

History of Science 203

Science in the 20th Century: A Historical Overview

Fall 2002

3 Credits; Z (Humanities or Social Studies)

2 hours lecture (1:20pm MW, 6104 Social Sciences), 1 hour discussion

Prerequisites: None

Instructor

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TA

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This course surveys the history of science in the twentieth century, from the discovery of x-rays and radioactivity in the 1890s through to the complex of scientific and social questions raised by the human genome project and stem cell research circa 2000. The period has seen spectacular transformations in the reach of modern science and technology, accompanied by the increasing specialization and fragmentation of knowledge. Here we explore the changing dimensions of science in an age of unprecedented promise and conflict. Tracing the evolution of physics and biology and exploring the emergence of environmentalism through the course of the century, we examine major conceptual developments, the interaction of science and society, and the impact of war on science and technology.

Book List (University Bookstore & Underground Exchange)

Diane B. Paul, *Controlling Human Heredity: 1865 to the Present* (Humanities Press, 1995) Required

Daniel J. Kevles and Leroy Hood, eds. *The Code of Codes: Scientific and Social Issues in the Human Genome Project* (Harvard University Press, 1992) Required

Arthur I. Miller, *Einstein, Picasso: Space, Time, and the Beauty that Causes Havoc* (Basic Books, 2001) Required

Richard Rhodes, *The Making of the Atomic Bomb* (Simon and Schuster, 1988) Required

James D. Watson, *The Double Helix*, ed. Gunther S. Stent, (Norton, 1980) Required

Course Packet Available from L&S Copy Center, 6120 Social Science, for \$12.97

Assessment

Assessment is through three take-home essay exams written on selected topics (75% of the total grade), and section participation (25%). The section participation grade will test your comprehension of both lectures and readings, and some informal writing will be required for discussion sections.

First Take-Home Exam (20%): Distributed Oct. 2; due Oct. 9.

Second Take-Home Exam (25%): Distributed Nov. 6; due Nov. 13.

Final Take-Home Exam (30%): Distributed Dec. 11; due Sat. Dec. 21.

Honors Assessment

Honors students will submit in addition a presentation and paper on a topic of their own choice (worth 20% of their overall grade), to be completed by Mon. Dec. 9.

Participation and Performance

If you have a conflict between an academic requirement and any religious observance, please notify me of the specific dates concerned within the first two weeks of the course and I will find an alternative means for you to fulfil the requirement. Such requests are confidential.

In compliance with the Americans with Disabilities Act, I will make every effort to honor requests for reasonable accommodations made by individuals with disabilities. (If you think you qualify for accommodation, please contact the McBurney Disability Resource Center [263-2741; <http://jumpgate.acadsvcs.wisc.edu/~mcburney/>] to establish your eligibility for services.) Requests for accommodation can be responded to more effectively if I receive them as far in advance as possible, preferably at the beginning of the semester. Such requests are confidential.

If any problems arise, either academic or personal, that might jeopardize your performance in the course, you must try to inform me of the problem at the next available office hour, or by leaving a message with the Department of the History of Science (262-1406).

Dramatic Interludes

This year several plays with themes related to this course are being produced in Madison. I recommend you take advantage of the opportunity!

David Auburn's **Proof** (Madison Repertory Theatre)

A young woman has spent years looking after her brilliant but unstable father; did she inherit his mathematical gifts, or his madness?

Isthmus Playhouse, Madison Civic Center, 211 State Street. September 4-8, 11-15, 18-22. Times vary. Box Office: 266-9055. Half-price students tickets are available at the Box Office with valid student ID. Prices range from \$7 to \$17, depending on time of performance. These performances often sell out, so make your ticket arrangements early. An online audience guide for this production is available at www.madisonrep.org.

Interested students are welcome to join myself, Profs. Clayton and Durand, and the FIG class "Science and the Stage" at the matinee performance on Sunday September 15, at 1:30 P.M., followed by pizza.

Friedrich Dürrenmatt's **The Physicists** (University Theatre)

Three physicists are patients in a mental asylum in Switzerland: Why are they there? Who are they? What will happen to their knowledge?

Mitchell Theatre, Vilas Hall, November 8-9, 14-16, 21-23. All performances are at 7:30. Vilas Hall Box Office: 262-1500. General public \$14, UW-Madison student \$10.

Note that you are welcome to join the Science and the Stage group on Thursday November 14, for a pizza at 6 P.M. followed by the evening performance at 7:30 P.M.

