Philosophy of Science

Syllabus

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Fall 2009

OFFICE DATA

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Office Hours: MWF 12:00 - 1:00 p.m. and by appointment

EXAMS AND GRADING

- **Midterm Quiz:** 2-hour, closed-book, in-class written exam, approximately after the first six weeks of lecturing (date and time will be announced later). Students will be required to answer five questions drawn from the lecture material and readings covered in class.
- **Final Exam:** Standard 2-hour closed-book in-class exam or a final 15+ pp. (double-spaced) term paper, exactly one of these two alternatives, chosen by the student seven days before the end of classes. In the in-class exam option, students will be asked to answer five questions drawn from the lecture material and readings covered in class after the midtem. Final-paper topic is chosen by the student, after consultation with the Instructor.
- **Contributions to Class Discussion:** Students are expected to discuss and analyze the concepts/theses presented during the lectures.

Each of these performance inputs will contribute, in respective proportions of ca. 40%, 50%, and 10% to the final grade.

COURSE OUTLINE

This self-contained course (presupposing no substantive prior background in

philosophy nor any extensive knowledge of science) provides an andvanced introduction to the central philosophical questions concerning the nature of scientific knowledge and its relation to experience, and the metaphysical assumptions underlying the natural sciences.

Broadly understood, *philosophy of science* is a branch of philosophy that studies and reflects on the presuppositions, concepts, theories, arguments, methods and aims of science. Philosophers of science are concerned with general questions which include the following: What is a scientific theory and when can it be said to be confirmed by its predictions? What are scientific models and how are they validated? In virtue of what are models representations of the structure and behavior of their target systems? In sum, a major task of philosophy of science is to analyze and make explicit common patterns that are implicit in scientific practice.

A BRIEF GUIDE TO THE LECTURES

I. Science and Pseudoscience:

The first two lectures introduce students to some of the basic questions about demarcation criteria for separating science from pseudoscience and non-science in general. We discuss different conceptions of demarcation. Specifically, we treat

1. Popper's Demarcation Line Between Science and Pseudoscience.
2. Kuhn's Paradigm-based Criteria for Determining Whether or Not a Theory is Scientific.
3. Lakatos's Account of Scientificity.
4. Thagard's Definition of Peudoscience.

II. The Nature of Scientific Laws:

Basic and fundamental scientific principles are usually referred to as "laws of nature." Philosophers ask "How are we able to distinguish between these so-called *laws* and mere accidental regularities?". Is there something "necessary" inherent in laws? Or is this a distinction without a difference? We review three major views about laws.

1. The Empiricist Regularity View.
2. Dretske's Necessitarian Approach.
3. Instrumentalist Conceptions.
4. Pros and Cons of Empiricist vs. Realist Perspectives on Laws.

5. Natural Kinds and Their Role in Laws and Theories.

III. Models of Scientific Explanation:

According to the so-called covering law model of explanation, a statement of fact (involving an event, phenomenon, etc.) is *explained* precisely when it is deduced from other statements, including at least one scientific law. We present this *deductive-nomological* model and explore how it stands up to a battery of objections that have been made to it. We review

1. Hempel's Deductive-Nomological Model of Explanation.
2. Hempel's Inductive Statistical Model of Explanation.
3. Causal and Teleological Models of Explanation.
4. Selection of Theories on the Basis of Their Explanatory Virtues.

IV. Duhem-Quine Thesis of Holism and the Underdetermination of Theories by Observation:

It is a central tenet of the empiricist philosophy of science that scientific theories are confirmed or refuted by observations. We look at some of the motivations for this view and some problems associated with *refutability*, theory-world relations, and the prospect of drawing a line between *observation* and *theoretical* terms. We treat

1. Popper's Falsificationism.
2. The Duhem Thesis and the Quine Thesis.
3. The Problem of Underdetermination.
4. Holism and Foundationalism.

V. Realism and Anti-realism:

Empiricist philosophy of science denies that science gives us knowledge of an unobservable part of reality (e.g., beyond the observer's light cone or near the Planck scale) We examine different versions of realism and anti-realism:

1. Two Accounts of how Theories Refer to Reality: Scientific Realism and Empiricism.
2. Arguments Concerning Scientific Realism.
3. Convergent and Experimental Realism.
4. Van Fraassen's Arguments for Constructive Empiricism.

