

ALISTER  
MCGRATH

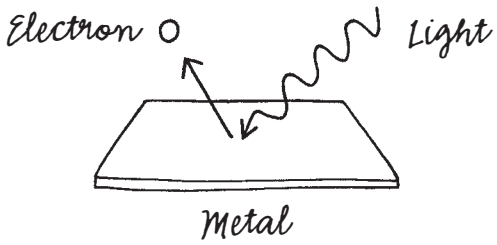
*a theory  
of  
everything  
(that matters)*

A BRIEF GUIDE TO EINSTEIN,  
RELATIVITY & HIS SURPRISING  
THOUGHTS ON GOD



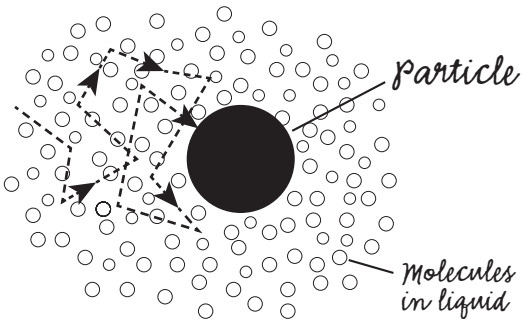
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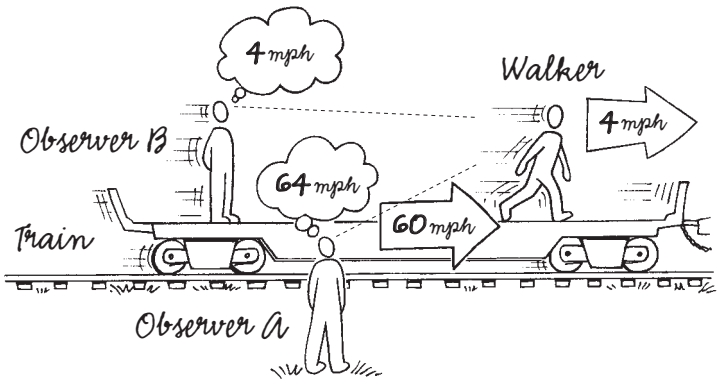


## Brownian Motion

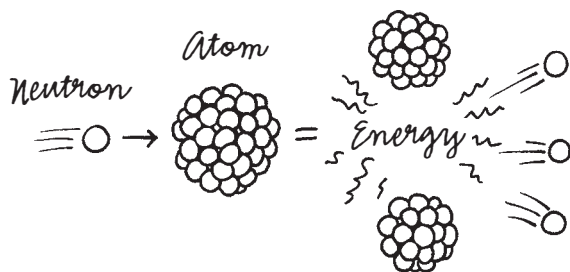
The random motion that occurs when small particles are suspended in liquid.



## Special Relativity Illustrated by a Train in Motion

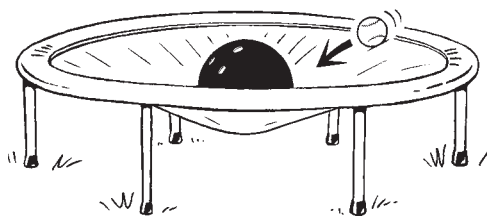


## Nuclear Fission: The Splitting of an Atom



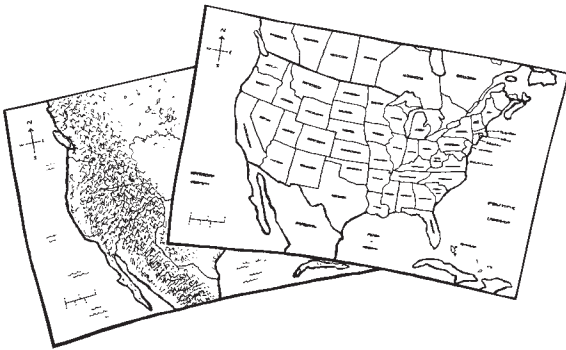
## The Trampoline

An illustration of how an object warps space and time.



