NYU PHIL-UA 88, Fall 2023

HOW SCIENCE WORKS

Time & Place Mondays and Wednesdays, 11 to 12:15 PM
238 Thompson St (GCASL), Room 288

Texts You'll need to buy or borrow the three books below. (They'll be at the NYU Bookstore.) Other readings will be distributed via NYU Brightspace.

- *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.)

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 16)	30%
Second paper (due Dec 11)	30%
Three exercises from a choice of four (due Oct 2, Oct 30, Nov 13, Nov 27)	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 Joe 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.

Joe Han Office hours are Monday 1:00–3:00 PM (tentatively) and by appointment

Room 516, 5 Washington Place

joehan@nyu.edu

Michael Strevens Office hours are Wednesday 1–2:30 PM and by appointment
Room 603, 5 Washington Place, phone (212) 998-3559
strevens@nyu.edu ■ www.strevens.org

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, as is using AI such as ChatGPT to generate the text you submit for grading. 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).

NYU PHIL-UA 88, Fall 2023

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 6 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 11 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 13 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 18 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 20 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 (optional)
- ▷ Strevens, *Knowledge Machine*, chapter 3, pp. 74–86

Thomas Kuhn's Paradigms

Sep 25 Kuhn on normal science
- ▷ Kuhn, *Structure*, chapters 1 through 6

Sep 27 "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 2 Kuhn on crisis and revolution ◁ *Due date*
- ▷ Kuhn, *Structure*, chapters 7 through 9, 12 (omit pp. 96–103)
- ■ First exercise due

Oct 4 Kuhn on revolution and progress
- ▷ Kuhn, *Structure*, chapter 13, Postscript
- ▷ Strevens, *Knowledge Machine*, rest of chapter 1 (pp. 22–32, 38–40)

Oct 9 Fall recess – class postponed till Tuesday

The Sociological Eye

Oct 10 Into the laboratory
- ▷ Latour and Woolgar, *Laboratory Life*, 15–21, 45–56, 142–149
- ▷ Collins, "The seven sexes", 208–216

Oct 11 Continental drift & subjectivity in science
- ▷ 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"

Oct 16 Feminist critiques ◁ *Due date*
- ▷ Richardson, "Sexes, species, and genomes" up to p. 833
- ▷ Okruhlik, "Gender and the biological sciences" up to p. 32
- ■ First paper due

Science's Iron Rule

Oct 18 Bacon's new method
- ▷ Bacon, *The New Organon*, Book I §§38–65, Book 2 §§10–20
- ▷ Strevens, *Knowledge Machine*, pp. 105–109

Oct 23 The Darwinian revolution
- ▷ Bowler & Morus, *Making Modern Science*, chapter 6 (pp. 134–171)

Oct 25 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 30 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 1 Explanatory relativism and shallow explanation
- ▷ Dear, *The Intelligibility of Nature*, chapter 1, pp. 15–28
- ▷ Aristotle, *Physics*, II.8
- ▷ Strevens, *Knowledge Machine*, chapter 6, pp. 120–142

Nov 6 The quantum shallows
- ▷ Strevens, *Knowledge Machine*, chapter 6, pp. 142–151

Nov 8 Only empirical evidence counts!
- ▷ Strevens, *Knowledge Machine*, chapter 8, pp. 183–197
- ▷ Christianson, *Isaac Newton*, chapters 3, 7 (pp. 24–33, 63–76)

Nov 13 Sterilizing the public record ◁ *Due date*
- ▷ Strevens, *Knowledge Machine*, chapter 7 (pp. 152–172)
- ■ Third exercise due

Nov 15 The replication crisis
- ▷ Ioannidis, "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 20 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 22 Thanksgiving recess – no class

Nov 27 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 29 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 4 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
- ▷ Markell, "How the discovery of HIV led to a transatlantic research war", https://www.pbs.org/newshour/health/how-the-discovery-of-hiv-led-to-a-transatlantic-research-war
- ▷ Casadevall and Fang, "Reforming science"
- ◇ Resource: Crick and Watson, "A structure for deoxyribose nucleic acid"

Dec 6 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 11 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 13 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 AR6 Synthesis Report—Summary for Policymakers https://www.ipcc.ch/report/ar6/syr/

Papers are due on Oct 16 and Dec 11

Exercises are due on Oct 2, Oct 30, Nov 13, Nov 27

HOW SCIENCE WORKS
REFERENCES

Aschwanden, C. (2015). Science isn't broken. URL = <https://fivethirtyeight.com/features/science-isnt-broken/>.

Bacon, F. (2000). *The New Organon*. Translated by M. Silverthorne. Edited by L. Jardine and M. Silverthorne. Cambridge University Press, Cambridge.

