

Philosophy Faculty reading List and Course Outline 2018-2019

PART IB PAPER 06: PHILOSOPHY OF SCIENCE

SYLLABUS

Realism, for and against: underdetermination of theory by data, the pessimistic induction, constructive empiricism, structural realism, incommensurability.
Confirmation: the hypothetico-deductive model; the paradoxes of confirmation; Bayesianism; falsificationism.
Scientific explanation and laws: what, if anything, distinguishes scientific explanation?; the deductive-nomological model of explanation and its rivals; 'best system' vs anti-reductionist views of laws.
Concepts of probability: subjective probability; logical probability; frequency interpretation; propensity interpretation.
Introduction to philosophy of physics: spacetime and relativity; time and thermodynamics; puzzles of quantum theory.

COURSE OUTLINE

The Part IB course introduces five philosophical issues in scientific theory and practice.

- (i) **Realism, for and against:** Are the entities postulated by scientific theories real? Or are theories no more than useful instruments for inferring from one set of observable circumstances to another?
- (ii) **Confirmation:** What is it for a piece of evidence to support a hypothesis? And when should a scientific theory count as having been tested?
- (iii) **Scientific explanation and laws:** What distinguishes scientific explanations? And what is a law of nature (as opposed to an accidental regularity)?
- (iv) **Concepts of probability:** What does it mean to say that an event has a probability of 75%? Are there objective chances or is it just subjective confidence?
- (v) **Introduction to philosophy of physics:** How is physics relevant to philosophy, and vice versa? What does modern physics tell us about time, and the nature of the quantum world – and why are such simple questions so hard to answer?

Prerequisites

It is *not* necessary to have background knowledge of any particular scientific theory. Some theories and historical episodes will be briefly touched on in lectures. Students should have a modest knowledge of formal logic.

Objectives

Students taking this paper will be expected to:

1. Acquire an introductory overview of debates on method, the status of theories, the nature of explanation and laws, and concepts of probability.
2. Critically engage with texts by some key authors in analytical philosophy of science in the last half century.
3. Acquire a more detailed understanding of some particular debates within the listed areas.
4. Develop their ability to think independently about philosophical problems by critically assessing arguments in these areas.

Preliminary Reading

BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). Also available online at: <https://doi.org/10.4324/9780203133972>
CHALMERS, Alan F., *What is This Thing Called Science?* 2nd ed. (Milton Keynes: The Open University, 1982).

READING LIST

General Reading

The philosophy of science is an area particularly well supplied with readable and reliable introductions. The following are particularly recommended:

BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). Also available online at: <https://doi.org/10.4324/9780203133972>.
CHALMERS, Alan F., *What is This Thing Called Science?* 2nd ed. (Milton Keynes: The Open University, 1982).
GODFREY-SMITH, Peter, *Theory and Reality: an Introduction to the Philosophy of Science* (Chicago, IL: University of Chicago Press, 2003). Also available online at: <http://lib.mylibrary.com/?id=264630>
LADYMAN, James, *Understanding Philosophy of Science* (London: Routledge, 2002).
LEWENS, Tim, *The Meaning of Science* (London: Pelican, 2015).
PAPINEAU, David, 'Methodology: The Elements of Philosophy of Science', in A.C. Grayling, ed., *Philosophy 1: A Guide through the Subject* (Oxford: Oxford University Press, 1998), pp. 125-80.

Lewen's is an excellent and accessible introduction, as is Bird's. Ladyman's book has a different emphasis: e.g. there's less on laws and more on Popper vs. Kuhn. Papineau's very clear essay deals primarily with issues about explanation, laws, confirmation etc., while Chalmers concentrates more on Popper's falsificationism, and the responses of Kuhn and Lakatos. Godfrey-Smith's book is longer and more comprehensive, but very lively, clear, and accessible.

Other introductions worth mentioning are:

HACKING, Ian, *Representing and Intervening* (Cambridge: Cambridge University Press, 1983).

HEMPEL, Carl G., *Philosophy of Natural Science* (Englewood Cliffs, NJ: Prentice-Hall, 1966).

KOSSO, Peter, *Reading the Book of Nature* (Cambridge: Cambridge University Press, 1992).

Of these, Kosso's book is the most introductory (useful perhaps for preliminary orientation or if you are transferring into philosophy). The Hempel volume is a short classic introduction. And Hacking's book is particularly interesting giving a newer take on some old issues.

Earlier classics include the following:

NAGEL, Ernest, *Structure of Science* (London: Routledge & Kegan Paul, 1961), chs. 1-6.

This presents very clearly a developed version of some 'traditional' lines in the philosophy of science on laws, explanation, the observation and theory distinction, etc. It very useful to read Nagel to get a sense of what quite a few of the later writers are reacting against.

KUHN, Thomas, *The Structure of Scientific Revolutions* (Chicago, IL: University of Chicago Press, 1962). Also available online at: <http://lib.myilibrary.com/?id=243761>

Enormously influential and highly readable, this is the book that introduced the paradigm in philosophy of science.

FEYERABEND, Paul, *Against Method* (London: New Left Books/ Verso, various editions which differ substantially: first published 1975).

Going even further than Kuhn, Feyerabend argues against the very idea of a scientific method (claiming that 'anything goes' is as good a methodological rule as anything suggested by mainstream philosophy of science). Controversial and again, highly readable.

Useful Collections of Articles

The following collections will be found particularly useful:

BOYD, Richard, Philip GASPHER, and J. D. TROUT, eds., *The Philosophy of Science* (Cambridge, MA: MIT Press, 1991).

CURD, Martin, and J. A. COVER, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).