5. Empiricism and Realism at Work.

VI. Objectivity and Value Judgment in Science:

Does science involve a smooth, rational, objective and value-free progression of cumulatively improving theories? We look at several accounts and explore how science may or may not be value-free.

1. Kuhn's Paradigm Shifts and Scientific Revolutions.
2. Do Scientists as Scientists Make Value Judgments?
3. Values and Objectivity in Science.
4. Rationality in Science.
5. Ethical Dimensions of Scientific Research.

VII. Reductionism and Intertheory Relations:

We review two different accounts of how some theories may be reduced to other theories, leading to a profound unification of scientific knowledge. For example, the classical theories or electricity and magnetism are reducible to Maxwell's theory of electromagnetism.

1. Two Concepts of Intertheoretic Reduction.
2. Reductionism and the Unity of Science.
3. Case Study: Are Mendel's Genes Reducible to DNA Sequents?
4. Levels of Organization and Description.

VIII. Induction, Prediction and Evidence:

Traditionally, the main roles claimed for induction have been (i) a *logic of discovery* (rules of passage from evidence to laws), and (ii) a *logic of justification*, formalizing how evidence should be related to pertinent theories. We shall explore the notion of induction and its role in science:

1. Hume's and Popper's Problem of Induction.
2. Hempel's Criteria of Hypothesis Confirmation.
3. Bayesian Approach to Induction.

IX. Hypothesis Testing and Confirmation of Scientific Theories:

Two lectures provide an introduction to Bayesian confirmation theory and its role in scientific reasoning. Here we also consider some philosophical approaches to the interpretation of the notion of probability.

1. Probabilistic Foundations of Belief Revision.
2. Deductive and Statistical Approaches to Testing Scientific Hypotheses.
3. Carnap's Method of Confirmation and Popperian Falsificationism.
4. Bayesian Approaches to Confirmation.

X. Metaphysical Implications of Modern Physics:

1. Philosophy of Physics: Nature of Matter, Forces and Space-Time.
2. On Einstein-Minkowski Space-time.
3. Space-time Substantivalism.
4. Ontology of Quantum Mechanics: Should it be Realist or Empiricist? The Einstein-Rosen-Podolsky Paradox and Bell's Theorem.

XI. Philosophy of Biology:

1. Universal Darwinism and the Nature of Fitness.
2. Evolution, Population Thinking, and Essentialism.
3. Natural Kinds.
4. Puzzles About Species.

XII. Classical Paradoxes in Scientific Methodology:

1. Hempel's Paradox of Indoor Ornithology.
2. Goodman's Paradox of the Green Emerald.
3. Zeno's Paradoxes of Motion.
4. Kyburg's Lottery Paradox.

READINGS

- **Required Readings in Philosophy of Science:**

  M. Curd & J. A. Cover (eds): *Philosophy of Science*, The Central Issues, W.W. Norton & Co., New York, 1998.

  The bulk of the course follows the topics covered in this popular book. Other recommended books which cover a broad range of topics are listed below.

- **Supplementary Readings for the Course:**

  M. Lange(ed.): *Philosophy of Science.* An Anthology. Blackwell Publishing Co., Malden, Ma, 2007

  McGrew, T., Alspector-Kelly, M., and Allhoff, F. (eds.): *Philosophy of Science*, An historical anthology. Wiley-Blackwell, 2009.

  R. Boyd, P. Gasper and J. D. Trout (eds): *The Philosophy of Science*, The MIT Press, Cambridge, Massachusetts 1991

Some sections from Supplementary Readings are provided as handouts. A large body of philosophy-of-science articles on realism and antirealism, etc., may be found at

1. `http://philsci-archive.pitt.edu`
2. `http://plato.stanford.edu` (alphabetic encyclopedia)
3. `http://www.scholar.google.com` (Enter a technical term or author's name of interest, and examine the list of relevant articles or books that google provides.)