

Notes

1. Beginnings of a revolution

1. Richard Feynman. *The Feynman Lectures on Computation*, edited by Tony Hey and Robin W. Allen. Perseus Books, 2000, xiii.
2. Herman Goldstine. *The Computer from Pascal to von Neumann*. Princeton University Press, 1972, 182.
3. Ibid.
4. Stan Augarten. *Bit by Bit: An Illustrated History of Computers*. Ticknor & Fields, 1984, 131, quotation attributed to Norris Bradbury.
5. John Mauchly. "Amending the ENIAC Story." *Datamation* 25, no. 11 (1979): 217.
6. Maurice Wilkes. *Memoirs of a Computer Pioneer*. MIT Press, 1985, 108.
7. B. E. Carpenter, Alan Turing, and Michael Woodger. A.M. Turing's ACE Report of 1946 and Other Papers. MIT Press, 1986, 21.
8. Martin Campbell-Kelly and William Aspray. *Computer: A History of the Information Machine*. Basic Books, 1996, 102.
9. Charles Babbage. *Passages from the Life of a Philosopher*. Longman, Green, Longman, Roberts, & Green, 1864, 42.
10. Philip Morrison and Emily Morrison (eds.). *Charles Babbage and His Calculating Engines*. Dover Publications, 1961, xiv.
11. Doron Swade. *The Difference Engine: Charles Babbage and the Quest to Build the First Computer*. Penguin Books, 2002, x.
12. Bernard Cohen. *Howard Aiken: Portrait of a Computer Pioneer*. MIT Press, 2000, 64.
13. Swade, *The Difference Engine*, 155.
14. Dorothy Stein. *Ada: Her Life and Her Legacy*. MIT Press, 1987, 82.
15. Luigi Menabrea. *Sketch of the Analytical Engine Invented by Charles Babbage*, printed by Richard and John E. Taylor, 1843, 696.
16. Ibid., 713.
17. Ronald Lewin. *Ultra Goes to War, the Secret Story*. Arrow Books, 1980, 64.
18. Jack Good, Donald Michie, and Geoffrey Timms. *General Report on Tunny*. Public Record Office, 1945, 51.
19. BBC Radio 4. *Electronic Brains*, Programme 3 "Then We Took the Roof off," <http://www.bbc.co.uk/radio4/science/electronicbrains.shtml>.

20. Mike Halley. *Electronic Brains*. Granta Books, 2005, 168.
- B1. George Polya and G. L Alexanderson. *The Polya Picture Album: Encounters of a Mathematician*. Birkhäuser, 1987, 154.
- B2. William Poundstone. *Prisoner's Dilemma: John Von Neumann, Game Theory and the Puzzle of the Bomb*. Doubleday, 1992, 25.
- B3. Thomas Flowers. "The Design of Colossus," in Foreword by Howard Campaigne. *Annals of the History of Computing* 5 no. 3 (July 1983): 239.

2. The hardware

1. John Horgan. "Claude E. Shannon." *IEEE Spectrum* 29, no. 4 (April 1992): 72.
2. Daniel Hillis. *The Pattern on the Stone: The Simple Ideas That Make Computers Work*. Basic Books, 1999, 18.
3. Ibid., 18.
4. Anthony Liversidge. "Claude E. Shannon, Interview: Father of the Electronic Information Age." *Omni Magazine* 9, no. 11 (August 1987): 65.
5. Robert Slater. *Portraits in Silicon*. MIT Press, 1989, 34, quotation from Claude Shannon.
6. Claude Shannon. "A Symbolic Analysis of Relay and Switching Circuits." *Transactions American Institute of Electrical Engineers* 57 (1938): 492.
7. Stan Augarten. *Bit by Bit: An Illustrated History of Computers*. Ticknor & Fields, 1984, 101.
8. Alan Perlis. "Epigrams on Programming," *ACM SIGPLAN Notices*, 17 (9) (September 1982): 9.
9. Mike Hally. *Electronic Brains: Stories from the Dawn of the Computer Age*. Granta Publications, 2005, 96, quotation from Freddie Williams.
10. Gerard O'Regan. *A Brief History of Computing*. Springer, 2008, 49.
11. Hally. *Electronic Brains: Stories from the Dawn of the Computer Age*. 96, quotation from Maurice Wilkes.
12. Ibid., 94.
13. Ibid., 97.
14. Ibid., 90.
15. Ibid.
- B1. Clifford A. Pickover. *The Math Book*. Sterling, 2012, 242, quotation from Augustus de Morgan.

- B2. Stephen Graubard and Paul O. Leclerc, eds. *Books, Bricks, and Bytes: Libraries in the Twenty-First Century*. Transaction Publishers, 1997, 126.

3. The software is in the holes

1. Dave Andrews. "Knuth Comments on Code." *BYTE* 21, no. 9 (September 1996): 40.
2. Butler Lampson. "The Ongoing Computer Revolution." *The Bridge* 34, no. 2 (Summer 2004): 39.
3. John Dooley. *Software Development and Professional Practice*. APRESS ACADEMIC, 2011, 181, quotation from Maurice Wilkes.
4. Edsger Dijkstra. "EWD 1308: What Led to 'notes on structured programming,'" in *Software Pioneers*, edited by Manfred Broy and Ernst Denert. Springer-Verlag, 2002, 342.
5. Rob Kitchin and Martin Dodge. *Code/Space: Software and Everyday Life*. MIT Press, 2011, 3, quotation from Bjarne Stroustrup.
6. Keith Curtis. *After the Software Wars*. keithcu press, 2009, 209, quotation from Richard Feynman.
7. Paul Ceruzzi. *A History of Modern Computing*. MIT Press, 1998, 82. Original source given as Grace Hopper in "Computers and Their Future: Speeches Given at the World Computer Pioneers Conference," Llandudno, Wales, 1970.
8. Neil Barrett. *The Binary Revolution*. Weidenfeld and Nicholson, 2006, 211.
9. Martin Campbell-Kelly and William Aspray, *Computer: A History of the Information Machine*. Westview Press, 2004, 169.
10. John Backus. "The History of FORTRAN I, II, AND III," *ACM SIGPLAN Notices* 13, no. 8 (August 1978): 166.
11. Ibid., 168.
12. Campbell-Kelly and Aspray, *Computer*, 171.
13. Michael Walder. *The Dream Machine: J.C.R. Licklider and the Revolution That Made Computing Personal*. Penguin Books, 2002, 164.
14. Ibid., 174.
15. Ceruzzi, *A History of Modern Computing*, 148, quotation from Maurice Wilkes.

