"Evidence"
Schedule of Lectures

(date of this version: 2. Aug 2022)

Dr. Erik Curiel

email: erik.curiel@lmu.de
office: Ludwigstr. 31, R130
office hours: by appointment (email me)

course webpage:
http://strangebeautiful.com/lmu/2022-summer-evidence.html

Summer, 2022
Wednesdays, 12:00–14:00 *C.T.*
Ludwigstr. 31 – 021
(possibly sometimes online; contact Dr. Curiel for Zoom coordinates)

Contents

Notes on the Readings, and Caveats **2**
Readings . . . 2

Suggested Readings **2**
Caveats . . . 3

Lecture 1: Introduction (27. Apr) **3**

Lectures 2–5: What Can One Have Evidence For? (4. May–8. June) **4**
Lecture 2: Newton's Investigations on Light and Color, Part I (4. May) . . . 4
Lecture 3: Newton's Investigations on Light and Color, Part II (18. May) . . . 5
Lecture 4: Newton's Doctrine, Its Framework and Evidential Structure, and His Disputes with Pardies, Hooke and Huygens (25. May) . . . 6
Lecture 5: To Confirm Frameworks and Methods (8. Jun) . . . 8

Lectures 6–9: What Can Evidence Consist Of? (15. Jun – 6. Jul) **9**
Lecture 6: Perrin on the Reality of Molecules – Part I (15. June) . . . 9
Lecture 7: Perrin on the Reality of Molecules – Part II (22. June) . . . 11
Lecture 8: Perrin on the Reality of Molecules – Part III (29. June) . . . 11
Lecture 9: Perrin on the Reality of Molecules – Part IV (6. Jul) . . . 11

Lecture 10: The Evidential Complexities of Modern Big Science (13. Jul) **12**

Lectures 11–13: How Does Something Act As Evidence? (20.–27. Jul) **12**
Lecture 11: The Bayesians (some day in the week of 18. Jul, TBD) 12
Lecture 12: Glymour's Bootstrapping (some day in the week of 18. Jul, TBD) 13
Lecture 13: The Role of Causal Structure (some day in the week of 25. Jul, TBD) . . . 14

Lecture 14: Bringing It All Back Home – A Guess at the Riddle and Valediction (some day in the week of 25. Jul, TBD) **14**

REGISTRATION FOR TERM PAPERS: 4.–15. JUL **15**

FINAL PAPER DUE: 30. SEP **15**

FINAL COURSE GRADES SUBMITTED: 21. OCT **15**

Bibliography **15**

Notes on the Readings, and Caveats

Readings

When there are more than one required readings, they are to be read in the order in which they appear in the list.

The only book I suggest you purchase (if you like having physical copies of important books) is:

Smith and Seth (2020), *Brownian Motion and Molecular Reality*

It's expensive. If you have the money to blow, however, it will be worth it. It is a *tour de force* of a historic-philosophical investigation of how science really works.

Some of the required and suggested readings are available online at the course's webpage, though they may not be listed as such in this document's bibliography:

http://strangebeautiful.com/lmu/2022-summer-evidence.html

Many of the required and suggested readings are available in the course's shared Dropbox folder. Contact Dr. Curiel to get access to it.

Journal articles that are available through LMU's online library system do not appear in either place. Many of the books are available through LMU's electronic resources, especially those made available to us during the coronavirus pandemic, such as ProQuest Ebook Central. As many of these latter won't be available for long, make sure to try to find all the relevant readings on them sooner rather than later. Some of the books are also available on the Internet Archive.

Suggested Readings

I neither expect nor request that you try to read all or indeed any of the suggested reading. I give extensive lists for each lecture only so you can delve more deeply into particular facets of the topic

or topics closely related if you are both interested and fired up. For most lectures, I divide the suggested readings into those that reflect my own sympathies and those that reflect the sympathies of others. That does not mean I agree with all the claims, arguments or conclusions of those in the former list, or disagree with all those in the latter. It has more to do with temperament, style and attitude, although, to be sure, something to do with conclusions as well.[1]

For a few lectures, I list prohibited reading. Sometimes, censorship *is* the answer. These are works that I find so intellectually scurrilous, abusive or dishonest that good conscience requires me to try to attempt to dissuade students from reading them. If they are to be read at all, they ought to be read only *after* one has already mastered the subject to a degree that will allow one to make one's own informed decision on whether one agrees with my assessment.

Caveats

I will be making changes to this document from time to time, as I decide to change some required reading, find new suggested reading I think is good, change the schedule of lectures to reflect the facts on the ground, *etc.* Please check it on the course's webpage periodically, as that will always be the most up-to-date version.

Lecture 1: Introduction (27. Apr)

What is evidence? I'm not sure. Some potential answers will be displayed and examined.

Required Reading

1. Curiel (2011), "Notes on Learning Philosophy"

Suggested Reading

1. Achinstein (2001), *The Book of Evidence*: chs. 1–4
2. Achinstein (2010), "Concepts of Evidence"
3. Carnap (1962), *Logical Foundations of Probability*: ch. II
4. Dretske (1981), *Knowledge and the Flow of Information*
5. Earman (1992), *Bayes or Bust?*: chs. 1–3
6. Goodman (1983), *Fact, Fiction and Forecast*: chs. III–IV
7. Hempel (1965b), "Studies in the Logic of Confirmation"
8. Hempel (1965c), "Postscript (1964) on Confirmation"
9. Hempel (1966), *Philosophy of Natural Science*
10. Fisher (1955), "Statistical Methods and Scientific Induction"
11. Haack (2007), *Defending Science – within Reason*
12. Levi (1980), *The Enterprise of Knowledge*
13. Levi (1991), *The Fixation of Belief and Its Undoing*
14. Longino (1990), *Science as Social Knowledge,* chs. 2–5
15. Mayo (1996), *Error and the Growth of Experimental Knowledge*
16. Neyman (1956), "Note on an Article by Sir Ronald Fisher"
17. Pearson (1955), "Statistical Concepts in Their Relation to Reality"

1. "Brotherhood of men comes not from community of thought but consanguinity of mind." – Proust, *Within a Budding Grove.*

18. Peirce (1877), "The Fixation of Belief"
19. Peirce (1878b), "How to Make Our Ideas Clear"
20. Peirce (1878c), "The Doctrine of Chances"
21. Peirce (1878d), "The Probability of Induction"
22. Peirce (1878a), "Deduction, Induction, and Hypothesis"
23. Peirce (1903), "The Nature of Meaning"
24. Peirce (1905), "What Pragmatism Is"
25. Popper (1959), *The Logic of Scientific Discovery*: chs. 4–6, 10
26. Quine (1969a), "Epistemology Naturalized"
27. Roush (2006), *Tracking Truth*
28. Williamson (2000), *Knowledge and Its Limits*: ch. 9
29. Wilson (1952), *An Introduction to Scientific Research*

Lectures 2–5: What Can One Have Evidence For? (4. May–8. June)

Well, seriously, what *can* one have evidence for?

Lecture 2: Newton's Investigations on Light and Color, Part I (4. May)

Required Reading

1. Newton (1672b), "Letter of February 6, 1671/72, to Henry Oldenburg, Secretary of the Royal Society, Outlining Newton's Researches on Light and Color": pp. 47–52
2. Curiel (2018), "Glossary for Newton's Studies on Light and Color"

Prohibited Reading[2]

1. Kuhn (1958), "Newton's Optical Papers"

Suggested Reading: Historical Background

1. Darrigol (2012), *A History of Optics from Greek Antiquity to the Nineteenth Century*: chs. 2–3
2. Park (1999), *The Fire Within the Eye*: chs. 5–7
3. Sabra (1967), *Theories of Light from Descartes to Newton*

Suggested Reading: My Sympathies

1. Bogen and Woodward (1988), "Saving the Phenomena"
2. Carnap (1962), *Logical Foundations of Probability*: ch. II
3. Duhem (1954), *The Aim and Structure of Physical Theory*: Part I, chs. II–III; Part II, chs. I–II, IV, VI–VII
4. Franklin (1981), "What Makes a 'Good' Experiment?"
5. Franklin (1986), *The Neglect of Experiment:* ch. 4
6. Hacking (1983), *Representing and Intervening:* chs. 9–11, 14

2. See the introductory section "Suggested Readings" above.

7. Isaac (2019), "Epistemic Loops and Measurement Realism"
8. Longino (1990), *Science as Social Knowledge,* chs. 2–5
9. Suppes (1969), "Models of Data"
10. Woodward (2011), "Data and Phenomena: A Restatement and Defense"

Suggested Reading: Those of Others

1. Chang (2008), *Inventing Temperature*: chs. 1–3
2. Chang (2012), *Is Water H_2O?*: ch. 4
3. Chang and Cartwright (2013), "Measurement"
4. Collins (1994), "A Strong Confirmation of the Experimenter's Regress"
5. Kuhn (1959), "The Essential Tension"
6. Kuhn (1996), *The Structure of Scientific Revolutions*: chs. VI-VIII
7. Leonelli (2009), "On the Locality of Data and Claims about Phenomena"
8. Leonelli (2015), "What Counts as Scientific Data? A Relational Framework"
9. Quine (1969a), "Epistemology Naturalized"
10. Tal (2013), "Old and New Problems in Philosophy of Measurement"
11. Tal (2016), "How Does Measuring Generate Evidence?"

