Stevens Institute of Technology
HHS 479 / CAL 529

History of Modern Science and Technology

Fall 2011
Mondays 6:15pm–8:45pm

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SYLLABUS
(draft as of June 28, 2011)

Advances in science and technology since the Renaissance have been extraordinary. In this course, we will survey those advances—in physics, industrial technology, chemistry, electricity, biology, social science, and medicine.

Of particular interest will be the methods that distinguish modern science. It is not just that Galileo, Newton, Faraday, Darwin, or Koch discovered things their predecessors did not, it's that they went about their work in a way different from the way a scientist (or "natural philosopher") in pre-modern times did. In watching these scientists at work, we want to understand their methods. We will find they were not all using "the scientific method" as we learn it today. What can they teach us about how best to pursue our own scientific, technological and engineering work?

To find out, we will mostly use primary sources; secondary sources will supplement, especially in the latter half. In other words, we will rely more on our own reading of, for example, Galileo, Darwin or Maxwell than on what some modern commentator says about them. We'll use the secondary sources to provide overviews of the period we are studying. In both writing and class preparation, you will have a chance to conduct your own historical research. If you happen to know a little Greek or Latin, you might get to use it.

When we finish, you will have an understanding of the different ways scientists have tried to explain nature and the implications of those attempts—both for them and for us.

We will concentrate on the period from the Scientific and Industrial Revolutions to the beginning of the twentieth century. The course will provide not just an overview of the history of western science, but also a foundation and context for further study in, say, the history of twentieth-century technology or the contemporary philosophy of science.

Course grade
Your course grade will be based on class participation and papers, according to the following schedule:

35% Class Participation
10% 1000-word paper #1
15% 1000-word paper #2
20% 1000-word paper #3
20% 1000-word paper #4
} or: 40% 2500-word research paper

Graduate students are encouraged to take the option of writing one research paper instead of the third and fourth short paper. Undergraduates may do so only with my approval.

The topics for the papers will be mutually agreed upon. Throughout our classroom discussions, I will note good paper topics as they come up.

Grades
I have no reservation about giving all As. I have no reservation about giving Bs and Cs. In a small seminar class, as this one is, I am capable of finding enough time and energy to help any student excel who wants to. The concepts in this course are not difficult. Wide and deep prior knowledge is not required. The reading can be heavy, and I demand critical thinking and clear presentation, but any Stevens student interested in history or philosophy of science, willing to budget the time, and committed to coming to every class prepared can do well in this course.

Course participation
When I say that 35% of your grade is for class participation, I'm serious. I do not mean class attendance, I mean active classroom participation. If you write all A papers but never engage in the class discussion, you could get a C for the course. Moreover, when I say class participation, I mean quality, not quantity. You do not need to be a pushy big-mouth. You can be reserved and naturally quiet. But you need to show me you have read and thought about the assignments, and you must be ready to engage in scholarly discussion with me and your classmates. I will make sure everyone has the opportunity to do so.

Workload and Pace
The course is a seminar and not a lecture. You will not sit and listen to me tell you what was in the readings. You must do all the week's reading *before* class, reflect on what you have read, and come ready to discuss it.

There will be a lot of reading. Fortunately not all the material needs to be read with equal care, and I'll give you hints along the way on how best to manage it. For example, we will in one week go through all of Isaac Newton's *Principia*. But we'll not really "read" all of it. You will, however, get a good grasp of all of what is in it. At other times, half the assignment might be the close reading of just a couple pages.

The papers are not long and do not require extensive outside research. They are due in weeks when the reading load is (a little) lighter, and due later in the week than our class. The workload will ramp up quickly and stay moderate to heavy for several weeks. I'll tweak the syllabus as we get near the end to accommodate students' interests.

We meet only once a week. That leaves you a lot time for reading. Do *not* wait until two or three days before class to start on a week's reading. If you do, you will not have enough time to finish all the material, reflect on it, and prepare for the class discussion.

Plagiarism
In a course like this, where the main focus is on analyzing the work of other writers, some students may need to learn more about how to incorporate and reference that other work while not appearing to attempt to pass off another's work as ones own. If you are in that situation, start at library.stevens.edu/plagiarism, but then feel welcome to talk to me too.

Intentionally trying to pass off another's work as your own is plagiarism. Until I had a student claim to have written what he copied nearly verbatim from an old journal article, I never thought I'd see a case of plagiarism at the high-end institutions where I teach. But now that I have, let all be forewarned. Some professors prefer to handle cases of plagiarism themselves, exercising their own discretion, and working the matter out with the student one on one. I don't. I prefer to utilize the school's formal procedures. This makes my life much easier, and it places decision-making authority in the hands of a panel composed of fellow students.