4. Programming languages and software engineering

1. Edsger Dijkstra. "The Humble Programmer." *Communications of the ACM* 15, no. 10 (1972): 861.
2. C. A. R. Hoare. "The Emperor's Old Clothes." *Communications of the ACM* 24, no. 2 (February 1981): 78.
3. Frederick Brooks Jr. *The Mythical Man-Month*. Addison-Wesley, 1995, 47.
4. Eric Raymond. *The Cathedral & the Bazaar*. O'Reilly Media, 2001, 19.
5. *Specifications for the IBM Mathematical FORmula TRANslating System*, FORTRAN. PRELIMINARY REPORT, Programming Research Group, Applied Science Division, International Business Machines Corporation, 10 November 1954, 2. http://archive.computerhistory.org/resources/text/Knuth_Don_X4100/PDF_index/k-7-pdf/k-7-u2763-Backus-Prelim-FORTRAN.pdf.
6. Edsger Dijkstra. "Go To Statement Considered Harmful." *Communications of the ACM* 11, no. 3 (March 1968): 147.
7. *Specifications for the IBM Mathematical FORmula TRANslating System*, 2.
8. Brooks, *The Mythical Man-Month*, 25.
9. IEEE Standard Glossary of Software Engineering Terminology. EEE std 610.12-1990, 1990, 67.
10. David Parnas and Paul Clements. "A Rational Design Process: How and Why to Fake It." *Journal IEEE Transactions on Software Engineering* 12, no. 2 (February 1986): 251.
11. David Harel. "Statecharts in the Making: A Personal Account." *Communications of the ACM* 52, no. 3 (2009): 70.
12. MSDN Magazine, February 2002, quotation from Grady Booch, <http://msdn.microsoft.com/en-us/magazine/cc301920.aspx>.
13. Edsger Dijkstra, "The Humble Programmer," 864.
14. NIST Planning Report 02-3. Summary – The Economic Impacts of Inadequate Infrastructure for Software Testing, NIST, 2002, 1, <http://samate.nist.gov/docs/econImpact-Summ.v23.pdf>.
15. Michael Cusumano and Richard Selby. *Microsoft Secrets*. 1st Touchstone ed. Simon and Schuster, 1988, 15.
16. Steve Ballmer. *Connecting with Customers*. 2 October 2002, <http://www.microsoft.com/mscorp/execmail/2002/10-02customers.mspx>.
17. Steve McConnell. *Code Complete*. 2nd ed. Microsoft Press, 2009, 521.
18. *Empirical Software Engineering*. <http://simula.no/research/se/emse>.
19. Steven Weber. *The Success of Open Source*. Harvard University Press, 2005, 28.
20. Ibid., 47.
21. Linus Torvalds. "Free Minix-like Kernel Sources for 386-AT." Posted to newsgroup comp.os.minix, 5 October 1991. <https://groups.google.com/forum/#!msg/comp.os.minix/4995SivOl9o/GwqLjIPSICE>.
22. Weber, *The Success of Open Source*, 69.
23. Quotation from the SourceForge website. <http://sourceforge.net/apps/trac/sourceforge/wiki/What%20is%20SourceForge.net>.
24. Ibid.
25. David Barron. *The World of Scripting Languages*. 1st ed. Wiley, 2000, 17.
26. Dennis Ritchie. *The Evolution of the Unix Time-Sharing System*. Bell Laboratories. <http://cm.bell-labs.com/who/dmr/hist.html>.
27. Brian Kernighan and Rob Pike. *The Unix Programming Environment*. Prentice Hall, 1984, viii.
28. Bill Gates. Keynote address. Windows Hardware Engineering Conference, 2002.
29. Edgar Codd. *The Relational Model for Database Management*. Addison-Wesley, 1990, iii.
30. Tony Long. "July 22, 1962: Mariner 1 Done In by a Typo." *Wired*, 2009, quotation from Arthur C. Clarke, http://www.wired.com/2009/07/dayintech_0722/.
31. Hoare, "The Emperor's Old Clothes," 83.
- B1. Edsger Dijkstra. "How Do We Tell Truths That Might Hurt?" In *Selected Writings on Computing: A Personal Perspective*. Springer-Verlag, 1982, 130. <http://www.cs.utexas.edu/users/EWD/transcriptions/EWD04xx/EWD498.html>.

- B2. Ibid.
 B3. Ibid.
 B4. Joshua Gay, Richard Stallman, and Lawrence Lessig. *Free Software, Free Society: Selected Essays of Richard M. Stallman*. Createspace, 2009, 15.

5. Algorithmics

1. Charles Babbage. "Of the Analytical Engine," in *Passages from the Life of a Philosopher*, 1864.
2. David Harel and Yishai Feldman. *Algorithmics: The Spirit of Computing*. 3rd ed. Addison Wesley, 2004, xii.
3. Roger Eckhard. "Stan Ulam, John von Neumann, and the MONTE CARLO METHOD." *Los Alamos Science Special Issue* (1987): 131, quotation from Stanislaw Ulam, <http://library.lanl.gov/cgi-bin/getfile?15-13.pdf>.
4. Thomas Misa. "An Interview with Edsger W. Dijkstra." *Communications of the ACM* 53 no.8 (2010): 42.
5. "Drummer's Delight: The Shortest Way Around." *Newsweek*, 26 July 1954, 74.
6. William Cook. *In Pursuit of the Traveling Salesman*. Princeton University Press, 2012, 94.
- B1. D. Shasha and C. Lazere. *Out of Their Minds: The Lives and Discoveries of 15 Great Computer Scientists*. Copernicus, 1998, 101, quotation from Donald Knuth.
- B2. John Francis. *Philosophy of Mathematics*. Global Vision Publishing House, 2008, 49, quotation from Richard Feynman.