Bekelman, J. E., Y. Li, and C. P. Gross. (2003). Scope and impact of financial conflicts of interest in biomedical research: A systematic review. *Journal of the American Medical Association* 289:454–465.

Bowler, P. J. and I. R. Morus. (2020). *Making Modern Science: A Historical Survey*. Second edition. University of Chicago Press, Chicago.

Burnet, T. (1684). *The Sacred Theory of the Earth*, volume 1. R. Norton, London.

Casadevall, A. and F. C. Fang. (2012). Reforming science: Methodological and cultural reforms. *Infection and Immunity* 80:891–896.

Christianson, G. E. (2005). *Isaac Newton*. Oxford University Press, Oxford.

Collins, H. M. (1975). The seven sexes: A study in the sociology of a phenomenon, or the replication of experiments in physics. *Sociology* 9:205–224.

Crick, F. H. C. and J. D. Watson. (1953). A structure for deoxyribose nucleic acid. *Nature* 171:737–738.

Daw, E. (2016). How does an experiment at LIGO actually work? URL = <https://phys.org/news/2016-02-ligo.html>.

Dear, P. (2006). *The Intelligibility of Nature*. University of Chicago Press, Chicago.

Douglas, H. (2000). Inductive risk and values in science. *Philosophy of Science* 67:559–579.

Dyson, S. F. W., A. S. Eddington, and C. Davidson. (1920). A determination of the deflection of light by the sun's gravitational field, from observations made at the total eclipse of May 29, 1919. *Philosophical Transactions of the Royal Society of London, Series A* 220:291–333.

Gell-Mann, M. (1962). Symmetries of baryons and mesons. *Physical Review* 125:1067–1084.

Hossenfelder, S. (2018). *Lost in Math: How Beauty Leads Physics Astray*. Basic Books, New York.

Ioannidis, J. P. A. (2005). Why most published research findings are false. *PLoS Medicine* 2(8):696–701.

Kuhn, T. S. (2012). *The Structure of Scientific Revolutions*. Fourth edition. University of Chicago Press, Chicago.

Latour, B. and S. Woolgar. (1986). *Laboratory Life: The Construction of Scientific Facts*. Second edition. Princeton University Press, Princeton, NJ.

Louis, K. S., L. M. Jones, and E. G. Campbell. (2002). Sharing in science. *American Scientist* 90:304–307.

Merton, R. K. (1942). The normative structure of science. *Journal of Legal and Political Sociology* 1:115–126, originally titled "Science and Technology in a Democratic Order". Reprinted in Merton, *The Sociology of Science*.

———. (1957). Priorities in scientific discovery. *American Sociological Review* 22:635–659.

Newton, I. (1984). *The Principia: Mathematical Principles of Natural Philosophy*. Translated by I. B. Cohen and A. Whitman. University of California Press, Berkeley, CA.

Okruhlik, K. (1994). Gender and the biological sciences. *Canadian Journal of Philosophy* supplementary volume 20:21–42.

Oreskes, N. (2018). The scientific consensus on climate change: How do we know we're not wrong? In E. A. Lloyd and E. Winsberg (eds.), *Climate Modelling: Philosophical and Conceptual Issues*, pp. 31–64. Palgrave Macmillan, London.

Popper, K. (1959). *The Logic of Scientific Discovery*. Hutchinson, London.

Richardson, S. S. (2010). Sexes, species, and genomes: Why males and females are not like humans and chimpanzees. *Biology and Philosophy* 25:823–841.

Schneider, S. H. (2010). Confidence, consensus and the uncertainty cops: Tackling risk management in climate change. In B. Bryson (ed.), *Seeing Further: The Story of Science, Discovery and the Genius of the Royal Society*, pp. 424–443. HarperCollins, New York.

Stanley, M. (2003). An expedition to heal the wounds of war: The 1919 eclipse and Eddington as Quaker adventurer. *Isis* 94:57–89.

Strevens, M. (2017). Scientific sharing: Communism and the social contract. In T. Boyer-Kassem, C. Mayo-Wilson, and M. Weisberg (eds.), *Scientific Collaboration and Collective Knowledge*. Oxford University Press, Oxford.

———. (2020). *The Knowledge Machine: How Irrationality Created Modern Science*. Liveright, New York.

Wade, N. (1981). *The Nobel Duel: Two Scientists' 21-Year Race to Win the World's Most Coveted Research Prize*. Anchor Doubleday, New York.

Waldrop, M. M. (1990). Of politics, pulsars, death spirals—and LIGO. *Science* 249:1106–1108.

Weinberg, S. (2016). *To Explain the World: The Discovery of Modern Science*. Harper Perennial, New York.

Whewell, W. (1837). *History of the Inductive Sciences, from the Earliest to the Present Times*. John W Parker, London.