

NOTES

1. A Latticework of Mental Models

1. Charles Munger's complete presentation to Dr. Babcock's class, in lightly edited form, appears in the May 5, 1995, edition of *Outstanding Investor Digest (OID)*, from which the passages quoted here are taken.

2. Benjamin Franklin, "Proposals Relating to the Education of the Youth in Pennsylvania," 1749. All quotes from Franklin in this section of the chapter are taken from this pamphlet, with his original spelling intact.

3. Professor Richard Beeman, interviewed by author, December 23, 1999.

4. George Lakoff and Mark Johnson, *Metaphors We Live By* (Chicago: University of Chicago Press, 1980), 3.

5. Munger's remarks to the Stanford class and his answers to questions from students appear in two issues of *Outstanding Investor Digest*, December 29, 1997, and March 13, 1998. Readers are encouraged to read the lecture, which *OID* editor Henri Emerson aptly describes as "Worldly Wisdom Revisited," in its entirety.

2. Physics

1. Sir Isaac Newton's first law of motion states that a moving object will continue to move in a straight line at a constant speed, and a stationary object will remain at rest unless acted on by an unbalanced force; this is the law of inertia. The second law

states that the acceleration produced on a body by a force is proportional to the magnitude of the force and inversely proportional to the mass of the object. The third law states that for every action there is an equal and opposite reaction.

2. Alfred Marshall takes another turn on our stage in Chapter 3.
3. Alfred Marshall, *Principles of Economics*, 8th ed. (Philadelphia: Porcupine Press, 1920), 276.
4. *Ibid.*, 269.
5. *Ibid.*, 287.
6. *Ibid.*, 288.
7. Paul Samuelson, quoted in Peter L. Bernstein, *Capital Ideas: The Improbable Origins of Modern Wall Street* (New York: The Free Press, 1992), 113.
8. *Ibid.*, 37.
9. Louis Bachelier, quoted in Bernstein, *Capital Ideas*, 21.
10. Paul Samuelson, "Proof That Properly Anticipated Prices Fluctuate Randomly," *Industrial management review* 6 (Spring 1965).
11. William F. Sharpe, "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk," *Journal of finance* 19, no. 3 (Summer 1964), 4336.
12. Brian Arthur et al., "Asset Pricing under Endogenous Expectations in an Artificial Stock Market" (working paper 96-12-093, Santa Fe Institute Economics Research Program, 1996).

3. Biology

1. Erasmus Darwin, a prominent and highly successful doctor, was also a poet. It was in his poetry, principally "Zoonomia," that he chose to express his speculations about evolution, in which he was decidedly ahead of his time. His contemporary, Samuel Taylor Coleridge, took to calling his friend's theories "darwinizing." Although in later years Charles Darwin would claim he was not particularly influenced by his grandfather's theories, it seems impossible that he was unaware of them.

2. Francis Darwin, ed., *The Autobiography of Charles Darwin* (New York: Dover Publications, 1958).
3. For all that Charles Darwin was able to accomplish, he was not able to explain how variations in species occurred. That question was settled by Gregor Johann Mendel, an Austrian botanist and plant experimenter, who was the first to present a mathematical foundation of the science of genetics. Today, biologists understand that variations within a species are caused by the variations of the genes of its individual members.
4. Richard Dawkins, "International Books of the Year and the Millennium," *Times literary supplement* (December 3, 1999).
5. American economists were paying attention, too. Most notable among them at the time was Thorstein Veblen at the University of Chicago. Today his reputation rests on his primary work, *The Theory of the Leisure Class*, in which he described his notion of conspicuous consumption. In his own time, his scholarly reputation was

somewhat overshadowed by his eccentric personal behavior and by his sardonic, satiric style of writing. Many contemporaries simply missed the satire. He frequently called for an evolutionary, post-Darwinian approach to the study of economics; unfortunately, he was light on specific details. Nonetheless, some of today's scholars credit him as a pioneer in this approach. British economist Geoffrey Hodgson, for example, claims "Veblen's writings constitute the first case of an evolutionary economics along Darwinian lines." (G. M. Hodgson, "On the Evolution of Thorstein Veblen's Evolutionary Economics," *Cambridge journal of economics* 22 [1998]: 415–431.)