And therein lies the warning: My experience is that in cases of honest ignorance about how to incorporate the work of others into one's own writing, there is nothing to fear, but in unambiguous and blatantly intentional cases of plagiarism, a panel of students judging other students can be flat-out merciless.

Texts **Warning: The bookstore will not have everything you need.**

We have a lot of material to read, but I've tried to keep costs down with public domain texts, course reader excerpts, and books you can find used.

Get paper copies. Do not rely on on-line copies. I prefer you have copies you can mark up, so I also prefer you not use library books.

You need to exercise judgment on what to buy. Except for the course reader the bookstore will have copies of what you need, but with good student programs at www.amazon.com/student, www.barnesandnoble.com, and www.textbooks.com, I presume you would rather buy online. I have posted a list of the books (except the course reader) at http://www.amazon.com/registry/wishlist/2KL738A2H4I75?sort=priority.

1. Buy the course reader from University Readers (www.universityreaders.com). **The bookstore will not have this and you need it right away. It is expensive and non-returnable.**
2. Buy the following. You might find used ones, but get these editions. The bookstore will have some copies.
    a. Michael Harvey, *The Nuts and Bolts of College Writing* (Hackett, 2003). It's short. Get it. Read it. If you have read it, read it again. When you are in the middle of a writing project, pick it up and read some little section again. That's what I do.
    b. Eric Dorn Brose, *Technology and Science in the Industrializing Nations 1500–1914*, second edition (Humanity Books, 2006). Be sure to get the second edition.
    c. *Faraday's Experimental Researches in Electricity: The First Series*, edited and annotated by Howard J. Fisher (Green Cat Books/Green Lion Press, 2004.) This is the thin, 84-page 2004 book for about $9, not the 619-page 2001 book with a similar title for $35.
    d. Karl Popper, *The Logic of Scientific Discovery* (Routledge, 2002). This edition, the second English edition, has been reprinted frequently since 1967. Any used copy after that is fine, but since used copies cost $10-$15 and you can get new ones for about the same price, you might as well buy a new one.
3. Get some edition of the following. You may already have a copy. I've noted my recommendations. The bookstore will have some copies of the editions I recommend.
    a. Francis Bacon, *Novum Organum* (sometimes printed as *New Organon* or *Instauratio Magna).* There are many translations and printings. Any will do. I normally would say

that you should not get an abridged or excerpted edition, but this one, I do know, has everything we need; it also has other good material and is inexpensive: Francis Bacon, *Selected Philosophical Works,* edited by Rose-Mary Sargent (Hackett, 1999).

b. Charles Darwin, *On the Origin of Species*. There are many printings of this. Get any unabridged version based on the first, 1859, edition. I recommend the Penguin Classics edition of 2009 with the introduction by William Bynum.

c. Isaac Newton, *Principia.*
    i. The cheap version is the Motte translation printed in the Great Mind Series by Prometheus Books, 1995. It's not superb but it will do.
    ii. The scholarly translation is by Cohen and Whitman, but it costs over $40 and has much we won't need. Buy it if you plan to work more in history of science.
    iii. (If you'd get a kick out of working through some of Newton's math, also get *Newton's Principia: The Central Arguments*, by Dana Densmore.)

4. Don't buy the following yet. We might add them, depending what we decide to do in the later weeks.
    a. Werner Heisenberg, *Physics and Philosophy*. Don't buy this yet. We might skip it. But if we don't, any edition will do. Used copies costing a few dollars are plentiful.
    b. Karl Popper, *The Logic of Scientific Discovery*, (Routledge, 2002). This edition, the second English edition, has been reprinted frequently since 1967. Any used copy after that is fine.
    c. Thomas Kuhn, *The Structure of Scientific Revolutions*. Don't buy this yet. In the past I've had students ask that we read it. We'll see what students want this time.

Finally

I consider past student evaluations of my courses and the comments posted at www.johnmccaskey.com, www.ratemyprofessors.com, etc. to be fair. If they are, you will find me supportive but demanding (especially in class engagement and in the quality of your writing), the readings thought-provoking, classroom meetings stimulating and fun, and the course overall rewarding and memorable. I'll do all I can to ensure you do.

Assignments.

This will likely change. I'll adjust as I learn students' interests.

Meeting 1
Aug 29

What makes science science?

Handouts that we will read in class. I will bring copies.

