are taken from the CBE style manual (1994), page 680.

Tables are commonly used in scientific writing because of the need to present large amounts of numeric and descriptive data. Below are some guidelines for the types of data to present in tables and for the design of tables, taken from the CBE style manual (1994).

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Types of information appropriate for presentation in tables:

1 Data for which precise numeric values are important (as opposed to conveying trends or proportions, for which a figure is often more effective).

2 A large number of numeric values in compact form.

3 A summary of information.

4 Information too complex to be easily or concisely explained in text or shown in a figure.

Style guidelines for creating tables in scientific texts:

1 A table should be complete enough to be understood without continual reference to the text, but it should contain only the data needed for the reader's understanding.

2 A table should be a simple as possible. When a simple structure is not possible with the information to be presented, the goal should be to provide a table that, although complex, is orderly and logically organized.

3 There should be some logical basis for the sequence of columns and rows.

4 The units, symbols, and data of the table must be consistent with those in the text.

5 Different tables containing similar types of information should have parallel formats.

6 The same data should not be presented in both tables and figures.

7 Data should not be put in a table if they can be adequately presented in a few sentences of text. No table may be needed if there are only 1 or 2 columns and only 2 or 3 rows of data.

8 When the design of a table is not satisfactory, redesigning the entire table is often easier than struggling to edit the existing table into a better form.

SAMPLE TABLE

Table 31-1. Typical fatty acid composition of selected dietary fats and oils (wt %).

	Saturated			Unsaturated		
Fat, oil	Palmitic	Stearic	Other	Oleic	Linoleic	Other[c]
Animal fat						
Lard	29.8	12.7	1.0	47.8	3.1	5.6
Chicken	25.6	7.0	0.3	39.4	21.8	5.9
Butter	25.2	9.2	25.6	29.5	3.6	7.2
Beef	29.2	21.0	3.4	41.1	1.8	3.5
Vegetable oil						
Corn	8.1	2.5	0.1	30.1	56.3	2.9
Peanut	6.3	4.9	5.9	61.1	21.8	---
Soybean	9.8	2.4	1.2	28.9	50.7	7.0
Coconut	10.5	2.3	78.4	7.5	trace	1.3

Figures are also numbered consecutively as they appear in the body of the text and are referred to by their number. Each figure has a legend (sometimes called a caption). The legend is a brief description of the figure and enables a figure to "stand alone"; that is, it enables the reader to understand the figure without having to read the text of the paper.

Photographs, diagrams and illustrations are labeled to point out the key features: the labeling is explained in the figure legend.

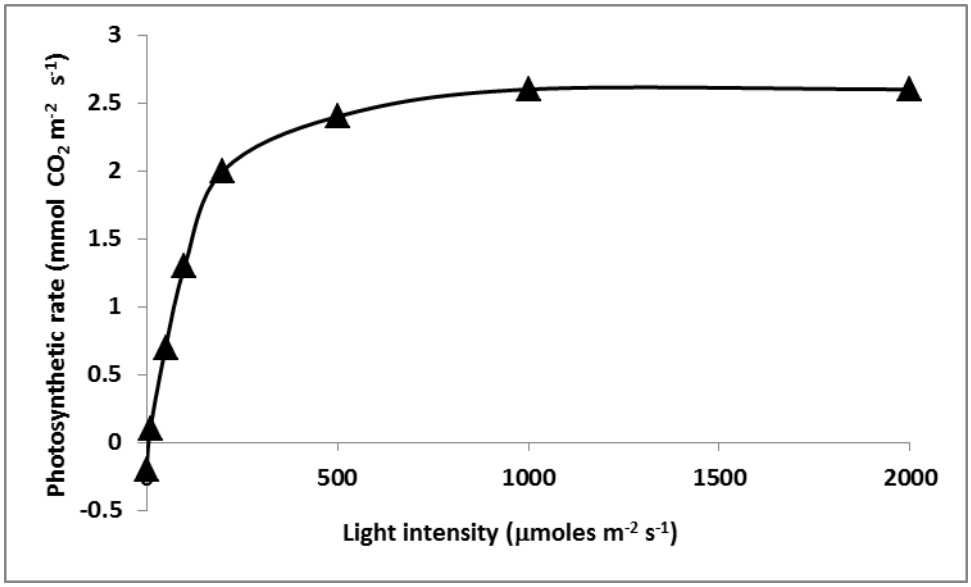

Figure 1. Influence of light intensity on photosynthetic rate of the herb *Mitchella repens*. Measurements were taken in the field.

Graphs are used to illustrate the relationship between two parameters or variables that have been measured in the experiment. The example above (Figure 1) illustrates the relationship between the amount of carbon assimilated by photosynthesis and the intensity of light. One variable is the independent variable which is graphed on the x-axis (horizontal). The other is the dependent variable and it is graphed on the y-axis (vertical). In the example above, the photosynthetic rate is the dependent variable because it depends on the light intensity (the independent variable).

There are many types of graphs in addition to X-Y graphs, including bar, pie, area, and others. In all cases it is imperative that the axes be clearly labeled with both the name of the variables and the units. You should use a computer to draw your graphs. Graphs should be drawn as accurately as possible, allowing the reader to determine the values of your data with reasonable precision.

The questions to be answered in the Results section are quite simply:

What were the results of the study?

What were the values (quantitative or qualitative) of the measurements?

Common Errors:

1 Not labeling axes.

2 Not including units.

3 Not providing legends.

4 Providing raw data rather than appropriate summaries.

5 Inserting tables or figures without a narrative description.

6 Not referencing tables and figures in the text in order.

Discussion

The Discussion section appears after the results. In the Discussion, the author provides an interpretation of the results presented in the paper, their significance and their implications. The discussed results are compared with information previously published and with the information described in the Introduction. The publications used for this purpose are cited so that the reader can locate them as well as to give credit (or discredit) to the authors.