6. Mr. Turing's amazing machines

1. Alan Turing. A *Programmers' Handbook for the Manchester Electronic Computer Mark II*. 1952. <http://www.computer50.org/kgill/mark1/progman.html>.
2. Andrew Hodges. *Alan Turing: The Enigma of Intelligence*. Vintage, 1992, 84.
3. Scott Soames. *The Analytic Tradition in Philosophy*, Vol. 1, *The Founding Giants*. Princeton University Press, 2014, 124, quotation from Gottlob Frege's letter.
4. Anne Rooney. *The History of Mathematics*. The Rosen Publishing Group, 2013, 201, quotation from David Hilbert.
5. Hodges, *Alan Turing: The Enigma of Intelligence*, 91.
6. Charles Petzold. *The Annotated Turing*. Wiley Publishing, 2008, 60.
7. David Harel. *Computers Ltd: What They Really Can't Do*. Oxford University Press, 2000, 52.
8. Oskar Morgenstern. "History of naturalization of Kurt Gödel." Institute for Advanced Study, 1971, 2. <http://cdm.itg.ias.edu/cdm/compoundobject/collection/coll12/id/2985/rec/3>.
9. Ibid
10. Hodges, *Alan Turing: The Enigma of Intelligence*, 145, quotation from Stanislaw Ulam.
11. Jack Copeland. *The Essential Turing: The Ideas that Gave Birth to the Computer Age*. Oxford University Press, 2004, 22, quotation from Stanley Frankel.
12. Petzold, *The Annotated Turing*, 167, quotation from John von Neumann.

13. Ibid., 163, quotation from Howard Aiken.
14. Alan Turing. "Computing Machinery and Intelligence." *Mind* 59 (1950): 441.
15. Hodges, *Alan Turing: The Enigma of Intelligence*, 113, quotation from Max Newman.
16. Ibid., 112, quotation from Max Newman.
17. Petzold, *The Annotated Turing*, 63, quotation from Alonzo Church.
- B1. Rebecca Goldstein. *Incompleteness: The Proof and Paradox of Kurt Gödel*. W. W. Norton & Company, 2005, 223, quotation from John von Neumann.
- B2. Ibid., 33, quotation from Oskar Morgenstern.
- B3. Dana Mackenzie. *The Universe in Zero Words: The Story of Mathematics as Told through Equations*. Princeton University Press, 2012, 189, quotation from Hilbert.

7. Moore's law and the silicon revolution

1. Tony Hey. *Feynman and Computation: Exploring the Limits of Computers*. Perseus Books Group, 1999, 23, quotation from Carver Mead.
2. Tony Hey and Patrick Walters. *The New Quantum Universe*. Cambridge University Press, 2003, 124, quotation from John Bardeen.
3. Ibid., 125, quotation from Geoffrey Dummer.
4. Jack Kilby. "Invention of the Integrated Circuit." *IEEE Transactions on Electron Devices* 23, no. 7 (1976): 650.
5. Stan Augarten. *Bit by Bit*. Houghton Mifflin, 1984, 236, quotation from Jack Kilby.
6. Hey and Walters, *The New Quantum Universe*, 185, quotation from Robert Noyce.
7. Augarten, *Bit by Bit*, 243, quotation from Robert Noyce.
8. Ross Bassett. *To the Digital Age: Research Labs, Start-up Companies, and the Rise of MOS Technology*. Johns Hopkins University Press, 2002, 25.
9. Paul Ceruzzi. *A History of Modern Computing*. MIT Press, 2003, 187.
10. Gordon Moore. "Cramming More Components onto Integrated Circuits." *Electronics* 38, no. 8 (19 April 1965): 114.
11. Richard Rhodes. *Visions of Technology*. Touchstone, 1999, 224, quotation from Gordon Moore, SPIE 1995 speech, "Lithography and the Future of Moore's Law."
12. Hey and Walters, *The New Quantum Universe*, 187, quotation from Carver Mead.
13. V. K. Jain and Hemlata. *Enterprise Electronics & Mobile Commerce*. Cyber Tech Publications, 2001, 61, quotation from Arthur Rock.
14. Tekla Perry. "Morris Chang: Foundry Father." *IEEE Spectrum* 48, no. 5 (2011): 48, quotation from James Plummer.
15. Ibid., 50, quotation from Jen-Hsung Huang.
16. Manek Dubash. "Moore's Law Is Dead, Says Gordon Moore." *Techworld* (13 April 2005), quotation from Gordon Moore, <http://news.techworld.com/operating-systems/3477/moores-law-is-dead-says-gordon-moore/>.
17. Hey and Walters, *The New Quantum Universe*, 107, quotation from Richard Feynman.
18. Quotation attributed to Seymour Cray.