- Euclid's proof that the angles of a triangle add to 180°, *Elements*, bk. 1, prop. 32.
- Hooke's Law. Robert Hooke, *On Spring*, 1678, pp. 1–4.
- "The Primary Prevention of Coronary Heart Disease in Women," *The New England Journal of Medicine* (June 29, 1995).
- Super Bowl Indicator
- Patti, Tereskerz, "Can We Bank on Objectivity?" www.scienceprogress.org.

Meeting 2
Sep 12

We don't meet on Labor Day, so you have two weeks to read this.

Do yourself a favor and get a jump on the following week by reading the material on *Physics* 4.8.

Also good time to read *Nuts & Bolts*.

Some perennial philosophical issues, starting in Classical Greece

Read and prepare to discuss the following. These are all in the course reader.

- Aristotle on Pythagoras, *Metaphysics* 1.5, 985b23–986a13.
- Plato on the ultimate constituents of creation, *Timaeus*, 52d–53d, 89c.
- These selections from Aristotle. In the Irwin and Fine readings, an asterisk indicates a word included in the Irwin and Fine glossary. The necessary glossary pages are included in the course reader.
    - *Posterior Analytics* I.2 (on episteme).
    - *Posterior Analytics* I.13 (on fact vs. reasoned fact). Figure out what the two syllogisms are.
    - *Physics* II.3 (on four kinds of causes). Read http://faculty.washington.edu/smcohen/320/4causes.htm, especially the first half, if this topic of Aristotle's four causes is new to you.
    - Beginning of *History of Animals* II.15 (labeled chapter XI in Cresswell's edition) (on the esophagus).
    - *Parts of Animals* III.3 (on the esophagus and windpipe).
- *Posterior Analytics* I.5 (on knowing triangles universally).
- Pierre Duhem, *To Save the Phenomena*, pp. 5–11.

Meeting 3
Sep 19

A light assignment that includes outside research that should be fun.

Write your paper now, because next week is tough.

The Technological and Scientific Renaissance, mid 1500s

Read and prepare to discuss the following, all in the course reader.

- William of Ockham, "Do the elements remain in a mixed thing?" *Quodlibetal Questions*, Third Quodlibetal, Question 5, pp. 185–89.
- Bernardino Telesio, Prooemium to book 1 of *De Rerum Natura*.
- Copernicus, "To the Reader" and "Preface," *De Revolutionibus*.

Do the following outside research.

- The 1540s were a remarkable time in the history of science. Books of tremendous importance were published in about a half-dozen separate fields. Pick an author and a book, track it down, read selections from a modern translation if necessary, and then be prepared to discuss what was found. Possibilities include Copernicus, Fuchs, Vesalius and Agricola, Benedetti. (Maybe Leonardo, too, though he was a little earlier.)

Between meetings 3 & 4
Sep 23

FIRST PAPER DUE by Friday, September 23, 8:00 pm

Before submitting your paper, remember to read or dip back into *The Nuts and Bolts of College Writing*.

Meeting 4
Sep 26

A lot of difficult reading this week.

Plan accordingly.

Some material has to be read slowly and carefully, some otherwise.

Don't confuse one for the other.

Methodological debates of the Scientific Revolution, early 1600s.
The early seventeenth century witnessed several contentious debates over what was and was not the proper way to study nature. An author could have his books banned over this or even get himself burned at the stake. Galileo was forced to recant some of his scientific beliefs. Philosophers, scientists, politicians, and the pope all weighed in. In this week, we'll explore four views of science, those of Cardinal Bellarmine, Galileo, Francis Bacon, and Rene Descartes, and scientific works based on each.

Read and prepare to discuss the following.

- Bellarmine's scientific method: "Cardinal Bellarmine to Foscarini, April 12, 1615," in the course reader.
- Bellarmine's science: *Louvian Lectures of Bellarmine*, ed. Ugi Baldini and George V. Coyne, 8–22 (even); in the course reader.

- Galileo's scientific method: "Galileo to Castelli (21 December 1613)," in the course reader.
- Galileo's science: Selections from Galileo, *Dialogues Concerning Two New Sciences*, on equal speed of descent regardless of weight, pp. 65–75 in Wall & Emerson, 2000 edition, in the course reader.

- Bacon's scientific method: Francis Bacon, *Novum Organum*. "Proemium"; the "Plan of the Work" through the description of the second part of the work (about six pages); Book 1, Aphorisms 1–38.
- Bacon's science: *Novum Organum*, Book 2, Aphorisms 10–20 (you can skim most of this, but slow down to see what the three tables are, and pay attention to the beginning and end of Aphorism 20); *Sylva Sylvarum*, p. 1 in the course reader.

