Fulbright Scholar Program
Lectureship: Scientific Research Methodology (Award #9291)
Scuola Superiore "Santa Chiara" dell'Università di Siena

Instructor: Lesly A. Temesvari, Ph.D.

RESOURCE TEXTS:
National Academy of Sciences. Committee on Science, Engineering and Public Policy (1995) *On being a Scientist: Responsible Conduct in Research*. 2nd Edition. National Academy Press, Washington, DC.

Glass D.J. (2007) *Experimental Design for Biologists*. Cold Spring Harbor Laboratory Press. 1st Edition. Cold Spring Harbor, NY.

Penrose A.M. and Katz S.B. (2004) *Writing in the Sciences: Exploring Conventions of Scientific Discourse*. 2nd or 3rd Edition. Longman, New York, NY.

Pechenik, J.A. (2007) *A Short Guide to Writing about Biology*. 6th Edition. Longman, New York, NY.

GENERAL COURSE DESCRIPTION AND PHILOSOPHY:
This course will focus on scientific research methodology, the social nature of scientific research, and the central role of communication in research. The topics will include the history of the scientific method, experimental design, collection and analyses of data, major communication genres, publication practices and openness, allocation of credit, authorship, social foundations of science, roles of science and scientists in society, values in science,conflicts of interest, errors and negligence in science, misconduct in science, and the impact monlingualism in science communication. Additional details about these topics are provided below in class descriptions.
While the course will consist of some lectures, the format will have a strong reliance on group discussion of case studies (see below). The approaches taken by the instructor will mirror those used for other graduate courses with which she is already involved. In particular, the philosophy of the course will be to focus discussion on student work and assigned exercises, creating a student-centered rather than teacher-led workshop. This type of "student-active teaching" or "student-based teaching" has been shown to significantly enhance student critical thinking skills and retention of knowledge. Furthermore, to enhance student engagement, participants will be encouraged to analyze communications and produce work relevant to their research interests.

SPECIFIC COURSE FORMAT:
In addition to some lectures, certain course topics will be covered through case studies. These cases will approach the topics **historically** and **realistically** (by using real historical cases or by providing situations encountered by the instructor), and **philosophically** (by using difficult cases for which solutions are complex). The instructor has collected a number of relevant cases with themes in molecular biology, cell biology, biochemistry, genetics, epidemiology, and the social sciences. Cases will be carefully chosen based on class roll and the research interests of the students. In order for students to be exposed to various perspectives, the instructor hopes to recruit colleagues at the host institution, who are at different career levels (post-doctoral fellows, junior faculty, and senior faculty), to participate on certain days during which relevant cases are discussed. Students will be required to complete three major assignments: (i) write a manuscript; (ii) design a research project; and (iii) develop a conference presentation (oral or poster). In addition, students will be required to complete a series of smaller homework assignments such as peerediting of classmate's work, comparing and contrasting indexing services (e.g. Medline, Biological Abstracts, Bibliography of Social Sciences, etc.), developing an

outline for a literature review, surveying colleagues regarding research practices, and developing responses to case studies. Grade allocation is described below.

CLASS SCHEDULE AND DESCRIPTIONS:

Class 1: The History of the Scientific Method.
Students will gain insight into the history and philosophical framework of the scientific research method. Students will examine a sampling of the writings of such historical figures as Galileo, Aristotle, Karl Popper, David Hume, Bertrand Russell, Francis Bacon, and René Descartes, all of whom have contributed extensively to the development of the modern scientific method.
Although an extensive review of these writings will be beyond the scope of this course, students will become aware, for example, that it was Bacon and Descartes who argued that knowledge can be gained from a series of inductive (Bacon) and deductive (Descartes) approaches. Students will also learn to define an experimental program. Students will also explore the history of communication practices in research. English language works dominate communications in the natural sciences and, to a lesser extent, in the social sciences. Interestingly, little research has been carried out to assess the impact of monolingualism in communication on academic investigation. A survey and class discussion on this topic will focus on the following questions: Should English be the *lingua franca* for scholarly works? To what extent is this embraced or contested by non-native English speakers? Does monolingualism in communication of findings enhance or inhibit efficiency in academic research? What is lost or gained when courses are taught or taken in a non-native language? What assistance should be provided to non-native English speaking students? This topic will be revisited throughout the semester where relevant.

Class 2: Hypothesis Testing versus Other Approaches in Research.
Students will compare and contrast the dominant research approach, hypothesis testing (critical rationalism), with other methods such as question/answer (inductive reasoning), survey, correlation, and case study approaches. Students will also learn instances where hypothesis testing may not be practical (e.g., sequencing an entire genome). Students will analyze examples of research projects that use one approach or another. The cases will be relevant to the research interests of the students and will lead the participants in discovering the advantages and disadvantages of the various approaches. By recognizing the advantages and disadvantages of these methods it is hoped that the students will be able to apply proper approaches in their own work.

