History of Science 108:
Science in the Twentieth Century

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Class Hours T Th 3:30-4:50
Center Hall 105

I. Synopsis The twentieth century witnessed radical changes in scientific understanding of the natural world. By the end of the century, humans had an altered vision of space and time, the nature of matter, the mechanism of human inheritance, and the workings of our planet and its place in the solar system. The new views resulted in a world far less predictable and more unstable than previously imagined. Time, once thought to be absolute, was now seen to be relative to one's frame of reference. Events on an atomic level were discovered to be indeterminate and acausal. Inheritance was discovered to involve the random distribution of genetic traits. Rocks—our very image of solidity—were found to be constantly moving beneath our feet. In the midst of all this conceptual change, humans also fulfilled the centuries-old ambition of travel to another planet, one of history's greatest technological feats. This course examines these changes, and the social, cultural, intellectual and political context in which they arose. At the end of the course, we will address the question: should we understand conceptual change as progress, in which wrong ideas are replaced by right ones, or does the history of science lead us to believe that our current ideas are simply another world view, which will prove as perishable as those of the past?

II. Required Texts Five books are required, on sale *at the UCSD bookstore* and on reserve at Geisel Library. Additional readings will be on electronic reserves at the library.

1. Albert Einstein, *Relativity: The Special and the General Theory*, Crown Books.

2. Peter Galison, *Einstein's Clocks, Poincare's Maps*, W. W. Norton & Company.

3. Naomi Oreskes, *Plate Tectonics: An Insider's History of the Modern Theory of the Earth*, Westview Press.

4. Walter A. MacDougall, …*The Heavens and the Earth: A Political History of the Space Age*.

5. Thomas S. Kuhn, *The Structure of Scientific Revolutions*, University Of Chicago Press.

For motivated students with a strong scientific background, the following is also recommended:

Robert Olby, *The Path to the Double Helix,* Dover Publications.

III. Logistics

Expectations and requirements I expect you to come to class each day, and to do the assigned readings. You will probably find the readings most manageable if you do them consistently after each lecture.

Late/make-up policy It's simple: Don't be late and don't miss exams! I do *not* offer make-up assignments except in case of illness or personal crisis, as documented by an appropriate official (dean, doctor, oral surgeon, ambulance driver…). If you anticipate a problem, come see me right away. I am nicer at the start of the term than at the end.

Coffee with the professor I encourage you to come to office hours throughout the term, but in addition, I will be available to have coffee with anyone who would like to come and chat on Thursday April 12. We can meet after class and grab a cup at the coffee cart. Please come, because if no one shows up I feel rejected. ☺

IV. Grading and Section (something new this year….)

Thanks to a new program in the history department, this class is offered with two options: a standard lecture-based option, and a writing-based option. In the standard option you come to class, take the exams, and that's that. In the writing-based option, you attend section, where you will discuss historical ideas and methods and write a term-paper, in exchange for which you get to skip the second hour exam and have the remaining exams count for less in your grade. The writing based option is STRONGLY recommended for all history majors and minors, and encouraged for any one who would like the opportunity to improve their writing and research skills.

Grading		Option 1		Option 2
Hour Exam 1		30%		20%
Hour Exam 2		30%		----
Final Exam		40%		30%
Research Paper				30%
Section Participation				20%

IV. Schedule of Lectures and Required Readings

Part I. The transformation of Physics
Before 1900, physicists thought they had the world figured out. Time and space were absolute, interactions of matter and energy were deterministic, and light traveled through an all-pervasive ether. Physics was orderly and explicable, until…

T 4/3 Introduction: From the mechanical world view to relativity
P.H. Harmon *Energy, Force and Matter: The Conceptual Development of Nineteenth Century Physics,* Cambridge University Press, 1982, 1985, pp. 1-11 and 72-119.

Sir Isaac Newton, P*rincipia Mathematica [Mathematical Principles of Natural Philosophy],* translated by F. Cajori, University of California Press, 1962, pp.1-12

Th 4/5 Relativity: the special theory and general theories
Einstein, *Relativity*, 1-78. [This isn't easy, but when you get it, you'll be pleased.]

T 4/10 Where did relativity come from (part 1)? The traditional view
H A Lorentz, 1895, "Michelson's Interference Experiment" reprinted in *Einstein, Lorentz, Weyl, Minkowski: The Principle of Relativity: A Collection of Original Papers on the Special and General Theory of Relativity, with notes by A. Sommerfeld,* Dover Publications, 1952 pp. 3-7.

Gerald Holton, *Thematic Origins of Scientific Thought: Kepler to Einstein,* Harvard University Press, 1973, pp. 165-195 and 261-352.

Th 4/12 Where did relativity come from (part 2)? Railroads, clocks & longitude.
Peter Galison, *Einstein's Clocks, Poincare's Maps: Empires of Time*, W. W. Norton and Company, 2003, pp. 15-41 and 221-293.

T 4/17 Did Einstein make "everything relative"?
Loren R. Graham, The reception of Einstein's Ideas: Two examples from contrasting political cultures, in *Albert Einstein: Historical and Cultural Perspectives,* edited by Gerald Holton and Yehuda Elkana, Princeton University Press, 1982, pp 107-136.

Gerald Holton, "Einstein's Influence on the culture of our time," in *Einstein, History, and Other Passions*, Addison Wesley, 1996, pp. 125-145.

Th 4/19 Science and its cultural origins: The "Forman thesis"
Paul Forman, "Weimar Culture, Causality, and Quantum Theory, 1918-1927: Adaptation to a Hostile Intellectual Environment," in C. Chant and J. Fauvel, editors, *Darwin to Einstein Historical Studies on Science and Belief,* Open University, 1980, pp. 267-302.

