

History of Science 203

Science in the 20th Century: A Historical Overview

Fall 2006

3 Credits; Z (Humanities or Social Studies)

2 hours lecture (1:20pm MW, 5106 Social Sciences), 1 hour discussion.

Instructor

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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 for \$18.68 from the L&S Copy Center, 6120 Social Science.

All reading materials are also available on reserve at the College Library.

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. 4; due Oct. 11.

Second Take-Home Exam (25%): Distributed Nov. 8; due Nov. 15.

Final Take-Home Exam (30%): Distributed Dec. 13; due Thurs. 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 Wed. Dec. 13.

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 fulfill 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://www.mcburney.wisc.edu/>] 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).

Syllabus

Items on the Book List are referred to by name (eg. **Paul**, chaps. 1-2). 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. 6 Introduction: Time Machines

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. On 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. 11 The Discovery of X-rays and Science at the 1900 World's Fair

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.

Bettyann Holtzmann Kevles, *Naked to the Bone: Medical Imaging in the Twentieth Century* (New Brunswick: Rutgers Univ. Press, 1997), pp. 9-32.

Part II: Biology and Society: Eugenics and Genetics

Sept. 13 Darwin's Legacy: Biology and Society circa 1900

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

Discussion Section: Science and Society

Sept. 18 The Rediscovery of Mendel

A useful overview of the development of genetic mapping from the nineteenth century right through 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 only read up to his discussion of *Drosophila*, pp. 37-49. Continue reading **Paul**, chap. 3.

Sept. 20 Model Organisms and the Rise of Experimental Genetics

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

Discussion Section: Model Organisms, Genetics and Eugenics

Sept. 25 Practical Breeding, 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.

Sept. 27 Biochemistry and World War I

Prina 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.

Discussion Section: The Rise of the Experimental Life Sciences

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

Oct. 2 Albert Einstein and the Rise of Theoretical Physics I

For Poincaré on space and time and an excerpt of his speech to the 1900 Congress of Physicists read Henri Poincaré, *Science and Hypothesis* in idem, *The Value of Science*, edited by Stephen Jay Gould (New York: Modern Library, 2001), pp. 73-74 and 109-117.

Miller, chaps. 1 and 3.

Note: Yom Kippur

Oct. 4 Einstein and Theoretical Physics II

Miller, Intermezzo and chap. 6 (pp. 173-213).

Note: First Take-Home Exam Distributed

Discussion Section: Einstein and the Development of Theoretical Physics

Oct. 9 Scientists and the Great War

Rhodes, pp. 86-103.

Oct. 11 Physics, Politics and Philosophy

On Eddington and the eclipse expedition read Matthew Stanley, "'An Expedition to Heal the Wounds of War': The 1919 Eclipse and Eddington as Quaker Adventurer," *Isis* 94 (2003): 57-89.

For an account of Bohr's work read Rhodes, pp. 53-85. On his philosophy more generally read 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.

Note: First Take-Home Exam Due

Discussion Section: Physics, Politics, Philosophy and War

Oct. 16 Science and Fiction: Nuclear Physics and the Concept of the 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.

Oct. 18 “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, read **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.

Discussion Section: The Atomic Bomb as Organized Science

Part IV: Cold War Sciences

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.

Oct. 25 Humans, Machines and Society (Computers and Cybernetics)

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 read Sherry Turkle, “Multiple Subjectivity and Virtual Community at the End of the Freudian Century,” *Sociological Inquiry* 67:1 (1997), 72-84.

Discussion Section: Mind-Man-Machine

Oct. 30 Molecular Genetics: Pathways to the Double Helix

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 read further in Judson, “A History of Gene Mapping,” in **Kevles and Hood**, eds. pp. 49-60.

Nov. 1 “A Personal Account” in Context: Watson and Crick’s Double Helix

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

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

Nov. 6 Molecular Biology

Watson’s account drew vigorous responses from other scientists and commentators. Read 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.

Nov. 8 Nature Management and the Rise of Environmentalism

For excerpts from two classics of environmentalism read 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, 85-100.

Linda J. Lear, "Bombshell in Beltsville: The USDA and the Challenge of 'Silent Spring'," *Agricultural History* 66:2 (1992), 151-170.

Note: Second Take-Home Exam Distributed

Discussion Section: The Environmental Sciences

Nov. 13 Test and Protest: The Radical Critique of Science in the 1960s

For an overview of new perspectives on science in the second half of the century read 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.

Nov. 15 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.

Note: Second Take-Home Exam Due

Discussion Section: Environmentalism and Geophysics

Nov. 20 Big Science and the Challenges facing Post Cold War Physics

On big science, read 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 political challenges 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. On the challenges nature poses read Harry Collins and Trevor Pinch, "Set the Controls for the Heart of the Sun: The Strange Story of the Missing Solar Neutrinos," in idem, *The Golem: What You Should Know about Science* (Cambridge: Canto, 2nd ed. 1998), pp. 121-138.

