

HOW SCIENCE WORKS

Time & Place Mondays and Wednesdays, 11 to 12:15 PM
Kimmel, Room 803

Texts *The Knowledge Machine*, Michael Strevens, Liveright, 2020.

- *Making Modern Science*, Peter Bowler and Iwan Rhys Morus, 2nd edition, University of Chicago Press, 2020. (The first edition will do at a pinch.)
- *The Structure of Scientific Revolutions*, Thomas Kuhn, University of Chicago Press, 2012. (Any edition that contains Kuhn's postscript will work. The pagination is just very slightly different in the latest edition.)
- Readings distributed via NYU Brightspace

Topics What is science? How does it work? Is there a scientific method? We will use a mix of logical argument, history, and sociology to investigate these questions. We will read the philosophers of science Karl Popper and Thomas Kuhn, as well as the early modern thinker Francis Bacon, and we will look at the history of scientific inquiry into the structure of the solar system, gravitation, the nature of heat, the question of the age of the earth, evolutionary theory, continental drift, and some modern physics including quantum theory. We'll travel into the lab with sociologists of science such as Harry Collins and Bruno Latour, as well as taking a more high-level look at the social organization of science and at the problems involved in "following the science" when formulating public policy to deal with climate change and covid.

Objectives Understand the debate about the nature of the scientific method; acquire familiarity with the ideas of some major thinkers about method

Learn to think critically about what is subjective and what is objective in scientific reasoning and argument

Appreciate the complexities and complications of scientific inquiry, both in conducting experiments and in evaluating the resulting evidence

Acquire some familiarity with a variety of illuminating episodes in the history of science

Learn some of the techniques used by sociologists to investigate science at both the micro and the macro level

Understand some aspects of the large-scale social organization of science; consider some proposals for reform

Understand some of the problems involved in applying scientific knowledge when formulating public policy

And finally: find out how science really works!

Evaluation Your total grade will be made up of:

First paper (due Oct 17)	30%
Second paper (due Dec 12)	30%
Three exercises from a choice of four (due Oct 3, Oct 31, Nov 14, Nov 28)	30%
Class participation	10%

Papers should be five to six pages long.

Exercises should be one to two pages long. Don't write more than two pages. Note that there are four exercises due on four different dates. You should only complete three of these exercises—it's your choice which three.

Extensions will be granted only for medical emergencies. However—you have two days of "free" lateness to spend as you choose on papers or exercises. For example, you might hand in the first paper one day late and the third exercise one day late, without penalty. Or you might hand in the second paper two days late, and so on. It's your choice how you "spend" these two days—just email Stephan before the official deadline letting him know that you plan to use your free extension. We suggest saving the days for when you really need them.

Participation means some combination of: turning up for class and recitations; making useful remarks or asking valuable questions in class and recitations; finding interesting and relevant examples in the science news or elsewhere to share with the class.

Attendance at lectures and recitations is not required, but absence or lateness will be noted, and will have a major impact on your participation grade.

Stephan Pohl Office hours are Monday 12:30–2:30 PM and by appointment
Room 414, 5 Washington Place
sp4963@nyu.edu (please include HSW2 or HSW3—depending on your recitation section—somewhere in the email)

Michael Strevens Office hours are Wednesday 1–2:30 PM and by appointment
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Moses Academic accommodations are available for students with disabilities. The Moses Center website is www.nyu.edu/csd. Please contact the Moses Center for Student Accessibility (212-998-4980 or mosescsd@nyu.edu) for further information. Students who are requesting academic accommodations are advised to reach out to the Moses Center as early as possible in the semester for assistance.

Integrity Academic integrity means that the work you submit is original. Bringing answers into an examination or copying all or part of a paper straight from a book, the Internet, or a fellow student is a violation of this principle. But there are other forms of cheating or plagiarizing which are just as serious—for example, presenting an oral report drawn without attribution from other sources (oral or written); writing a sentence or paragraph which, despite being in different words, expresses someone else's ideas without a reference to the source of the ideas; or submitting essentially the same paper in two different courses (unless both instructors have given their permission in advance). Receiving or giving help on a take-home paper, examination, or quiz is also cheating, unless expressly permitted by the instructor (as in collaborative projects).