Carl Djerassi and Roald Hoffmann's **Oxygen** (University Theatre)

Who discovered O₂? The Nobel Prize Committee sets out to award a posthumous prize to the father of the chemical revolution. But who should they reward?

Mitchell Theatre, Vilas Hall, March 28-29, April 3-5, 10-12, 2003. All performances are at 7:30. Vilas Hall Box Office: 262-1500. General public \$14, UW-Madison students \$10.

Syllabus

Items on the Book List are referred to by name (eg. **Miller**, pp. 25-28). The other material is in the Course Packet. The readings listed are core material and ideally should be read before the relevant lecture.

Part I: Time and Space Machines: New Views of Man and Matter, circa 1900

Sept. 4 Introduction

H.G. Wells, *The Time Machine*, in *The Works of H.G. Wells*, Atlantic Edn., vol. 1 (New York: Charles Scribner's Sons, 1924), pp. 3-15.

For a brief study of its background see Jim Bennett, et al. *1900: The New Age. A Guide to the Exhibition* (Cambridge: Whipple Museum of the History of Science, 1993), "The Time Machine," pp. 13-16.

Discussion Section: Introductions

Sept. 9 New Matter: The Discovery of X-rays and Radioactivity

For original papers on the discoveries, see:

W.C. Roentgen, "On a New Kind of Rays," *Nature* 53 (23.1.1896), 274-276 and A.A.C. Swinton, "Professor Röntgen's Discovery," *Nature* 53 (23.1.1896), 276-277.

Henri Becquerel, excerpt on "The Radiation from Uranium," *Comptes Rendus* 122 (1896), p. 420 as translated in W.F. Magie, *A Source Book in Physics* (Cambridge, MA: Harvard University Press, 1963), pp. 610-613

P. and M.S. Curie, excerpts on "Polonium," and "Radium," *Comptes Rendus* 127 (1898), pp. 175 and 1215, as translated in Magie, *Source Book*, pp. 613-616.

For a brief discussion of the popular experience and understanding of new science and technology, see **Miller**, pp. 25-28. On Marie Curie's collaboration with her husband Pierre, see Helena Pycior, "Reaping the Benefits of Collaboration while Avoiding Its Pitfalls: Marie Curie's rise to Scientific Prominence," *Social Studies of Science* 23 (1993), 301-323.

Sept. 11 The Century in Prospect and Retrospect: Science at the 1900 World's Fair

On the World's Fair in general see Bennett, et al. "L'Exposition Universelle de 1900," pp. 17-32.

For excerpts of Poincaré's speech to the Congress of Physicists see Henri Poincaré, *Science and Hypothesis* (London: Walter Scott, 1905), pp. 141-153 and 172-182.

Discussion Section: Experimental Discoveries and the Unity of Physics

Part II: Biology and Society: Eugenics and Genetics

Sept. 16 Darwin's Legacy in Biology and Heredity: Morphology and Eugenics (note Yom Kippur)

Paul describes those facets of 19th century biology particularly concerned with heredity. See chaps. 1-2. For a contemporary (neo Lamarckian) perspective on evolution see Wells, *The Time Machine*, pp. 59-66.

Sept. 18 The Rediscovery of Mendel

A useful overview of the development of genetic mapping from the nineteenth century to 1990 is provided in Horace Freeland Judson, "A History of the Science and Technology Behind Gene Mapping and Sequencing," in **Kevles and Hood**, eds., pp. 37-80. For now read up to his discussion of *Drosophila*, pp. 37-49. Continue reading **Paul**, chap. 3.

Discussion Section: Science and Society

Sept. 23 Model Organisms and the Formation of Experimental Genetics

Robert E. Kohler, "Drosophila: A Life in the Laboratory," *Journal of the History of Biology* 26 (1993), 281-310.

Sept. 25 Genetics and Eugenics

Henry Herbert Goddard, *The Kallikak Family* (Arno Press: New York, 1973, reprint of the 1912 Macmillan edn.), pp. 101-117. **Paul**, chaps. 4-6.

Discussion Section: Model Organisms, Genetics and Eugenics

Sept. 30 Post World War I Biochemistry

Pnina G. Abir-Am, "The Molecular Transformation of Twentieth-Century Biology," in John Krige and Dominique Pestre, eds. *Science in the Twentieth Century* (Amsterdam: Harwood Academic, 1997), pp. 495-524.

Part III: The New Physics and the Birth of the Atomic Age

Oct. 2 The New Theories, I: Einstein's Quantum Theory

Miller, pp. 1-8 and 41-83.