Nov. 22 Film: "Gattaca"

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

Thanksgiving: No Discussion Section

Part V: Beyond the Cold War

Nov. 27 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. Read also the final part of Judson, "A History of Gene Mapping," in **Kevles and Hood** eds., pp. 60-80.

Nov. 29 The Formation of the Human Genome Project

On the background to the project read Daniel J. Kevles, "Out of Eugenics: The Historical Politics of the Human Genome," in **Kevles and Hood** eds., pp. 3-36. For contrasting perspectives read 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/sci/techresources/Human_Genome/home.shtml

Discussion Section: The Human Genome Project

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, Genomics: GTL.

Claude Alvares, "Does the Real World Need 'Modern' Science?" in Tom Wakeford and Martin Walters, eds. *Science for the Earth: Can Science Make the World a Better Place?* (Chichester, NY: John Wiley, 1995), pp. 65-86.

Dec. 6 Stem Cell Research

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

For NIH reports read: U.S. Department of Health and Human Services, "Executive Summary," in *Stem Cells: Scientific Progress and Future Research Directions*, June 2001, <http://stemcells.nih.gov/info/scireport>, pp. ES1-ES10 and Department of Health and Human Services, "NIH Strategies for Implementing Human Embryonic Stem Cell Research," February 28, 2002, <http://www.nih.gov/stemcell022802implement.htm>, accessed 7/30/02. See also the NIH website <http://stemcells.nih.gov/index.asp>.

Robert Best and George Khushf, "The Stem Cell Controversy in the United States: Scientific, Philosophical, Political and Theological Aspects," in *Grenzüberschreitungen/Crossing Borders: Kulturelle, religiöse und politische Differenzen im Kontext der Stammzellenforschung weltweit/Cultural, Religious, and Political Differences Concerning Stem Cell Research. A Global Approach*, eds. Wolfgang Bender, Christine Hauskeller and Alexandra Manzei, (Münster: agenda, 2005) pp. 241-262.

Discussion Section: Stem Cells and Science in the 21st Century

Dec. 11 How Political is Accuracy? Missile Testing and Missile Defense

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.

Dec. 13 Of Mice and Men and Missiles: Concluding Thoughts

Note: Final Take-Home Exam Distributed

Discussion Section: Review

Thursday Dec. 21 Final Examination Due (7:45 – 9:45 A.M.)

Grading Criteria

- A: For outstanding essays only. The thesis and argument are clear, thought-provoking, and based on correctly understood facts. Material used to support the argument synthesizes ideas from different parts of the course (readings, lectures, discussions from different weeks). The relationships drawn between facts and ideas are sophisticated, subtle, and/or original. The writing is grammatically correct and succinct, and the argument flows well from point to point. Not a word is wasted!
- AB: For very good essays that for some reason fall short of the criteria described above. The argument may be murky at one point; information may be presented that doesn't directly or clearly contribute to the argument; the writing style may be awkward occasionally, or flawed by one or two consistent (if minor) grammatical errors.
- B: The basic good grade. The essay may pursue a straightforward but not particularly deep or sophisticated argument; it is okay as far as it goes, but doesn't penetrate into the material very far. It may have a flash of brilliance that isn't brought to fruition, because it is counterbalanced by a weakness in argumentation, minor grammatical problems, and/or a significant misunderstanding of events or chronology.
- BC: The essay shows some of the basics of the ideal essay, but is weakened by a lack of serious thinking, or by writing problems. It may make superficial connections without offering sufficient evidence to make the connections plausible or persuasive, or it may have what is in principle a good argument supported by incorrect facts or chronology. Alternatively, it may provide a fairly solid argument with minor flaws, from which the reader is continually distracted by awkward or ungrammatical prose.
- C: A grade signifying some serious problem in essay writing. It may deliver facts without a recognizable thesis or argument; it may wander away from the point; or it may be a thoughtful attempt so weakened by writing problems (grammar, punctuation, word choice) that it is difficult for the reader to understand a crucial point you are trying to make.
- D: A marginal grade. There may be enough here to show that you have attended a few lectures and/or done some of the reading, but the essay indicates no attempt at synthesis or thinking on your own, or shows a serious misunderstanding of the nature of the material and/or the assignment. Also used for essays that are just barely coherent.
- F: For unacceptable essays. An essay may be judged unacceptable if it contains plagiarism; if it consists primarily of content inappropriate to the question or the material for this course; if it shows a complete misunderstanding of the course content; or if the writing fails to meet standard college-level requirements of basic communication in English.

Note that **plagiarism** is grounds for automatic failure on the assignment. If you use three or more words in a row from another source, the phrase must be placed in quotation marks and footnoted. Otherwise it is plagiarism. For more on what constitutes plagiarism and how to avoid it, consult *A Pocket Style Manual* by Diana Hacker, or the UW-Madison Writing Center website.