6. The poignancy is that, despite years of work, he never completed volume 2.

7. *The Theory of Economic Development* was of course written in Schumpeter's native German. The common translation of the title is somewhat misleading. The German word *entwicklung*, usually translated as "development," also means "evolution." In fact, Schumpeter himself wrote to a colleague, while the book was in press, that the title was *The Theory of Economic Evolution*. (Esben Andersen, "Schumpeter's General Theory of Social Evolution" [paper presented at the Conference on Neo-schumpeterian Economics, Trest, Czech Republic, June 2006].)

8. Christopher Freeman, in *Techno-economic Paradigms: Essays in Honor of Carlota Perez* (London, UK: Anthem Press, 2009), 126.

9. Sylvia Nasar, *Grand Pursuit: The Story of Economic Genius* (New York: Simon & Schuster, 2011).

10. *Ibid.*

11. Alfred Marshall, *Principles of Economics* (Philadelphia: Porcupine Press, 1994).

12. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, [1962] 1970), 90.

13. In an intriguing bit of serendipity, the conference, many months in the planning, was held in 1987, the same year as the stock market debacle that caused many people to question the concept of absolute equilibrium in the market.

14. J. Doyne Farmer, "Market Force, Ecology, and Evolution" (working paper, version 4.1, Santa Fe Institute, February 14, 2000).

15. *Ibid.*, 1, 34.

16. J. Doyne Farmer and Andrew W. Lo, "Frontiers of Finance: Evolution and Efficient Markets" (working paper 99–06–039, Santa Fe Institute April 11, 1999).

17. *Ibid.*

18. Jane Jacobs, *The Nature of Economies* (New York: Modern Library, 2000), 137.

4. Sociology

1. *Church of England quarterly review* (1850), 142.

2. Norman Johnson, S. Ramsussed, and M. Kantor, "The Symbiotic Intelligence Project: Self-Organizing Knowledge on Distributed Networks Driven by Human Interaction," Los Alamos National Laboratory, LA-UR-98–1150, 1998.

3. Marco Dorigo, Gianni Di Caro, and Luca M. Gambardella, "An Algorithm for Discrete Optimization," *Artificial life* 5, no. 3 (1999): 137–172.

4. We have observed anecdotal evidence of emergent behavior, perhaps without realizing what we were seeing. The bestseller *Blind Man's Bluff: The Untold Story of American Submarine Espionage*, by Sherry Sontag and Christopher Drew, presents a very compelling example of emergence. Early in the book, the authors relate a story of the 1966 crash of a B-52 carrying four atomic bombs. Three of the four bombs were soon recovered, but a fourth remained missing, with the Soviets quickly closing in. A naval engineer named John Craven was given the task of locating the missing bomb. He constructed several different scenarios of what possibly could have happened to the fourth bomb and asked members of his salvage team to wager a bet on where they thought the bomb could be. He then ran each possible location through a computer formula and—without ever going to sea—was able to pinpoint the exact location of the bomb based on a collective solution.

5. James Surowiecki, *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Businesses, Economics, Societies, and Nations* (New York: Doubleday, 2004), xvi.

6. *Ibid.*, xvi.

7. *Ibid.*, xv.

8. *Ibid.*, 41.

9. Scott E. Page, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Princeton, NJ: Princeton University Press, 2007).

10. *Ibid.*, 13.

11. *Ibid.*, 13.

12. Michael J. Mauboussin, *Think Twice: Harnessing the Power of Counterintuition* (Boston: Harvard Business Press, 2009), 50.

13. *Ibid.*, 55.

14. Per Bak, M. Paczuski, and M. Shubik, "Price Variations in a Stock Market with Many Agents" (working paper 96-09-078, Santa Fe Institute Economics Research Program, 1996).

15. Diana Richards, B. McKay, and W. Richards, "Collective Choice and Mutual Knowledge Structures," *Advances in complex systems* 1 (1998): 221-236.

5. Psychology

1. Michael Lewis, "The King of Human Error," *Vanity fair* (December 2011): 154.

2. Richard Thaler and Shlomo Benartzi, "Myopic Loss Aversion and the Equity Risk Premium Puzzle," *Quarterly journal of economics* 110, no. 1 (February 1995): 80.

3. Buffett paraphrases Benjamin Graham's famous quote, "Investment is most intelligent when it is business-like." Benjamin Graham, *The Intelligent Investor* (New York: Harper & Row, [1949] 1973), 286.