PAPINEAU, David, ed., *The Philosophy of Science* (Oxford: Oxford University Press, 1996). [Oxford Readings in Philosophy]

RUBEN, David-Hillel, ed., *Explanation* (Oxford: Oxford University Press, 1993). [Oxford Readings in Philosophy]

Pre-amble on the Selected Readings

Think of IB work on a topic as having two stages. (A) Getting a grounding in a problem area, writing a supervision essay, and getting feedback (to confirm that you have grasped the basics, and to suggest problems to think about, further lines to pursue etc.). (B) Additional reading and work on the topic (perhaps to be further discussed in Easter term additional supervisions, revision classes etc.). If you get stuck at stage (A) you won't do particularly well in Tripos!

Some of these readings are divided into (A) and (B) lists below: some attempt is made to put material in the basic (A)-lists in a sensible reading order. (B)-lists are in alphabetical order, and for dipping into (no-one expects you to read everything).

REALISM, FOR AND AGAINST

General

For an introductory survey of some of the issues about realism in the philosophy of science, see:

LADYMAN, James, *Understanding Philosophy of Science* (London: Routledge, 2002), chs. 5, 6 & 8.

And for another survey, at a slightly more sophisticated level, try:

CHAKRAVARTTY, Anjan, 'Scientific Realism', in E.N. Zalta, ed., *Stanford Encyclopedia of Philosophy* (Summer 2017 Edition) [Online]. Available at: <http://plato.stanford.edu/archives/sum2017/entries/scientific-realism/> (Accessed: 9 August 2018).

For a rather deflationary approach to issues about realism, much referred to, you should read:

FINE, Arthur, 'The Natural Ontological Attitude', in J. Leplin, ed., *Scientific Realism* (Berkeley, CA: University of California Press, 1984), pp. 83-107. Reprinted in his *The Shaky Game: Einstein realism and the quantum theory* (Chicago, IL: University of Chicago Press, 1986), and also in D. Papineau, ed., *The Philosophy of Science (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1996), and M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).

For an excellent book-length treatment, see:

PSILLOS, Stathis, *Scientific Realism* (London: Routledge, 1999), ch. 8 'Underdetermination undermined'. Also available online at: www.dawsonera.com

For an important critical perspective on the notion of objectivity sometimes associated with scientific realism, see:

LONGINO, Helen, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton: Princeton University Press, 1990), ch. 4 'Values and objectivity'.

For an earlier classic, still very much worth reading, see:

HESSE, Mary, *Revolutions and Reconstructions in the Philosophy of Science* (London: Harvester Press, 1980).

Underdetermination of Theory by Data

Theory is underdetermined by data (i.e., in principle, different theories are compatible with the same data). Does that observation show that we shouldn't take a realist attitude, even to our best theories?

(A)

PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 152-56. [General overview]

LADYMAN, James, *Understanding Philosophy of Science* (London: Routledge, 2002), sect. 6.1. [Another introduction]

DUHEM, Pierre, *The Aim and Structure of Physical Theory*, translated by P. Wiener (Princeton, NJ: Princeton University Press, 1954), ch. 6 'Physical theory and experiment'. [Original publication 1914. Do look at this historical source]

QUINE, W.V.O., 'On Empirically Equivalent Systems of the World', *Erkenntnis*, 9 (1975): 313-28. <http://www.jstor.org/stable/20010476>. Or 'Empirical Content' in his *Theories and Things* (Cambridge, MA: Harvard University Press, 1981).

LAUDAN, Larry, 'Demystifying Underdetermination', in C. Wade Savage, ed., *Scientific Theories* (Minneapolis, MN: University of Minnesota Press, 1990), pp. 267-97. Reprinted in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).

MAYO, Deborah, *Error and the Growth of Experimental Knowledge* (Chicago, IL: University of Chicago Press, 1996), ch. 6 'Severe tests and methodological underdetermination'. Also available online at: http://www.phil.vt.edu/dmayo/personal_website/EGEK_6.pdf

PSILLOS, Stathis, *Scientific Realism* (London: Routledge, 1999), ch. 8, 'Underdetermination undermined'. Also available online at: www.dawsonera.com

(B)

GLYMOUR, Clark, *Theory and Evidence* (Princeton, NJ: Princeton University Press, 1980), ch. 2 'Logical empiricist theories of confirmation'.

JARDINE, Nicholas, *The Fortunes of Inquiry* (Oxford: Clarendon Press, 1986), ch. 6 'Underdetermination of theory'.

KUKLA, André, *Studies in Scientific Realism* (Oxford: Oxford University Press, 1998), chs. 5 & 6.

LAUDAN, Larry, and Jarrett LEPLIN, 'Empirical Equivalence and under-Determination', *Journal of Philosophy*, 88 (1991): 449-72. <http://www.jstor.org/stable/2026601>

The Pessimistic Induction

In the history of science, time and again scientists have got things badly wrong. Should we pessimistically infer that our current best theories are also (probably) wrong, for all we know?

(A)

PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 156-58.

LAUDAN, Larry, 'A Confutation of Convergent Realism', *Philosophy of Science*, 48 (1981): 19-49. <http://www.jstor.org/stable/187066>. Reprinted in J. Leplin, *Scientific Realism* (Berkeley, CA: University of California Press, 1984), and in R. Boyd, P. Gasper and J.D. Trout, eds., *The Philosophy of Science* (Cambridge, MA: MIT Press, 1991), M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998) and D. Papineau, ed., *The Philosophy of Science (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1996).

HARDIN, Clyde, and Alexander ROSENBERG, 'In Defense of Convergent Realism', *Philosophy of Science*, 49 (1982): 604-15. <http://www.jstor.org/stable/187168>

WORRALL, John, 'Structural Realism: The Best of Both Worlds?' *Dialectica*, 43 (1989): 99-124. <http://doi.org/10.1111/j.1746-8361.1989.tb00933.x>. Reprinted in D. Papineau, ed., *The Philosophy of Science (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1996). Also in A. Bird and J. Ladyman, eds., *Arguing about Science* (London: Routledge, 2013), pp. 765-84.