## Multiple Maps for the Same Reality

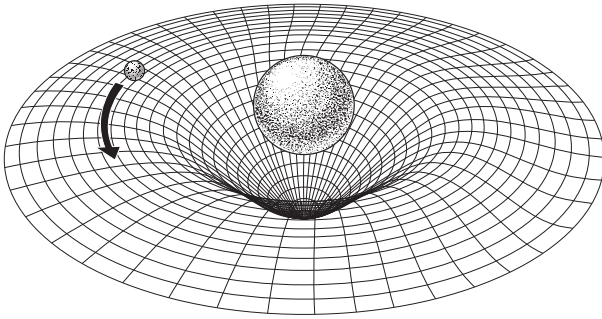
An illustration of how we understand complex realities.





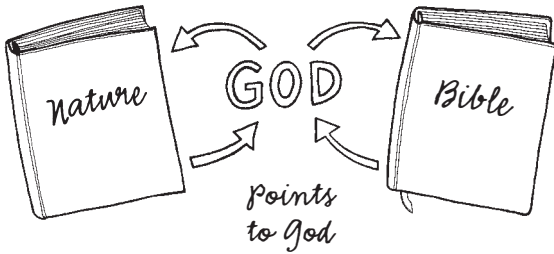
## The Curvature of Space and Time

Space and time curve in response to the mass of an object.



### The Metaphor of the Two Books

*God created*



# notes

## INTRODUCTION: ALBERT EINSTEIN: THE WORLD'S FAVORITE GENIUS

1. Einstein, *Ideas and Opinions*, 45.

## CHAPTER 1: APPROACHING EINSTEIN: THE WONDER OF NATURE

1. For the background, see Sponcel, "Constructing a 'Revolution in Science.'"
2. Brian, *Einstein*, 191.
3. Pais, "*Subtle Is the Lord*", 346.
4. Eddington, *The Mathematical Theory of Relativity*.
5. Overbye, "Gravitational Waves Detected, Confirming Einstein's Theory."
6. Einstein, *Ideas and Opinions*, 38.
7. Ortega y Gasset, "El origen deportivo del estado," 259.
8. Rushdie, *Is Nothing Sacred?*, 8.
9. For Coulson's views, see McGrath, *Enriching Our Vision of Reality*, 27–41.
10. Dewey, *The Quest for Certainty*, 255.
11. See Einstein's preface to Planck, *Where Is Science Going?*, 9.
12. See Menninghaus, "Atoms, Quanta, and Relativity in Aldous Huxley's Analogical Mode of Thinking."
13. Woolf, *The Diary of Virginia Woolf*, vol. 3, 68. This was a common misunderstanding at the time of the "twin paradox," in which someone could age more slowly than someone else by approaching the speed of light.

14. Einstein in conversation with William Hermanns: Hermanns, *Einstein and the Poet*, 132.
15. Letter to Eberhard Zschimmer, dated September 30, 1921.
16. Dawkins, *The God Delusion*, 18.
17. Dawkins uses Max Jammer's excellent work *Einstein and Religion* as a source for his citations for Einstein, perhaps predictably failing to quote from those that speak of God or a transcendent reality behind or beyond creation.
18. Letter to an unidentified recipient, dated August 7, 1941. Einstein Archive, Reel 54-927. For comment, see Jammer, *Einstein and Religion*, 97.
19. Jammer, *Einstein and Religion*, 150. Emphasis mine.