Note: First Take-Home Exam Distributed

Discussion Section: The Rise of the Experimental Life Sciences

Oct. 7 The New Theories, II: Einstein's Relativity

Miller, pp. 173-213.

Oct. 9 Scientists and World War I

Rhodes, pp. 86-103.

Note: First Take-Home Exam Due

Discussion Section: Einstein and the Development of Theoretical Physics

Oct. 14 Popular Physics and New Epistemologies: Relativity and Quantum Mechanics

On the public response to the eclipse observations see Albrecht Fölsing, *Albert Einstein: A Biography*, tr. Ewald Osers (New York: Penguin, 1997), pp. 442-452. On popularisations in different contexts see Loren R. Graham, "The Reception of Einstein's Ideas: Two Examples from

Contrasting Political Cultures,” in Gerald Holton and Yehuda Elkana, eds. *Albert Einstein: Historical and Cultural Perspectives* (Princeton: Princeton University Press, 1982), pp. 107-136.

For an account of Bohr’s work see **Rhodes**, pp. 53-85. On his philosophy more generally see Aage Petersen, “The Philosophy of Niels Bohr,” in *Niels Bohr: A Centenary Volume*, eds. A.P. French and P.J. Kennedy (Cambridge, MA and London: Harvard University Press, 1985), pp. 299-310. On the abandonment of classical imagery see **Miller**, pp. 253-267.

Oct. 16 Nuclear Physics and the Idea of an Atomic Bomb

Reading for this and the following lecture comes from **Rhodes**, a complex book interweaving several narrative and thematic threads in each chapter. Ideal would be to read the whole, but I can suggest a number of excerpts that are particularly relevant. On the discovery of fission, pp. 247-264; on the US decision to build the bomb, and German research, pp. 367-393; and on the appointment of Groves to head the Manhattan Project and the building of the first atomic pile in Chicago, pp. 422-442.

Discussion Section: Physics, Philosophy and War

Oct. 21 “The Greatest Achievement of Organized Science in History”

On moving from experiment to production of U235 through electromagnetic isotope separation and gaseous diffusion, and on the pile for plutonium, see **Rhodes**, pp. 486-512; for an example (one amongst many) of work at Los Alamos, pp. 573-578; on the Trinity explosion, pp. 651-678.

Oct. 23 The Invention of the Computer

Martin Campbell-Kelly and William Aspray, *Computer: A History of the Information Machine* (New York: Basic Books, 1996), chapter 4 “Inventing the Computer,” pp. 79-104.

Discussion Section: Mobilizing Science for Bombs

Part IV: Cold War Sciences

Oct. 28 Cybernetics and Information

Charles R. Dechert, “The Development of Cybernetics,” in idem, ed. *The Social Impact of Cybernetics* (Notre Dame and London: University of Notre Dame Press, 1966), pp. 11-36.

For a perspective on present computer use see Sherry Turkle, “Multiple Subjectivity and Virtual Community at the End of the Freudian Century,” *Sociological Inquiry* 67:1 (1997), 72-84.

Oct. 30 The Structural, Informational and Biochemical Approaches to Molecular Genetics

Reading for this and the following two lectures comes from **Watson**, a book that has been influential in shaping popular images of the post-war scientist. Read as much of the book as you can, for this first lecture focusing on pp. 1-48. For a brief overview see Judson, “A History of Gene Mapping,” in **Kevles and Hood**, eds. pp. 49-60.

Discussion Section: Mind-Man-Machine

Nov. 4 Watson and Crick’s Double Helix

Watson, rest of the book. For Watson’s account of the discovery, see pp. 87-133.

Nov. 6 Molecular Biology

Watson's account drew vigorous responses from other scientists and commentators. See in particular the letters from Klug, Lewontin, Ellman, Sinsheimer, Perutz, Wilkins and Watson, and Merton in **Watson**, pp. 153-158, 185-194, 200-207, 213-218.

Note: Second Take-Home Exam Distributed

Discussion Section: Watson and Crick's Discovery of the Double Helix Structure of DNA

Nov. 11 Nature Management and the Rise of Environmentalism

For excerpts from two classics of environmentalism see Aldo Leopold, *A Sand County Almanac and Sketches Here and There* (London, Oxford and New York: Oxford University Press, 1949), pp. 6-18 and Rachel Carson, *Silent Spring* (Boston and New York, Houghton Mifflin, 1962), pp. 1-13.