PSILLOS, Stathis, *Scientific Realism* (London: Routledge, 1999), chs. 5-7. Also available online at: www.dawsonera.com

(B)

CUMMISKEY, David, 'Reference Failure and Scientific Realism: A Response to the Meta-Induction', *British Journal for the Philosophy of Science*, 43 (1992): 21-40. <http://www.jstor.org/stable/687883>

HOBBS, Jesse, 'A Limited Defense of the Pessimistic Induction', *British Journal for the Philosophy of Science*, 45 (1994): 171-91. <http://www.jstor.org/stable/687966>

JARDINE, Nicholas, *The Fortunes of Inquiry* (Oxford: Clarendon Press, 1986).

LAUDAN, Larry, 'Discussion: Realism without the Real', *Philosophy of Science*, 51 (1984): 151-62. <http://www.jstor.org/stable/187738>

LEPLIN, Jarrett, *A Novel Defense of Scientific Realism* (Oxford: Oxford University Press, 1997), ch. 6 'Counterarguments'.

Constructive Empiricism

The most influential non-realist theory of science in the last two decades and more is van Fraassen's constructive empiricism. For van Fraassen's own presentation and criticism see:

(A)

- VAN FRAASSEN, Bas C., *The Scientific Image* (Oxford: Clarendon, 1980), chs. 2 & 4. Also available online at: <http://doi.org/10.1093/0198244274.001.0001>. Excerpts from ch. 2 also reprinted in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).
- MONTON, Bradley, and Chad MOHLER, 'Constructive Empiricism', in E.N. Zalta, ed., *Stanford Encyclopedia of Philosophy* (Summer 2017 Edition) [Online]. Available at: <http://plato.stanford.edu/archives/sum2017/entries/constructive-empiricism> (Accessed: 9 August 2018).
- CHURCHLAND, Paul, and Clifford HOOKER, eds., *Images of Science* (Chicago, IL: University of Chicago Press, 1985). [In particular, essays by Boyd, Churchland, and Musgrave, and van Fraassen's replies. Musgrave's paper is reprinted in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998)]
- PSILLOS, Stathis, *Scientific Realism* (London: Routledge, 1999), ch. 9 'Constructive empiricism scrutinised'. Also available online at: www.dawsonera.com
- LADYMAN, James, 'What's Really Wrong with Constructive Empiricism? Van Fraassen and the Metaphysics of Modality', *British Journal for the Philosophy of Science*, 51 (2000): 837-56. <http://www.jstor.org/stable/3541729>
- HORWICH, Paul, 'On the Nature and Norms of Theoretical Commitment', *Philosophy of Science*, 58 (1991): 1-14. <http://www.jstor.org/stable/187886>. Reprinted in his *From a Deflationary Point of View* (Oxford: Clarendon, 2004). Also available online at: <http://doi.org/10.1093/0199251266.003.0006>

(B)

Recent debate on constructive empiricism has focused upon the specific epistemological framework in which van Fraassen advances his empiricism, and upon the appropriate epistemological framework for the philosophy of science in general:

- VAN FRAASSEN, Bas C., *Laws and Symmetry* (Oxford: Clarendon, 1989), Part II 'Belief as Rational But Lawless'. Also available online at: <http://doi.org/10.1093/0198248601.001.0001>
- VAN FRAASSEN, Bas C., *The Empirical Stance* (New Haven, CT: Yale University Press, 2002), Lecture 2 'What is empiricism and what could it be?'. Also available online at: <http://lib.myilibrary.com/browse/open.asp?id=172986>
- MONTON, Bradley, ed., *Images of Empiricism* (Oxford: Oxford University Press, 2007). Also available online at: <http://doi.org/10.1093/acprof:oso/9780199218844.001.0001>. [In particular, essays by Chakravartty, Ladyman, and Psillos, and van Fraassen's replies]

Structural Realism

A recently popular form of realism, advertised as avoiding some of the problems of older forms of scientific realism.

(A)

- WORRALL, John, 'Structural Realism: The Best of Both Worlds?', *Dialectica*, 43 (1989): 99-124. <http://doi.org/10.1111/j.1746-8361.1989.tb00933.x>. Reprinted in D. Papineau, ed., *The Philosophy of Science (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1996). Also in A. Bird and J. Ladyman, eds., *Arguing about Science* (London: Routledge, 2013), pp. 765-84.
- LADYMAN, James, 'What is Structural Realism?', *Studies in History and Philosophy of Science*, 29 (1998): 409-24. [http://doi.org/10.1016/S0039-3681\(98\)80129-5](http://doi.org/10.1016/S0039-3681(98)80129-5)
- PSILLOS, Stathis, *Scientific Realism* (London: Routledge, 1999), ch. 7 'Worrall's structural realism'. Also available online at: www.dawsonera.com
- LADYMAN, James, 'Structural Realism', in E.N. Zalta, ed., *Stanford Encyclopedia of Philosophy* (Winter 2016 Edition) [Online]. Available at: <http://plato.stanford.edu/archives/win2016/entries/structural-realism> (Accessed: 9 August 2018).

(B)

- CHAKRAVARTTY, Anjan, *A Metaphysics for Scientific Realism* (Cambridge: Cambridge University Press, 2007), chs. 2 & 3. Also available online at: <http://doi.org/10.1017/CBO9780511487354>
- PSILLOS, Stathis, 'Is Structural Realism Possible?', *Philosophy of Science, Suppl. Vol.*, 68 (2001): S13-S24. <http://www.jstor.org/stable/3080931>
- VAN FRAASSEN, Bas C., 'Structuralism(S) About Science: Some Common Problems', *Proceedings of the Aristotelian Society*, 81 (2007): 45-61. <http://www.jstor.org/stable/20619101>

Ladyman's SEP article, above, provides a rich guide to the further literature for enthusiasts.