## CHAPTER 2: THE OLD WORLD: NEWTON'S CLOCKWORK UNIVERSE

1. For the science, see Kragh, *Conceptions of Cosmos*, 46–65.
2. McKie and de Beer, "Newton's Apple."
3. See Chapman, *England's Leonardo*.
4. Epstein, "Voltaire's Myth of Newton."
5. Newton, *Principia*, 507.
6. See the argument of Curry, "Losing Faith."
7. Sklar, *Space, Time, and Spacetime*, 162.
8. Einstein, "Ernst Mach," 102.
9. Von Soldner, "Ueber die Ablenkung eines Lichtstrals von seiner geradlinigen Bewegung."
10. For a very readable account of what we know about black holes, see Susskind, *The Black Hole War*.
11. Maxwell, *The Scientific Papers*, vol. 2, 244.
12. Michelson, "Some of the Objects and Methods of Physical Science," 15.
13. Newcomb, "The Place of Astronomy among the Sciences," 69–70.
14. Millikan, *Autobiography*, 269–70.
15. See especially Kuhn, *The Structure of Scientific Revolutions*.
16. This "precession of the perihelion" of Mercury takes place at the rate of 574 arcseconds (0.159 degree) per century.
17. Le Verrier, "Théorie du mouvement de Mercure."
18. For the background, see Baum and Sheehan, *In Search of Planet Vulcan*.

**CHAPTER 3: A SCIENTIFIC REVOLUTIONARY: EINSTEIN'S  
FOUR PAPERS OF 1905**

1. Iliffe, *Priest of Nature*. For further reflections on the social context of the idea of “genius” at the time, see Fara, *Newton: The Making of Genius*.
2. Albury, “Halley’s Ode on the *Principia* of Newton,” 27.
3. Letter to John Adams, dated October 28, 1813.
4. For an excellent account of these developments, see Rigden, *Einstein 1905*.
5. For a full account of Einstein’s life, career, and achievements, see Isaacson, *Einstein: His Life and Universe*; Pais, “*Subtle Is the Lord*.”
6. Brush, “Mach and Atomism.”
7. Einstein, “Folgerungen aus den Capillaritätserscheinungen.”
8. See, for example, Krstić, *Mileva & Albert Einstein*.
9. For the critical report by the PBS ombudsman into the factual basis of *Einstein’s Wife*, see [http://www.pbs.org/ombudsman/2006/12/einsteins\\_wife\\_the\\_relative\\_motion\\_of\\_facts.html](http://www.pbs.org/ombudsman/2006/12/einsteins_wife_the_relative_motion_of_facts.html).
10. The best study of the background to these articles, which deals with these assertions in depth, is Stachel, *Einstein’s Miraculous Year*. For a good general account, see Isaacson, *Einstein*, 90–106.
11. See the careful study of Martinez, “Handling Evidence in History.”
12. Hertz, “Über den Einfluß des ultravioletten Lichtes auf die electriche Entladung.”
13. Lenard, “Über die lichtelektrische Wirkung.”
14. Nauenberg, “Max Planck and the Birth of the Quantum Hypothesis.”
15. Millikan, “A Direct Photoelectric Determination of Planck’s ‘*h*.’”
16. Brown, “A Brief Account of Microscopical Observations on the Particles Contained in the Pollen of Plants.”
17. Ford, “Confirming Robert Brown’s Observations of Brownian Movement.”
18. For what follows, see Maiocchi, “The Case of Brownian Motion.”
19. For details, see Maiocchi, “The Case of Brownian Motion,” 263–74.
20. See especially Perrin, “Mouvement brownien et réalité moléculaire.”
21. Rutherford, “The Scattering of  $\alpha$  and  $\beta$  Particles by Matter and the Structure of the Atom.”
22. Einstein, “Autobiographische Skizze,” 10.
23. Renn, “Einstein as a Disciple of Galileo.”

