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Science & Communication

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The Goal. This seminar is intended to help Joint Program students develop a broader perspective on their thesis research by considering some aspects of science in the large. Topics to include -- What are the goals and what are the limits of natural science? Is there a method of scientific research? What constitutes an explanation? and, What ethics are scientists expected to follow in dealings with their colleagues and the public? These questions do not allow a single, concise answer, in part because there are many varieties of science. Our aim will be to develop a thoughtful view towards these questions that we can use as part of our research process, and that will help us articulate research findings. This overview of science and research will require a little more than the first half of the semester.

The second half of the semester will emphasize a theme - science as a social process - and the important roles of written and oral communication. Most good research reports are organized as stories in three parts: a beginning, which poses a problem and sets the context for its solution; a middle, which describes the methods used to arrive at the solution; and the end, where we learn what the author thinks the solution may mean for his or her field. By far the greatest fraction of our graduate education is directed at the middle part of this process, problem solving, the prerequisite for making a research report. To contribute to science, research results must be conveyed into the public record in an effective way, i.e., we aren't done until we teach our colleagues what we have learned. The specific goal of this seminar is to help participants learn to communicate more effectively by developing the beginning and the end of their research story. To practice this, seminar participants will have the opportunity to give a short oral report that emphasizes the goals, the logical structure and the interpretation of their research.

To summarize, this seminar
- -- is not likely to change the ways in which you carry out your thesis research,
- -- may change how you think about the goals and the interpretation of your research,
- -- should help you learn to communicate research results more effectively.

Prerequisites. This seminar is open to all Joint Program students. It is desirable (not mandatory) that participants have defined a thesis problem that they can develop as a model of research and science. Class size will be limited to about ten, and preference will be given to post-generals students.

Schedule. To be offered in Spring 2004. Class to meet once per week, tentatively on Thursdays, 1300 - 1430 in Clark 201 at WHOI (this can be changed to suit the majority of participants). There will be no P-tel link to MIT. The first class meeting will be for organization only, and will be on 5 February.

Resources. There will be a weekly reading assignment of up to about 80 pages and requiring about four hours. The reading assignments will come from several sources, including the following that are recommended for purchase:

HP97, *Science and Its Ways of Knowing* by Hatton and Plouffe, 1997,
M79, *Advice to A Young Scientist* by Medawar, 1979,
NAS95, *On Being A Scientist*, by the National Academy of Sciences, 1995 (this is available free from the Ed. Ofc.), and,
C99, *What Is This Thing Called Science?,* by Chalmers, 1999.

In most cases the readings are one or a few chapters extracted from a long monograph. Even well written chapters taken out of their context will lose some clarity and some of their meaning, and, for example, it would be much better to read Medawar's *Advice to a Young Scientist* straight through rather than in bits and pieces as is indicated in this syllabus. Because the reading selections come from a wide range of sources you will often notice a significant and sometimes jarring difference in style and perspective from one piece to the next. This can make the articles a good deal harder to assimilate on first reading than they would be if we could take the time to read the full volume from which they are taken.

Preparation for Class Meetings. The first ten meetings will be conducted as discussions of the questions that are listed below. The reading assignments provide one plausible view to consider, and are an essential common basis for this discussion. These discussions will be stimulating and valuable only to the extent that we all come to class prepared to offer a critique of the reading assignment, to offer our own views, and to ask new questions. The aim is not necessarily to come to a closed solution, but to develop a working understanding of the issues as they relate to our research.

Part I. What Is Science, and How Does It Work?

1) The goals and institutions of natural science. Three meetings.

a) The goals and scope of natural science.
i) How does natural science differ from fine arts, mathematics or engineering and technology?
ii) Varieties of science.
iii) What is the character (as in ii) and what are the goals of your thesis research?
Readings: Bronowski, 1995; Popper, HP97, pp 81-86; Bauer, HP97, pp 25-37; M79, Preface and Ch 1-4;

b) Scientific knowledge.
i) Discovery and justification.
ii) Science as a social process.
iii) Can natural science sustain a claim for the production of especially reliable knowledge?
Readings: Root-Bernstein, HP97, pp 108-118. Ziman, from Klemke et el. 1998, pp 48-53; NAS95, pp 1-5; C99, Ch 1.

c) Scientific progress and change.
i) Is the history of science best characterized as a steady progression or an occasional revolution?
ii) What forces compel change in a scientific discipline? Is there a change taking place in your field today?
iii) Can you characterize the paradigm of your field? Of your thesis research?
Readings: Kuhn, 1996, Ch 9; C99, Ch 8.

2) The process of scientific research. Three meetings.

a) Scientific Method or Myth?
i) Albert Einstein has been quoted as saying that scientific thinking is no more than good common sense. Is that true of you and your thesis research, or is something more required?
ii) What are the limitations characteristic of inductive and deductive method?
iii) What logical scheme characterizes your thesis research?
Readings: (a) Generic Proposal Problems, NSF; C99 Ch 4, 5; Pirsig, HP97 pp 7-11; Kneller, HP97, pp 11-25.

b) Theory and Observation.
i) What are the roles of theory and observation in science?
ii) Are decisive experiments possible?
iii) Can experiment proceed and succeed in the absence of a comprehensive theory?
Readings: M79, Ch 9; Collins and Pinch, HP97, pp 37-45; Scudder, HP97, 143-146; C99 Ch 2, 3, 13.

c) Explanation.
i) What constitutes a useful scientific explanation?
ii) When does (or must) explanation stop? What would you mean if you were to say that you understood a phenomenon?
Readings: Miller, 1985, Ch 12; Salmon, 1992, pp 7-41.