Lecture 3: Newton's Investigations on Light and Color, Part II (18. May)

Required Reading

1. Newton (1726), *Philosophiæ Naturalis Principia Mathematica*: Book III, "Rules of Reasoning in Philosophy"
2. Newton (1672b), "Letter of February 6, 1671/72, to Henry Oldenburg, Secretary of the Royal Society, Outlining Newton's Researches on Light and Color": pp. 53–59
3. Newton (1672c), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response (in Latin) to Pardies' Second Criticism of Newton's Doctrine of Light": the diagram on p. 101
4. Curiel (2018), "Glossary for Newton's Studies on Light and Color"

Prohibited Reading

1. Kuhn (1958), "Newton's Optical Papers"

Suggested Reading: Newton's More Developed Account of Light and Color

1. Newton (1730), *Opticks: Or, A Treatise of the Reflections, Refractions, Inflections and Colours of Light*: Book I, Part I, "Definitions"; Book I, Part I, "Axioms"; Book I, Part I, Propositions I–VII; Book I, Part II, Propositions I–XI; Book III, Part I, Queries 27–31

Suggested Reading: My Sympathies

1. Carnap (1956), "Empiricism, Semantics and Ontology"
2. Curiel (2017a), "Kinematics, Dynamics, and the Structure of Physical Theory"
3. Curiel (2017b), "On Newton's Third Rule of Reasoning in Philosophy, 'the Universal Qualities of All Bodies Whatsoever', and the Taxonomy of Physical Systems"
4. Dingler (1928), *Das Experiment*

5. Franklin (1986), *The Neglect of Experiment:* ch. 5–6
6. Hacking (1983), *Representing and Intervening:* chs. 12–13, 15
7. Locke (1931), *An Essay Concerning the Understanding, Knowledge, Opinion, and Assent*: §§61, 94[3]
8. Locke (1979), *An Essay Concerning Human Understanding*: Bk. II, ch. VIII[4]
9. Quine (1969b), "Natural Kinds"[5]
10. Stein (2004b), "The Enterprise of Understanding and the Enterprise of Knowledge—For Isaac Levi's Seventieth Birthday"
11. Stein (unpublished[d]), "On Metaphysics and Method in Newton"
12. Stein (unpublished[e]), "Further Considerations on Newton's Method"
13. Suppes (1974), "The Structure of Theories and the Analysis of Data"

Suggested Reading: Those of Others

1. Beebee and Sabbarton-Leary (2012), *The Semantics and Metaphysics of Natural Kinds*: chs. 1–3, 6–7, 9–11
2. Chakravartty (2007), *A Metaphysics for Scientific Realism*
3. Chang (2008), *Inventing Temperature*: chs. 4–5
4. Dasgupta (2013), "Absolutism vs Comparativism about Quantity"
5. van Fraassen (2008), *Scientific Representation*: chs. 4–7
6. van Fraassen (2012), "Modeling and Measurement: The Criterion of Empirical Grounding"
7. Khalidi (2013), *Natural Categories and Human Kinds*
8. Kuhn (1996), *The Structure of Scientific Revolutions*: chs. IX-XIII,
9. LaPorte (2003), *Natural Kinds and Conceptual Change*
10. Lewis (1970), "How to Define Theoretical Terms"
11. Schaffer (1989), "Glass Works: Newton's Prisms and the Uses of Experiment"
12. Tal (2017), "A Model-Based Epistemology of Measurement"
13. Tal (2019), "Individuating Quantities"
14. Wolff (2020), *The Metaphysics of Quantities*: chs. 2–5

Lecture 4: Newton's Doctrine, Its Framework and Evidential Structure, and His Disputes with Pardies, Hooke and Huygens (25. May)

N.b.: READ THEM IN THE ORDER GIVEN HERE. In particular PLEASE NOTE that the correspondence between Huygens and Newton was published in the wrong order, both in the original in the *Transactions* and in their reprinting in Cohen (1958). (The screw-up is explained in Stein unpublished(c), footnote 13, p. 7.) Please make sure you read Huygens' and Newton's letters in the order given here, checking the pages given in the bibliography for where those letters appear in Cohen (1958). Do NOT read them in the order they appear in Cohen (1958).

3. See Stein (2004b) for a marvellous discussion of Locke's account of primary and secondary qualities, especially with regard to how well that account conforms (and does not) with Newton's doctrine of light and color.

4. See Stein (2004b) for a marvellous discussion of Locke's account of primary and secondary qualities, especially with regard to how well that account conforms (and does not) with Newton's doctrine of light and color.

5. For those who know me: don't drop dead of shock at my claim of sympathy with Quine. Not *everything* the dude said was total crap.

Required Reading

1. Pardies (1672a), "Letter of April 9, 1672, to Henry Oldenburg, Secretary of the Royal Society, Containing Pardies' First Response to Newton's Investigations on Light"
2. Newton (1672a), "Letter of April 13, 1672, to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Pardies' First Criticism of Newton's Doctrine of Light"
3. Pardies (1672b), "Letter of May 21, 1672, to Henry Oldenburg, Secretary of the Royal Society, Containing Pardies' Second Response to Newton's Investigations on Light"
4. Newton (1672e), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Pardies' Second Criticism of Newton's Doctrine of Light"
5. Hooke (1672), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Hooke's Response to Newton's Investigations on Light"
6. Newton (1672d), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Hooke's Criticism of Newton's Doctrine of Light"
7. Huygens (1673a), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Huygens' First Response to Newton's Investigations on Light"
8. Newton (1673a), "Letter of April 3, 1673, to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Huygens' First Criticism of Newton's Doctrine of Light"
9. Huygens (1673b), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Huygens' Second Response to Newton's Investigations on Light"
10. Newton (1673b), "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Huygens' Second Criticism of Newton's Doctrine of Light"

Suggested Reading: More Historical and Scientific Material

1. Huygens (1690), *Treatise on Light*: "Preface"
2. Newton (1959), *The Correspondence of Isaac Newton*: the passage in Item 40 ("Newton to Oldenburg, 6 February 1671/2", pp. 92–102) starting on p. 96, marked by editorial endnote '(19)', Newton's remarks about mathematical theories and doctrines that Oldenburg elided from the letter as published in the *Transactions* (and as reprinted in Cohen 1958); "NOTES" to Item 40, pp. 102–107
3. Newton (1959), *The Correspondence of Isaac Newton*: "NOTES" to Items 44, 54–55, 61, 66–67, 76, 103
4. [*** letters of Linus and Lucas, and Newton's replies, in Cohen (1958) ***]

Strongly Suggested Reading

1. Stein (unpublished[d]), "On Metaphysics and Method in Newton": pp. 1–28 (to the end of the long quote from Newton)
2. Stein (unpublished[e]), "Further Considerations on Newton's Method": pp. 1–20 (up to the paragraph beginning "The second passage...")