Incommensurability

A theme in Kuhn and Feyerabend is the supposed 'incommensurability' of (sufficiently different) rival theories. The idea is that observation-sentences embedded in sufficiently different theories can't be directly compared. For some background on observation/theory issues, you need to look at e.g.:

- BOGEN, Jim, 'Theory and Observation in Science', in E.N. Zalta, ed., *Stanford Encyclopedia of Philosophy* (Summer 2017 Edition) [Online]. Available at: <http://plato.stanford.edu/archives/sum2017/entries/science-theory-observation/> (Accessed: 9 August 2018).

Two other useful background introductions are:

CHALMERS, Alan F., *What Is This Thing Called Science?*, 2nd ed. (Milton Keynes: The Open University Press, 1982), ch. 3 'Experiment'.

GILLIES, Donald, *Philosophy of Science in the Twentieth Century* (Oxford: Blackwell, 1993), chs. 6 & 7.

And for the debate about incommensurability, see:

(A)

NEWTON-SMITH, W.H., *The Rationality of Science* (London: Routledge & Kegan Paul, 1981), ch. 1, especially sect. 4.

HACKING, Ian, *Representing and Intervening* (Cambridge: Cambridge University Press, 1983), Introduction.

KUHN, Thomas, *The Structure of Scientific Revolutions* (Chicago, IL: University of Chicago Press, 1962), ch. 10 'Revolutions as Changes of World View'. Also available online at: <http://lib.mylibrary.com/?id=243761>

FEYERABEND, Paul, 'How to Be a Good Empiricist', in P.H. Nidditch, ed., *Philosophy of Science* (Oxford: Oxford University Press, 1968), pp. 12-39. Reprinted in his *Knowledge, Science and Relativism, Philosophical Papers*. Vol. 3 (Cambridge: Cambridge University Press, 1999), pp. 78-103. Also in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).

FEYERABEND, Paul, 'Explanation, Reduction and Empiricism', in his *Realism, Rationalism, and Scientific Method: Philosophical Papers*. Vol. 1 (Cambridge: Cambridge University Press, 1981).

NEWTON-SMITH, W.H., *The Rationality of Science* (London: Routledge & Kegan Paul, 1981), chs. 5 & 7.

SHAPER, Dudley, 'Meaning and Scientific Change', in R. Colodny, ed., *Mind and Cosmos* (Pittsburg, PA: Pittsburg University Press, 1980), pp. 41-85. Reprinted in I. Hacking, ed., *Scientific Revolutions* (Oxford: Oxford University Press, 1981).

KUHN, Thomas, *The Road since 'Structure'* (Chicago, IL: University of Chicago Press, 2000), ch. 2 'Commensurability, Comparability, Communicability'.

BIRD, Alexander, *Thomas Kuhn* (Chesham: Acumen, 2000), ch. 5 'Incommensurability and meaning'. Also available on [Moodle](#)

(B)

BOYD, Richard, 'Metaphor and Theory Change', in A. Ortony, ed., *Metaphor and Thought* (Cambridge: Cambridge University Press, 1979), pp. 481-532. . Also available online at: <http://doi.org/10.1017/CBO9781139173865.023>

BOYD, Richard, 'On the Current Status of the Issue of Scientific Realism', *Erkenntnis*, 19 (1983): 45-90. <http://www.jstor.org/stable/20010835>. Reprinted in R. Boyd, P. Gasper and J.D. Trout, eds., *The Philosophy of Science* (Cambridge, MA: MIT Press, 1991).

FEYERABEND, Paul, *Against Method* (London: NLB, 1975; various later editions), Introduction and chs.1-5 & 15-18.

FIELD, Harry, 'Theory Change and the Indeterminacy of Reference', *Journal of Philosophy*, 70, no. 14 (1973): 462-81. <http://www.jstor.org/stable/2025110>

KITCHER, Philip, 'Theories, Theorists and Theoretical Change', *Philosophical Review*, 87 (1978): 519-47. <http://www.jstor.org/stable/2184458>

KUHN, Thomas, 'Commensurability, Comparability, Communicability...' in P.D. Asquith and T. Nickles, eds., *Psa 1982: Proceedings of the 1982 Biennial Meeting of the Philosophy of Science Association*. Vol. 2 (East Lansing, MI: Philosophy of Science Association, 1983), pp. 669-88. Also available online at: www.jstor.org/stable/192452.

KUHN, Thomas, *The Essential Tension* (Chicago, IL: University of Chicago Press, 1977), ch. 13 'Objectivity, Value Judgment, and Theory Choice'. Reprinted in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W.W. Norton, 1998).

PAPINEAU, David, *Theory and Meaning* (Oxford: Clarendon Press, 1979), ch. 5 'Objectivity and realism', especially pp. 147-68.

SANKEY, Howard, 'Incommensurability: The Current State of Play', *Theoria*, 12 (1997): 425-45. Also available online at: <http://www.jstor.org/stable/23917952>

SANKEY, Howard, 'Kuhn's Changing Concept of Incommensurability', *British Journal for the Philosophy of Science*, 44 (1993): 759-74. <http://www.jstor.org/stable/688043>

CONFIRMATION

Hypothetico-Deductive Model, and Bayesian Responses

A classic view (a.k.a. 'deductivism', 'the hypothetico-deductive model') is that a scientific theory is a body of hypothesized laws from which observational consequences are deduced, and a theory is tested by checking how the observational consequences tally with reality, and is confirmed by positive outcomes. For some initial orientation, see:

HÁJEK, Alan, and James M. JOYCE, 'Confirmation', in S. Psillos and M. Curd, eds., *Routledge Companion to Philosophy of Science* (Abingdon: Routledge, 2008, 2nd ed. 2013), pp. 115-28. Also available online at: <http://doi.org/10.4324/9780203744857.ch14>

Also useful is:

SANKEY, Howard, 'Scientific Method' in S. Psillos and M. Curd, eds., *Routledge Companion to Philosophy of Science* (Abingdon: Routledge, 2008, 2nd ed. 2013). Also available online at: <http://doi.org/10.4324/9780203744857.ch26>

Hempel and Nagel give classic outlines in:

HEMPEL, Carl G., *Philosophy of Natural Science* (Englewood Cliffs, NJ: Prentice Hall, 1966), chs. 1-4.