HOW SCIENCE WORKS READINGS

Sources identified as “resources” (and itemized with a ◇) are to be examined rather than read. It should be obvious what level of engagement is feasible, but we will give you some guidance in the course of the semester.

Introduction

- Sep 7 Science and the Scientific Revolution
- ▷ Strevens, *Knowledge Machine*, Introduction
 - ▷ Bowler & Morus, *Making Modern Science*, chapter 2 (pp. 25–57)
- Read both at your leisure

Karl Popper’s Falsification

- Sep 12 Falsificationism
- ▷ Strevens, *Knowledge Machine*, pp. 13–22
 - ▷ Popper, *Logic of Scientific Discovery*, pp. 3–24, 27–29, 57 (intro to chapter 4), 60–67 (starting at “Thus my conflict. . .”)
- Sep 14 Eddington’s eclipse experiment
- ▷ Stanley, “An expedition to heal the wounds of war”
 - ◇ Resource: Dyson, Eddington, and Davidson, “A determination of the deflection of light”
- Sep 19 Auxiliary assumptions
- ▷ Popper, *Logic of Scientific Discovery*, pp. 264–273, 278–282
 - ▷ Strevens, *Knowledge Machine*, chapter 3, pp. 66–74
 - ▷ Douglas, “Inductive risk and values in science”
- Sep 21 The age of the earth
- ▷ Bowler & Morus, *Making Modern Science*, chapter 5 (pp. 108–133)
 - ▷ Burnet, *The Sacred Theory of the Earth*, volume 1, pp. 152–158
 - ▷ Strevens, *Knowledge Machine*, chapter 3, pp. 74–86

Thomas Kuhn’s Paradigms

- Sep 26 Kuhn on normal science
- ▷ Kuhn, *Structure*, chapters 1 through 6

- Sep 28 "A detail and depth that would otherwise be unimaginable"
- ▷ Strevens, *Knowledge Machine*, chapter 1, pp. 32–38
 - ▷ Wade, *The Nobel Duel*, chapter 8 & timeline (Appendix 1) (pp. 102–118, 284–287)
 - ▷ Waldrop, "Of politics, pulsars, death spirals—and LIGO"
 - ◇ Resource: Daw, "How does an experiment at LIGO actually work?", <https://phys.org/news/2016-02-ligo.html>
 - ◇ Resource: "Gravitational waves detected 100 years after Einstein's prediction" (LIGO press release), <https://www.ligo.caltech.edu/news/ligo20160211>
- Oct 3 Kuhn on crisis and revolution ◁ Due date
- ▷ Kuhn, *Structure*, chapters 7 through 9, 12 (omit pp. 96–103)
 - First exercise due
- Oct 5 Kuhn on revolution and progress
- ▷ Kuhn, *Structure*, chapter 13, Postscript
 - ▷ Strevens, *Knowledge Machine*, rest of chapter 1 (pp. 22–32, 38–40)
- Oct 10 Fall recess – class postponed till Tuesday

The Sociological Eye

- Oct 11 Into the laboratory
- ▷ Latour and Woolgar, *Laboratory Life*, 15–21, 45–56, 142–149, 151–159
 - ▷ Collins, "The seven sexes", 208–216
- Oct 12 Feminist critiques
- ▷ Richardson, "Sexes, species, and genomes"
 - ▷ Okruhlik, "Gender and the biological sciences"
- Oct 17 Continental drift & subjectivity in science ◁ Due date
- ▷ Bowler & Morus, *Making Modern Science*, chapter 10 (pp. 245–261)
 - ▷ Strevens, *Knowledge Machine*, chapter 2 (pp. 41–65)
 - ◇ Resource: Bekelman, Li, and Gross, "Scope and impact of financial conflicts of interest in biomedical research: A systematic review"
 - First paper due

Science's Iron Rule

- Oct 19 Bacon's new method
- ▷ Bacon, *The New Organon*, Book I §§38–65, Book 2 §§10–20
 - ▷ Strevens, *Knowledge Machine*, pp. 105–109
- Oct 24 The Darwinian revolution
- ▷ Bowler & Morus, *Making Modern Science*, chapter 6 (pp. 134–171)

- Oct 26 The chemical revolution and the iron rule
- ▷ Bowler & Morus, *Making Modern Science*, chapter 3 (pp. 58–82)
 - ▷ Strevens, *Knowledge Machine*, chapter 4 (pp. 89–104); chapter 5, pp. 109–119

