The Rise of Modern Science: Origins and Revolutions

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Tues. 3:00-4:00
Thurs. 3:45-4:45
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Tues. 2:00-3:00
Wed. 9:00-10:00
and by appointment

Our conversation about the scientific enterprise begins with a semester focused on revolutions in science. We will study three revolutions in some detail: the Copernican revolution, the Darwinian revolution, and the twentieth-century revolution that gave rise to modern neuroscience. We will learn about the landmark scientific theories in each historical episode and about the scientific evidence and arguments of the day; we will also explore the philosophical, religious, and cultural debates that surrounded each theory. In conjunction with our study of these three revolutions, we will examine the scientific enterprise through the lens of Thomas Kuhn’s seminal book, The Structure of Scientific Revolutions. This year marks the 50th anniversary of that influential and provocative work.

Copernicus’s theory of a sun-centered universe was published in 1543. But only after 1600, when scientific heavyweights like Kepler and Galileo began to argue for the truth of the Copernican model, did scientific and religious controversy surrounding it heat up. Galileo in particular became the standard-bearer of the new ideas. He not only amassed empirical and theoretical support for Copernicus’ theory, but also argued for revolutionary ideas about the methods and the reach of “natural philosophy” (or as we would call it, natural science). Galileo’s passionate support of Copernicanism eventually resulted in his trial and condemnation by the Catholic Church—in spite of his ardent efforts to convince his own Church that this scientific theory was compatible with Scripture. Half a century later, the Copernican revolution was brought to completion by Newton’s Principia and its unified physics of planets and projectiles.

From the seventeenth century, we leap ahead to the nineteenth. Darwin’s theory of evolution by natural selection was the product of decades of careful observation and reflection on the relationships among living things. Darwin and his supporters held up this theory as showing that questions about origins in biology, like questions about planetary motions, could be answered by appeal to general laws. However, there are deep differences between science as exemplified by Darwin’s achievement and science as exemplified in the work of Galileo and Newton; what of Galileo’s insistence on mathematics as essential to scientific understanding, for example? We will consider the scientific and religious responses to the publication of Darwin’s theory in his own day.

Next, we stand back and explore Thomas Kuhn’s highly influential theory of the development of science, drawing on our knowledge of the two revolutions we have already studied. Kuhn’s book has been highly influential; just consider that he is responsible for making the term ‘paradigm shift’ part of everyday speech. But many of his ideas are also controversial, and they challenge some commonly-held conceptions about the rationality and objectivity of the scientific enterprise.

Finally, we turn to the past century and the development of a “new” science. Neuroscience is an amalgamation of psychology, biology, chemistry, physics, and philosophy, and it utilizes methods of all these disciplines to explore the form and function of the brain. At the present time, much is known about the molecular and cellular aspects of brain function. The big questions, however—questions about how to understand consciousness, memory, and free will in the light of what we know about the brain—remain. We will explore the origins of neuroscience and our ability to probe the mysteries of the human brain, and we will reflect on ways neuroscience challenges previous ideas about science and about ourselves.
Class meetings: Tuesday 9:35-11:00, Thursday 9:30-10:50, Old Main 340

Grading and Assessment:

1. Examinations. We will have one mid-term examination and one final examination. Both exams will be in-class, closed-book, and primarily essays.

2. Papers. Each student will write one response essay (about 2 pages) and two papers (about 5 pages each). We will provide a list of topics for the two papers, though students may write on some other topic of their choice with instructor approval. We encourage you to discuss ideas, drafts, or outlines with us as you write these papers.

3. Preparation and Engagement. This class will be run seminar-style. Students are expected to complete all assigned readings prior to the meeting in which they will be discussed, attend all class meetings, and actively participate in discussions. It’s been our experience that being able to post a question or thought right when it occurs to you, even in the middle of the night, can greatly increase participation in class. To this end, we will create forums (or would it be fora?) on Moodle for each class meeting. You are expected to post something prior to each class meeting; to allow for life intervening occasionally, missing up to 3 posts during the semester is acceptable. These posts can be simple questions, long rambling thoughts or responses to something a colleague has posted. The goal here is to help you to get in the habit of thinking and reflecting on the readings, and to get some ideas and conversations rolling even before we arrive in the classroom. We will sometimes use your posts as starting points for class discussion.