24. I here use material from various sections of Einstein, *Relativity*, although I have presented it in a different order than Einstein for the sake of clarity. This work is very accessible and is recommended as a starting point for serious exploration of both special and general relativity.
25. Einstein, *Relativity*, 17.
26. Davies, *About Time*, 59–65.
27. See, for example, Feuer, “The Social Roots of Einstein’s Theory of Relativity,” 2.
28. Harman and Thomson, *Moral Relativism and Moral Objectivity*, 3.
29. Sommerfeld, “Philosophie und Physik seit 1900,” 99.
30. Feynman, *Six Not-So-Easy Pieces*, 73–74.
31. Russell, “Relativity,” 331.
32. Einstein and Infeld, *The Evolution of Physics*, 77.
33. Boughn, “Fritz Hasenöhr and  $E = mc^2$ .”
34. For the debate, see Ohanian, “Did Einstein Prove  $E = mc^2$ ?”
35. Hecht, “How Einstein Confirmed  $E = mc^2$ .”
36. The best of these, in my view, is his 1935 article “Elementary Derivation of the Equivalence of Mass and Energy.”
37. See Duhem, *La science allemande*. This work was written during the First World War, which might help explain its hostility towards German science.
38. Einstein, *Ideas and Opinions*, 226.
39. Wertheimer, *Productive Thinking*, 213–28. For this remarkable relationship, see Miller, “Albert Einstein and Max Wertheimer.”
40. Cockcroft and Walton, “Disintegration of Lithium by Swift Protons.”
41. Cockcroft and Walton noted that the sum of the rest-masses of the original proton and the lithium nucleus was 8.0176 atomic mass units. However, the sum of the rest-masses of the two alpha particles produced by this reaction was 8.0022 atomic mass units. The reaction thus led to a loss of mass of 0.0154 atomic mass units.
42. Speech given to the British Association for the Advancement of Science, September 11, 1933.
43. See Lanouette and Silard, *Genius in the Shadows*. There is a good account of Einstein’s involvement with the development of the atomic bomb in Isaacson, *Einstein*, 471–86.
44. Jerome, *The Einstein File*.
45. Einstein, “On My Participation in the Atom Bomb Project.”
46. Einstein, *Essays in Humanism*, 24–25.

**CHAPTER 4: THE THEORY OF GENERAL RELATIVITY:  
FINAL FORMULATION AND CONFIRMATION**

1. Technically, Einstein was appointed as “außerordentlicher Professor,” which is not easy to convert into an English-language equivalent.
2. Maxwell, “A Dynamical Theory of the Electromagnetic Field,” 466.
3. Wheeler, *Geons, Black Holes and Quantum Foam*, 235.
4. Einstein, *Ideas and Opinions*, 100–105.
5. O’Raifeartaigh et al., “One Hundred Years of the Cosmological Constant.”
6. Einstein, “Erklärung der Perihelbewegung des Merkur aus der allgemeinen Relativitätstheorie.”
7. See Holberg, “Sirius B and the Measurement of the Gravitational Redshift.”
8. For an excellent study, see Almassi, “Trust in Expert Testimony.”
9. Sponcel, “Constructing a ‘Revolution in Science,’” 448.
10. “Lights All Askew.”
11. See especially Waller, *Einstein’s Luck*, 102–3.
12. Harvey, “Gravitational Deflection of Light.”
13. Cited in Holton, “Einstein’s Search,” 1–15.
14. Pais, “*Subtle Is the Lord*”, 30.
15. Goenner, “The Reaction to Relativity Theory I.”
16. These are discussed in van Dongen, “Reactionaries and Einstein’s Fame.”
17. Thüring, “Physik und Astronomie in jüdischen Händen.”
18. For this period of Einstein’s life, see Goenner, *Einstein in Berlin 1914–1933*; Hoffmann, *Einstein’s Berlin*.
19. See, for example, Hentschel, *Interpretationen*.
20. For what follows, see Friedman, *The Politics of Excellence*.
21. Ravin, “Gullstrand, Einstein, and the Nobel Prize.”
22. Rowe and Schulmann, *Einstein on Politics*, 151–52.
23. Forster, “What I Believe,” 67.
24. For the story, see Paterniti, *Driving Mr. Albert*.
25. Letter to Willem de Sitter, in *Collected Papers*, vol. 8.
26. This quote is found in a private letter from Einstein to the Hungarian physicist Cornelius Lanczos, who was then based at Princeton, dated March 12, 1942. Einstein wrote, “It seems hard to sneak a look at God’s cards. But that he plays dice and uses ‘telepathic’ methods (as the present quantum theory requires of him) is something that

I cannot believe for a single moment.” This is unfortunately often simplified to “God does not play dice.” For a good discussion, see Ghirardi, *Sneaking a Look at God’s Cards*, 149–64.