How Isaac Newton Invented Modern Science

- Oct 31 Newton's theory of gravitation ◁ Due date
- ▷ Weinberg, *To Explain the World*, pp. 225–247
 - ◇ Resource: Newton, *The Principia*, General Scholium to the second edition (pp. 585–590)
 - Second exercise due
- Nov 2 Explanatory relativism and shallow explanation
- ▷ Dear, *The Intelligibility of Nature*, chapter 1, pp. 15–28
 - ▷ Strevens, *Knowledge Machine*, chapter 6, pp. 120–142
- Nov 7 The quantum shallows
- ▷ Strevens, *Knowledge Machine*, chapter 6, pp. 142–151
- Nov 9 Only empirical evidence counts!
- ▷ Strevens, *Knowledge Machine*, chapter 8, pp. 183–197
 - ▷ Christianson, *Isaac Newton*, chapters 3, 7 (pp. 24–33, 63–76)
- Nov 14 Sterilizing the public record ◁ Due date
- ▷ Strevens, *Knowledge Machine*, chapter 7 (pp. 152–172)
 - Third exercise due
- Nov 16 The replication crisis
- ▷ Ioannides, "Why most published research findings are false"
 - ▷ Aschwanden, "Science isn't broken", <https://fivethirtyeight.com/features/science-isnt-broken/>
 - ◇ Resource: Try out the p-hacking simulator in the Aschwanden piece

Religion, Beauty, and Irrationality in Science

- Nov 21 Religion and science
- ▷ Strevens, *Knowledge Machine*, chapter 8, pp. 173–183
 - ▷ Whewell, *History of the Inductive Sciences*, volume III, Book 18, Chapter 6, §§ 1, 5 (pp. 569–570, 580–588)
 - ▷ Bowler & Morus, *Making Modern Science*, chapter 16, pp. 386–396
- Nov 23 Thanksgiving recess – no class
- Nov 28 Is non-empirical thinking irrational? ◁ Due date
Or is science irrationally narrow?
- ▷ Strevens, *Knowledge Machine*, chapter 9 (pp. 201–208)
 - ▷ Strevens, *Knowledge Machine*, chapter 10, pp. 209–227
 - Fourth exercise due

- Nov 30 Beauty as a guide to truth
- ▷ Strevens, *Knowledge Machine*, chapter 10, pp. 227–238
 - ▷ Hossenfelder, *Lost in Math*, chapter 2 (pp. 17–41)
 - ◇ Resource: Gell-Mann, “Symmetries of baryons and mesons”

The Social Organization of Science

- Dec 5 Credit capitalism
The reward system in science: who gets how much credit for what discoveries
- ▷ Merton, “Priorities in scientific discovery”, pp. 635–643, 658–659
 - ▷ Latour and Woolgar, *Laboratory Life*, pp. 200–208
 - ▷ Casadevall and Fang, “Reforming science”
 - ◇ Resource: Crick and Watson, “A structure for deoxyribose nucleic acid”
- Dec 7 Data socialism
Merton’s “communist” norm and information sharing in science
- ▷ Merton, “The normative structure of science”
 - ▷ Louis, Jones, and Campbell, “Sharing in science”
 - ▷ Strevens, “Scientific sharing: Communism and the social contract”, first 9 pages (pp. 3–11)

Science and Public Policy

- Dec 12 The voice of science ◁ Due date
Methods for deciding when science has reached a consensus, given that it never reaches a consensus
- ▷ Oreskes, “The scientific consensus on climate change”
 - Second paper due
- Dec 14 How to “follow the science”
The job of interpreting science for politicians, policy-makers, and the public
- ▷ Strevens, *Knowledge Machine*, chapter 14 (pp. 278–290)
 - ▷ Schneider, “Confidence, consensus and the uncertainty cops: Tackling risk management in climate change”
 - ◇ Resource: IPCC Fifth Assessment Report – Synthesis, at <https://www.ipcc.ch/report/ar5/syr/>

Papers are due on Oct 17 and Dec 12

Exercises are due on Oct 3, Oct 31, Nov 14, Nov 28

HOW SCIENCE WORKS REFERENCES

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