Prohibited Reading

1. Kuhn (1958), "Newton's Optical Papers"

Suggested Reading: My Sympathies

1. Curiel (2001), "A Plea for Modesty: Against the Current Excesses in Quantum Gravity": §2
2. Domski (2012), "Introduction: Newton and Newtonianism"
3. Harper and Smith (1995), "Newton's New Way of Inquiry"
4. Stein (1993), "On Philosophy and Natural Philosophy in the Seventeenth Century"
5. Stein (2004a), "Newton's Metaphysics"
6. Stein (unpublished[a]), "Nevvtonus ab quibusdam næibus vindicatus"
7. Stein (unpublished[b]), "Newton: Philosophy of Inquiry and Metaphysics of Nature"
8. Stein (unpublished[d]), "On Metaphysics and Method in Newton": pp. 28*ff.*
9. Stein (unpublished[e]), "Further Considerations on Newton's Method": pp. 20*ff.* (starting from the paragraph beginning "The second passage...")

Suggested Reading: Those of Others

1. Jalobeanu (2014), "Constructing Natural Historical Facts: Baconian Methodology in Newton's First Paper on Light and Colors"
2. Kuhn (1976), "Mathematical vs. Experimental Traditions in the Development of Physical Science"
3. Shapiro (1980), "The Evolving Structure of Newton's Theory of White Light and Color"
4. Shapiro (1996), "The Gradual Acceptance of Newton's Theory of Light and Color"
5. Shapiro (2004), "Newton's Optics and Atomism"

Lecture 5: To Confirm Frameworks and Methods (8. Jun)

Required Reading

1. Curiel (2021a), "Framework Confirmation by Newtonian Abduction"

Suggested Reading: Technical Background

1. Newton (1999), *The Principia: Mathematical Principles of Natural Philosophy*: Preface to First Edition, Introduction; "Definitions"'; "Axioms, or the Laws of Motion"; Book I, propositions 1–4, 11, 14–15, 45–46, and all corollaries and scholia; Book III, "Rules for the Study of Natural Philosophy", "Phenomena", propositions 1–14
2. Harper (1990), "Newton's Classic Deductions from Phenomena"
3. Harper (1999), "The First Six Propositions in Newton's Argument for Universal Gravity"
4. Harper (2011), *Isaac Newton's Scientific Method: Turning Data into Evidence about Gravity and Cosmology*
5. Smith (2014), "Closing the Loop: Testing Newtonian Gravity Then and Now"
6. Stein (1990), ""From the Phænomena of Motions to the Forces of Nature": Hypothesis or Deduction?"

Suggested Reading: My Sympathies

1. Bokulich and Parker (2021), "Data models, Representation and Adequacy-for-Purpose"

2. Carnap (1956), "Empiricism, Semantics and Ontology"
3. Curiel (2001), "A Plea for Modesty: Against the Current Excesses in Quantum Gravity"
4. Friedman (2001), *The Dynamics of Reason*: Part 1, chs. II–III; Part 2, chs. 1–2
5. Lakatos (1980), "Falsification and the Methodology of Scientific Research Programmes"
6. Laudan (1977), *Progress and Its Problems: Towards a Theory of Scientific Growth*
7. Norton (2005), "A Little Survey on Induction"
8. Peirce (1878a), "Deduction, Induction, and Hypothesis"
9. Peirce (1903), "The Nature of Meaning"
10. Romeijn (2013), "Abducted by Bayesians?"
11. Stein (1994), "Some Reflections on the Structure of Our Knowledge in Physics"
12. Stein (1992), "Was Carnap Entirely Wrong, After All?"

Suggested Reading: Those of Others

1. Earman and Salmon (1992), "The Confirmation of Scientific Hypotheses"
2. Henderson et al. (2010), "The Structure and Dynamics of Scientific Theories: A Hierarchical Bayesian Perspective"
3. Kuhn (1996), *The Structure of Scientific Revolutions*: chs. IX-X
4. Lipton (2004), *Inference to the Best Explanation*
5. Quine (1980)
6. Quine (1951), "On Carnap's Views on Ontology"
7. Quine (1969a), "Epistemology Naturalized"
8. Stanford (2006), *Exceeding Our Grasp: Science, History, and the Problem of Unconceived Alternatives*

Lectures 6–9: What Can Evidence Consist Of? (15. Jun – 6. Jul)

Everything but the kitchen sink? The kitchen sink sometimes as well? Next to nothing? Nothing at all? Some (un)happy medium?

Lecture 6: Perrin on the Reality of Molecules – Part I (15. June)

Required Reading

1. Smith and Seth (2020), *Brownian Motion and Molecular Reality*: chs. 1–3

Strongly Suggested Reading

1. van Fraassen (2009), "The Perils of Perrin, in the Hands of Philosophers"
2. van Fraassen (2012), "Modeling and Measurement: The Criterion of Empirical Grounding"

Suggested Reading: Scientific and Historical Background

1. Chandrasekhar (1943), "Stochastic Problems in Physics and Astronomy"
2. Maxwell (1867), "On the Dynamical Theory of Gases" [*** (fix bib entry) ***]
3. [*** Maxwell and Boltzmann papers ***]

4. [*** Einstein on Brownian motion ***]
5. [*** Ostwald's book ***]

Suggested Reading: My Sympathies

1. another case-study—Maxwell's formulation of electromagnetism:
   a. Maxwell (1864), "A Dynamical Theory of the Electromagnetic Field"
   b. Buchwald (1985), *From Maxwell to Microphysics: Aspects of Electromagnetic Theory in the Last Quarter of the Nineteenth Century*
   c. Nersessian (1984), *Faraday to Einstein*
   d. Nersessian (2002), "Maxwell and the "Method of Physical Analogy": Model-Based Reasoning, Generic Abstraction and Conceptual Change"
   e. Nersessian (2008), *Creating Scientific Concepts,* chs. 1–2, 5
   f. Stein (1970a), "On the Notion of Field in Newton, Maxwell and Beyond"
   g. Buchdahl (1970), "Comment on "On the Notion of Field in Newton, Maxwell and Beyond" by Howard Stein"
   h. Hesse (1970), "Comment on "On the Notion of Field in Newton, Maxwell and Beyond" by Howard Stein"
   i. "Replies to Comments by G. Buchdahl and M. Hesse on "On the Notion of Field in Newton, Maxwell and Beyond"", "Replies to Comments by G. Buchdahl and M. Hesse on "On the Notion of Field in Newton, Maxwell and Beyond""
2. Bogen and Woodward (1988), "Saving the Phenomena"
3. Bokulich (2020), "Calibration, Coherence, and Consilience in Radiometric Measures of Geologic Time"
4. Mayo (1996), *Error and the Growth of Experimental Knowledge:* ch. 6
5. Popper (1959), *The Logic of Scientific Discovery*: Part II, ch. 5
6. Smith and Seth (2020), *Brownian Motion and Molecular Reality*: "Preface", "Bibliographical Notice"; "Appendix: On Ostwald (1889–1890), Nernst (1893), and Meyer (1899)"
7. Woodward (2011), "Data and Phenomena: A Restatement and Defense"

Suggested Reading: Those of Others

1. Achinstein (2001), *The Book of Evidence*: ch. 12
2. [*** Chalmers ***]
3. [*** Chang ***]
4. Psillos (1999), *Scientific Realism*
5. [*** Psillos *contra* van Fraassen ***]
6. [*** Roush ***]
7. [*** Tal ***]

Lecture 7: Perrin on the Reality of Molecules – Part II (22. June)

Required Reading

1. Smith and Seth (2020), *Brownian Motion and Molecular Reality*: chs. 4–5

Suggested Reading: Scientific Background

1. Perrin (1910), *Brownian Movement and Molecular Reality*: [*** especially pp. ***]

Suggested Reading: My Sympathies

1. another case-study—Hertz's search for electromagnetic radiation:
   a. Hertz (1893), *Electric Waves, Being Researches on the Propagation of Electric Action with Finite Velocity through Space*
   b. Buchwald (1994), *The Creation of Scientific Effects: Heinrich Hertz and Electric Waves*
   c. [*** philosophical analysis ***]
2. Mayo (1996), *Error and the Growth of Experimental Knowledge:* ch. 7

Suggested Reading: Those of Others

1.