NAGEL, Ernest, *Structure of Science* (London: Routledge & Kegan Paul, 1961), chs. 2 & 3.

The H-D model of confirmation can seem so compelling that it is difficult to conceive of alternatives. So for a different sort of model, see:

GIERE, Ronald, *Explaining Science* (Chicago, IL: Chicago University Press, 1988), chs. 2 & 3.

Finally, to round out the Hájek/Joyce discussion of Bayesian views, see:

HOWSON, Colin, and Peter URBACH, *Scientific Reasoning: The Bayesian Approach* (La Salle, IL: Open Court, 1989), ch. 4 'Bayesian versus non-Bayesian approaches'.

The Paradoxes of Confirmation

i) The 'Ravens' Paradox

Since 'all ravens are black' is equivalent to 'all non-black things are non-ravens' does that mean that observing white shoes is a way of confirming that indeed all ravens are black?

(A)

BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). ch. 2 'Explanation'. Also available online at: <https://doi.org/10.4324/9780203133972>

HEMPEL, Carl G., *Aspects of Scientific Explanation* (New York: Free Press, 1965), ch. 1 'Studies in the Logic of Confirmation', especially sects. 3-5.

HOWSON, Colin, and Peter URBACH, *Scientific Reasoning: The Bayesian Approach* (La Salle, IL: Open Court, 1989), ch. 4 'Bayesian versus non-Bayesian approaches'.

MACKIE, J.L., 'The Paradox of Confirmation', *British Journal for the Philosophy of Science*, 13 (1963): 265-77. <http://www.jstor.org/stable/685324>. Reprinted in P. Nidditch, ed., *The Philosophy of Science*, Oxford Readings in Philosophy (Oxford: Oxford University Press, 1968).

PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 158-71.

(B)

HESSE, Mary, *The Structure of Scientific Inference* (London: Macmillan, 1974), chs. 6 & 7.

LIPTON, Peter, *Inference to the Best Explanation* (London: Routledge, 1991), chs. 5 & 6. Also available online at: <http://lib.myilibrary.com/?id=11209>

MILLER, Richard W., *Fact and Method* (Princeton, NJ: Princeton University Press, 1987), ch. 4 'Confirmation as causal comparison'.

ii) The 'Grue' Paradox

Define 'Grue' to mean 'Either green and observed before midnight on 31.12.2010 or blue and not observed before midnight on 31.12.2010'. Then all observations to date equally well support e.g. 'all emeralds are green' and 'all emeralds are grue'. What's to choose?

(A)

BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). Introduction. Also available online at: <https://doi.org/10.4324/9780203133972>

PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 125-38.

GOODMAN, Nelson, *Fact, Fiction and Forecast*. 4th ed. (Cambridge, MA: Harvard University Press, 1983), chs. 3 & 4.

BARKER, S.F., and Peter ACHINSTEIN, 'On the New Riddle of Induction', *Philosophical Review*, 69 (1960): 511-22. <http://www.jstor.org/stable/2183485>. Reprinted in P. Nidditch, ed., *The Philosophy of Science (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1968).

BLACKBURN, Simon, *Reason and Prediction* (Cambridge: Cambridge University Press, 1973), ch. 4 'Goodman's paradox'.

HESSE, Mary, *The Structure of Scientific Inference* (London: Macmillan, 1974), chs. 2 & 3.

(B)

BLACKBURN, Simon, *Spreading the Word* (Oxford: Clarendon Press, 1984), ch. 3 'How is meaning possible? (2)'.

HACKING, Ian, 'Entrenchment', in D. Stalker, ed., *Grue: The New Riddle of Induction* (Chicago, IL: Open Court, 1994), pp. 193-223.

JACKSON, Frank, 'Grue', *Journal of Philosophy*, 72 (1975): 113-31. <http://www.jstor.org/stable/2024749>. Reprinted in D. Stalker, ed., *Grue: the New Riddle of Induction* (Chicago, IL: Open Court, 1994).

QUINE, W.V.O., 'Natural Kinds', in his *Ontological Relativity and Other Essays* (New York: Columbia University Press, 1969), pp. 114-38. Reprinted in D. Stalker, ed., *Grue: the New Riddle of Induction* (Chicago, IL: Open Court, 1994).

SKYRMS, Brian, *Choice and Chance: An Introduction to Inductive Logic*. 3rd ed. (Belmont, CA: Wadsworth, 1986), ch. 3 'The Goodman paradox and the new riddle of induction'.

SOBER, Elliott, 'No Model, No Inference', in D. Stalker, ed., *Grue: The New Riddle of Induction* (Chicago, IL: Open Court, 1994), pp. 225-40.

The Stalker collection contains enough other papers to keep the most gruesomely enthusiastic satisfied!

Bayesianism

CHALMERS, Alan F., *What is This Thing Called Science?*, (Maidenhead: Open University Press, 3rd ed. 1999 or 4th ed. 2013), ch. 12 'Bayesian Approaches'.

GLYMOUR, Clark, *Theory and Evidence* (Princeton, NJ: Princeton University Press, 1980), ch. 3 'Why I am not a Bayesian'. Reprinted in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).

HORWICH, Paul, *Probability and Evidence* (Cambridge: Cambridge University Press, 1982), especially pp. 11-15.

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- SALMON, Wesley, 'Rationality and Objectivity in Science or Tom Kuhn Meets Tom Bayes', in C. Wade Savage, ed., *Scientific Theories* (Minneapolis, MN: University of Minnesota Press, 1990), pp. 175-204. Reprinted in M. Curd and J.A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).