19. Ibid.
20. Eric Raymond. *The New Hacker's Dictionary*. MIT Press, 1996, 270.
- B1. Gosta Ekspong. *Nobel Lectures, Physics: 1996–2000*. World Scientific Pub. Co. Inc., 2003, 472, quotation from Jack Kilby.
- B2. The United States Patent and Trademark Office. The National Medal of Technology and Innovation Recipients, 2002, <http://www.uspto.gov/about/nmti/recipients/2002.jsp>.
23. James Wallace and Jim Erickson. *Hard Drive: Bill Gates and the Making of the Microsoft Empire*. John Wiley, 1992, 252, quotation from Rowland Hanson.
24. Campbell-Kelly and Aspray, *Computer*, 246, quotation from Bill Gates.
25. Ibid., 279.
26. *Computer Law Reporter* 20, nos. 1–3 (1994): 271.
27. Walter Isaacson. *Steve Jobs: The Exclusive Biography*. Little, Brown, 2013, 178, quotation from Bill Gates.
28. Hiltzik, *Dealers of Lightning*, 12.
29. Robert W. Taylor. "In Memoriam: J. C. R. Licklider 1915–1990." Digital Research Center Research Report #61, Palo Alto, CA, 7 August 1990. <http://memex.org/licklider.pdf>.
30. Vannevar Bush. "As We May Think." *Atlantic Monthly*, July 1945: 102.
31. Ibid., 107.
32. Campbell-Kelly and Aspray, *Computer*, 237, quotation from Doug Engelbart.
33. Hiltzik, *Dealers of Lightning*, 17.
34. Ibid., 382.
35. Stan Augarten. *Bit by Bit*. Houghton Mifflin, 1984, 257.
36. Butler Lampson, personal communication, 2013.
37. Ken Olsen, see <http://www.snopes.com/quotes/kenolsen.asp>.
38. Gordon Bell, personal communication, 2013.
39. Gordon Bell. In Edgar H. Schein, *DEC Is Dead, Long Live DEC: The Lasting Legacy of Digital Equipment Corporation*. Berrett-Koehler Publishers Inc., 2003, 2.
40. Hiltzik, *Dealers of Lightning*, xxii.
41. Ibid., 168.
42. Ibid., 200, quotation from Charles Simonyi.
43. Ibid., 205, quotation from Tim Mott.
44. Ibid., 228, quotation from Tim Mott.
45. Ibid., 7, quotation from Butler Lampson.
46. Ibid., 4, quotation from Chuck Thacker.
47. Chris Bidmead. "ARM Creators Sophie Wilson and Steve Furber, Part Two: The accidental chip." *The Register*, May 2012, quotation from Sophie Wilson. http://www.theregister.co.uk/Print/2012/05/03/unsung_heroes_of_tech_arm_creators_sophie_wilson_and_steve_furber/.
48. Jason Fitzpatrick. "An Interview with Steve Furber." *Communications of the ACM* 54, no. 5 (2011): 39.
49. David Bradley email from 2008, <http://mail.computerhistory.org/pipermail/inforoots/2008-April/001914.html>.
50. Wallace and Erickson, *Hard Drive*, 267.
- B1. Dan Bricklin. <http://www.bricklin.com/history/saiidea.htm>.
- B2. Plaque in Aldrich 108 at Harvard Business School. <http://www.bricklin.com/history/saiproduct1.htm>.
- F1. Robert Metcalfe and David Boggs. "Ethernet: Distributed Packet Switching for Local Computer Networks." *Communications of the ACM* 19, no. 7 (1976): 395.
- F2. Paul Freiberger. "History of Microcomputing, Part 1: Homebrew Club." *InfoWorld* 4, no. 7 (1982): 17.
- F3. Computer History Museum website. <http://www.computerhistory.org/revolution/personal-computers/17/300>.
- F4. ACM A. M. Turing Award website. <http://awards.acm.org/amturing/all.cfm>.

- F5. John Markoff. "A Maverick Scientist Gets an I.B.M. Tribute." *The New York Times*, 26 June 1990.
- F6. Ute Bradley. *Applied Marketing and Social Research*. J. Wiley, 1987, 114.
- F7. ACM A. M. Turing Award website. <http://awards.acm.org/amturing/all.cfm>.
5. Stewart Brand. "Founding Father." *Wired* 9, no. 3 (2001), interview with Paul Baran. <http://www.wired.com/wired/archive/9.03/baran.html>.
6. Katie Hafner and Matthew Lyon. *Where Wizards Stay Up Late: The Origins of the Internet*. Touchstone, 1998, 55.
7. Brand, "Founding Father."
8. Hafner and Lyon, *Where Wizards Stay Up Late*, 59.
9. Brand, "Founding Father."
10. Ibid.

9. Computer games

1. David Evans, Andrei Hagiu, and Richard Schmalensee. *Invisible Engines*. MIT Press 2006, 115, quotation from Shigeru Miyamoto.
2. Graham Nelson. *Inform Designer's Manual*. 4th ed. The Interactive Fiction Library, 2001, 343, quotation from William Crowther.
3. Mark Wolf. *The Video Game Explosion*. Greenwod Publishing, 2008, 71.
4. Chris Kohler. *Power-Up: How Japanese Video Games Gave the World an Extra Life*. BradyGAMES/Pearson Education, 2005, 56.
5. David Sheff. *Game Over: How Nintendo Conquered the World*. Vintage Books, 1994, 51.
6. Allison Cerra and Christina James. *Identity Shift: Where Identity Meets Technology in the Networked-Community Age*. John Wiley & Sons, 2011, 168.
7. *Computer Gaming World's Anniversary Edition*, 1996. <http://www.cdaccess.com/html/pc/150best.htm>.
8. Tom Cheshire. "Want to Learn Computer-Aided Design (CAD)? Play Minecraft." *Wired Magazine* (UK), November 2012, quotation from Cody Sumter. <http://www.wired.co.uk/magazine/archive/2012/11/play/minecrafted>.
9. "Google Quantum A.I. Lab Team." 18 October 2013. <https://plus.google.com/+QuantumAILab/posts/grMbaaDGChH>.
10. *Guinness World Records 2014: Gamer's Edition*. Guinness World Records Ltd., 2014.
11. Tom Cheshire. "In Depth: How Rovio Made Angry Birds a Winner (and What's Next)." *Wired*, 7 March 2011, quotation from Niklas Head. <http://www.wired.co.uk/magazine/archive/2011/04/features/how-rovio-made-angry-birds-a-winner>.
- F1. Ibid., quotation from Niklas Head.
- B1. Wolf, *The Video Game Explosion*, 71.
- B2. Tom Hoggins. "Interview: Meeting Shigeru Miyamoto." *Telegraph*, 28 October 2008, http://blogs.telegraph.co.uk/technology/tomhoggins/5525247/Interview_Meeting_Shigeru_Miyamoto/.
5. Donald Davies. "An Historical Study of the Beginnings of Packet Switching." *The Computer Journal* 44 (2001): 160.
12. Janet Abbate. "From Arpanet to Internet: A History of ARPA-Sponsored Computer Networks, 1966–1988." PhD dissertation, University of Pennsylvania, 1994, 41, quotation from Larry Roberts.
13. Davies, "An Historical Study of the Beginnings of Packet Switching," 157.
14. Hafner and Lyon, *Where Wizards Stay Up Late*, 38.
15. Campbell-Kelly and Aspray, *Computer*, 261.
16. Segaller, NERDS 2.0.1, 60.
17. Hafner and Lyon, *Where Wizards Stay Up Late*, 80.
18. Ibid., 86, quotation from Leo Beranek.
19. Ibid., 84, quotation from Leo Beranek.
20. BBN website. <http://www.bbn.com/resources/pdf/arpanet04.01.05.pdf>.
21. Hafner and Lyon, *Where Wizards Stay Up Late*, 122, quotation from Will Crowther.
22. Ibid., 123, quotation from Will Crowther.
23. Segaller, NERDS 2.0.1, 89, quotation from Vint Cerf.
24. Hafner and Lyon, *Where Wizards Stay Up Late*, 146, quotation from Vint Cerf.
25. Ibid., 130, quotation from Bob Kahn.
26. Ibid., 157, quotation from Bob Kahn.
27. Segaller, NERDS 2.0.1, 95, quotation from Larry Roberts.
28. Ibid., 104, quotation from Ray Tomlinson.
29. Ibid., 105, quotation from Bob Kahn.
30. Ibid., 106, quotation from Ray Tomlinson.
31. Hafner and Lyon, *Where Wizards Stay Up Late*, 238.
32. Ibid., 237, quotation from Jon Postel.
33. Alec Gambling. Invited talk at 50th Anniversary Symposium for the Department of Electronics at the University of Southampton, 1997.
34. *Laser Focus World*, Vol. 2. International Data Publishing Company, April 1966, 144, www.sff.net/people/jeff.hecht/history.html.
35. Jeff Hecht. *City of Light: The Story of Fiber Optics*. Oxford University Press, 1999, 117, quotation from Charles Kao.
36. David Payne. Invited talk at 50th Anniversary Symposium for the Department of Electronics at the University of Southampton, 1997.
37. Anonymous. "The Central Telegraph Office." *Illustrated London News*, November 1874, 506.
- B1. The Nobel Prize in Physics 2009. Press Release 6 October 2009, http://www.nobelprize.org/nobel_prizes/physics/laureates/2009/press.html.
- B2. The Franklin Institute Awards. 1998, <http://archive.today/ixBRZ>.