Lecture 8: Perrin on the Reality of Molecules – Part III (29. June)

Required Reading

1. Smith and Seth (2020), *Brownian Motion and Molecular Reality*: ch. 6

Suggested Reading: My Sympathies

1. Mayo (1996), *Error and the Growth of Experimental Knowledge:* ch. 8

Suggested Reading: Those of Others

1. van Fraassen (2009), "The Perils of Perrin, in the Hands of Philosophers"
2. [*** Chang ***]
3. [*** Roush ***]
4. [*** Tal ***]

Lecture 9: Perrin on the Reality of Molecules – Part IV (6. Jul)

Required Reading

1. Smith and Seth (2020), *Brownian Motion and Molecular Reality*: ch. 7; "Postscript on the Realism-Instrumentalism Debate"

Suggested Reading: My Sympathies

1. Mayo (1996), *Error and the Growth of Experimental Knowledge:* ch. 5

Suggested Reading: Those of Others

1. van Fraassen (2009), "The Perils of Perrin, in the Hands of Philosophers"
2. [*** Chang ***]
3. [*** Roush ***]
4. [*** Tal ***]

Lecture 10: The Evidential Complexities of Modern Big Science (13. Jul)

LIGO – more than a big, circular mess?

Required Reading

1. Elder (2020), "The Epistemology of Gravitational Wave Astrophysics": ch. 1, §2 (pp. 11–21); ch. 3
2. Patton (2020), "Expanding Theory Testing in General Relativity: LIGO and Parametrized Theories"

Suggested Reading: Scientific Background

1. Abbott, B. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration) (2016a), "Observation of Gravitational Waves from a Binary Black Hole Merger"
2. Abbott, B. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration) (2016b), "Tests of General Relativity with GW150914"
3. [*** more LIGO methodology papers? ***]
4. Yunes and Pretorius (2009), "Fundamental Theoretical Bias in Gravitational Wave Astrophysics and the Parametrized Post-Einsteinian Framework"
5. Bondi (1955), "Fact and Inference in Theory and in Observation"
6. Thorne and Will (February 1971), "Theoretical Frameworks for Testing Relativistic Gravity. I. Foundations" [*** and subsequent papers in the series ***]
7. Will (1993), *Theory and Experiment in Gravitational Physics*

Suggested Reading: My Sympathies

1. Elder (2020), "The Epistemology of Gravitational Wave Astrophysics": [*** selections ***]

Suggested Reading: Those of Others

1. [*** hacking on astrophysics ***]

Lectures 11–13: How Does Something Act As Evidence? (20.–27. Jul)

N.b.: in order to make up the 2 missed lecture days from earlier in the term, we will be having 2 lectures in the week of 18. July, one on the regular lecture day of 20. July, and the other to be determined closer to that week. We will do the same, *mutatis mutandis*, for the week of 25. July.

On the nominal topic of the lectures: What do philosophers say about this more generally? And what evidence do they have—*can* they have—for saying it?

Lecture 11: The Bayesians (some day in the week of 18. Jul, TBD)

Required Reading

1. Sprenger and Hartmann (2019), *Bayesian Philosophy of Science*: "Variation 1: Confirmation and Induction"

Suggested Reading: My Sympathies

1. Earman (1992), *Bayes or Bust?*
2. Franklin (1990), *Experiment, Right or Wrong:* chs. 6–7
3. [*** glymour against Bayes ***]
4. [*** Glymour, Clark. 1975. "Relevant Evidence" Journal of Philosophy 72:403–26 ***]
5. Forster (2006), "Counterexamples to a Likelihood Theory of Evidence"
6. Good (1971), "46656 Varieties of Bayesians"
7. [*** Isidore Jacob Good, Probability and the Weighing of Evidence, 1950; review: Probability and the Weighing of Evidence L. Stein, 1 July 1950, British Journal of Social Medicine, 4(3):170–171, 10.1136/jech.4.3.170 ***]
8. [*** Irving John Good, The Estimation Of Probabilities: An Essay on Modern Bayesian Methods, 1965 ***]
9. [*** I. J. Good, The Foundations of Probability and Its Applications, 1983 ***]
10. Goodman (1983), *Fact, Fiction and Forecast*
11. [*** Haenni, Rolf, Jan-Willem Romeijn, Gregory Wheeler, and Jon Williamson (2011). Probabilistic Logic and Probabilistic Networks. Berlin: Springer.
12. [*** Jeffrey conditionalization ***]
13. [*** Kyburg, *Theory and Measurement* ***]
14. "The Deductive Model: Does It Have Instances?", "The Deductive Model: Does It Have Instances?"
15. [*** Levi, *The Enterprise of Knowledge* ***]
16. Mayo (1996), *Error and the Growth of Experimental Knowledge:* chs. 3–4, 10
17. [*** Mayo in Achinstein (2005) ***]
18. Neta (2008), "What Evidence Do You Have?"
19. [*** Norton against Bayes ***]
20. Thešić et al. (2017), "Confirmation by Explanation: A Bayesian Justification of IBE"

Suggested Reading: Those of Others

1. Achinstein (2001), *The Book of Evidence*: chs. 4–6, 12
2. [*** selections from Achinstein, *Evidence, Explanation, and Realism: Essays in the Philosophy of Science*
3. Howson and Urbach (2005), *Scientific Reasoning: The Bayesian Approach*
4. [*** Horwich, *Probability and Evidence* ***]

Lecture 12: Glymour's Bootstrapping (some day in the week of 18. Jul, TBD)

Required Reading

1. Glymour (Princeton), *Theory and Evidence*: chs. [***]

Suggested Reading: My Sympathies

1. van Fraassen (1983b), "Theory Comparison and Relevant Evidence"
2. van Fraassen (1983a), "Glymour on Evidence and Explanation"

3. Earman (1992), *Bayes or Bust?*: [*** relevant sections ***]
4. Glymour (1983), "On Testing and Evidence"

Suggested Reading: Those of Others

1. Lipton (2004), *Inference to the Best Explanation*

Lecture 13: The Role of Causal Structure (some day in the week of 25. Jul, TBD)

Required Reading

1. Boyd (2018), "Evidence Enriched"

Suggested Reading: My Sympathies

1. Curiel (2021b), "Schematizing the Observer and the Epistemic Content of Theories"
2. Hacking (1983), *Representing and Intervening*: [*** stuff on possibility of "exploratory" experiments without well developed theory, *contra* theory-ladenness ***]
3. "Theory, Intervention and Realism", "Theory, Intervention and Realism"
4. [*** Norton's material theory of induction ***]
5. Woodward (2003), "Experimentation, Causal Inference, and Instrumental Realism"

Suggested Reading: Those of Others

1. Davis (2004), *Thing Knowledge*
2. [*** hacking on astrophysics ***]
3. Heidelberger (2003), "Theory-ladenness and scientific instruments in experimentation"
4. Hon (2003), "The Idols of Experiment"
5. Shapere (1982), "The Concept of Observation in Science and Philosophy"
6. Steinle (1998), "Exploratives vs. theoriebestimmtes Experimentieren"

Lecture 14: Bringing It All Back Home – A Guess at the Riddle and Valediction (some day in the week of 25. Jul, TBD)

N.b.: in order to make up the 2 missed lecture days from earlier in the term, we will be having 2 lectures in the week of 25. July, one on the regular lecture day of 27. July, and the other to be determined closer to that week.

On the nominal topic of this lecture: What I have to say about it all, now that we've slogged our way through the course.

Required Reading

1. [*** draft of my paper "Evidence", or Curiel (2021b) ***]

Suggested Reading: My Sympathies

1. Giere (1983), "Testing Theoretical Hypotheses"
2. Stein (1994), "Some Reflections on the Structure of Our Knowledge in Physics"

Suggested Reading: Those of Others

1. [*** hacking on astrophysics ***]
2. Shapere (1982), "The Concept of Observation in Science and Philosophy"

REGISTRATION FOR TERM PAPERS: 4.–15. JUL

FINAL PAPER DUE: 30. SEP

FINAL COURSE GRADES SUBMITTED: 21. OCT

Bibliography

Abbott, B. *et al.* (LIGO Scientific Collaboration and Virgo Collaboration). 2016a. "Observation of Gravitational Waves from a Binary Black Hole Merger". *Physical Review Letters* 116 (6): 061102. Preprint: arXiv:1602.03837 [gr-qc], doi:10.1103/PhysRevLett.116.061102.

———. 2016b. "Tests of General Relativity with GW150914". *Physical Review Letters* 116 (22): 221101. doi:10.1103/PhysRevLett.116.221101.

Achinstein, Peter. 2001. *The Book of Evidence.* Oxford Studies in Philosophy of Science. Oxford: Oxford University Press.

———, editor. 2005. *Scientific Evidence: Philosophical Theories and Applications.* Baltimore: John Hopkins University Press.

