Writing in the Sciences

A. *Why is effective written communication essential in the sciences and health sciences?*

I. Writing is the primary tool for the dissemination of scientific knowledge, including the results and implications of all new research. It is primarily through writing that scientists are able to convince others—inside and outside the scientific community—of the value of their discoveries.

II. Moore points out that historically, effective writing has made the difference between valuable discoveries that were ignored (e.g. Avery, et al.) and valuable discoveries that were accepted, funded, and applied (e.g. Watson and Crick). Science writing is not merely the reporting of raw data; it involves the careful—and ethical--selection of detail toward a persuasive goal.

III. For science students, effective writing is a key component of academic success, as students are expected to express their ideas clearly and in a style suitable to scientific discussions. Students must also learn the basics of critical thinking and argument in order to present concepts effectively in (1) lab reports, (2) primary research articles, (3) critiques of published research articles, and (4) research papers based on bibliographic sources.

B. *What are the characteristics of writing in the sciences?*

I. Writing in the sciences is valued primarily as a means of communication. Language is not intentionally used in an elaborate, subjective, or ambiguous way, as it might be in literature.

II. In science writing, precision and economy of language are valued most highly. This exactitude is meant to mirror the objectivity of the scientific process of research. Anyone writing in the sciences is constantly faced with the challenge of expressing concepts in the most precise way possible, using appropriate terminology, yet *simultaneously* using the fewest words and the clearest possible structure for sentences and paragraphs. The goal is to write prose that is as simple, clear, and readable as possible.

III. Writers should strive to (1) use the active and passive voices appropriately; (2) place "old" information at the beginnings of sentences (see Gopen & Swan for a detailed discussion of this key principle); (3) write clear topic sentences for paragraphs; (4) use "signal" words as needed, and (5) use the appropriate verb tenses. (For further information on verb usage in science writing, see www.hswriting.ca).

IV. Science writing does involve some art, particularly in the coining of new terms and the use of imagery; however, this always serves the purpose of increasing a reader's understanding. One example would be the discussions of the genetic "code" which has become an "alphabet." Students themselves often create new analogies in their writings.

C. *What is critical thinking, and how is it used in writing in the sciences?*

I. In good science writing, the data is not expected to speak for itself. In order for data to be made understandable as results or findings, the writer must enter into a process of critical thinking. As one author has stated: "....*critical* is used to indicate that all evidence, supporting or contrary, must be assessed for validity and then accepted or rejected as part of the argument" (Bell 137). Bell further identifies the steps of constructing a critical argument:

- describing the question or finding
- presenting evidence, both supportive and contrary
- assessing the evidence, accepting it, or discarding it
- examining and weighing the implications
- reaching a verdict (137)

II. The goal of most writing assignments is not only to research, organize, and report facts clearly, but also to show that one is capable of assessing the facts and creating a logical, persuasive discussion that supports a particular conclusion or set of conclusions.

III. In a lab report, all data will be carefully noted, but in research reports or articles data are first selected on the basis of their relevance to the research question. This does not mean, however, that scientists eliminate data that do not support a hypothesis.

IV. You will also be expected to identify important findings that do *not* seem to support your hypothesis and to explain their implications: i.e., do they indicate a need for further research in a certain area? Or can they be explained as the result of a factor relating to methodology? Is the evidence conclusive, or does it suggest a *possible* interpretation?

IV. Thus, effective critical thinking leads to the presentation of a convincing critical argument, yet that argument is not necessarily "black and white"—it may be quite complex.

D. *What is IMRAD?*

I. IMRAD is an acronym that stands for the basic structure of a lab report or published primary research article: *Introduction/ Methods/ Results/ Discussion*. Both lab reports and published studies follow this pattern, though an article meant for outside readership has been through an extended process of selection and critical thinking, usually resulting in a more developed discussion section. In both these forms, precision of language is a key goal. Here are some characteristics of the various sections:

Introduction. A research problem is defined, and the writer briefly explores previous research that attempted to answer the question. Literature is reviewed. The writer then outlines and justifies his or her present approach to the research question. Both past and present tense verbs may be needed in this section.

Methods. The type of study is identified, and the choice of subjects and procedures/ interventions is justified. Enough detail should be present to allow a repetition of the experiment and also an assessment of its validity. Past tense is used here, as well as passive voice. (*Note: In a critique assignment, students are often expected to evaluate the validity of subject choice or methodology as well as the ethical standards expressed by the authors).

Results. Both major and minor relevant findings are presented in this section, often solely with the use of tables, figures, and statistics. The data must be clearly summarized for the reader in order to show its significance to the research question. This section is of key importance, yet it is often the shortest. Past tense verbs are used here, as well as active voice wherever possible. (*Note: In some assignments, students are given experimental results in a table or figure and asked to analyze their significance in an original discussion section).

Discussion. (1) This section is where the critical argument is fully developed. Findings are referred to, though not repeated in detail (it is often a challenge for students to keep all the sections of IMRAD from overlapping).

(2) In a discussion section, each major finding or group of findings must be evaluated critically by the writer, who will show:

- which of them support the hypothesis and why;
- which do not support the hypothesis and why;
- what conclusions may be drawn from the patterns in the results, and
- the degree to which these findings may be generalized to subjects.

(3) The goal of the discussion section is persuasion, to convince the reader that the interpretations put forth are accurately drawn from the evidence. However, it is important to avoid claiming too much and overstepping the logic of one's argument. Directions for further research may also be identified. Present tense verbs are used to identify general principles that have been established by research. Active voice is used wherever possible.

(4) Goldbort has created a helpful set of questions that students writing lab reports can use to develop the critical argument of a *Discussion* section:

- To what extent were the hypotheses supported or rejected?
- Were there any unexpected or surprising results?
- Were there anomalies in the results that suggest further experiments or new approaches?
- Do such unexpected results suggest important implications or applications regarding the phenomena studied?
- Did the equipment or procedures present measurement limitations?
- Could any such limitations be addressed with access to or acquisition of other equipment, or by certain procedural changes? (78)

This workshop is based on my own experience as well as the following sources:

Bell, Louise. *Effective Writing: A Guide for Health Professionals.* Toronto: Copp Clark, 1995.
Gilpin, Andrea & Patricia Patchet-Golubev. *A Guide to Writing in the Sciences.* Toronto: University of Toronto Press, 2000.
Goldbort, Robert. *Writing for Science.* New Haven & London: Yale University Press, 2006.
Gopen, George D. & Judith A. Swan. "The Science of Scientific Writing." *American Scientist* 78 (1990): 550-558.
Moore, Randy. "Writing About Biology: How Rhetorical Choices Can Influence the Impact of a Scientific Paper." *Bioscene* 26.1 (2000): 23-25.

For further information, visit the *Comprehensive Guide to Writing in the Health Sciences*, by Dena Taylor, at www.hswriting.ca