4. The frequency with which stocks and portfolios outperform the market on a frequency basis is rarely 100 percent. I have spent a good deal of time looking at hold-periods of both individual stocks and portfolios and have found that the ones that

do outperform over long periods of time seem to do so about 40–60 percent of the periods. (See Robert G. Hagstrom, *The Warren Buffett Portfolio: Mastering the Power of the Focus Investment Strategy* [New York: John Wiley & Sons, 1999].) Still, there is much work to be done in this research area.

5. Charles Ellis, “A Conversation with Benjamin Graham,” *Financial analysts journal* (September/October 1976): 20.

6. Graham, *Intelligent Investor*, 107.

7. Terrance Odean, “Do Investors Trade Too Much?” *American economic review* (December 1999).

8. Terrance Odean and Brad Barber, “Trading Is Hazardous to Your Wealth: The Common Stock Investment Performance of Individual Investors,” *Journal of finance* 55, no. 2 (April 2000).

9. Terrance Odean and Brad Barber, “The Internet and the Investor,” *Journal of economic perspectives* 15, no. 1 (Winter 2001).

10. Hagstrom, *Warren Buffett Portfolio*, 155.

11. *Ibid.*

12. *Ibid.*

13. Michael Lupfer and Mark Jones, “Risk Taking as a Function of Skill and Chance Orientations,” *Psychological reports* 28 (1971): 27–32.

14. In this respect, the phrase “mental models” as used here is more specific than Charlie Munger’s use of the same phrase; his meaning is closer to “key principle, core idea” than to a sense of dimensional representation.

15. Kenneth Craik, *The Nature of Explanation* (London: Cambridge University Press, 1952).

16. Michael Shermer, *How We Believe* (New York: W. H. Freeman, 2000), 36.

17. Fischer Black, quoted in Peter L. Bernstein, *Capital Ideas: The Improbable Origins of Modern Wall Street* (New York: The Free Press, 1992), 124.

18. Claude Shannon, “A Mathematical Theory of Communication,” *The Bell Systems technical journal* (July 1948).

19. Charles T. Munger, *Outstanding investor digest* (May 5, 1995): 51.

6. Philosophy

1. Lee McIntyre, “Complexity: A Philosopher’s Reflections,” *Complexity* 3, no. 6 (1998): 26.

2. *Ibid.*, 27.

3. *Ibid.*, 28.

4. Benoit Mandelbrot, “Introduction,” *The Fractal Geometry of Nature* (New York: W. H. Freeman, 1982).

5. Brian McGuinness, *Wittgenstein: A Life—Young Ludwig 1889–1921* (Berkeley, CA: University of California Press, 1988), 118.

6. Ludwig Wittgenstein, *Philosophical Investigations* (Englewood Cliffs, NJ: Prentice-Hall, 1958), v.

7. Douglas Lackey, "What Are the Modern Classics? The Baruch Poll of Great Philosophy in the Twentieth Century," *Philosophical forum* 30, no. 4 (December 1999): 329–345.

8. Wittgenstein, *Philosophical Investigations*, 200.

9. Amazon.com has been owned in my portfolios at Legg Mason Capital Management since 2003. It continues to be a top holding for the fund as well as our firm's institutional separate accounts.

10. Susan Crawford, "The New Digital Divide," *New York times, Sunday review* (December 4, 2011): 1.

11. Rita Charon, MD, PhD, "Narrative Medicine," *JAMA* 286, no. 15 (October 17, 2001).

12. C. P. Snow, *The Two Cultures* (The Rede Lecture, Cambridge, UK, May 7, 1959), in *The Two Cultures and the Scientific Revolution* (1963).

13. John Allen Paulos, *Once Upon a Number: The Hidden Mathematical Logic of Stories* (New York: Basic Books, 1998), 12.

14. John Allen Paulos, "Stories vs. Statistics," *New York times* (October 24, 2010), <http://www.NYTimes.com>.

15. Ibid.

16. James Boswell, quoted in John Allen Paulos, *A Mathematician Reads the Newspaper* (New York: Basic Books, 1995), 6.

17. Charles S. Peirce, "How to Make Our Ideas Clear," *Popular science monthly* (January 1878). Also in *Pragmatism: A Reader*, ed. Louis Menand (New York: Random House, 1997), 26.

18. William James, "Pragmatism: Conception of Truth," lecture 6 in *Pragmatism* (New York: Dover Publications, [1907] 1995), 30.

