

History of Science 224: Revolutions in Science

Spring 2003
MWF 11:00-11:50 a.m.

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117 Bronfman (XT 2239)

Scientific facts and theories affect our beliefs about our world, about our selves, and about how we think we should live. Since its 16th century creation in the West, "modern" science has become the epitome of authoritative and objective knowledge. What have been the critical periods of change in the structure of scientific knowledge, and what effects have those changes had on other sciences, as well as the non-scientific world?

This course aims first at determining the key concepts of the paradigm formations or shifts characteristic of scientific revolutions. Just what does constitute Copernican (Keplerian) astronomy, Newtonian (Galilean) physics, [Lavoisierian chemistry, Lyellian (Huttonian) geology,] Darwinian (Wallacean) biology, and modern physics (quantum theory and relativity)? What evidence is there to support those paradigms, and how adequate and reliable is it? What countervailing views did the "modern" science replace?

The second aim of the course is to try to determine how, and to what extent, science and society interacted to form the "modern world view." That is, in terms of the sensibilities and values which we moderns (Westerners) have, what scientific foundations are there? For example, what do we take for granted as constituting certain fact, and what consequences spring from that?

Class sessions will be a mixture of lectures about the history of major revolutions in science, which the assigned readings complement, and discussions of questions and ideas raised by those assigned readings. Check this syllabus, or the department website under "curriculum."

The following are the required texts for the course:

P.J. Bowler	Evolution – The History of an Idea
H. Butterfield	The Origins of Modern Science
B. L. Cline	Men Who Made a New Physics
I.B. Cohen	Birth of a New Physics

There is additional xeroxed material to read as well, in a course packet obtainable Feb. 7 from Kate Fletcher, Bronfman 189.

Grades will be based on four short papers [3-4 pp], 6 problem sets, and two hour exams, with about 32%, 36%, and 32% of the final grade deriving from each category respectively. Class participation [attendance, quality and frequency of contributions] may affect the final grade.

For the papers, choose a work, genre, or movement from the humanities (poetry, prose, fine arts, music, drama) or "social sciences", to argue or demonstrate the influence (or lack thereof) of the revolutionary science we've been studying on themes, modes of expression, beliefs, philosophies, or other aspects of the non-sciences. If you are more technically minded, choose a work or field from science, and discuss to what extent its development reflected (or was unaffected)

by) the revolutionary science dealt with in class. Or, create your own relevant thesis. Appended to the outline of classes is a brief bibliography of some of the better works covering some of the course topics.

The following is a schedule of classes and assignments:

1. Fri., Feb. 7 **Introduction**

2. Mon., Feb. 10 **The Medieval World View - a Lecture.**
Everything you need to know to satisfy the Division III requirement at a medieval university.

- Background to the Copernican Revolution

3. Wed. Feb. 12 **Basic Astronomical Phenomena and Planetary Models.**
Packet: "What Every Young Person Should Know about Naked-Eye Astronomy." and "Astronomical Coordinate Systems"

- Fri. Feb. 14 No Class VALENTINE'S DAY and WINTER CARNIVAL WEEKEND

4. Mon., Feb. 17 **Astronomical Models. Qualitative and quantitative. "Saving the Appearances."**

5. Wed., Feb. 19 **Planetary Astronomy and the Ptolemaic Paradigm. A model of success for 1500 years.**
Cohen, 25-35, "The Earth and the Universe"

6. Fri., Feb. 21 **Strains in the Fabric: Social Change and Astronomical Reform; Copernicus' Revolutionary Ideas**
Problem Set 1
DUE
(basic astron)
Cohen, 24-25; 35-45, "The Earth and the Universe"

- Fri. Feb. 16 No Class =====WINTER CARNIVAL WEEKEND =====

7. Mon., Feb. 24 **Copernicus v. Ptolemy. The Copernican Revolution as anomalistic. The equivalence of Copernican and Ptolemaic astronomical models.**
Butterfield, 29-48, "The Conservatism of Copernicus"
Cohen, 45-52, "The Earth and the Universe"
Packet, "Equivalence of Geocentric/Heliocentric"

8. Wed., Feb. 26 **Consolidation and Change: An Overview.**
[Brahe, Kepler, Galileo.]

Butterfield, 67-88, "The Downfall of Aristotle and Ptolemy"

Cohen, 53-80, "Exploring the Depths of the Universe"
[B,K,G; telescope; Sidereus Nuncius]

9. Fri., Feb. 28

Kepler's Laws; Heavenly harmony and Pythagoreanism.