Falsificationism

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PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 128-32. [Introduction]

Popper's classic *The Logic of Scientific Discovery* is highly readable; but for a briefer introduction to his views in their mature form see:

- POPPER, Karl, *Objective Knowledge* (Oxford: Clarendon Press, 1972; 1979), ch. 1 'Conjectural knowledge'.
- POPPER, Karl, 'Science: Conjectures and Refutations', in his *Conjectures and Refutations* (London: Routledge & Kegan Paul, 1963; 1989), pp. 33-65. Reprinted in M. Curd and J. A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).
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For initial discussion, see:

- CHALMERS, Alan F., *What is This Thing Called Science?* 2nd ed. (Milton Keynes: The Open University Press, 1982), chs. 4-7.
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- LAKATOS, Imre, 'Falsification and the Methodology of Scientific Research Programmes', in I. Lakatos and A. Musgrave, eds., *Criticism and the Growth of Knowledge* (Cambridge: Cambridge University Press, 1970), pp. 91-196. Also available online at: <http://doi.org/10.1017/CBO9781139171434.009>. Reprinted in J. Worrall and G. Currie, eds., *Imre Lakatos Philosophical Papers*. Vol. 1 (Cambridge: Cambridge University Press, 1978), sects. 1 & 2.
- MILLER, David, *Critical Rationalism: A Restatement and Defence* (Chicago: Open Court, 1994). [Especially chs. 1-3]
- O'HEAR, Anthony, *Karl Popper* (London: Routledge & Kegan Paul, 1980), chs. 3, 4 & 6.
- PAPINEAU, David, *Theory and Meaning* (Oxford: Clarendon Press, 1979).
- POPPER, Karl, *The Logic of Scientific Discovery* (London: Hutchinson, 1959), chs. 1-6. Also available online at: www.dawsonera.com

SCIENTIFIC EXPLANATION AND LAWS

What, if Anything, Distinguishes Scientific Explanation?

For a general introduction, see:

BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). chs. 1 & 2. Also available online at: <https://doi.org/10.4324/9780203133972>

And for a longer treatment, see the excellent:

PSILLOS, Stathis, *Causation and Explanation* (Chesham: Acumen, 2002), parts 2 & 3. Also available online at: www.dawsonera.com

See also:

- CARTWRIGHT, Nancy, *How the Laws of Physics Lie* (Oxford: Clarendon Press, 1983). Also available online at: <http://doi.org/10.1093/0198247044.001.0001>
- KITCHER, P., and W.C. SALMON, eds., *Scientific Explanation*. Vol. 13 *Minnesota Studies in the Philosophy of Science* (Minneapolis, MN: University of Minnesota Press, 1989).

- RUBEN, David-Hillel, *Explaining Explanation*. 2nd ed. (Boulder, CO: Paradigm Publishers, 2012).
- WOODWARD, James, 'Scientific Explanation', in E.N. Zalta, ed., *Stanford Encyclopaedia of Philosophy (Winter 2014 edition)* [Online]. Available at: <http://plato.stanford.edu/archives/win2014/entries/scientific-explanation/> (Accessed: 9 August 2018).

The Deductive-Nomological Model and Its Rivals

On the Deductive-Nomological Model, see:

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- BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). ch. 2 'Explanation'. Also available online at: <https://doi.org/10.4324/9780203133972>
- GASPER, Philip, 'Introductory Essay: Causation and Explanation', in R. Boyd, P. Gasper and J.D. Trout, eds., *The Philosophy of Science* (Cambridge, MA: MIT Press, 1991), pp. 289-98.
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- RUBEN, David-Hillel, *Explaining Explanation* (London: Routledge, 1990). These excerpts are reprinted in M. Curd and J. A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).
- LIPTON, Peter, 'The Seductive-Nomological Model', *Studies in the History and Philosophy of Science*, 23 (1992): 691-98. [http://doi.org/10.1016/0039-3681\(92\)90020-7](http://doi.org/10.1016/0039-3681(92)90020-7)
- PSILLOS, Stathis, *Causation and Explanation* (Chesham: Acumen, 2002), ch. 8 'Deductive–nomological explanation'. Also available online at: www.dawsonera.com

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- COFFA, J.A., 'Hempel's Ambiguity', *Synthese*, 28 (1974): 141-63. <http://www.jstor.org/stable/20114960>. Reprinted in D-H. Ruben, ed., *Explanation (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1993).
- FRIEDMAN, Michael, 'Explanation and Scientific Understanding', *Journal of Philosophy*, 71 (1974): 5-19. <http://www.jstor.org/stable/2024924>. Reprinted in J. Pitt, ed., *Theories of Explanation* (Oxford: Oxford University Press, 1988).
- HEMPEL, Carl G., and Paul OPPENHEIM, 'Studies in the Logic of Explanation', *Philosophy of Science*, 15 (1948): 135-75. <http://www.jstor.org/stable/185169>. Reprinted in J. Pitt, ed., *Theories of Explanation* (Oxford: Oxford University Press, 1988).

- POPPER, Karl, *Objective Knowledge* (Oxford: Clarendon Press, 1972), ch. 5 'The Aim of Science'.
- SALMON, Wesley, *Causality and Explanation* (Oxford: Oxford University Press, 1998), ch. 6 'A Third Dogma of Empiricism' and ch. 8 'Why Ask "Why"?'. Also available online at: <http://doi.org/10.1093/0195108647.003.0009>
- SCRIVEN, Michael, 'Explanation, Predictions and Laws', in H. Feigl and G. Maxwell, eds., *Scientific Explanation, Space, and Time* (Minneapolis, MN: Minnesota University Press, 1962), pp. 170-230. Reprinted in J. Pitt, ed., *Theories of Explanation* (Oxford: Oxford University Press, 1988).
- VAN FRAASSEN, Bas C., 'The Pragmatics of Explanation', *American Philosophical Quarterly*, 14 (1977): 143-50. <http://www.jstor.org/stable/20009661>. Reprinted in R. Boyd, P. Gasper, J. D. Trout, eds., *The Philosophy of Science: The Central Issues* (Cambridge, MA: MIT Press, 1991), pp. 317-28.