19. Ibid., 22.

20. Ibid., 23.

21. Ibid., 24.

22. Ibid., 26.

23. Ibid., 31.

24. Correct use of the dividend discount model requires us to make difficult calculations. What will be the future growth rate of the company over its lifetime? How much cash will the company generate? What is the appropriate discount rate for projecting the growth of cash flows? Answers to these tough questions are necessary input variables. Adding to the difficulty is the fear that the uncertainty of long-range forecasts makes using the model suspect. A further difficulty is that determining value is highly sensitive to its initial condition; even a slight change in growth rate or discount factor can have a large effect on value. For this reason, investors often use shortcuts (second-order models) to determine value.

25. James, *Pragmatism*, 321–324.

26. I am grateful to my friend and colleague Bill Miller for his insights on the philosophy of pragmatism and how it relates to the philosophy of investing.

7. Literature

1. A number of other institutions of higher learning have special liberal arts programs grounded in the works of history's greatest thinkers. Some are part of the university's honors programs while others are short-term intensive-study programs. St. John's is the only university I am aware of that is dedicated to teaching the "great books," and its list of curriculum materials is continuously reviewed and updated.

2. Indeed, St. John's dates back to 1696, five years before Yale was founded, fifty years before Princeton, and fifty-three years before Franklin's famous education manifesto.

3. Don Bell and Lee Munson were interviewed by the author June 7, 2000; Greg Curtis was interviewed November 10, 2011; Steve Bohlin was interviewed December 15, 2011.

4. Mortimer Adler served as editor of the fifty-four-volume *Great Books of the Western World* and as chairman of *Encyclopedia Britannica's* board of editors for twenty years. Until his death on June 28, 2011, he remained active writing and speaking on his lifelong passion: the value of a broad general education based in the humanities.

5. Few reference works in any discipline have the staying power of *How to Read a Book*. The copy I own is from the thirty-sixth printing of the revised edition.

6. Mortimer Adler and Charles Van Doren, *How to Read a Book*, rev. ed. (New York: Simon & Schuster, [1940] 1972), 46–47.

7. *Ibid.*, 291.

8. *Ibid.*, 301.

9. *Ibid.*, 205.

10. Benjamin Doty was interviewed by the author on November 27, 2011.

11. Rolf Potts, "Cannon Fodder," *The New Yorker* (May 2, 2011): 22–23.

12. Robert G. Hagstrom, *The Detective and the Investor* (New York: John Wiley & Sons, 2002).

13. Alan Jacobs, *The Pleasure of Reading in an Age of Distraction* (Oxford: Oxford University Press, 2011).

14. Charlie Munger (address at Stanford Law School, Stanford, CA, 1996), reprinted in *Outstanding investor digest* (March 13, 1998): 58.

15. *Ibid.*, 61, 63.

8. Mathematics

1. Warren Buffett, *Berkshire Hathaway 2000 Annual Report*, 13.

2. Robert G. Hagstrom, *The Warren Buffett Way: Investment Strategies of the World's Greatest Investor* (New York: John Wiley & Sons, 1994).