4. Grading: Participation, exams, and papers will form the basis for your final grade in this course. The “participation” category includes both engagement in class discussion and preparation for class, including your posts on Moodle before each class. All five course elements will be equally weighted:

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<td>First paper</td>
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Reflection Paper. Toward the end of the term, all students will compose a brief (2-3 page) reflection paper on their learning experience in this class. Papers should address the main educational benefits and drawbacks of the class, and the ways in which the class met or failed to meet their expectations as a student.

Attendance & etiquette: Given the nature of a discussion-based class, being present is an important part of doing well in this course. We realize that life happens (even to faculty!) and there may be times you will have to miss class or will be unable to complete an assignment on time. Please let us know about these things sooner rather than later. In general, we are willing to give people the benefit of the doubt. However, when “life happens” chronically, we’re much less likely to be understanding.

Except under highly unusual circumstances, cell phones will be turned off during class.

GE Credit: Students who complete the three-course Science Conversation program will earn HWC, BTS-T, HBS, SED or IST, and WRI general education credits.
Writing Assistance: The Writing Help Desk, located in Rolvaag Memorial Library next to the Reference Desk, provides one-stop service for research and writing. Students can get help with writing “on the spot” when tutors are available, or they may make appointments by calling x3288. http://www.stolaf.edu/services/asc/writing-help.html

Disabilities: If you have a documented disability for which accommodations may be required in this class, please contact Connie Ford (ford@stolaf.edu) or Erin Bang (bang@stolaf.edu) in the Academic Support Center (507-786-3288, Buntrock 108) as soon as possible to discuss accommodations. Accommodation letters will be sent to us via email; please arrange a brief meeting with one of us once the letter has been submitted. If you have already arranged accommodations through Student Accessibility Services, please double-check that we have received your letter. Accommodations will only be provided after the letter is submitted to us and with sufficient lead-time to arrange testing or other accommodations. http://www.stolaf.edu/services/asc/sds.html

Academic Misconduct and Plagiarism will be dealt with in accordance with college policy. Conduct during exams is subject to the Honor System: http://www.stolaf.edu/stulife/thebook/academic/honor.html. Other matters of academic integrity, including plagiarism, fall under the academic integrity policy: http://www.stolaf.edu/stulife/thebook/academic/integrity.html

Plagiarism is “the presentation of the work of another as one’s own,” and the policy says the following about it:

Plagiarism may take the form of inadequate or misleading use of sources, or the presentation of a written assignment as one’s own when, in fact, a significant portion or all of it is the work of others. Students must be especially vigilant in their use of electronic sources, as no distinction will be made between misuse of such sources and misuse of written, non-electronic sources.

When you submit a paper you must cite every source you used in writing the paper, and indicate which words or ideas came from which source.

Required Texts


Course Pack, available at the bookstore: additional readings will be made available on Moodle.
COURSE SCHEDULE
“CP” = course pack. “M” = Moodle. Any changes will be posted on Moodle.

Thursday, September 8  Introductions, overview, and initial thoughts

I.  The Copernican Revolution
   a.  Galileo and the Two Chief World Systems

Tuesday, September 11
Galileo, *Dialogue Concerning the Two Chief World Systems*, pp. 1-9, 36-42, 53-100, 122-131
   Aristotelian cosmology and physics; Galileo’s life and works

Thursday, September 13
Cohen, ch. 3-4
CP: Lewis, “The Heavens,” ch. 5 of *The Discarded Image* (CP 1-18)
CP: Foreword and Dedication to Copernicus’ *On the Revolutions of the Heavenly Spheres* (CP 20-24)
M: Galileo, *The Starry Messenger* (selections)
   The Ptolemaic and Copernican systems; Galileo’s telescopic discoveries

Tuesday, September 18
Cohen, ch. 5
   Arguments concerning the daily motion of the earth

Thursday, September 20  RESPONSE ESSAY DUE
   Arguments concerning the annual motion of the earth; Galileo’s argument from the tides

b.  Religious Responses to Copernicanism, and the Galileo Affair

Tuesday, September 25
CP: Foreword and Dedication to Copernicus’ *On the Revolutions of the Heavenly Spheres* (CP 20-24)
CP: Westman, “The Copernicans and the Churches,” ch. 3 of *God and Nature* (CP 77-95)
CP: Finocchiaro, introduction to *The Galileo Affair: A Documentary History* (CP 27-48)
   Reactions to Copernicus before Galileo; the history of the Galileo affair