The Causal Model

The causal model of explanation is argued, inter alia, to avoid the problems of the DN model. On the causal and related methods of explanation, see:

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- GASPER, Philip, 'Introductory Essay: Causation and Explanation', in R. Boyd, P. Gasper and J.D. Trout, eds., *The Philosophy of Science* (Cambridge, MA: MIT Press, 1991), pp. 289-98.
- SALMON, Wesley, *Scientific Explanation and the Causal Structure of the World* (Princeton, NJ: Princeton University Press, 1984), chs. 1-2. Also excerpted in D-H. Ruben, ed., *Explanation (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1993), pp.78-112.
- LIPTON, Peter, *Inference to the Best Explanation* (London: Routledge, 1991), chs. 2 & 3. Also available online at: <http://lib.myilibrary.com/?id=11209>
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- SALMON, Wesley, *Causality and Explanation* (Oxford: Oxford University Press, 1998), ch. 4 'Scientific Explanation: Causation and Unification'. Also available online at: <http://doi.org/10.1093/0195108647.003.0005>
- SALMON, Wesley, *Causality and Explanation* (Oxford: Oxford University Press, 1998), ch. 19 'Scientific Explanation: How We Got From There To Here'. Also available online at: <http://doi.org/10.1093/0195108647.003.0020>
- WOODWARD, James, 'A Theory of Singular Causal Explanation', *Erkenntnis*, 21 (1984): 231-62. <http://www.jstor.org/stable/20011928>. Also in D-H. Ruben, ed., *Explanation (Oxford Readings in Philosophy)* (Oxford: Oxford University Press, 1993).

Best System vs. Anti-Reductionist Views of Laws

Are laws just universal generalizations with some special feature? What makes the difference between a law and a mere accidental generalization? Armstrong's review of 'Humean' views, preparatory to giving his own preferred account, is exemplary.

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- BIRD, Alexander, *The Philosophy of Science* (London: Routledge, 1998). ch. 1 'Laws of nature'. Also available online at: <https://doi.org/10.4324/9780203133972>. Reprinted in M. Curd and J. A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).
- COHEN, Jonathan, and Craig CALLENDER, 'A Better Best System Account of Lawhood', *Philosophical Studies*, 145, no. 1 (2009): 1-34. <https://doi.org/10.1007/s11098-009-9389-3>
- PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 139-47.
- NAGEL, Ernest, *Structure of Science* (London: Routledge & Kegan Paul, 1961), ch. 4 'The logical character of scientific laws'.
- LEWIS, David, *Counterfactuals* (Oxford: Blackwell, 1973), pp. 72-77.
- ARMSTRONG, David M., *What is a Law of Nature?* (Cambridge: Cambridge University Press, 1983), chs. 1-6.
- DRETSKE, Fred, 'Laws of Nature', *Philosophy of Science*, 44 (1977): 248-68. <http://www.jstor.org/stable/187350>. Reprinted in M. Curd and J. A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998). Also in A. Bird and J. Ladyman, eds., *Arguing about Science* (London: Routledge, 2013), pp. 423-38.
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- AYER, A.J., 'What is a law of nature?', in his *The Concept of a Person and Other Essays* (London: Macmillan, 1963), pp. 209-234. Reprinted in B. Brody and R. Grandy, eds., *Readings in the Philosophy of Science* (Englewood Cliffs, NJ: Prentice-Hall, 1970; 1989) and also in M. Curd and J. A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton, 1998).
- BRAITHWAITE, Richard B., *Scientific Explanation* (Cambridge: Cambridge University Press, 1953).
- CARROLL, John, *Laws of Nature* (Cambridge: Cambridge University Press, 1994). [Especially chs. 1 & 2]
- CARTWRIGHT, Nancy, 'Where Do Laws of Nature Come From?', *Dialectica*, 51 (1997): 65-78. <http://doi.org/10.1111/j.1746-8361.1997.tb00021.x>
- GOODMAN, Nelson, *Fact, Fiction and Forecast* (London: Athlone, 1954), ch. 1, sect. 3 & ch. 3.
- HARRÉ, Rom, *The Principles of Scientific Thinking* (London: Macmillan, 1969), ch. 4 'Laws of nature'.
- LEWIS, David, 'New Work for a Theory of Universals', *Australasian Journal of Philosophy*, 61 (1983): 343-77. <http://doi.org/10.1080/00048408312341131>. Reprinted in his *Papers in Metaphysics and Epistemology* (Cambridge: Cambridge University Press, 1999). [Especially the section 'Laws and Causation']
- MACKIE, J.L., 'Counterfactuals and Causal Laws', in R.J. Butler, ed., *Analytical Philosophy (1st Series)* (Oxford: Blackwell, 1962), pp. 66-80. Also available on [Moodle](#)
- MELLOR, D.H., *Science, Belief and Behaviour* (Cambridge: Cambridge University Press, 1980), ch. 8 'Necessities and Universals in Natural Laws'. Also available online at: <http://www.dspace.cam.ac.uk/handle/1810/194180>. Reprinted in his *Matters of Metaphysics* (Cambridge: Cambridge University Press, 1991).
- PAPINEAU, David, 'Laws and Accidents', in C. Wright and G. MacDonald, eds., *Fact, Science and Morality* (Oxford: Blackwell, 1986), pp. 189-218. Also available on [Moodle](#)
- TOOLEY, Michael, 'The Nature of Laws', *Canadian Journal of Philosophy*, 7 (1977): 667-98. <http://www.jstor.org/stable/40230714>
- WOODWARD, Jim, 'What is a Mechanism? A Counterfactual Account', *Proceedings of the Philosophy of Science Association*, 3 (2002): S366-S77. <http://www.jstor.org/stable/10.1086/341859>