3. Peter L. Bernstein, *Against the Gods: The Remarkable Story of Risk* (New York: John Wiley & Sons, 1996), 3.

4. *Ibid.*

5. *Ibid.*

6. Sharon Bertsch McGrayne, *The Theory That Would Not Die* (New Haven: Yale University Press, 2011), 8.
7. Charles T. Munger, *Outstanding investor digest* (May 5, 1995): 49.
8. Robert L. Winkler, *An Introduction to Bayesian Inference and Decision* (New York: Holt, Rinehart and Winston, 1972), 17.
9. J. L. Kelly's most celebrated moment occurred in 1962 when he programmed an IBM 704 computer to synthesize speech. Kelly had built a "vocoder" (voice recorder synthesizer) and recreated the song "Daisy Bell" with musical accompaniment from Max Mathews. Coincidentally, Arthur C. Clarke was visiting the Bell Labs at the same time. Science fiction buffs already get the connection. In *2001: A Space Odyssey*, the computer HAL 9000 sings "Daisy Bell" as he is being put to sleep by astronaut Dave Bowman.
10. J. L. Kelly Jr., "A New Interpretation of Information Rate," *The Bell Systems technical journal* 35, no. 3 (July 1956).
11. Ed Thorp, interviewed by the author, November 25, 1998.
12. The following section is based on a 1985 article in *Discover* titled, "The Median Isn't the Message" and on Stephen Jay Gould, "Case One: A Personal Story," chap. 4 in *Full House: The Spread of Excellence from Darwin to Plato* (New York: Three Rivers Press, 1996).
13. Sam L. Savage, *The Flaw of Averages: Why We Underestimate Risk in the Face of Uncertainty* (New York: John Wiley & Sons, 2009), 11.
14. Robert G. Hagstrom, "Who's Afraid of a Sideways Market?" *Legg Mason perspectives* (January 2010).
15. Gould, *Full House*, 41.
16. Bernstein, *Against the Gods*, 162.
17. Sir Francis Galton, quoted in Bernstein, *Against the Gods*, 167. It is referenced in the biography by D. W. Forest, *Francis Galton: The Life and Work of a Victorian Genius* (New York: Taplinger, 1974).
18. Gottfried Leibniz, quoted in Bernstein, *Against the Gods*, 329.
19. Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House, 2007), xvii.
20. William Safire, "On Language: Fat Tail," *New York Times* (2009), <http://www.nytimes.com/2009/02/08/magazine/08wwwwln-safire-y.html>.
21. Kenneth Arrow, quoted in Bernstein, *Against the Gods*, 7.
22. Bernstein, *Against the Gods*, 207.
23. Gilbert Keith Chesterton, "The Paradoxes of Christianity," chap. 6 in *Orthodoxy* (Charleston, SC: BiblioBazaar, [1908] 2007).

9. Decision Making

1. These three puzzles can be found in Shane Frederick, "Cognitive Reflection and Decision Making," *Journal of economic perspectives* 19, no. 4 (Fall 2005): 25–42. The ball costs \$.05. It takes 5 minutes for 100 machines to make 100 widgets. It will take 47 days for the lily pad to cover half the lake.

2. Daniel Kahneman, *Thinking Fast and Slow* (New York: Farrar, Straus, and Giroux, 2001), 241.
3. Daniel Kahneman and Shane Frederick, "Representativeness Revisited: Attribute Substitution in Intuitive Judgment," in *Heuristics and Biases: The Psychology of Misjudgment*, ed. Thomas Gilovich, Dale Griffin, Daniel Kahneman (Cambridge: Cambridge University Press, 2002), 54.
4. Philip E. Tetlock, *Expert Political Judgment: How Good Is It? How Can We Know?* (Princeton: Princeton University Press, 2005).
5. Philip Tetlock, "Why Foxes Are Better Forecasters Than Hedgehogs," Seminars About Long-Term Thinking, hosted by Stewart Brand, January 26, 2007.
6. Jahanbegolo Ramin, *Conversations with Isaiah Berlin* (London: Halban Publishers, 2007), 188.
7. Philip Tetlock, "Coming to Existential Terms with Unpredictability" (presentation to the Legg Mason Capital Management Thought Leader Forum, Baltimore, MD, October 6–7, 2011).
8. Keith Stanovich, *What Intelligence Tests Miss: The Psychology of Rational Thought* (New Haven: Yale University Press, 2009). Also see Keith Stanovich, "Rationality versus Intelligence," Project Syndicate (2009–04–06), <http://www.project-syndicate.org>.
9. Keith Stanovich, "Rational and Irrational Thought: The Thinking That IQ Tests Miss," *Scientific American mind* (November/December 2009): 35.
10. D. N. Perkins, "Mindware and Metacurriculum," *Creating the Future: Perspectives on Educational Change*, comp. and ed. Dee Dickinson (Baltimore: Johns Hopkins University School of Education, 2002).
11. Ibid.
12. Ibid.
13. Kahneman, *Thinking Fast and Slow*, 4.
14. Ibid., 46.
15. I am indebted to John Holland, professor of psychology and engineering and computer science at the University of Michigan, for his graceful presentation on the concepts of building blocks, the need for models that are dynamic, and the flight simulator analogy.
16. Charles T. Munger, "The Need for More Multidisciplinary Skill," (presentation, Fiftieth Reunion of the Harvard Law School Class Graduated in 1948, Cambridge, MA, May 1998). The full text of the speech appears in Appendix B of Janet Lowe's book, *Damn Right: Behind the Scenes with Berkshire Hathaway Billionaire Charlie Munger* (New York: Vintage Books, 1999), 8.
17. Edward O. Wilson, *Consilience: The Unity of Knowledge* (New York: Vintage Books, 1999), 8.