10. Licklider's Intergalactic Computer Network

1. J. C. R. Licklider. "Man-Computer Symbiosis." *IRE Transactions on Human Factors in Electronics*, HFE-1 (1960): 4. <http://memex.org/licklider.pdf>.
2. Stephen Segaller. *NERDS 2.0.1*. TV Books, 1998, 40, quotation from Larry Roberts.
3. Segaller, *NERDS 2.0.1*, 235, quotation from Scott McNealy.
4. Tom Standage. *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's On-line Pioneers*. Phoenix, 1999, 2.
5. Stewart Brand. "Founding Father." *Wired* 9, no. 3 (2001), interview with Paul Baran. <http://www.wired.com/wired/archive/9.03/baran.html>.
6. Katie Hafner and Matthew Lyon. *Where Wizards Stay Up Late: The Origins of the Internet*. Touchstone, 1998, 55.
7. Brand, "Founding Father."
8. Hafner and Lyon, *Where Wizards Stay Up Late*, 59.
9. Brand, "Founding Father."
10. Ibid.
11. Donald Davies. "An Historical Study of the Beginnings of Packet Switching." *The Computer Journal* 44 (2001): 160.
12. Janet Abbate. "From Arpanet to Internet: A History of ARPA-Sponsored Computer Networks, 1966–1988." PhD dissertation, University of Pennsylvania, 1994, 41, quotation from Larry Roberts.
13. Davies, "An Historical Study of the Beginnings of Packet Switching," 157.
14. Hafner and Lyon, *Where Wizards Stay Up Late*, 38.
15. Campbell-Kelly and Aspray, *Computer*, 261.
16. Segaller, NERDS 2.0.1, 60.
17. Hafner and Lyon, *Where Wizards Stay Up Late*, 80.
18. Ibid., 86, quotation from Leo Beranek.
19. Ibid., 84, quotation from Leo Beranek.
20. BBN website. <http://www.bbn.com/resources/pdf/arpanet04.01.05.pdf>.
21. Hafner and Lyon, *Where Wizards Stay Up Late*, 122, quotation from Will Crowther.
22. Ibid., 123, quotation from Will Crowther.
23. Segaller, NERDS 2.0.1, 89, quotation from Vint Cerf.
24. Hafner and Lyon, *Where Wizards Stay Up Late*, 146, quotation from Vint Cerf.
25. Ibid., 130, quotation from Bob Kahn.
26. Ibid., 157, quotation from Bob Kahn.
27. Segaller, NERDS 2.0.1, 95, quotation from Larry Roberts.
28. Ibid., 104, quotation from Ray Tomlinson.
29. Ibid., 105, quotation from Bob Kahn.
30. Ibid., 106, quotation from Ray Tomlinson.
31. Hafner and Lyon, *Where Wizards Stay Up Late*, 238.
32. Ibid., 237, quotation from Jon Postel.
33. Alec Gambling. Invited talk at 50th Anniversary Symposium for the Department of Electronics at the University of Southampton, 1997.
34. *Laser Focus World*, Vol. 2. International Data Publishing Company, April 1966, 144, www.sff.net/people/jeff.hecht/history.html.
35. Jeff Hecht. *City of Light: The Story of Fiber Optics*. Oxford University Press, 1999, 117, quotation from Charles Kao.
36. David Payne. Invited talk at 50th Anniversary Symposium for the Department of Electronics at the University of Southampton, 1997.
37. Anonymous. "The Central Telegraph Office." *Illustrated London News*, November 1874, 506.
- B1. The Nobel Prize in Physics 2009. Press Release 6 October 2009, http://www.nobelprize.org/nobel_prizes/physics/laureates/2009/press.html.
- B2. The Franklin Institute Awards. 1998, <http://archive.today/ixBRZ>.

- F1. Taylor, "In Memoriam: J. C. R. Licklider 1915–1990," 34, <http://memex.org/licklider.pdf>.
 F2. Ibid., 26.