27. Paty, “The Nature of Einstein’s Objections to the Copenhagen Interpretation of Quantum Mechanics.”
28. Van Dongen, *Einstein’s Unification*, 186.
29. Greene, *The Elegant Universe*, 15.
30. For a good discussion, see Paty, *Einstein Philosophie*.

## CHAPTER 5: EINSTEIN AND THE BIGGER PICTURE: WEAVING THINGS TOGETHER

1. On the importance of this, see Carroll, *The Big Picture*, 69.
2. Letter to Robert Thornton, dated December 7, 1944. Einstein Archive, Reel 6-574.
3. Planck, *Where Is Science Going?*, 218.
4. Planck, *Where Is Science Going?*, 214.
5. Einstein and Infeld, *The Evolution of Physics*, 159.
6. Einstein here anticipates aspects of what is now known as the “unificationist” approach to scientific explanation.
7. Einstein, *Cosmic Religion with Other Opinions and Aphorisms*, 97.
8. Downie, “Science and the Imagination in the Age of Reason”; Locke, *Image and Reality*.
9. Einstein, *Cosmic Religion with Other Opinions and Aphorisms*, 97.
10. Wertheimer, *Productive Thinking*, 213–28.
11. Einstein, *Mein Weltbild*. Although written in German, this book was published in Amsterdam in 1934 by Querido Verlag, which published titles of German writers in exile from Nazi Germany. Emanuel Querido, who established this publishing house, was killed by the Nazis in Sobibor extermination camp on July 23, 1943.
12. Einstein, *Ideas and Opinions*, 292.
13. Bergmann, “The Quest for Unity.”
14. Metz, *Meaning in Life*, 249.
15. Pears, *Hume’s System*, 99. See also Lynch, “Hume and the Limits of Reason.”
16. Letter to Heinrich Zangger, dated March 10, 1914, in *Collected Papers*, vol. 5, 381.
17. Kessler, *The Diaries of a Cosmopolitan 1918–1937*, 332.
18. Einstein, “Elsbachs Buch,” 1685.



19. For example, see Einstein, *Ideas and Opinions*, 224–27.
20. Heisenberg, “Die Kopenhagener Deutung der Quantentheorie,” 85. Emphasis mine.
21. Isaacson, *Einstein*, 14.
22. Schilpp, *Albert Einstein: Philosopher-Scientist*, 47.
23. Chaplin, *My Autobiography*, 317. I have found no record of what music Einstein actually played during this process of reflection.
24. For comment, see Moszkowski, *Einstein the Searcher*, 222.
25. Miller, “A Genius Finds Inspiration in the Music of Another.”
26. Einstein, *Cosmic Religion with Other Opinions and Aphorisms*, 100.
27. Hawking, *A Brief History of Time*, 193.
28. Rigden, *Einstein 1905*, 147–49.
29. Letter to an unidentified recipient, dated August 7, 1941. Einstein Archive, Reel 54-927.
30. For comment, see Jammer, *Einstein and Religion*, 125–27.
31. See Wilczek, *A Beautiful Question*.
32. Einstein, *Cosmic Religion with Other Opinions and Aphorisms*, 84.
33. Einstein, *Ideas and Opinions*, 151–58.
34. Einstein, *Ideas and Opinions*, 152.
35. For the issue, and its wider implications, see McGrath, *The Territories of Human Reason*.
36. Einstein, *Ideas and Opinions*, 41–49.
37. Einstein, *Ideas and Opinions*, 41–42.
38. Einstein, *Ideas and Opinions*, 148. For comment, see Michalos, “Einstein, Ethics, and Science.”
39. Einstein, *Ideas and Opinions*, 42.
40. Rowe and Schulmann, *Einstein on Politics*, xxiv–xxv.
41. For what follows, see the fuller discussion in Midgley, *Science and Poetry*, 170–213.
42. For Midgley’s critique of aggressive reductionisms, which insist we use only one map for everything, see Midgley, “Reductive Megalomania.”