Classes 3 and 4: Experimental Design.
After the first two modules, students will be prepared to engage in experimental design. Students will work together to design experiments to address questions posed by the instructor and/or by the class. The participants will be guided to consider appropriate methodology and ways to validate such methodology. Students will gain insight into the notions that many experimental techniques (i.e. statistical tests of significance, double-blind trials, proper phrasing of questions in surveys) must be designed to minimize bias and that researchers must generate results that are reproducible. Students will also be guided in their choice of controls including, positive, negative, method, reagent, subject, assumption, and experimentalist controls. Finally, students will learn about the necessity for randomization of subjects, the use of representative conditions, and the use of time courses versus repetitions.

Class 5: Gathering, Analyzing, and Reporting Research Data.
In this module students will determine the best way to treat and present various research data. Students will examine sample data sets with outlying data and discuss the treatment of the outliers. Students will also compare and contrast verbal, graphical and tabular representation of data. Since graphical or tabular representations of data may differentially influence readers, this topic naturally ushers in the communication aspects of the course.

Class 6: Communication in Science (Journal Articles): Materials/Methods and Results.
In this module students will begin to examine a major communication genre in research, namely the journal article. Students will examine Results and Materials/Methods sections of articles in their field. Students will determine the level of detail required when describing Methods and importance of Results sections. In particular, students will gain an appreciation for the fact that the Results section plays an important role in developing an argument and that Results remain unchanged even if future interpretations change. Students will also make note of tense and voice used in reporting Methods and Results. Students will be invited to begin working on a sample manuscript for their field of interest (Major Project 1). Senior students will be encouraged to use their own data. Sample data may be provided for more junior class participants.

Class 7: Communication in Science (Journal Articles): Introductions and Discussions.
Students will examine Introduction and Discussion sections of articles in their field. Students will gain insight into the anti-parallel structure of these sections. Students will learn how to make claims within the established parameters of knowledge in the field, while, at the same time, acknowledging that their claims are interpretations of their data. Students will continue their work on their sample manuscripts.

Class 8: Communication in Science (Journal Articles): Completing the Manuscript.
Students will learn to put the "finishing touches" on a manuscript by examining sample abstracts, titles, and citation and acknowledgement sections of articles in their fields. Participants will gain insight into different types of abstracts (informative versus descriptive) and the 4 common moves of an abstract. Students will gain experience in crafting titles and in using appropriate citations (i.e. avoiding plagiarism). Through case studies, this module will also address authorship practices (i.e. what constitutes authorship, authorship order, etc.). Much can be learned about effective communication through revision of scientific works. Therefore, this module will address the importance of revising for content, clarity, interest, teleology, anthropomorphism, grammar, and word usage. Students will work on revising works provided by the instructor. Furthermore, students will conduct peer-revision and peer-review of their classmate's manuscripts. Finally, this unit will examine the submission and peer-review processes and conclude with a discussion on what constitutes conflict of interest in peer-review.

Class 9: Communication in Science (Proposals).
Another important genre in communication is the proposal. This type of communication is used to secure funding from funding agencies and to present proposed dissertation work to examining committees. It has been the experience of the instructor that once students understand experimental design and the form and function of manuscripts, they readily grasp proposal preparation. Students will compare the sections of the manuscript with sample proposal sections. Students will draw on their knowledge of experimental design (Classes 1-4) and manuscript writing (Classes 5-8) and note the similarities and differences in structure, voice, and tense. Students will be invited to expand on their experimental design projects (Classes 3-4) to develop a major research project in their field of interest (Major Project 2). A short (5-7 page) write-up of this project will be required.

Class 10: Communication in Science (Conference Proceedings).
An important form of scientific communication is the conference proceeding (oral and poster). Students will be guided in discussions on how to adapt a manuscript to oral or poster presentations. Students will examine and critique sample PowerPoint presentations and posters. Students will work in groups to adapt their manuscripts to one or both of these conference genres (Major Project 3).

Class 11: Communication in Science (Literature Reviews).
Students will examine the literature review genre which is important for both dissertations, as well as for summarizing bodies of research. Students will gain insight into the importance of comprehensiveness and timeliness in this genre. Students will learn strategies of identifying

trends and patterns in research and of avoiding author bias in such reports. Class participants will also learn that introductions in manuscripts and proposals are, in fact, “mini-reviews”.

Classes 12: Values in Science, Science in Society.
The course will conclude with an important discussion on values in research, the role of science and scientists in society, and the impact of monolingualism in research communication. A unit on the values in science will include discussion of errors and negligence in science, misconduct in science, and how to handle cases of misconduct. On some occasions errors occur through honest mistakes due to faulty laboratory note-taking**.** Therefore, students will discuss strategies to avoid this potential situation. Students will also gain a clear understanding of misconduct by discussing the differences between plagiarism, falsification of data, and fabrication of data. While most of the course concentrates on the responsibilities of scientists for the advancement of knowledge, students will gain insight into the notion that researchers have additional responsibilities to society. For example, even researchers conducting the most fundamental research need to be aware that their work can have great impact on society. Students will discuss ways in which scientists should communicate with the general public.