- Outline of Rene Descartes, *Principia philosophiae* in the course reader. There is no reason to read all of this book, but it is important to know its high-level outline and to get a sense of its scope. This chart will help. As you read through, as instructed below, see if you can figure out what the three shaded parts in the outline indicate.
- Descartes' scientific method: *Principia philosophiae*, Part 1. I'll email you a copy. Read the first few paragraphs slowly; then go quickly, reading the headings and just enough of the paragraphs to get a sense of Descartes' style of arguing; slow down at and carefully read paragraph 24; flip through the rest, slowing down to read paragraphs 30, 45, 75, 76.
- Descartes' science: Selections from Principia philosophiae, Parts 2, 3, and 4. Most is in the PDF I'll mail around; the rest is at at http://www.princeton.edu/~hos/mike/texts/descartes/desc-mot.html. Read part 2, paragraph 1; then go quickly, reading the headings and just enough of the paragraphs to get a sense of Descartes' style of arguing; notice paragraph 11 (does it say something is the same as nothing?); skim forward into the laws of motion. Switch over to the Princeton web site. Again, keep skimming, but slow down and read paragraphs 46 through 52 (i.e., rules 1 through 7). Are these rules true? Just flip quickly through the rest of the book (in the pdf file), slowing down only to read part 4, paragraphs 199 and 207.

Meeting 5
Oct 3

Isaac Newton's *Principia*, 1687

The name, method, and science of Isaac Newton dominated the following two centuries and still permeate modern thought.

Take a deep breath and pace yourself.

You are about to read the *Principia*.

Major bragging rights will ensue.

- Read the following, in this order.
  - Preface to Book 3 (p. 319 in Great Minds edition).
  - The unpublished preface, pp. 49–54 in Cohen and Whitman, in the course reader.
  - Editor's preface to 2nd edition, pp. 385-399 in Cohen and Whitman, in the course reader.
  - Author's preface to 1st edition (pp. 3–5 in Great Minds edition).
  - "Rules of philosophizing," or "Rules of Reasoning in Philosophy" at the beginning of Book 3 (pp. 320–21 in Great Minds edition).

- Skim the following, guided by my comments in the prior class. As throughout the course, we need not focus on all the details of the author's science. Read and skim so as to understand the kind of argument Newton is making and the kind of science he presents.
  - Definitions, axioms, sections 1, 2 and 3 of Book 1.
  - Book 3, through Proposition 7.

- See if you can wrap your head around Book 1, Proposition 1. These will help:
  - http://www.greenlion.com/NG3-I-1.pdf
  - http://www.johnmccaskey.com/PrincipiaProposition1.pdf.

Meeting 6
Oct 11

The Industrial Revolution, mid 1700s

We'll now start incorporating secondary sources.

This week, we meet on Tuesday not Monday

Read and prepare to discuss:

- Eric Dorn Brose, *Technology and Science in the Industrializing Nations, 1500–1914*, pp. 1–75.

Do a little research on the life of John Desaguliers (1683–1744) and poke around in his writings. You can find copies at Google Books. Prepare to discuss your impressions of what you found.

Meeting 7
Oct 17

The Chemical Revolution, late 1700s

Read and prepare to discuss:

- John Gribbin, *The Scientists*,pp. 241–284, 359–372, in the course reader.
- Selections from *A Source Book in Chemistry*, in the course reader.

Between meetings 7 & 8
Oct 21

SECOND PAPER DUE by Friday, October 21, 8:00 pm

Again, before submitting your paper, remember to dip back into *The Nuts and Bolts of College Writing.*

Meeting 8
Oct 24

A good bit of reading here.

Beginning of a Science of Electromagnetism, early 1800s

Recall Francis Bacon's method of induction; read and prepare to discuss:

- Excerpt from "Electromagnetism," *Encyclopedia Britannica* in the course reader.
- *Faraday's Experimental Researches in Electricity: The First Series.* The introduction pp. 1–28 is valuable, but if pressed for time, you can skip it at first and refer back to it as needed when reading Faraday's text. The editor's notes at the bottom of the pages can be helpful.

Week 9
Oct 31

A challenging week of hard-core philosophy of science.

A lot of reading that must be done carefully.

The 19th-Century Debate over Scientific Method
Vigorous debates over scientific method arose in the 1830s and ran through mid-century. A particularly prominent and important one was over the nature of the philosophy of induction.