Cohen, 127-147, "Kepler's Celestial Music"

10. Mon., Mar. 3

Reflections on the Copernican Revolution

**1st PAPER
DUE**

Class Discussion, using ideas from the papers...

11. Wed., Mar. 5

From the Old to The New Physics: Aristotle, Impetus, and Kinematics - the 'how' of motion.

The Old Physics of Motion: Aristotle. Impetus.

Cohen, 3-23: [Ch. 1 & 2]. "The Physics of a Moving Earth," and "The Old Physics"

Butterfield, 13-28, "The Historical Importance of a Theory of Impetus"

Packet, Excerpt from Aristotle's Physics

Cohen, 81 - 126, "Towards an Inertial Physics"

Packet, "Accelerated Motion" [Galileo]

12. Fri., Mar. 7

The New Physics: Kinetics - the 'why' of motion.

**Problem Set 2
DUE (astron)**

Cohen, 81-126, "Towards an Inertial Physics"

13. Mon. Mar. 10

The New Physics Completed. Galileo's Trial.

14. Wed., Mar. 12

Newton. His life. The apple myth.

Cohen, 148-184, "The Grand Design -- A New Physics"

Butterfield, 151-170, "The History of the Modern Theory of Gravitation"

Packet, Heuristic $1/r^2$; Huyghens; Moon-Apple

15. Fri., Mar. 14

The Grand Design: Newton's Principia. Contents, Laws, Rules of Reasoning.

Packet, Excerpts from Principia

16. Mon., Mar. 17

The New Scientific Method of the Seventeenth Century. [Galileo], Bacon, and Descartes. An Exemplar

**Problem Set 3
Due (physics)**

Butterfield, 89-150, "The Experimental Method in the Seventeenth Century," "Bacon and Descartes," and

"The Effect of the Scientific Revolution on the
Non-Mechanical Sciences"
Packet, "Opticks," [Newton]

17. Wed., Mar. 19

Hour Exam

18. Fri., Mar. 21

**The Legacy of the Scientific Revolution.
Considerations and Reflections.**

Paper 2 Due

Class Discussion, using ideas from the papers,
or, from (recommended, but not required)
Butterfield, 171-202 "The Transition to the
Philosophe Movement in the Reign of Louis XIV," and
"The Place of the Scientific Revolution in the History
of Western Civilisation"
Packet: "The Newtonian World Machine" [Randall]

-----Spring Vacation-----

19. Mon. Apr. 7

**Revolutions in Chemistry – 1 (Phlogiston Theory.
Pneumatic Chemistry Lavoisier's *Traité*.**

Butterfield, 203-221, "The Postponed Scientific
Revolution in Chemistry"

20. Wed., Apr. 9

**Revolutions in Chemistry – 2 (Atomic Theory, the
Periodic Table, The Role of Error)**

Lecture

21. Fri., Apr. 11

**Revolutions in Cosmogony - the Origins of
Things**

Bowler, Ch. 2 (23-36) "Early Theories of the Earth"

22. Mon., Apr. 14

Revolutions in Geology

Bowler, Ch. 2 (26-45) "Early Theories of the Earth, and
Ch. 5 (103-141) "Geology and Natural History, 1800-
1859"

23. Wed., Apr. 16

**Revolution in Biology. Time, Taxonomy,
Variability; from organisms to cells to ...**

Bowler, Ch. 3 (46-84) "Evolution in the Enlightenment"
and Ch. 4 (85-102) "Changing Views of Man and Nature"

24. Fri., Apr. 18

**Darwin, the Beagle, and the Origin. His
Theory. Wallace. Scientific Debate.**

Bowler, Ch. 6 (146-175) "The Origins of Darwinism"
and Ch. 7 (176-205) "Darwinism: the Scientific Debate"