11. Weaving the World Wide Web

1. Tim Berners-Lee. Proposal for the World Wide Web, 1989. www.w3.org/History/1989/proposal.html.
2. Bush, "As We May Think," 101.
3. Ibid.
4. Ibid., 106.
5. Ibid., 107.
6. Ted Nelson. "Ted Nelson's Computer Paradigm Expressed as One-Liners." 1999. <http://xanadu.com.au/ted/TN/WRITINGS/TCOMPARADIGM/tedCompOneLiners.html>.
7. Bush, "As We May Think," 108.
8. Jean Armour-Polly. "Surfing the Internet." *University of Minnesota Wilson Library Bulletin*, June 1992.
9. Tim Berners-Lee. *Weaving the Web*. Orion Business Books, 1999, 11.
10. Ibid., 16.
11. Ibid., 26.
12. James Gillies and Robert Cailliau. *How the Web Was Born: The Story of the World Wide Web*. Oxford Paperbacks, 2000, 196.
13. Berners-Lee, *Weaving the Web*, 30.
14. Ibid., 56.
15. Ibid., 80.
16. Bill Gates. "Internet Tidal Wave," memo. May 1995, <http://www.lettersofnote.com/2011/07/internet-tidal-wave.html>.
17. Ibid.
18. Mozilla Foundation website. <https://www.mozilla.org/en-US/foundation/>.
19. David Vise. *The Google Story*. Delacourt Press, 2008, 37.
20. Harry Shum. January 2011. http://www.bing.com/community/site_blogs/b/search/archive/2011/02/01/thoughts-on-search-quality.aspx.
21. Darcy DiNucci. "Fragmented Future." *Print* 53, no. 4 (1999): 32. http://darcydi.com/fragmented_future.pdf.
22. Ward Cunningham. "What Is Wiki?" 2002. <http://www.wiki.org>.
23. Lars Aronsson. Quoted in Wikipedia article on Wiki. <http://en.wikipedia.org/wiki/Wiki>.
24. Tim Berners-Lee. "developerWorks Interviews: Tim Berners-Lee." *developerWorks*, 22 August 2006, <http://www.ibm.com/developerworks/podcast/dwi/cm-int082206txt.html>.
25. Tim Berners-Lee, James Hendler, and Ora Lassilla. "The Semantic Web." *Scientific American*, 17 May 2001, 30.
- B1. Pascal Zachary. *Endless Frontier: Vannevar Bush, Engineer of the American Century*. MIT Press, 1999, 125.

12. The dark side of the web

1. David Sanger. *Confront and Conceal: Obama's Secret Wars and Surprising Use of American Power*. Broadway Books, 2013, xiv.
2. *The Capstone Encyclopaedia of Business*. Capstone Publishing, 2003, 444, definition by Fred Cohen.

3. Merrill Chapman. *In Search of Stupidity: Over Twenty Years of High Tech Marketing Disasters*. APRESS, 2006, 262, quotation from Thomas Hesse.

4. Bob Brown. "Sony BMG Rootkit Scandal: 5 Years Later." *NetworkWorld*, 1 November 2010, quotation from Mikko Hypponen, <http://www.networkworld.com/article/2194292/network-security/sony-bmg-rootkit-scandal-5-years-later.html>.
5. Clifford Stoll. *The Cuckoo's Egg*. Pan Books, 1991, 371.
6. "Microsoft Security Intelligence Report Warns of Ongoing Conficker Threat and Clarifies Reality of Targeted Attacks." 25 April 2012, <http://www.microsoft.com/en-us/news/pres/2012/apr12/04-25sirvapr12pr.aspx>.
7. Richard Boscovich. "Microsoft Works with Financial Services Industry Leaders, Law Enforcement and Others to Disrupt Massive Financial Cybercrime Ring." 5 June 2013, http://blogs.technet.com/b/microsoft_blog/archive/2013/06/05/microsoft-works-with-financial-services-industry-leaders-law-enforcement-and-others-to-disrupt-massive-financial-cybercrime-ring.aspx.
8. The Official Microsoft Blog. "Microsoft Disrupts the Emerging Nitol Botnet Being Spread through an Unsecure Supply Chain." 13 September 2012, http://blogs.technet.com/b/microsoft_blog/archive/2012/09/13/microsoft-disrupts-the-emerging-nitol-botnet-being-spread-through-an-unsecure-supply-chain.aspx.
9. Jonathan Katz and Yehuda Lindell. *Introduction to Modern Cryptography: Principles and Protocols*. Chapman & Hall/CRC, 2008, 10.
10. Simon Singh. *The Code Book*. Fourth Estate Limited, 1999, 267.
11. Ibid., 252.
12. Ibid., 266.
13. Text adapted from Singh, *The Code Book*, 266.
14. Ibid., 308, quotation from Ron Rivest.
15. Monty Python. "Spam," Episode 25, December 1970, <http://www.montypython.net/scripts/spam.php>.
16. Singh, *The Code Book*, 256.
17. Ibid., 288.

13. Artificial intelligence and neural networks

1. Herbert Simon and Allen Newell. "Heuristic Problem Solving: The Next Advance in Operations Research." *Operations Research* 6, no. 1, INFORMS 1958, 8.
2. Norbert Wiener. *Cybernetics, or Control and Communication in the Animal and the Machine*. 2nd ed. MIT Press, 1961, 43.
3. Alan Turing. "Computing Machinery and Intelligence." Reprinted in *The Essential Turing*, edited by B. Jack Copeland. Clarendon Press, 2005, 441.
4. Stuart Russell and Peter Norvig. *Artificial Intelligence: A Modern Approach*. 3rd ed. Prentice Hall, 2010, 2.
5. Turing, "Computing Machinery and Intelligence," 449.
6. Ibid., 395.
7. Ibid., 452.
8. John McCarthy et al. "A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence." 31 August 1955.

9. Allen Newell, J. Shaw, and Herbert Simon. "Elements of a Theory of Human Problem Solving." *Psychological Review* 65, no. 3 (1958): 156.
10. Allen Newell, J. Shaw, and Herbert Simon. "The Processes of Creative Thinking." *RAND Corporation Report P-1320*, 1958.
11. John McCarthy. "Programs with Common Sense," in *Semantic Information Processing*. MIT Press, 1968, 403.
12. Russell and Norvig, *Artificial Intelligence: A Modern Approach*, 25, quotation from David McAllester.
13. Donald Michie. *On Machine Intelligence*. 2nd ed. Ellis Horwood Ltd., 1986, 78.
14. David Levy. "Computer Chess – Past, Present and Future." *Chess Life & Review*, December 1973, 726.
15. David Levy. *More Chess and Computers: The Microcomputer Revolution, the Challenge Match*. Computer Science Press, 1980, 30.
16. Garry Kasparov. "IBM Owes Me a Rematch." *Time* 149, no. 21 (1997): 66.
17. Hippocrates. *On the Sacred Disease*, translated by Francis Adams. <http://classics.mit.edu/Hippocrates/sacred.html>.
18. Mo Costandi. "The Discovery of the Neuron." 2006, quotation from Ramón y Cajal, <http://neurophilosophy.wordpress.com/2006/08/29/the-discovery-of-the-neuron/>.
19. Lisa Rezende. *Chronology of Science*. Checkmark Books, 2007, 244.
20. Charles Sherrington. *Man on His Nature*. Cambridge University Press, 1942, 178.
21. Turing, "Computing Machinery and Intelligence," 405.
22. Russell and Norvig, *Artificial Intelligence: A Modern Approach*, 761.
23. Larry Crockett. *The Turing Test and the Frame Problem*. Ablex Publishing Corporation, 1994, 183.