## CHAPTER 6: A “FIRM BELIEF IN A SUPERIOR MIND”:

### EINSTEIN ON RELIGION

1. For the complexity of the term *religion*, see Harrison, “The Pragmatics of Defining Religion.”
2. Dürrenmatt, “Albert Einstein,” 58.
3. Einstein, *Ideas and Opinions*, 262.

4. Jammer, *Einstein and Religion*, 150.
5. Dawkins, *The God Delusion*, 35.
6. Einstein, *Ideas and Opinions*, 38–39.
7. This is Einstein's famous response in 1929 to Rabbi Herbert S. Goldstein, who asked him whether he believed in God: Jammer, *Einstein and Religion*, 49.
8. For a good summary of Einstein's relation to Spinoza, see Jammer, *Einstein and Religion*, 43–51.
9. Although some trace aspects of Einstein's scientific theories back to the influence of this Dutch Jewish philosopher, these associations need to be treated with caution. See Jammer, *Einstein and Religion*, 46.
10. Michalos, "Einstein, Ethics, and Science," 347–48.
11. The best study remains Jammer, *Einstein and Religion*, which scrupulously documents the multiple elements of his understanding of religion.
12. Dennett, *Breaking the Spell*, 9.
13. Southwold, "Buddhism and the Definition of Religion."
14. My own analysis leads me to more or less the same conclusions as Jammer's.
15. Letter to Eduard Büsching, dated October 25, 1929, quoted in Jammer, *Einstein and Religion*, 51.
16. Einstein, *Ideas and Opinions*, 47–48.
17. Einstein, *Ideas and Opinions*, 38.
18. Letter to Eric Gutkind, dated January 3, 1954.
19. Jammer, *Einstein and Religion*, 50–51. "Karl Eddi" was a pseudonym for the German journalist Eduard Karl Büsching, author of a book titled *Es gibt keinen Gott* ("There is no God"). On reading the book, Einstein suggested that its argument was such that it ought to have a different title: *Es gibt keinen persönlichen Gott* ("There is no personal God").
20. Kessler, *The Diaries of a Cosmopolitan 1918–1937*, 322.
21. This is the view, for example, of Richard Dawkins: Dawkins, *The God Delusion*, 18.
22. Nadler, *Spinoza's Heresy*, 140–41.
23. Jammer, *Einstein and Religion*, 125–27.
24. Dukas and Hoffmann, *Albert Einstein, the Human Side*, 39.
25. Letter to Albert Chapple, dated February 23, 1954. Einstein Archive 59–405.