25. Mon., Apr. 21 **Reception and Response: Religion, Morality, and Scientific Eclipse.**
Problem Set 4 Due (chem/geol) Bowler, Ch. 8 (206-232) "Darwinism: Religious and Moral Problems" and Ch. 9 (233 - 265) "The Eclipse of Darwinism"
26. Wed., Apr. 23 **Social Implications and Movements; The Modern Synthesis: Darwin Redux**
Bowler, Ch. 10 (266-288) "The Social Implications of Evolutionism" and Ch. 11 (289-316) "The Evolutionary Synthesis"
27. Fri., Apr. 25 **The Darwinian Revolution - Reception and Legacy**
Paper #3 Due Class Discussion, Presentations, Review
28. Mon., Apr. 28 **The Convergent Century.**
Problem Set 5 Due (biol) Unification and Synthesis in 19th Century Science. Fin du Siècle.
29. Wed., Apr. 30 **The Beginning of Modern Physics: Rutherford to Planck**
Cline, 1-63, "Ernest Rutherford: Discovery of the Nucleus," "Ernest Rutherford: Radioactivity," "Max Planck: Pursuit of an 'Absolute,' the Entropy Law," "Max Planck: The Quantum Theory"
30. Fri., May 2 **Einstein, 1905 and Special Relativity; General Relativity.**
Cline, 64-87, "Albert Einstein: Work of 1905"
Cline, 219-234, "Albert Einstein: The General Theory of Relativity"
31. Mon., May. 5 **Bohr and the Theory of the Atom**
Cline, 88-126, "Niels Bohr: Early Quantum Theory of the Atom," "Early Days of Quantum Physics"
32. Wed., May 7 **Copenhagen, and the Creation of Quantum Mechanics**
Cline, 127-191, "Wolfgang Pauli, Werner Heisenberg, and Bohr's Institute," "An Introduction to Modern Quantum Theory," "Creation of Quantum Mechanics"
33. Fri., May 9 **The Interpretation of Quantum Mechanics; The Legacy of Modern Physics**
Problem Set 6 Due (20c. phys) Cline, 192-218; 235-244, "Interpretation of Quantum Mechanics," "The Debate between Niels Bohr and Albert Einstein"

Cline, 245-259, "Afterward"

34. Mon., May 12

Hour Exam #2

35. Wed., May 14

Retrospect. SCS.

Scientific Revolutions: what can we expect?
Do we have any unifying vision like the Medieval
World View? Should we? Need we?

36. Fri., May 16

Paper #4 Due

The Legacy of Relativity and Quantum Theory

Class Discussion, using ideas from the papers...

Brief Bibliography

(more or less synchronic with the course)

T.S. Kuhn	The Structure of Scientific Revolutions
P. Thagard	Conceptual Revolutions
Peter Barker & Roger Ariew eds	Revolution and continuity
D.C. Lindberg & R. S. Westman eds.	Reappraisals of the scientific revolution
S.Mason	A History of the Sciences
T.S. Kuhn	The Copernican Revolution
A. Koestler	The Sleepwalkers
A. Koyre	From the Closed World to the Infinite Universe
A. Armitage	Copernicus
J.Dreyer	Tycho Brahe
E.J. Dijksterhuis	Mechanization of the World Picture
H. Kearney	Science and Change, 1500-1700
A.R. Hall	From Galileo to Newton
A.R. Hall	The revolution in science, 1500-1750
L. Jardine	Ingenious pursuits : building the scientific revolution
P. Redondi	Galileo Heretic
R. Westfall	Never at Rest
R. Westfall	The Construction of Modern Science
S. Drake	Discoveries and Opinions of Galileo
I. Newton	Principia
G. Galileo	Dialogues Concerning the Two Chief Systems of the World
G. Galileo	Discourses on the Two New Sciences
I. Newton	Opticks
Steven Shapin	The Scientific Revolution
H.M.Leicester	The Historical Background of Chemistry
D. McKie	Antoine Lavoisier
David Knight	Ideas in chemistry : a history of the science
Dean, Dennis R.	James Hutton and the history of geology
S. J. Gould	Time's Arrow, Time's Cycle

M. Greene	Geology in the 19th Century
L. Eiseley	Darwin's Century
G. Himmelfarb	Darwin and the Darwinian Revolution
C. Darwin	The Origin of Species
P. Appleman,ed.	Darwin (Norton Anthology, 2nd ed.)
A.Desmond & J. Moore	Darwin
Bowler, Peter J.	The non-Darwinian revolution
D. Kevles	In the Name of Eugenics
Stephen G. Brush	The history of modern science : a guide to the second scientific revolution, 1800-1950
Mary Jo Nye	Before big science : the pursuit of modern chemistry and physics, 1800-1940
T.S. Kuhn	Black Body Theory and the Quantum Discontinuity (tech.)
V. Guillemin	The Story of Quantum Mechanics
B. Hoffman	Albert Einstein, Creator and Rebel
W. Heisenberg	Physics and Philosophy
A. Pais	Subtle is the Lord: the Science and the Life of A. Einstein
E. A. Burt	The Metaphysical Foundations of Modern Science
G. Holton	Thematic Origins of Scientific Thought: Kepler to Einstein
P.J.Bowler	The Eclipse of Darwinism
J. D. Watson	The Double Helix
A. N. Whitehead	Science and the Modern World
H.F. Judson	The Eighth Day of Creation
LeGrand, H. E.	Drifting continents and shifting theories