As an undergraduate student you are not expected to have a thorough knowledge of the literature pertaining to your work. As you progress thorough your major, you will be expected to become more knowledgeable and to be better able to search and extract appropriate information from the scientific literature. However, in the introductory biology class, you should emphasize the meaning of the results that you obtained. If the results deviated from the expected, you should attempt to explain why by giving possible sources of error. Often an experiment turns out to be only a partial success the first time that it is conducted. Experience with methods and materials is often required to obtain the best results.

In the discussion section, you should answer questions such as:

- How do my findings relate to what is already known about this topic?
- Do my findings have any implications for advancing knowledge in the particular area? (The "So, what?" question).
- How do my findings compare to what I expected?

References

This section is sometimes called *References Cited* or *Literature Cited.* It is a listing of all the references that you cited in your paper. They are a critical part of the paper and are useful to the reader who wishes to pursue the topic further. Journals vary in the specific formats they require for citations, but all forms of citation provide enough information so that the reader can find the original work for themselves. The CSE style manual (Council of Science Editors 2012) is a generally accepted authority for style in scientific writing and you may wish to refer to that reference for difficult citations.

There are basically two systems of citation under CSE: the name-year system and the citation-sequence system. We generally prefer the name-year system because it allows for the easiest editing, because it allows the reader who is familiar with the literature to immediately recognize some or most of the references that you cite, and because it is the most commonly used format in the scientific literature.

The name-year system lists all citations using the surname of the author and the date of the publication. In this system, the *References* section consists of an alphabetical listing of all citations. The citation-sequence system indicates a citation by using a numeric notation in the text; subsequent references to the same source use the same numeric identifier. The *References* section then includes the list of reference in numeric order (the order in which they were first cited. This section should include only those items that are cited in the text.

Examples of Name-year system citations

"Simple analyses based only on relationships among carbon assimilation in biomass, temperature, and carbon dioxide concentrations yield predictions that are markedly different, often even in sign, from those that account for the coupled response of carbon and nutrient cycles (Schimel et al. 1990, 1994, Townsend and Rastetter 1996)".

General format of a journal references in the name-year system:

Schimel DS, Parton WJ, Kittle TGF, Ojima DS, Cole CV. 1990. Grassland biogeochemistry: links to atmospheric processes. Climatic Change 17:13-15.

Examples of Citation-sequence system

"Simple analyses based only on relationships among carbon assimilation in biomass, temperature, and

carbon dioxide concentrations yield predictions that are markedly different, often even in sign, from those that account for the coupled response of carbon and nutrient cycles [2,4,5]." [indicating the 2nd, 4th and 5th references cited]

General format of a journal reference in the citation-sequence system:

2. Schimel DS, Parton WJ, Kittle TGF, Ojima DS, Cole CV. Grassland biogeochemistry: links to atmospheric processes. Climatic Change 1990; 17:13-15

Note that both contain the same information, only the location of the date changes.

Following are further examples of correct reference formats:

Scientific journal
Steiner U, Klein J, Eiser E, Budkowski A, Fetters LJ. 1992. Complete wetting from polymer mixtures. Science 258:1122-9.

Book (with editors)
Gilman AG, Rall TW, Nies AS, Taylor P, editors. 1990. The pharmacological basis of therapeutics. 8th ed. New York: Pergamon. 1811 p.

Book chapter
Hebel R, Stromberg MW. 1976. Anatomy of the laboratory rat. Baltimore: Williams & Wilkins. Part C, Digestive system; p 43-54.

Web page
Abilock, D. 1996. Research on a Complex Topic. Neuva Library Help. <http://www.nueva.pvt.k12.ca.us/~debbie/library/research/advice.html> (3 September 1996).

The general format for a web citations is:
Author. Year. Title of Web Page. Complete work (if part of a group of documents). <Full net address (URL)> (date you saw it).

If the citation has DOI (digital object identifier) that should be included.

Interviews and personal communications are NOT cited in the Literature cited section, but attribution should be given parenthetically in the text.

Acknowledgments

This is not a required section of your paper, but you may find it appropriate to acknowledge people who assisted with your project. For example other students who may have collected data but were not involved enough to qualify for authorship, sources of financial or material support, and persons who reviewed your manuscript. State the name and the assistance they provided. For example: "I thank Debbie Smith for assistance with animal care."

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Other important considerations

Text preparation

Unless otherwise specified, your entire paper should be printed, double-spaced using 10 to 12 point type and a non-decorative font (Times New Roman is good). Margins (sides, top and bottom) should not exceed one inch. Tables and figures can be inserted into the text or added in numerical sequence at the end of the typescript. Computer produced tables and figures are preferred.

Academic integrity

Plagiarism, fabrication of data, or use of data collected by someone else without their permission or giving them credit will, as a minimum, result in a zero on the assignment. Refer to the section in the University catalog on Academic Honesty.

Literature cited

Alley M. 1996. The Craft of Scientific Writing, 3rd edition. New York, Springer.

Council of Biology Editors. 1994. Scientific style and format: the CBE manual for authors, editors, and publishers. 6th edition New York: Cambridge University Press

Council of Science Editors. 2012. Scientific style and format: The CSE manual for authors, editors, and publishers. 8th ed. Reston, VA: Council of Science Editors in cooperation with the Rockefeller University Press.

CSE Style Guide [Internet]. 2016. Scientific Style and Format Online. 8th ed. [Viewed October 31, 2016] Available from: http://www.scientificstyleandformat.org/