———. 2010. "Concepts of Evidence: Essays in the Philosophy of Science". Chapter 1 in *Evidence, Explanation, and Realism: Essays in the Philosophy of Science,* 3–33. Oxford: Oxford University Press.

Beebee, Helen, and Nigel Sabbarton-Leary, editors. 2012. *The Semantics and Metaphysics of Natural Kinds.* Routledge Studies in Metaphysics. Boca Raton, FL: CRC Press.

Biener, Zvi, and Eric Schliesser, editors. 2014. *Newton and Empiricism.* Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199337095.001.0001.

Bogen, James, and James Woodward. 1988. "Saving the Phenomena". *The Philosophical Review* XCVII (3): 303–352. doi:10.2307/2185445.

Bokulich, Alisa. 2020. "Calibration, Coherence, and Consilience in Radiometric Measures of Geologic Time". *Philosophy of Science* 87 (3): 425–456. doi:10.1086/708690.

Bokulich, Alisa, and Wendy Parker. 2021. "Data models, Representation and Adequacy-for-Purpose". *European Journal for Philosophy of Science* 11:31. doi:10.1007/s13194-020-00345-2.

Bondi, Hermann. 1955. "Fact and Inference in Theory and in Observation". *Vistas in Astronomy* 1:155–162. Reprinted in the collected volume *Vistas in Astronomy*, A. Beer (ed.), volume 1, Pergamon Press, Oxford, 1960, a *Festschrift* for F. J. M. Stratton, as a special Supplement (No. 3) to the *Journal of Atmospheric and Terrestrial Physics*, doi:10.1016/0083-6656(55)90020-9.

Boyd, Nora Mills. 2018. "Evidence Enriched". *Philosophy of Science* 85:403–421. doi:10.1086/697747.

Buchdahl, G. 1970. "Comment on "On the Notion of Field in Newton, Maxwell and Beyond" by Howard Stein". In Stuewer 1970, 287–298.

Buchwald, Jed Z. 1985. *From Maxwell to Microphysics: Aspects of Electromagnetic Theory in the Last Quarter of the Nineteenth Century.* Chicago: University of Chicago Press. ISBN: 0226078825.

———. 1994. *The Creation of Scientific Effects: Heinrich Hertz and Electric Waves.* Chicago: University of Chicago Press.

Carnap, Rudolf. 1956. "Empiricism, Semantics and Ontology". In *Meaning and Necessity: A Study in Semantics and Modal Logic,* Second edition, 205–221. Chicago: The University of Chicago Press. An earlier version was published in *Revue Internationale de Philosophie* 4(1950):20–40.

———. 1962. *Logical Foundations of Probability.* Second. Chicago: University of Chicago Press.

Chakravartty, Anjan. 2007. *A Metaphysics for Scientific Realism: Knowing the Unobservable.* Cambridge: Cambridge University Press. doi:10.1017/CBO9780511487354.

Chandrasekhar, Subrahmanyan. 1943. "Stochastic Problems in Physics and Astronomy". *Review of Modern Physics* 15 (1, January). doi:10.1103/RevModPhys.15.1.

Chang, Hasok. 2008. *Inventing Temperature: Measurement and Scientific Progress.* Oxford: Oxford University Press. doi:10.1093/0195171276.001.0001.

———. 2012. *Is Water H_2O? Evidence, Realism and Pluralism.* Boston Studies in the Philosophy and History of Science 293. Dordrecht: Springer. doi:10.1007/978-94-007-3932-1.

Chang, Hasok, and Nancy Cartwright. 2013. "Measurement". Chapter 38 in *The Routledge Companion to Philosophy of Science,* Second, edited by Martin Curd and Stathis Psillos, 411–419. London: Routledge. doi:10.4324/9780203744857.ch38.

Cohen, I. Bernard, editor. 1958. *Isaac Newton's Papers & Letters on Natural Philosophy.* Cambridge, MA: Harvard University Press.

Cohen, I. Bernard, and George E. Smith, editors. 2004. *The Cambridge Companion to Newton.* Cambridge: Cambridge University Press.

Collins, Harry. 1994. "A Strong Confirmation of the Experimenter's Regress". *Studies in History and Philosophy of Modern Physics* 25 (3): 493–503. doi:10.1016/0039-3681(94)90063-9.

Curiel, Erik. 2001. "A Plea for Modesty: Against the Current Excesses in Quantum Gravity". *Philosophy of Science* 68 (3): S424–S441. doi:10.1086/392926.

———. 2011. "Notes on Learning Philosophy". Unpublished manuscript, latest version available at http://strangebeautiful.com/papers/curiel-learning-philosophy.pdf.

———. 2017a. "Kinematics, Dynamics, and the Structure of Physical Theory". Unpublished manuscript. Preprint: arXiv:1603.02999 [physics.hist-ph]. Most recent draft available at <http://strangebeautiful.com/phil-phys.html>.

Curiel, Erik. 2017b. "On Newton's Third Rule of Reasoning in Philosophy, 'the Universal Qualities of All Bodies Whatsoever', and the Taxonomy of Physical Systems". Unpublished manuscript.

———. 2018. "Glossary for Newton's Studies on Light and Color". Unpublished manuscript, available at http://strangebeautiful.com/papers/curiel-newton-light-color-glossary.pdf.

———. 2021a. "Framework Confirmation by Newtonian Abduction". *Synthese* 198 (Supplement 16, July): S3813–S3851. Part of the special issue "Reasoning in Physics", doi:10.1007/s11229-019-02400-9.

———. 2021b. "Schematizing the Observer and the Epistemic Content of Theories". Forthcoming in *Studies in History and Philosophy of Modern Physics*. Preprint: arXiv:1903.02182 [physics.hist-ph]. The most up-to-date version can always be found at http://strangebeautiful.com/phil-phys.html.

Darrigol, Olivier. 2012. *A History of Optics from Greek Antiquity to the Nineteenth Century.* Oxford: Oxford University Press.

Dasgupta, Shamik. 2013. "Absolutism vs Comparativism about Quantity". Chapter 3 in *Oxford Studies in Metaphysics,* edited by Karen Bennett and Dean W. Zimmerman, 8:105–148. Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199682904.003.0003.

Davis, Baird. 2004. *Thing Knowledge: A Philosophy of Scientific Instruments.* Berkeley: University of California Press.

Dingler, Hugo. 1928. *Das Experiment: Sein Wesen und seine Geschichte.* München: Verlag Ernst Reinhardt.

Domski, Mary. 2012. "Introduction: Newton and Newtonianism". *The Southern Journal of Philosophy* 50 (3): 363–369. doi:10.1111/j.2041-6962.2012.00127.x.

Dretske, Fred. 1981. *Knowledge and the Flow of Information.* Cambridge, MA: MIT Press.

Duhem, Pierre. 1954. *The Aim and Structure of Physical Theory.* Translated by Philip P. Wiener. Princeton, NJ: Princeton University Press.

Earman, J., and W. Salmon. 1992. "The Confirmation of Scientific Hypotheses". In *Introduction to the Philosophy of Science,* edited by M. Salmon, J. Earman, C. Glymour, and J. Lennox, 42–103. Englewood Cliff, NJ: Prentice Hall.

Earman, John, editor. 1983. *Testing Scientific Theories.* Minnesota Studies in the Philosophy of Science, x. Minneapolis: University of Minnesota Press.

———. 1992. *Bayes or Bust? A Critical Examination of Bayesian Confirmation Theory.* Cambridge, MA: MIT Press.

Elder, Jamee. 2020. "The Epistemology of Gravitational Wave Astrophysics". PhD thesis, University of Notre Dame, History and Philosophy of Science Program.

Fisher, Ronald. 1955. "Statistical Methods and Scientific Induction". *Journal of The Royal Statistical Society: Series B (Methodological)* 17 (1): 69–78. doi:10.1111/j.2517-6161.1955.tb00180.x.

Forster, Malcolm R. 2006. "Counterexamples to a Likelihood Theory of Evidence". *Minds and Machines* 16 (3, August): 319–338. doi:10.1007/s11023-006-9038-y.

van Fraassen, Bas C. 2008. *Scientific Representation: Paradoxes of Perspective.* Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199278220.001.0001.

———. 2009. "The Perils of Perrin, in the Hands of Philosophers". *Philosophical Studies* 143:5–24. doi:10.1007/s11098-008-9319-9.