14. Machine learning and natural language processing

1. Warren Weaver's letter to Norbert Wiener. 1949, 4, <http://www.mt-archive.info/Weaver-1949.pdf>.
2. Jamie MacLennan, ZhaoHui Tang, and Bogdan Crivat. *Data Mining with SQL Server 2008*. Wiley Publishing, 2009, 216.
3. Sharon McGayne. *The Theory That Would Not Die*. Yale University Press, 2011, 25.
4. Irving Good. *Good Thinking: The Foundations of Probability and Its Applications*. Dover Publications, 2009, 124.
5. McGayne, *The Theory That Would Not Die*, 220, quotation from Adrian Smith.
6. McGayne, *The Theory That Would Not Die*, 242, quotation from David Heckerman.
7. "Alumnus Dr Jamie Shotton and the Development of Kinect for Xbox 360." Cambridge University Engineering Department. 20 January 2011, news quotation from Jamie Shotton, http://www.eng.cam.ac.uk/news/stories/2011/Xbox_Kinect/.
8. Ibid.
9. Stephen Baker. *Final Jeopardy*. Houghton Mifflin Harcourt, 2011, 7, quotation from Paul Horn.
10. Cynthia Lowry. "Merv Griffin: Question and Answer Man," *Independent Star-News*, Associated Press, 29 March 1964.
11. Baker, *Final Jeopardy*, 123, quotation from David Ferrucci.

12. Ibid., 130, quotation from David Ferrucci.
13. Ibid., 251, quotation from Ken Jennings.
14. Ibid., 14, quotation from David Ferrucci.
15. Robert Wilson and Frank Keil. *The MIT Encyclopedia of the Cognitive Sciences*. MIT Press, 2001, 115, quotation from John Searle.
16. John Searle. "Watson Doesn't Know It Won on Jeopardy!" *Wall Street Journal*, 23 February 2013, <http://online.wsj.com/article/SB10001424052748703407304576154313126987674.html>.

15. The end of Moore's law

1. Gordon Moore. "Cramming More Components onto Integrated Circuits." *Proceedings of the IEEE* 86, no. 1 (January 1998): 84.
2. Richard Feynman. "There's Plenty of Room at the Bottom." Transcript of a talk presented to the American Physical Society, in Pasadena, California, December 1959.
3. Ibid.
4. Ibid.
5. BBC News website. "IBM Researchers Make 12-Atom Magnetic Memory Bit." 13 January 2012, quotation from Sebastian Loth, <http://www.bbc.co.uk/news/technology-16543497>.
6. Manek Dubash. "Moore's Law Is Dead, Says Gordon Moore." *Techworld*, 13 April 2005, <http://news.techworld.com/operating-systems/3477/moores-law-is-dead-says-gordon-moore/>.
7. IRC. "International Technology Roadmap for Semiconductors 2013 Edition IRC Overview." 6, <http://www.public.itrs.net/Links/2013ITRS/2013Chapters/2013Overview.pdf>.
8. Ibid., 14.
9. Alistair Kemp. "Intel Reinvents Transistors Using New 3-D Structure." Intel UK Newsroom, 4 May 2011. http://newsroom.intel.com/community/en_uk/blog/2011/05/04/intel-reinvents-transistors-using-new-3-d-structure.
10. Karen Rhodes. "Radical New Intel Transistor Based on UC Berkeley's FinFET." <http://vcresearch.berkeley.edu/news/radical-new-intel-transistor-based-uc-berkeley-s-finfet>.
11. Michio Kaku. "What Happens When Computers Stop Shrinking?" *Salon*, 19 March 2011, http://www.salon.com/2011/03/19/moores_law_Ends_Excerpt/.
12. The Nobel Prize in Physics 2010. [nobelprize.org](http://www.nobelprize.org/nobel_prizes/physics/laureates/2010/), http://www.nobelprize.org/nobel_prizes/physics/laureates/2010/.
13. Richard Feynman. "Simulating Physics with Computers." *International Journal of Theoretical Physics* 21, nos. 6–7 (1982): 486.
14. Ibid., 474.
15. Ervin Schrödinger. "Discussion of Probability Relations between Separated Systems." *Proceedings of the Cambridge Philosophical Society* 31 (1935): 555.
16. Brian Clegg. *The God Effect: Quantum Entanglement, Science's Strangest Phenomenon*. St. Martin's Griffin, 2009, 3, quotation from Einstein's letter to Max Born, 3 March 1947.
17. Chris Monroe and Jungsang Kim. "Scaling the Ion Trap Quantum Processor." *Science* 339, no. 6124 (2013): 1165.

18. Tom Knight. "Taming Biology as an Engineering Technology." Yale Department of Electrical Engineering Seminar, 12 November 2009, <http://robotics.research.yale.edu/index.php?n>Main.2009>.
- B1. The Kavli Foundation website. <http://www.kavli-foundation.org/2010-nanoscience-citation>.