Thursday, September 27
CP: Bellarmine, Letter to Foscarini, in *The Galileo Affair* (CP 49-50)
CP: Shea, “Galileo and the Church” ch. 4 of *God and Nature* (CP 96-106)
   Galileo on science and scripture

c.  From Galileo to Newton

Tuesday, October 2
Cohen, ch. 6
CP: Westfall, “The Mechanical Philosophy” (CP 108-117)
CP: Descartes, *The Principles of Philosophy*, (selections) (CP 130-143)
   Kepler; Descartes and the mechanical philosophy
Thursday, October 4
Cohen, ch. 7
M: Newton, *Principia*, (selections)
    Newton’s laws and universal gravitation

II. Darwin and the Theory of Evolution by Natural Selection

Tuesday, October 9
FIRST PAPER DUE
CP: Westfall, “The Mechanical Philosophy and Biology” (CP 118-129)
Herbert, *Charles Darwin and the Question of Evolution*, pp. 1-15, 41-69
M: Selections from Lamarck, Paley, etc.
Desmond, Moore, and Browne, *Charles Darwin*, ch. 1
    The rise of evolutionary ideas

Thursday, October 11
Herbert, pp. 16-29, 73-89
Desmond, Moore, and Browne, ch. 2-3
    Darwin aboard the *Beagle*; a theory takes shape

FALL BREAK October 13 - 16

Thursday, October 18
Desmond, Moore, and Browne, ch. 4-5
Herbert, pp. 89-102
Darwin, *On the Origin of Species*, introduction and ch. 1-4, pp. 105-173 of *Writings*
    *Origin of Species* part 1: Darwin’s theory

Tuesday, October 23
Darwin, *Origin*, ch. 6 and 14, pp. 173-211 of *Writings*
Herbert, pp. 29-34, 111-116
Desmond, Moore, and Browne, ch. 6-8
M: Elliott Sober, “Did Darwin Write the *Origin* Backwards?”
    *Origin of Species* part 2—components of the theory; influences and evidence

Thursday, October 25
CP: Brooke, “Evolutionary Theory and Religious belief” (CP 146-169)
Reviews and Responses, pp. 212-230 of *Writings*
    Scientific and religious responses to Darwin

Tuesday, October 30
*****MID-TERM EXAM*****

III. The Structure of Scientific Revolutions

Thursday, November 1
    Preliminaries; normal science and paradigms
Tuesday, November 6  
**Kuhn** chs. V-VIII  
Anomalies and crises

Thursday, November 8  
**Kuhn**, ch. IX-XI, P.S. sec. 4  
Scientific revolutions

Tuesday, November 13  
**Kuhn**, chs. XII-XIII, P.S. secs. 5-7  
Incommensurability; rationality & revolutions

**IV. Neuroscience: A Twentieth-Century Revolution?**

Thursday, November 15  
**M**: Exorcizing animal spirits - science blog entry  
**CP**: Descartes on the mind-body problem  
**CP**: Smith, “Brain and Mind in the ‘Long’ Eighteenth Century”  
The origins of neural science

Tuesday, November 20  
**SECOND PAPER DUE**  
**M**: the discovery of the neuron - science blog entry  
**CP**: Glickstein, “Golgi and Cajal: The neuron doctrine and the 100th anniversary of the 1906 Nobel Prize”  
**CP**: Ramón y Cajal, *Recollections of My Life* (selections)  
Early descriptions of neurons and their functions; rivalry of Golgi and Ramón y Cajal

**THANKSGIVING BREAK November 21 - 25**

Tuesday, November 27  
**Kandel**, ch. 4-7, pp. 53-115  
The development of neural science; development of a Nobel laureate

Thursday, November 29  
**Kandel**, ch. 8-11, pp. 116-179  
Neurobiology of memory; doing modern neuroscience

Tuesday, December 3  
**Kandel**, ch. 13-18 & 20-23 (pp. 187-246; 279-316)  
The neurobiology of memory

Thursday, December 6  
**Kandel**, ch. 28 & 30 (pp. 376-390; 416-429)  
**M**: Jackson (1982) “Epiphenomenal Qualia”  
The brain and the mind

Tuesday, December 11  
**TBA**  
**REFLECTION PAPER DUE**

**FINAL EXAM: Monday, December 17th, 9:00-11:00 AM**