———. 2012. "Modeling and Measurement: The Criterion of Empirical Grounding". *Philosophy of Science* 79 (5): 773–784. doi:10.1086/667847.

———. 1983a. "Glymour on Evidence and Explanation". In Earman 1983, 165–176.

———. 1983b. "Theory Comparison and Relevant Evidence". In Earman 1983, 27–42.

Franklin, Allan D. 1981. "What Makes a 'Good' Experiment?" *The British Journal for the Philosophy of Science* 32 (4, December): 367–374. doi:10.1093/bjps/32.4.367.

———. 1986. *The Neglect of Experiment.* Cambridge: Cambridge University Press. doi:10.1017/CBO9780511624896.

———. 1990. *Experiment, Right or Wrong.* Cambridge: Cambridge University Press. doi:10.1017/CBO9780511527302.

Friedman, M. 2001. *The Dynamics of Reason.* Stanford, CA: CSLI Publications. Delivered as the 1999 Kant Lectures at Stanford University.

Giere, Ronald N. 1983. "Testing Theoretical Hypotheses". In Earman 1983, 269–298.

Glymour, Clark. 1983. "On Testing and Evidence". In Earman 1983, 3–26.

———. Princeton. *Theory and Evidence.* Princeton, NJ: Princeton University Press.

Good, I. 1971. "46656 Varieties of Bayesians". *Letter in American Statistician* 25 (5, January): 62–63. Reprinted in Good's *Good Thinking*, University of Minnesota Press, 1982, pp. 20-21.

Goodman, Nelson. 1983. *Fact, Fiction and Forecast.* Fourth. Cambridge, MA: Harvard University Press.

Haack, Susan. 2007. *Defending Science – within Reason: Between Scientism And Cynicism.* Amherst: Prometheus Books.

Hacking, Ian. 1983. *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science.* Cambridge: Cambridge University Press.

Harper, W. 1990. "Newton's Classic Deductions from Phenomena". *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 2:183–196. Stable URL: <https://www.jstor.org/stable/193067>.

Harper, W. 1999. "The First Six Propositions in Newton's Argument for Universal Gravity". *The St. John's Review* XLV (2): 74–93. In the special issue of the proceedings of the conference "Beyond Hypothesis: Newton's Experimental Philosophy", St. John's College, Annapolis, MD 19–21 March, 1999. Electronic copy available at <http://digitalarchives.sjc.edu/files/original/5d140db01fbf5fe6562615e2d3713b6e.pdf>.

Harper, William L. 2011. *Isaac Newton's Scientific Method: Turning Data into Evidence about Gravity and Cosmology.* Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199570409.001.0001.

Harper, William L., and George E. Smith. 1995. "Newton's New Way of Inquiry". In *The Creation of Ideas in Physics: Studies for a Methodology of Theory Construction,* edited by E. Leplin, 113–166. The Western Ontario Series in Philosophy of Science. Boston: Kluwer Academic Publishers.

Heidelberger, Michael. 2003. "Theory-ladenness and scientific instruments in experimentation". In Radder 2003, 138–151.

Hempel, Carl G. 1965a. *Aspects of Scientific Explanation: And Other Essays in the Philosophy of Science.* New York: Free Press.

———. 1965b. "Studies in the Logic of Confirmation". In Hempel 1965a, chapter 1.

———. 1965c. "Postscript (1964) on Confirmation". In Hempel 1965a, 47–51.

———. 1966. *Philosophy of Natural Science.* Englewood, NJ: Prentice-Hall.

Henderson, L., N. Goodman, J. Tenenbaum, and J. Woodward. 2010. "The Structure and Dynamics of Scientific Theories: A Hierarchical Bayesian Perspective". *Philosophy of Science* 77 (2): 172–200. doi:10.1086/651319.

Hertz, H. 1893. *Electric Waves, Being Researches on the Propagation of Electric Action with Finite Velocity through Space.* New York: Dover Press. Trans. D. Jones. Originally published as *Untersuchungen über die Ausbreitung der elektrischen Kraft* (Leipzig: J. A. Barth, 1892). This is a 1962 reprint of the English edition which first appeared in 1893, published by Macmillan and Sons.

Hesse, M. 1970. "Comment on "On the Notion of Field in Newton, Maxwell and Beyond" by Howard Stein". In Stuewer 1970, 298–299.

Hon, Giora. 2003. "The Idols of Experiment: Transcending the 'Etc. List'". In Radder 2003, 174–197.

Hooke, Robert. 1672. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Hooke's Response to Newton's Investigations on Light". In Cohen 1958, 110–115.

Howson, Colin, and Peter Urbach. 2005. *Scientific Reasoning: The Bayesian Approach.* Third. LaSalle, IL: Open Court Press.

Huygens, Christiaan. 1673a. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Huygens' First Response to Newton's Investigations on Light". In Cohen 1958, 136.

Huygens, Christiaan. 1673b. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Huygens' Second Response to Newton's Investigations on Light". In Cohen 1958, 148.

———. 1690. *Treatise on Light.* Translated by Silvanus P. Thompson. New York City: Dover Publications, Inc. The Dover 1962 unaltered republication of the 1912 Macmillan and Co. edition.

Isaac, Alistair M. C. 2019. "Epistemic Loops and Measurement Realism". *Philosophy of Science* 86 (5): 930–941. doi:10.1086/705476.

Jalobeanu, Dana. 2014. "Constructing Natural Historical Facts: Baconian Methodology in Newton's First Paper on Light and Colors". In Biener and Schliesser 2014, chapter 2.

Khalidi, Muhammad Ali. 2013. *Natural Categories and Human Kinds: Classification in the Natural and Social Sciences.* Cambridge: Cambridge University Press. doi:10.1017/CBO9780511998553.

Kuhn, S., Thomas. 1976. "Mathematical vs. Experimental Traditions in the Development of Physical Science". *The Journal of Interdisciplinary History Vol. 7, No. 1, Summer,* 7 (1, Summer): 1–31. Reprinted in Kuhn (1977), ch. 3, pp. 31–65, doi:10.2307/202372.

Kuhn, Thomas S. 1958. "Newton's Optical Papers". In Cohen 1958, 27–45.

———. 1959. "The Essential Tension: Tradition and Innovation in Scientific Research". In Kuhn 1977, chapter 9.

———. 1977. *The Essential Tension: Selected Studies in Scientific Tradition and Change.* Chicago: The University of Chicago Press.

———. 1996. *The Structure of Scientific Revolutions.* Third edition. Chicago: University of Chicago Press. The first edition was published in 1962.

Kyburg, Henry. 1983. "The Deductive Model: Does It Have Instances?" In Earman 1983, 299–312.

Lakatos, Imre. 1980. "Falsification and the Methodology of Scientific Research Programmes". Chapter 1 in *Methodology of Scientific Research Programmes: Philosophical Papers,* edited by J. Worrall and G. Currie., 1:8–101. Cambridge: Cambridge University Press.

LaPorte, Joseph. 2003. *Natural Kinds and Conceptual Change.* Cambridge Studies in Philosophy and Biology. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511527319.

Laudan, L. 1977. *Progress and Its Problems: Towards a Theory of Scientific Growth.* Berkeley: University of California Press.

Leonelli, Sabina. 2009. "On the Locality of Data and Claims about Phenomena". *Philosophy of Science* 76 (5): 737–749. doi:10.1086/605804.

———. 2015. "What Counts as Scientific Data? A Relational Framework". *Philosophy of Science* 82 (5): 810–821. doi:10.1086/684083.

Levi, Isaac. 1980. *The Enterprise of Knowledge: An Essay on Knowledge, Credal Probability, and Chance.* Cambridge, MA: MIT Press.

Levi, Isac. 1991. *The Fixation of Belief and Its Undoing: Changing Beliefs through Inquiry.* Cambridge: Cambridge University Press. doi:10.1017/CBO9780511663819.

Lewis, David. 1970. "How to Define Theoretical Terms". *The Journal of Philosophy* 67 (13): 427–446. http://www.jstor.org/stable/2023861.

Lipton, Peter. 2004. *Inference to the Best Explanation.* Second. London: Routledge.

Locke, John. 1931. *An Essay Concerning the Understanding, Knowledge, Opinion, and Assent.* Edited by Benjamin Rand. Cambridge, MA: Harvard University Press. This is often referred to as 'The Essay, Draft B' (or just 'Draft B' for short).