Read and prepare to discuss:

- John McCaskey, "William Whewell (1794–1866)," in the course reader. This is a highly condensed summary of Whewell's epistemology. It will save us a lot of reading.
- William Whewell, "On the Logic of Induction," from *The Mechanical Euclid* (Cambridge, 1837), 172–82, in the course reader.
- William Whewell, "Attempts to Conceive Elementary Composition," in *The History of Scientific Ideas*, vol II. (London: 1858), 3–14, in the course reader.
- Richard Whately, "Of Induction," *Elements of Logic*, bk. IV, ch. 1, pp. 255–66, in the course reader.
- John Stuart Mill, *A System of Logic, Ratiocinative and Inductive*
    - "On the Ground of Induction," bk. III, ch.III ;
    - "Of the Evidence of the Law of Universal Causation," bk. III, ch. XXI;
    - "Of the Four Methods of Experimental Inquiry," bk. III, ch. VIII.
    - Of these three chapters, you need to read the first two. You might not need to read the third. It explains what are now called "Mill's Methods." You need to know what Mill's Methods are, but you don't really need to read Mill to learn them. They are now explained in shorter and often clearer form in many textbooks and web sites. If you know the methods, you don't need to read Mill's chapter on them.
    - Regardless which you read, be sure to work through the summary and examples of Mill's methods included in the course Reader.

Week 10
Nov 7

Science of the Unobservable: Evolution

The mid-19th century was also the time of remarkable and provocative scientific advances, many involving things that could not be directly observed, such as electricity, atoms, the distant past, and the core of the earth. In class, we will examine one of these, Darwin's proposal for evolution by natural selection.

Read and prepare to discuss:

- Phillip R. Sloan, "The Making of a Philosophical Naturalist," *The Cambridge Companion to Darwin*, pp. 17–39. You can read this lightly, but give attention to section IV, "The Transformation of 1831," in the course reader.
- Charles Darwin, *Origin of Species*, "Introduction" and first four chapters (to page 130 in first edition). You will find you can read through some parts of this quickly, but take care to follow Darwin's overall argument. For class, sketch out his argument in an outline or block diagram—not a lot of detail, just the central three to ten points and their relationships.
- M. J. S. Hodge, "Darwin's Argument in the Origin," *Philosophy of Science*, Vol. 59, No. 3. (Sep., 1992), pp. 461-464, in the course reader.

Week 11
Nov 14

Social Sciences and the Rise of Statistical Thinking

Read and prepare to discuss:

- A short introduction to Adolphe Quetelet, in, say, *Encyclopedia Britannica* or *Wikipedia*.
- Adolphe Quetelet, "Preface" and "Introductory," *A Treatise on Man*, in the course reader.
- James Clerk Maxwell, "Essay for the Eranus Club on Science and Free Will," in the course reader.
- James Clerk Maxwell, "Molecules," in the course reader.
- Theodore M. Porter, *The Rise of Statistical Thinking 1820–1900*, pp. 110–28, in the course reader.

Between meetings 11 & 12
Nov 18

THIRD PAPER DUE by Friday, November 18, 8:00 pm

The third paper is due here, unless you are doing the larger research paper, due later.

Again, before submitting your paper, remember to dip back into *The Nuts and Bolts of College Writing*.

Week 12
Nov 21

Don't skip class just because it's Thanksgiving week. A lot comes together here.

The Medical Revolution: Germ Theory

We'll decide later which of these to use, the Waller book or the primary documents.

- John Waller, *The Discovery of the Germ*. It's a whole book, but a small one, easy to read.

or:

- Antony van Leeuwenhoek in the course reader, "Observations," http://www.spaceship-earth.de/OrigLit/Anton01.htm.
- Robert Koch, "Methods for the study of Pathogenic Organisms," http://www.asm.org/ccLibraryFiles/FILENAME/0000000223/1881p101.pdf.
- Robert Koch, "The etiology of tuberculosis [Koch's postulates], http://www.asm.org/ccLibraryFiles/FILENAME/0000000228/1882p109.pdf.
- Robert Koch, "The etiology of tuberculosis," http://www.asm.org/ccLibraryFiles/FILENAME/0000000234/1884p116.pdf.

Regardless which of these we do, also:

- Using old medical dictionaries that you can find in Google Books, trace out the changing definition of "cholera," from 1870 to 1920.

Week 13
Nov 28

I'll tweak this according to students' interest.

20th Century: Futility of the Search for Scientific Certainty

Read and prepare to discuss:

- Read Werner Heisenberg, *Physics and Philosophy*. Pages to be determined.
- Read Karl Popper, *The Logic of Scientific Discovery*, pp. 1–73.
- Thomas Kuhn . . . ?

Week 14
Dec 5

Science at the End of the Twenty Century

Do some independent research on Intelligent Design. What are its arguments? What method does it use? Is it science? By which standards?

FOURTH PAPER (or the RESEARCH PAPER) DUE at the end of the time scheduled for our final exam.