For an account linking the power of Rachel Carson's argument on pesticides to pervasive public concern with radioactive fallout, see Ralph Lutts, "Chemical Fallout: Rachel Carson's *Silent Spring*, Radioactive Fallout and the Environmental Movement," *Environmental Review* 9 (Fall 1985), 211-225. On the background to Carson's argument and the Department of Agriculture's complacent response, see Linda J. Lear, "Bombshell in Beltsville: The USDA and the Challenge of 'Silent Spring'," *Agricultural History* 66:2 (1992), 151-170.

Nov. 13 The Radical Critique of Science in the 1960s

For an overview of new perspectives on science in the second half of the century see J.R. Ravetz, "Orthodoxies, Critiques and Alternatives," in R.C. Olby, et al. *Companion to the History of Modern Science* (London: Routledge, 1990), pp. 898-908.

Note: Second Take-Home Exam Due

Discussion Section: The Environmental Sciences

Nov. 18 Geophysics and the Global Perspective

R.E. Doel, "The Earth Sciences and Geophysics," in Krige and Pestre, eds. *Science in the Twentieth Century*, pp. 391-416.

Nov. 20 Particle Physics and the Search for a Final Theory: (Post) Cold War Physics

On recent particle physics see Frank Close, Michael Marten and Christopher Sutton, *The Particle Explosion* (New York, Tokyo and Melbourne: Oxford University Press, 1987), pp. 7-19. On big science in general, see Peter Galison, "The Many Faces of Big Science," in Peter Galison and Bruce Hevly, eds. *Big Science: The Growth of Large-Scale Research* (Stanford, CA: Stanford University Press, 1992), pp. 1-17.

For a study of the SSC controversy see Daniel J. Kevles, "The Death of the Superconducting Super Collider in the Life of American Physics," 1995 Preface to *The Physicists: The History of a Modern Scientific Community in America* (Cambridge, MA and London: Harvard University Press, 1995), pp. ix-xlii.

Discussion Section: Post-War Physics: Particles and Politics

Part V: Beyond the Cold War

Nov. 25 Genetic Engineering and Biotechnology

Sally Smith Hughes, "Making Dollars Out of DNA: The First Major Patent in Biotechnology and the Commercialization of Molecular Biology, 1974-1980," *Isis* 92 (2001), 541-75. See also Judson, "A History of Gene Mapping," pp. 60-80.

Nov. 27 Film: "Gattaca"

Written and directed by Andrew Niccol, Columbia Pictures, 1997.

Thanksgiving: No Discussion Section

Dec. 2 The Human Genome Project

On the background to the project see Daniel J. Kevles, "Out of Eugenics: The Historical Politics of the Human Genome," in **Kevles and Hood** eds., pp. 3-36. For contrasting perspectives see James D. Watson, "A Personal View of the Project," *ibid*, pp. 164-173, and Evelyn Fox Keller, "Nature, Nurture, and the Human Genome Project," *ibid*, pp. 281-299.

The Human Genome Project is coordinated by the U.S. Department of Energy and the National Institutes of Health. Information on it, including its own historical timeline, can be found at its web-site: http://www.ornl.gov/TechResources/Human_Genome/home.html

Dec. 4 The Human Genome Project and the Future of Biology

Reading as for Dec. 2. Note in particular the way the DOE has responded to criticism of the HGP in the formation of its next program, Genomes to Life: Biological Solutions for Energy Challenges.

Discussion Section: The Human Genome Project

Dec. 9 Stem Cell Research

On James Thomson at UW-Madison see Katherine Esposito, "The Cell Scientist," *Isthmus*, 09/08/00, pp. 9-10.

For NIH reports see: "Stem Cells: Scientific Progress and Future Research Directions." Department of Health and Human Services, June 2001 (in the course packet, but located at <http://www.nih.gov/news/stemcell/scireport.htm>), and "NIH Strategies for Implementing Human Embryonic Stem Cell Research." Department of Health and Human Services. February 28, 2002 (in course packet and at <http://www.nih.gov/news/stemcell/022802implement.htm>).

Dec. 11 How Political is Accuracy? Missile Testing

Donald Mackenzie, "Nuclear Missile Testing and the Social Construction of Accuracy," in Mario Biagioli, ed. *The Science Studies Reader* (New York and London: Routledge, 1999), pp. 342-357.

Note: Final Take-Home Exam Distributed

Discussion Section: Perspectives on Projections (of Mice and Men and Missiles): The Dependence of Scientific Research on Future Scenarios

Saturday Dec. 21 Final Examination Due by 12 Noon