———. 1979. *An Essay Concerning Human Understanding.* Edited by Peter H. Nidditch. Clarendon Edition of the Works of John Locke. Oxford: Oxford University Press.

Longino, Helen E. 1990. *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry.* Princeton: Princeton University Press.

Maxwell, James Clerk. 1864. "A Dynamical Theory of the Electromagnetic Field". In *The Scientific Papers of J. C. Maxwell,* edited by W. D. Niven, volume I, 526–597. Cambridge: University of Cambridge Press. Originally published in three parts: Part I, read before the Royal Society on December 8, 1864, and subsequently published in the *Royal Society Proceedings*, III, 531–536. Part II: *Philosophical Transactions of the Royal Society*, 1865, CLV, 459–512. Part III: *Philosophical Magazine*, 1865, XXIX, 152–157.

———. 1867. "On the Dynamical Theory of Gases". Reprinted in *The Scientific Papers of J. C. Maxwell* (2 volumes printed as one), Volume II, W. Niven (Ed.). New York: Dover Publications, Inc., 1965, pp. 26–78. *Philosophical Transactions of the Royal Society (London)* 157:49–88.

Mayo, Deborah. 1996. *Error and the Growth of Experimental Knowledge.* Chicago: University of Chicago Press.

Morrison, Margaret. 1990. "Theory, Intervention and Realism". *Synthese* 82 (1, January): 1–22. doi:10.1007/BF00413667.

Nersessian, Nancy J. 1984. *Faraday to Einstein: Constructing Meaning in Scientific Theories.* Dordrecht: Martinus Nijhoff/Kluwer Academic.

———. 2002. "Maxwell and the "Method of Physical Analogy": Model-Based Reasoning, Generic Abstraction and Conceptual Change". In *Reading Natural Philosophy: Essays in the History and Philosophy of Science and Mathematics,* edited by David Malament, 129–167. Chicago: Open Court Press. Essays presented to Howard Stein in honor of his 70th birthday, delivered at a conference in Stein's honor at the University of Chicago, May, 1999.

———. 2008. *Creating Scientific Concepts.* Cambridge, MA: MIT Press.

Neta, Ram. 2008. "What Evidence Do You Have?" *The British Journal for the Philosophy of Science* 59 (1): 89–119. doi:10.1093/bjps/axn003.

Newton, Isaac. 1672a. "Letter of April 13, 1672, to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Pardies' First Criticism of Newton's Doctrine of Light". In Cohen 1958, 90–92.

———. 1672b. "Letter of February 6, 1671/72, to Henry Oldenburg, Secretary of the Royal Society, Outlining Newton's Researches on Light and Color". In Cohen 1958, 47–59.

———. 1672c. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response (in Latin) to Pardies' Second Criticism of Newton's Doctrine of Light". In Cohen 1958, 99–103.

———. 1672d. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Hooke's Criticism of Newton's Doctrine of Light". In Cohen 1958, 116–135.

———. 1672e. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Pardies' Second Criticism of Newton's Doctrine of Light". In Cohen 1958, 106–109.

———. 1673a. "Letter of April 3, 1673, to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Huygens' First Criticism of Newton's Doctrine of Light". In Cohen 1958, 143–146.

———. 1673b. "Letter to Henry Oldenburg, Secretary of the Royal Society, Containing Newton's Response to Huygens' Second Criticism of Newton's Doctrine of Light". In Cohen 1958, 137–142.

———. 1726. *Philosophiæ Naturalis Principia Mathematica.* Third. Volume II. Berkeley, CA: University of California Press. The translation by A. Motte of the third edition (1726), originally produced in 1729, revised by F. Cajori and published in 1934. The first edition of the *Principia* was published in 1686, the second in 1713.

———. 1726[1999]. *The Principia: Mathematical Principles of Natural Philosophy.* Translated by I. Cohen and A. Whitman. Berkeley, CA: University of California Press. Translation of *Philosophiæ Naturalis Principia Mathematica*, based on the Third Edition text of 1726.

———. 1730. *Opticks: Or, A Treatise of the Reflections, Refractions, Inflections and Colours of Light.* Fourth. New York: Dover Publications, Inc. A 1952 reprint of the 1931 volume of G. Bell & Sons, Ltd., based on the fourth edition of William Innys, London, 1730. An online version, stable URL: http://www.gutenberg.org/files/33504/33504-h/33504-h.htm.

———. 1959. *The Correspondence of Isaac Newton: 1661–1675.* Edited by H. W. Turnbull. Volume 1. Cambridge: Cambridge University Press.

———. 1999. *The Principia: Mathematical Principles of Natural Philosophy.* Translation of *Philosophiæ Naturalis Principia Mathematica* by I. Cohen and A. Whitman, based on the Third Edition text of 1726. Berkeley, CA: University of California Press.

Neyman, Jerzy. 1956. "Note on an Article by Sir Ronald Fisher". *Journal of The Royal Statistical Society: Series B (Methodological)* 18 (2): 288–294. doi:10.1111/j.2517-6161.1956.tb00236.x.

Norton, J. 2005. "A Little Survey on Induction". In Achinstein 2005, 9–34.

Pardies, I. 1672a. "Letter of April 9, 1672, to Henry Oldenburg, Secretary of the Royal Society, Containing Pardies' First Response to Newton's Investigations on Light". In Cohen 1958, 86–89.

———. 1672b. "Letter of May 21, 1672, to Henry Oldenburg, Secretary of the Royal Society, Containing Pardies' Second Response to Newton's Investigations on Light". In Cohen 1958, 104–106.

Park, David. 1999. *The Fire Within the Eye: A Historical Essay on the Nature and Meaning of Light.* Princeton: Princeton University Press.

Patton, Lydia. 2020. "Expanding Theory Testing in General Relativity: LIGO and Parametrized Theories". *Studies in History and Philosophy of Modern Physics* 69:142–153. doi:10.1016/j.shpsb.2020.01.001.

Pearson, E. S. 1955. "Statistical Concepts in Their Relation to Reality". *Journal of The Royal Statistical Society: Series B (Methodological)* 17 (2): 204–207. doi:10.1111/j.2517-6161.1955.tb00194.x.

Peirce, Charles Sanders. 1877. "The Fixation of Belief". In Peirce 1992a, chapter 7.

———. 1878a. "Deduction, Induction, and Hypothesis". In Peirce 1992a, chapter 12.

———. 1878b. "How to Make Our Ideas Clear". In Peirce 1992a, chapter 8.

———. 1878c. "The Doctrine of Chances". In Peirce 1992a, chapter 9.

———. 1878d. "The Probability of Induction". In Peirce 1992a, chapter 10.

———. 1903. "The Nature of Meaning". In Peirce 1992b, chapter 15.

———. 1905. "What Pragmatism Is". In Peirce 1992b, chapter 24.

———. 1992a. *The Essential Peirce: Selected Philosophical Writings.* Edited by N. Houser and C. Kloesel. Volume 1 (1867–1893). Bloomington, IN: Indiana University Press.

———. 1992b. *The Essential Peirce: Selected Philosophical Writings,* edited by The Peirce Edition Project, volume 2 (1893–1913). Bloomington, IN: Indiana University Press.

Perrin, Jean. 1910. *Brownian Movement and Molecular Reality.* London: Taylor & Francis. Translated by F. Soddy from the *Annales de Chimie et de Physique*, 8me Series, September, 1909.

Popper, K. 1959. *The Logic of Scientific Discovery.* London: Hutchinson & Co.

Psillos, Stathis. 1999. *Scientific Realism: How Science Tracks Truth.* London: Routledge.

Quine, Willard Van Orman. 1951. "On Carnap's Views on Ontology". *Philosophical Studies* 2 (5): 65–72. doi:10.1007/BF02199422.

———. 1969a. "Epistemology Naturalized". In Quine 1969c, chapter 3.

———. 1969b. "Natural Kinds". In Quine 1969c, chapter 5.

———. 1969c. *Ontological Relativity and Other Essays.* John Dewey Essays in Philosophy 1. New York: Columbia University Press.

Quine, Willard Van Orman. 1980. "Two Dogmas of Empiricism". Chapter II in *From a Logical Point of View: Nine Logico-Philosophical Essays,* 2nd, revised, 20–46. Cambridge, MA: Harvard University Press. Emended version of the article originally published in the *Philosophical Review*, 1951, 60(1, January):20–43.