John Hendry, "Weimar Culture and Quantum Causality, in C. Chant and J. Fauvel, editors, *Darwin to Einstein Historical Studies on Science and Belief,* Open University, 1980, pp. 303-326.

T 4/24 <u>First hour exam in class.</u>
The exam will consist of fact-based short answers (40%) and two essay questions (60%). I will give you a list of potential essay questions in advance, to help guide your review.

Part II. The transformation of biology Unlike physicists, biologists at the start of the century admitted they had troubles. Darwin had convinced the world of the reality of evolution, but no one had any idea how it happened. What, in particular, was the mechanism of inheritance? This became a focus of scientific attention, ultimately creating a new field of science—molecular biology—culminating in the proof that DNA is the stuff of inheritance, and the unraveling of its structure.

Th 4/26 From proteins to DNA: Avery, Chargaff, and the Hershey-Chase experiment
Garland Allen, "The Origin and Development of Molecular Biology," Chapter VII in *Life Science in the Twentieth Century,* Cambridge University Press, 1975, pp. 187-228.
[For those reading Olby, *Path to the Double Helix,* 70-295]

T 5/1 The great discovery: The double helix structure of DNA
James Watson, *The Double Helix,* New York, Athaneaum, 1968, 68-74.
[Olby *Path to the Double Helix*, 297-352 and 385-443]

Th 5/3 Fame, fairness, & scientific credit: Ostwald Avery and Rosalind Franklin
Gunther Stent, "Prematurity in Scientific Discovery," in *Prematurity in Scientific Discovery: On Resistance and Neglect,* edited by Ernest B. Hook, pp. 22-33.

Norton D. Zinder, "The timeliness of the discoveries of the three modes of gene transfer in bacteria," in *Prematurity in Scientific Discovery: On Resistance and Neglect*, edited by Ernest B. Hook, pp. 59-69.

Naomi Oreskes, "Stepping forward too far?" *Science* 300 (16 May 2003): 1094-1095.

Aaron Klug, "Rosalind Franklin and the Discovery of the Structure of DNA," *Nature* 219 (24 August 1968): 808-810, 843-844, and 880.

Sharon Bertsch McGrayne, "Rosalind Elsie Franklin," *Nobel Prize Women in Science,* Birch Lane Press, 1993, pp. 304-332.

T 5/8 Molecular biology since 1953
Reading: To be announced …

Part III. The Exploration/Transformation of Space The Twentieth Century saw space exploration take off from the pages of science fiction to become a heavily funded and very public science. This unit will discuss the technological, scientific, political and social aspects of the US and Soviet Space Programs. We will explore the question of whether or not space exploration was a technological/scientific revolution or a political pet project. We will ask what science was done in the name of the space program. We will ask what policy agendas were served by the program. Finally, we will also ask what social impact

the space program had and what the state of space science and exploration today says about the legacy of the space program.

Th 5/10 From Hobbyist "Rocketeers" to NASA Administrators: How Technological Systems Are Born, How New Frontiers are Established
Steven Pyne, "Seeking Newer Worlds," in *Critical Issues in the History of Spaceflight*, ed. S. Dick (Washington, DC: NASA History Division, 2006), pp 7-35.

Walter McDougal, …*The Heavens and the Earth*, pp 3-111.

Optional: Walter McDougall, "Technocracy and Statecraft in the Space Age – Toward the History of a Saltation," *The American Historical Review* 87, no. 4 (Oct., 1982), pp. 1010-1040.

T 5/15 Space Science and the New Frontier: Planetary Science from the Moon to Mars
Joseph N. Tatarewicz, "Federal Funding and Planetary Astronomy, 1950-75: A Case Study," *Social Studies of Science* 16 (1986), pp 79-103.

Walter McDougal, …*The Heavens and the Earth*, pp 112-230.

Optional: McDougal, …*The Heavens and the Earth*, Part IV.

Th 5/17 Do We Really Live In A Space Age? Societal Impacts of Space Exploration
Walter McDougall, …*The Heavens and the Earth*, pp 301-407.

Optional: McDougal, …*The Heavens and the Earth*, Part VI.

T 5/22 <u>Second hour exam in class</u>. Format as per first exam.

IV. The transformation of earth science. At the start of the twentieth century, geologists knew great deal about the Earth, its history, and the species that had inhabited it through time, but they lacked a unifying theory to put it all together. In 1912, German geophysicist Alfred Wegener suggested that many questions could be answered and problems solved by accepting the idea that the continents are in motion. Most scientists rejected his views, despite considerable supporting evidence. Thirty years later, moving continents became established fact. Why was the idea rejected the first time and accepted the second? What does this tell us about science and scientists?

T 5/22 Problems in Earth Science, and how continental drift could solve them
Oreskes, *The Rejection of Continental Drift*, 3-80

Th 5/24 The Rejection of Continental Drift
Oreskes, *The Rejection of Continental Drift*, 80-120.

T 5/29 The question re-opened: Marine geophysics and discovery of sea-floor spreading
Plate Tectonics, 28-107.

Th 5/31 Making and proving the new theory
Plate tectonics, 128-147, 155-190, 201-224, 331-345 and editor's note on 406.

Part V. The idea of a scientific revolution

T 6/5 Scientific change: The idea of scientific revolutions
Kuhn: Structure of scientific revolutions, 1-91.

Th 6/7 Conclusion: If science isn't true, then why does it work?
Kuhn, Structure of scientific revolutions, 92-173.

FINAL EXAM as scheduled by university registrar
RESEARCH PAPER FOR THOSE IN GRADING OPTION 2 – DUE JUNE 5.