3) Ethics of scientific research. Two meetings.

a) Free and Open Communication?
i) What are the obligations of a scientist? To whom or to what do you owe your highest loyalty?
ii) What constitutes intellectual property? When is it appropriate to withhold data and other information?
Readings: NAS95, pp 5-12; M79, Ch 6; Sayre, HP97, pp 124-131.

b) The Reward System in Science.
i) What are society's motives for sponsoring scientific research? Are these consistent with your personal motives for being a scientist? How do you expect to be rewarded for your efforts as a scientist?
ii) On what basis do we choose or agree to become a coauthor?
iii) Are science ethics undergoing a change?
Readings: NAS95, pp 12-28; Bishop, 1984, Ch 6; Woodward and Goodstein, 1996.

Part II. Communication.

4) Scientific publication. One meeting.

a) What is the role of written communication? What constitutes 'scientific publication'
b) How much should we publish and when is a research project at the right stage for publication?
c) How is a paper judged by referees and editors? What constitutes a conflict of interest and what should you do if you have one?
d) What makes a good scientific paper? What are your favorite scientific papers, and most of all, why?
Readings: M79, Ch 8; Dodd, 1986, Ch 1; Medawar, 1990, pp 228-233.

5) Oral communication. One meeting.

a) What is the role of seminars? In what ways might the content of a seminar be different from that of a scientific paper?
b) How do you plan and prepare for a seminar?
c) What qualities make for a good seminar?
Readings: M79, Ch 8; Anholt, 1994, Ch 1-2.

6) The practice of scientific communication. Four meetings, times and dates to be arranged.

In the remainder of the semester the participants will have a chance to give a short oral report of their thesis research (or of a paper they find interesting) to a critical but sympathetic audience, their classmates. Each class member will give the presenter a written evaluation.

Our goal in these short seminars is to emphasize the beginning and the end parts of the research story, while largely omitting the technical details of the middle (which are, of course, crucially important but you deal with that at length elsewhere). This seminar will have been successful if the participants find that they are even slightly more comfortable writing and talking about the goals, the logical structure and the interpretation of their research. Are the goals, as you write them down now, any different than at the time of the first class, Question 1(a)?

References.

Anholt, R. R. H., 1994: *Dazzle'em With Style, the Art of Scientific Presentation.* W. H. Freeman and Co., New York. 200 pp. (Don't be put off by the title; this book is full of excellent, usable advice on planning and delivering effective seminars. Recommended for purchase.)

Bishop, C. T., 1984: *How to Edit a Scientific Journal.* ISI Press, Philadelphia PA, pp 138. (A straightforward prescription for scientific journal editors [a much bigger audience than you might have imagined] but it isn't hard to see it from the perspective of an author.)

Bronowski, J., 1995: The creative process. *Scientific American, A special collection on science and the arts*. 4-11.

C99 - Chalmers, A. F., 1999; *What is This Thing Called Science? 3rd Ed.* Hackett Publishing. (A very readable introduction to philosophy of science. Recommended for purchase.)
Dodd, J. S., 1986: *The ACS Style Guide.* American Chemical Society, Washington, D. C., pp 264.

HP97 - Hatton, J., and P. B. Plouffe, 1997: *Science and Its Ways of Knowing.* Prentice Hall, Upper Saddle River, New Jersey. 150 pp. (An anthology dealing with the nature and methods of science. A lightweight compared to CC98, but quite worthwhile and enjoyable. Recommended for purchase.)

Kuhn, T. S., 1996: *The Structure of Scientific Revolutions, 3rd ed.* University of Chicago Press. 212 pp. (A very influential interpretation of the history and practice of science as viewed from a great distance. This book was not written to inspire and guide a new generation of scientists and it is not brimming with useful advice. It is, however, an indelible part of the culture of science ['paradigm' was given life here] and it is highly recommended.)

Klemke, E. D., R. Hollinger, D. W. Rudge and A. D. Kline, 1998; *Introductory Readings in the Philosophy of Science*. Prometheus Books. (An excellent anthology.)

M79 - Medawar, P. B., 1979: *Advice to a Young Scientist.* Basic Books, United States. 109 pp. (This inspiring little book, by one of the most literate and thoughtful scientists of our time, encapsulates much of the intended content of this seminar and is highly recommended for purchase.)

Miller, D., 1985: *Popper Selections.* Princeton Univ. Press, Princeton, NJ. (An anthology selected from among Karl Popper's extensive and often very important writings on philosophy of science, social philosophy, and theory of knowledge.)

NAS95 - National Academy of Sciences, 1995: *On Being a Scientist, Responsible Conduct in Research.* 2nd edition. National Academy Press, Washington, D. C.. 27 pp. (A superb, concise discussion of science generally and ethics in science in particular. Available free of charge from the WHOI Ed. Ofc.)

Woodward, J. and D. Goodstein, 1996: Conduct, misconduct and the structure of science. *American Scientist.* 84, 479-490.