CONCEPTS OF PROBABILITY

Background on the Probability Calculus

A good introduction to the probability calculus for philosophers is still:

- KYBURG, Henry E., *Probability and Inductive Logic* (New York: Macmillan, 1970). Also available on [Moodle](#). [Part I, especially ch. 2]

See also:

- HOWSON, Colin, and Peter URBACH, *Scientific Reasoning: The Bayesian Approach* (La Salle, IL: Open Court, 1989), ch. 2 'The probability calculus'.
- STEINHART, Eric, *More Precisely: The Math You Need to Do Philosophy* (Peterborough, ON: Broadview Press, 2009), ch. 5 'Probability'.

The Interpretations

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For brief introductions, see:

- PAPINEAU, David, 'Methodology', in A.C. Grayling, ed., *Philosophy: A Guide through the Subject* (Oxford: Oxford University Press, 1995), pp. 160-66.
- MELLOR, D.H., *Probability: A Philosophical Introduction* (London: Routledge, 2005). Also available online at: www.dawsonera.com. [Chs. 1-6 will probably suffice]

See also:

- HÁJEK, Alan, 'Interpretations of Probability', in E.N. Zalta, ed., *Stanford Encyclopedia of Philosophy* (Winter 2012 Edition) [Online]. Available at: <http://plato.stanford.edu/archives/win2012/entries/probability-interpret> (Accessed: 9 August 2018).

It is worth looking at some of the historical sources:

- KEYNES, John M., *A Treatise on Probability* (London: Macmillan, 1921), ch. 1 'The 'logical' interpretation'.
- RAMSEY, Frank P., 'Truth and Probability', in his *Philosophical Papers* (Cambridge: Cambridge University Press, 1990), pp. 62-71, sect. 63. [Subjective probability]
- POPPER, Karl, *A World of Propensities* (Bristol: Thoemmes, 1990), pp. 9-12. Or the opening pages of "Propensities, Probabilities and the Quantum Theory", in S. Kömer, ed., *Observation and Interpretation* (London: Butterworths, 1957), reprinted in D. Miller, ed., *The Pocket Popper* (London: Fontana, 1983). [The propensity (chance) interpretation]
- RUSSELL, Bertrand, *Human Knowledge: Its Scope and Limits* (London: Allen & Unwin, 1948), Part V, chs. 3-4, pp. 368-371. [Frequency interpretation]
- CARNAP, Rudolf, 'Statistical and Inductive Probability', in E.H. Madden, ed., *The Structure of Scientific Thought* (London: Routledge & Kegan Paul, 1968), pp. 269-79. Or 'The Two Concepts of Probability', in H. Feigl and W. Sellars, eds., *Readings in Philosophical Analysis* (New York: Appleton-Century-Crofts, 1949). [Two-concept view]

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- GILLIES, Donald, *An Objective Theory of Probability* (London: Methuen, 1973), ch. 1 'Von Mises' philosophy of science: its Machian origins'.

- HORWICH, Paul, *Probability and Evidence* (Cambridge: Cambridge University Press, 1982).
- LEWIS, David, 'A Subjectivist's Guide to Objective Chance', in his *Philosophical Papers*. Vol. 2 (Oxford: Oxford University Press, 1986), pp. 83-92. Also available online at: <http://doi.org/10.1093/0195036468.003.0004>

INTRODUCTION TO PHILOSOPHY OF PHYSICS

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- KOSSO, Peter, *Appearance and Reality: an Introduction to the Philosophy of Physics* (Oxford: Oxford University Press, 1998). [Good short introduction, covering most of the material that will be in the lectures, in all three sections]
- ALBERT, David, *Quantum Mechanics and Experience* (Cambridge, MA: Harvard University Press, 1993). [Good non-technical introduction to quantum mechanics and its puzzles]
- ALBERT, David, *Time and Chance* (Cambridge, MA: Harvard University Press, 2003), chs. 1-4. [Good non-technical introduction to issues about thermodynamics and irreversibility]
- PENROSE, Roger, *The Emperor's New Mind* (Oxford: Oxford University Press, 1989), chs. 5, 6 and (especially) 7. [Highly readable introduction to the central philosophically significant parts of modern physics, relevant to all three sections]
- PRICE, Huw, *Time's Arrow and Archimedes' Point* (Oxford: Oxford University Press, 1996), especially chs. 1-2 & 8-9. Also available online at: www.dawsonera.com [Relevant to the time and thermodynamics and puzzles of quantum theory sections]

(B)

- CUSHING, James, *Philosophical Concepts in Physics* (Cambridge: Cambridge University Press, 1998). Also available online at: <http://doi.org/10.1017/CBO9781139171106>. [Good and thorough]
- SKLAR, Lawrence, *Space, Time and Spacetime* (Berkeley, CA: University of California Press, 1974). [Classic and readable book on the spacetime and relativity material, in much more detail than we will deal with it]
- WHITAKER, Andrew, *Einstein, Bohr and the Quantum Dilemma: From Quantum Theory to Quantum Information*. 2nd ed. (Cambridge: Cambridge University Press, 2006). Also available online at: <http://doi.org/10.1017/CBO9780511805714>

We welcome your suggestions for further readings that will improve and diversify our reading lists, to reflect the best recent research, and important work by members of under-represented groups. Please email your suggestions to phillib@hermes.cam.ac.uk including the relevant part and paper number. For information on how we handle your personal data when you submit a suggestion please see <https://www.information-compliance.admin.cam.ac.uk/data-protection/general-data>.