Radder, Hans, editor. 2003. *The Philosophy Of Scientific Experimentation.* Pittsburgh: University of Pittsburgh Press.

Romeijn, Jan-Willem. 2013. "Abducted by Bayesians?" *Journal of Applied Logic* 11 (4): 430–439. Part of special issue "Combining Probability and Logic: Papers from Progic 2011", ed. J. Helzner, doi:10.1016/j.jal.2012.09.003.

Roush, Sherrilyn. 2006. *Tracking Truth: Knowledge, Evidence and Science.* Oxford: Oxford University Press. doi:10.1093/0199274738.001.0001.

Sabra, A. I. 1967. *Theories of Light from Descartes to Newton.* London: Oldbourne Press.

Schaffer, Simon. 1989. "Glass Works: Newton's Prisms and the Uses of Experiment". Chapter 2 in *The Uses of Experiment: Studies in the Natural Sciences,* edited by David Gooding, Trevor Pinch, and Simon Schaffer, 67–104. Cambridge: Cambridge University Press.

Shapere, D. 1982. "The Concept of Observation in Science and Philosophy". *Philosophy of Science* 49 (4): 485–525. doi:10.1086/289075.

Shapiro, A. 1980. "The Evolving Structure of Newton's Theory of White Light and Color". *Isis* 71 (2): 211–235. doi:10.1086/352461.

———. 2004. "Newton's Optics and Atomism". In Cohen and Smith 2004, chapter 7.

Shapiro, Alan. 1996. "The Gradual Acceptance of Newton's Theory of Light and Color". *Perspectives in Science* 4:59–140.

Smith, George E. 2014. "Closing the Loop: Testing Newtonian Gravity Then and Now". In Biener and Schliesser 2014, chapter 10.

Smith, George E., and Raghav Seth. 2020. *Brownian Motion and Molecular Reality: A Study in Theory-Mediated Measurement.* Oxford Studies in Philosophy of Science. Oxford: Oxford University Press. doi:10.1093/oso/9780190098025.001.0001.

Sprenger, Jan, and Stephan Hartmann. 2019. *Bayesian Philosophy of Science.* Oxford: Oxford University Press. doi:10.1093/oso/9780199672110.001.0001.

Stanford, P. 2006. *Exceeding Our Grasp: Science, History, and the Problem of Unconceived Alternatives.* Oxford: Oxford University Press. doi:10.1093/0195174089.001.0001.

Stein, Howard. 1970a. "On the Notion of Field in Newton, Maxwell and Beyond". In Stuewer 1970, 264–287.

———. 1970b. "Replies to Comments by G. Buchdahl and M. Hesse on "On the Notion of Field in Newton, Maxwell and Beyond"". In Stuewer 1970, 299–310.

Stein, Howard. 1990. ""From the Phænomena of Motions to the Forces of Nature": Hypothesis or Deduction?" *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 2:209–222. Stable URL: <www.jstor.org/stable/193069>.

———. 1992. "Was Carnap Entirely Wrong, After All?" *Synthese* 93:275–295. doi:10.1007/BF00869429.

———. 1993. "On Philosophy and Natural Philosophy in the Seventeenth Century". *Midwest Studies in Philosophy* XVIII (1): 177–201. doi:10.1111/j.1475-4975.1993.tb00264.x.

———. 1994. "Some Reflections on the Structure of Our Knowledge in Physics". In *Logic, Metholodogy and Philosophy of Science,* edited by D. Prawitz, B. Skyrms, and D. Westerståhl, 633–655. Proceedings of the Ninth International Congress of Logic, Methodology and Philosophy of Science. New York: Elsevier Science B.V.

———. 2004a. "Newton's Metaphysics". In Cohen and Smith 2004, chapter 8.

———. 2004b. "The Enterprise of Understanding and the Enterprise of Knowledge—For Isaac Levi's Seventieth Birthday". *Synthese* 140 (1–2): 135–176. doi:10.1023/B:SYNT.0000029946.38831.c9.

———. unpublished(a). "Nevvtonus ab quibusdam næibus vindicatus". Unpublished manuscript. Available at <http://strangebeautiful.com/other-minds.html>.

———. unpublished(b). "Newton: Philosophy of Inquiry and Metaphysics of Nature". Unpublished manuscript. Available at <http://strangebeautiful.com/other-minds.html>.

———. unpublished(c). "On Metaphysics and Method in Newton". Unpublished manuscript. Available at <http://strangebeautiful.com/other-minds.html>.

———. unpublished(d). "On Metaphysics and Method in Newton". Available at <http://strangebeautiful.com/other-minds.html>.

———. unpublished(e). "Further Considerations on Newton's Method". Available at <http://strangebeautiful.com/other-minds.html>.

Steinle, Friedrich. 1998. "Exploratives vs. theoriebestimmtes Experimentieren: Ampères erste Arbeiten zum Elektromagnetismus". In *Experimental Essays – Versuche zum Experiment,* edited by Michael Heidelberger and Friedrich Steinle, 272–297. Baden-Baden: Nomos Verlagsgesellschaft.

Stuewer, R., editor. 1970. *Historical and Philosophical Perspectives of Science.* Volume V. Minnesota Studies in the Philosophy of Science. Freely available online at <https://cla.umn.edu/mcps/publications/minnesota-studies-philosophy-science>. Minneapolis: University of Minnesota Press.

Suppes, Patrick. 1969. "Models of Data". Chapter 2 in *Studies in the Methodology and Foundations of Science: Selected Papers from 1951 to 1969,* 24–35. Dordrecht: D. Reidel Publishing Co.

———. 1974. "The Structure of Theories and the Analysis of Data". In *The Structure of Scientific Theories,* edited by Frederick Suppe, 266–307. Chicago: University of Illinois Press.

Tal, Eran. 2013. "Old and New Problems in Philosophy of Measurement". *Philosophy Compass* 8 (12): 1159–1173. doi:10.1111/phc3.12089.

———. 2016. "How Does Measuring Generate Evidence? The Problem of Observational Grounding". *Journal of Physics: Conference Series* 772:012001. doi:10.1088/1742-6596/772/1/012001.

———. 2017. "A Model-Based Epistemology of Measurement". Chapter 17 in *Reasoning in Measurement,* edited by Nicola Mößner and Alfred Nordmann, 233–253. History and Philosophy of Technoscience 9. London: Routledge.

———. 2019. "Individuating Quantities". *Philosophical Studies, volume 176,* 176:853–878. doi:10.1007/s11098-018-1216-2.

Thešić, M., B. Eva, and S. Hartmann. 2017. "Confirmation by Explanation: A Bayesian Justification of IBE". Unpublished manuscript. Preprint: <http://philsci-archive.pitt.edu/13328/>.

Thorne, K., and C. Will. February 1971. "Theoretical Frameworks for Testing Relativistic Gravity. I. Foundations". *The Astrophysical Journal* 163 (): 595–610. doi:10.1086/150803.

Will, Clifford. 1993. *Theory and Experiment in Gravitational Physics.* Revised. Cambridge: Cambridge University Press. The first edition was published in 1981.

Williamson, Timothy. 2000. *Knowledge and Its Limits.* Oxford: Oxford University Press. doi:10.1093/019925656X.001.0001.

Wilson, E. Bright, Jr. 1952. *An Introduction to Scientific Research.* A 1990 unabridged reprint, with minor revisions and a new preface, of the original 1952 edition by McGraw-Hill Book Company, Inc., New York. New York: Dover Publications, Inc.

Wolff, J. E. 2020. *The Metaphysics of Quantities.* Oxford: Oxford University Press. doi:10.1093/oso/9780198837084.001.0001.

Woodward, J. 2011. "Data and Phenomena: A Restatement and Defense". *Synthese* 182:165–179. doi:10.1007/s11229-009-9618-5.

Woodward, Jim. 2003. "Experimentation, Causal Inference, and Instrumental Realism". In Radder 2003, chapter 5.

Yunes, N., and F. Pretorius. 2009. "Fundamental Theoretical Bias in Gravitational Wave Astrophysics and the Parametrized Post-Einsteinian Framework". *Physical Review D* 80 (12): 122003. doi:10.1103/PhysRevD.80.122003.