16. The third age of computing

1. Butler Lampson. "What Computers Do: Model, Connect, Engage." *Theory and Applications of Models of Computation*. Lecture Notes in Computer Science 7287 (2012): 23.
2. Ibid., 24.
3. Ibid., 25.
4. George Devol. "Programmed Article Transfer." U.S. Patent 2988237, 1961, <http://www.google.com/patents/US2988237>.
5. Kevin Ashton. "That 'Internet of Things' Thing." *RFID Journal*, 22 July 2009. <http://www.rfidjournal.com/articles/view?4986>.
6. Ray Ozzie. "Dawn of a New Day." Memo to Microsoft staff, 28 October 2010. <http://ozzie.net/docs/dawn-of-a-new-day/>.
7. Ibid.
8. Russell and Norvig, *Artificial Intelligence* 1020.
9. McCarthy et al. "Proposal for the Dartmouth Summer Research Project on Artificial Intelligence," 1.
10. Russell and Norvig, *Artificial Intelligence*, 30.
11. Russell and Norvig, *Artificial Intelligence*, 1020.
12. Francis Crick. *The Astonishing Hypothesis: The Scientific Search for the Soul*. Simon & Schuster, 1995, 271.
13. Stevan Harnad. Personal communication. April 2013.
14. Ibid.
15. Alan Turing. "Computing Machinery and Intelligence." *Mind* 59, no. 236 (1950): 444.
16. Jeff Hawkins and S. Blakeslee. *On Intelligence*. St. Martin's Press, 2004, 68.
17. Ibid., 69.
18. Ibid., 104.
19. Ibid., 105.
20. David Dennett. *Consciousness Explained*. Penguin Books, 1993, 73.
21. Chris Koch. *Consciousness: Confessions of a Romantic Reductionist*. MIT Press, 2012, 27.
22. Ibid., 33.
23. Dennett, *Consciousness Explained*, 21.

17. Computers and science fiction – an essay

1. Stan Augarten. *State of the Art*. Ticknor & Fields, 1983; iii, quotation in foreword by Ray Bradbury.
2. Tony Hey and Patrick Walter. *Einstein's Mirror*. Cambridge University Press, 1997, 242, quotation from Jules Verne.
3. E. Forster. *The Machine Stops*. Penguin Classics, 2011, 7.
4. Danny Wallace. *Knowledge Management: Historical and Cross-disciplinary Themes*. 2nd ed. Libraries Unlimited Inc., 2007, 151, quotation from H. G. Wells from the 1936 speech delivered at the Royal Institution.
5. John Malone. *Predicting the Future: From Jules Verne to Bill Gates*. M. Evans & Co Inc., 1997, 3, quotation from Pierre-Jules Hetzel.
6. Jules Verne. *Paris in the Twentieth Century*. Ballantine Books, 1996, 51.
7. Ibid., 53.
8. Gary Westfahl. *Hugo Gernsback and the Century of Science Fiction*. McFarland & Co Inc., 2007, 20, quotation from Hugo Gernsback.
9. John Campbell. "The Last Evolution," in *Classic Science Fiction*, edited by Lester Del Rey. Ballantine Books, 1976, 2.
10. Isaac Asimov. *The Early Asimov*, Volume 1. Victor Gollancz Ltd., 1973, 14.
11. David Seed. *Science Fiction: A Very Short Introduction*. Oxford University Press, 2011, 120, quotation from John Campbell.
12. Kurt Vonnegut. "EPICAC." *Welcome to the Monkey House*. Granada Publishing, 1968, 257.
13. Isaac Asimov. *Robot Dreams*. Ace Books, 1990, xv.
14. Murray Leinster. "A Logic Named Called Joe." *Astounding Science Fiction*, 1946. Republished in Billee J. Stallings and Jo-an J. Evans, *Murray Leinster Life and Works*. McFarland, 2011, 176.
15. Josh Lowensohn. "Samsung Cites Kubrick Film in Apple Patent Spat." *C/Net*, 23 August 2011. http://news.cnet.com/8301-27076_3-20096061-248/samsung-cites-kubrick-film-in-apple-patent-spat/.
16. Asimov, *The Early Asimov*, Volume 1, 150.
17. Isaac Asimov. "Runaround," *Astounding Science Fiction*, March 1942.
18. Michael Anderson and Susan Leigh Anderson. *Machine Ethics*. Cambridge University Press, 259, quotation from Isaac Asimov.
19. Isaac Asimov. *Foundation and Earth*. Doubleday and Company, Inc, 1986, 347.
20. *Red Dwarf*. Season IV, Episode 5, "Dimension Jump." http://www.cervenytrpaslik.cz/scenare/EN-23-4_Dimension_Jump.htm.
21. Douglas Adams. *The Restaurant at the End of the Universe (Hitchhiker's Guide 2)*. Pan Books, 1999, 34.
22. Ibid., 44.
23. Greg Bear. *Queen of Angels*. Warner Books, 1991, 38, quotation from Martin Burke.
24. Ibid.
25. Neal Stephenson. *The Diamond Age*. Reissue ed. Penguin, 2011, 64.
26. Ibid., 56.
27. Michael Crichton. *Prey*. Avon Books, 2003, 201.
28. Michael Crichton. *Timeline*. Arrow Books, 2000, 138.
29. Ibid., 445.
30. William Gibson and Bruce Sterling. *The Difference Engine*. Gollancz, 2011, 126.
31. Ibid., 132.
32. Ibid., 172.
33. Ibid., 376.
34. Ibid., 377.
35. John Carlin. "A Farewell to Arms," *Wired*, May 1997, <http://archive.wired.com/wired/archive/5.05/netizen.html>.

36. Mark Russinovich. *Zero Day*. Thomas Dunne Books, 2011, 327.
37. Ibid., 93.
38. William Gibson. *Neuromancer*. Voyager paperback ed., HarperCollins Publishers, 1995, 67.
39. Marvin Minsky. <http://web.media.mit.edu/~minsky/papers/> option.chapters.txt.
40. Harry Harrison and Marvin Minsky. *The Turing Option*. Viking Penguin Group, 1992, 70.
41. Ibid., 315.
42. Ibid., 316.
43. Marvin Minsky. *The Society of Mind*. Simon & Schuster, 1988, 308.
44. Source: <http://en.wikipedia.org/wiki/Cortana>.
45. Greg Iles. *The Footprints of God*. Pocket Star Books, 2003, 78.
46. Ibid., 81.
- B1. Richard Dawkins. *A Devil's Chaplain: Selected Writings*. Phoenix, 2004, 195.

Epilogue

1. Alan Turing. "Intelligent Machinery, A Heretical Theory." Reprinted in *The Essential Turing*, edited by Jack Copeland, Clarendon Press, 2005, 474.
2. J. C. R. Licklider, "Man-Computer Symbiosis," 4.
3. Blay Whitby. *Reflections on Artificial Intelligence*. Intellect Books, 1996, 20, quotation from Marvin Minsky.