26. Einstein, *The World as I See It*, 90.
27. Einstein, *Ideas and Opinions*, 50.
28. Einstein's letter of January 3, 1954, to the philosopher Eric Gutkind, which is not included in the material reviewed by Jammer, *Einstein and Religion*, makes this point, which is repeated elsewhere in his published writings.
29. Levitin, "The Experimentalist as Humanist."
30. Einstein, *Ideas and Opinions*, 38–39.
31. Harrison, "Sentiments of Devotion and Experimental Philosophy in Seventeenth-Century England."
32. Other scholars offer different categories. For example, Ian Barbour develops four such options: conflict, independence, dialogue, and integration. See Cantor and Kenny, "Barbour's Fourfold Way."
33. Einstein, *Ideas and Opinions*, 41–42.
34. For a systematic dismantling of this work's arguments and evidence, see Numbers, ed., *Galileo Goes to Jail and Other Myths about Science and Religion*.
35. Brooke, *Science and Religion*, 6.
36. Harrison, "Introduction," 4.
37. Einstein, *Ideas and Opinions*, 41–44.
38. Einstein, *Ideas and Opinions*, 41–42.
39. Einstein, *Ideas and Opinions*, 44–49.
40. Einstein, *Ideas and Opinions*, 44.
41. Einstein, *Ideas and Opinions*, 48–49.
42. Einstein, *Ideas and Opinions*, 45.
43. Gould, "Nonoverlapping Magisteria."
44. Einstein, *Ideas and Opinions*, 45.
45. Einstein, *Ideas and Opinions*, 46.
46. Einstein, *Ideas and Opinions*, 50.
47. Earnshaw, *Existentialism*, 1–25.
48. Planck, *Where Is Science Going?*, 217.
49. For a good discussion, see Brueggemann, *The Land*.
50. Weyl, *Philosophy of Mathematics and Natural Science*, 116.
51. Lewis, *Surprised by Joy*, 197.
52. Eddington, *The Nature of the Physical World*, 68. For a good discussion, see Galison, "Minkowski's Space-Time." Although Einstein developed special relativity without any of the mathematical formalism introduced

by Minkowski, similar existential concerns can be raised about both ways of conceptualizing space and time.

53. Schilpp, *The Philosophy of Rudolf Carnap*, 37–38. I have altered the translation of the final section of this sentence to capture the sense of Carnap’s original German: “. . . es gäbe etwas Wesentliches am Jetzt, das einfach außerhalb der Reichweite der Wissenschaft liege.”

## CHAPTER 7: GOD AND A SCIENTIFIC UNIVERSE: TOWARDS A CHRISTIAN READING OF EINSTEIN

1. Einstein, *The Travel Diaries*.
2. The theologian Thomas F. Torrance is a rare example of someone who took Einstein’s ideas seriously and explored their significance for Christian thought, particularly in relation to the doctrine of the Incarnation. See especially Torrance, *Theological Science*.
3. Polkinghorne, “Space, Time, and Causality,” 975.
4. This and the following quotes are from Popper, “Natural Selection and the Emergence of Mind,” 341–42.
5. On Coulson and his approach, see McGrath, *Enriching Our Vision of Reality*, 27–41.
6. Dürrenmatt, “Albert Einstein,” 59.
7. On these themes, see McGrath, *The Intellectual World of C. S. Lewis*. There are interesting parallels between Einstein and Lewis on the role of intuition and imagination in discovering the structures of reality that merit closer examination.
8. Mitchell, *The Justification of Religious Belief*, 99.
9. Kenney, *The Remarkable Case of Dorothy L. Sayers*.
10. Einstein, *Ideas and Opinions*, 292.
11. James, *The Will to Believe*, 51.
12. Polkinghorne, “The New Natural Theology.” For Polkinghorne’s approach to these questions, see McGrath, *Enriching Our Vision of Reality*, 59–73.
13. Polkinghorne, *Science and Creation*, 20–21.
14. Polkinghorne, *Theology in the Context of Science*, xx.
15. Polkinghorne, *Theology in the Context of Science*, 95.
16. For the best recent studies, see Brooke, *Science and Religion*; Harrison, *Territories of Science and Religion*.
17. Thomas Browne, *Religio Medici*, section 16.

18. John Calvin, *Institutes of the Christian Religion*, I.vi.1. More generally, see Adams, "Calvin's View of Natural Knowledge of God."
19. Palmerino, "The Mathematical Characters of Galileo's Book of Nature," 27–28.
20. Einstein, *Ideas and Opinions*, 262.
21. Polkinghorne, "Cross-Traffic between Science and Theology," 146.
22. James, *The Will to Believe*, 127.
23. See, for example, Polkinghorne, *Science and Creation*, 17–33.
24. Letter dated March 21, 1955; *Albert Einstein—Michele Besso Correspondence, 1903–55*, 537–38.
25. Kalanithi, *When Breath Becomes Air*, 170.
26. Wood, *In Pursuit of Truth*, 102.

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