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1. How It All Began

5 **something was terribly wrong:** Eighteen years later modern diagnostic methods would reveal a third of Elizabeth's cerebellum was missing. Her official diagnosis was cerebral hypoplasia.

2. From Fixing to Connecting

19 **The brain has the ability to figure itself out:** The brain is the ultimate self-organizing system. Thompson E, Varela FJ. 2001. Radical embodiment: Neural dynamics and consciousness. *Trends in Cognitive Sciences* 5: 418–25. Lewis MD, Todd RM. 2005. Getting emotional—A neural perspective on emotion, intention and consciousness. *Journal of Consciousness Studies* 12(8–10): 213–38.

22 **These random experiences . . . are in fact required for every child's brain to form itself as fully as it might:** Coq J-O, Byl N, Merzenich MM. 2004. Effects of sensorimotor restriction and anoxia on gait and motor cortex organization: Implications for a rodent model of cerebral palsy. *Neuroscience* 129(1): 141–56.

23 **to help a child who is unable to crawl, it might seem perfectly logical . . . to assist him in making crawling motions.** What research there is often shows little effect, and part of the reason for this may be a focus on the end result. Damiano DL. 2009. Rehabilitative therapies in cerebral palsy: The good, the not as good, and the possible. *Journal of Child Neurology* 24(9): 1200–04. See also Palmer FB, Shapiro BK, Wachtel RC, et al. 1988. The effects of physical therapy on cerebral palsy. A controlled trial in infants with spastic diplegia. *New England Journal of Medicine* 318(13): 803–08. Butler C, Darrah J. 2001. Effects of neurodevelopmental treatment (NDT) for cerebral palsy: An AACPDM evidence report. *Developmental Medicine & Child Neurology* 43(11): 778–90. Wiart L, Darrah J, Kembhavi G.. 2008. Stretching with children with cerebral palsy: What do we know and where are we going? *Pediatric Physical Therapy* 20(2): 173–78. Dreifus L. 2003. Commentary: Facts, myths and fallacies of stretching. *Journal of Chiropractic Medicine* 2(2): 75–77.

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25 **all children *learn their experience*:** "Experience coupled with attention leads to physical changes in the structure and functioning of the nervous system": Decharms RC, Merzenich M. 1996. Neural representations, experience and change. In Llinàs R, Churchland PS, eds. *The Mind-Brain Continuum*. Cambridge, MA: MIT Press.

27 **what your child "should" be doing now according to age and known developmental stages:** Many of the researchers who identified such stages intended them not as dogma but as indicators of a developmental process. Gesell A. 1940. *The First Five Years of Life: A Guide to the Study of the Pre-School Child*. New York: Harper & Brothers.

3. Your Child's Amazing Brain

28 **Our brains . . . create order out of chaos:** Evidence shows that the cerebral cortex shows ongoing activity in the absence of a stimulus that is comparable in size to stimulus-driven activity. Murphy BK, Miller KD. 2009. Balanced amplification: A new mechanism of selective amplification of neural activity patterns. *Neuron* 61: 635–48. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25: 252–77.

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30 **The child's ability to notice differences . . . is the source of information for the brain:** Physiologically, the basis of all sensory perception is contrast. Guyton AC. 1981. *Textbook of Medical Physiology*. Philadelphia: Saunders.

32 **Recently researchers Michael Merzenich and colleagues:** Merzenich and his team at the University of California San Francisco have done experiments to show the importance of what he terms *randomized movements*. Coq J-O, Byl N, Merzenich MM. 2004. Effects of sensorimotor restriction and anoxia on gait and motor cortex organization: Implications for a rodent model of cerebral palsy. *Neuroscience* 129(1): 141–56.

34 **Kassi's brain was . . . organizing a growing complement of sensations with finer and finer differentiation:** As we gain experience we gain control through using our muscles in a more refined and precise way. This process has been demonstrated in the brain. Jenkins WM, Merzenich MM, Ochs MT, et al. 1990. Functional reorganization of primary somatosensory cortex in adult owl monkeys after behavior-

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35 **The brain uses information it acquires through perceiving differences to create new connections between different brain cells; this capacity is called *differentiation*:** Differentiation is a fundamental process underlying all forms of life. Prasad KN. 1980. *Regulation of differentiation in mammalian nerve cells.* Plenum, NY. Scientists are able to measure and track the process of differentiation as it is taking place in the brain. Hebrew University of Jerusalem. 2007. Scientist observes brain cell development in "Real Time." *ScienceDaily*, May 29. Mizrahi A. 2007. Dendritic development and plasticity of adult-born neurons in the mouse olfactory bulb. *Nature Neuroscience* 10(4): 444–52.

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4. Essential One: Movement with Attention

48 **Research shows that movement done automatically creates little or no *new* connections in the brain:** "[T]he variable determining whether or not the brain changes is . . . the attentional state of the animal." Schwartz J, Begley S. 2002, rpnt 2003. *The Mind and the Brain: Neuroplasticity and the Power of Mental Force*. New York: HarperCollins. Recanzone G.H, Merzenich MM, Jenkins WM, et al. 1992. Topographic reorganization of the hand representation in cortical area 3b of owl monkeys trained in a frequency discrimination task. *Journal of Neurophysiology* 67: 1031–56. Nudo RJ, Milliken GW, Jenkins WM, Merzenich MM. 1996 Use-dependent alterations of movement representations in primary motor cortex of adult squirrel monkeys. *Journal of Neuroscience* 16: 785–807. See Doidge N. 2007. *The Brain That Changes Itself*. New York: Viking/Penguin.

48 **when attention is brought to movement, the brain creates new connections and possibilities at an incredibly rapid rate:** My teacher and colleague, Moshe Feldenkrais, used movement to increase awareness, which in turn helped to upgrade people's functioning, often in breakthrough ways; he had his students pay close attention while moving as a way to enhance functioning. However, he did not formulate *Movement with Attention* as an Essential per se, that is, distinct from awareness.

48 **What it does do is reinforce or "groove in" the existing patterns more deeply:** The more often one nerve cell excites another the more likely they are to fire together in the future, or "Cells that fire together wire together." Hebb DO. *The Organization*

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48 **a young child's brain forms 1.8 million new connections per second:** A conservative estimate of the total number of synapses in the adult brain is 100,000,000,000,000, or 100 trillion. The formation of synapses begins in the cerebral cortex—for example, during the 7th week of gestation and continues well into childhood. It is estimated that at its peak each neuron forms an average of 15,000 connections. See Gopnik A., Meltzoff AN, Kuhl PK. 1999. *The Scientist in the Crib: Minds, Brains and How Children Learn*. New York: William Morrow. Eliot L. 1999. *What's Going on in There? How the Brain and Mind Develop in the First Five Years of Life*. New York: Bantam. Ratey JJ. 2000. *A User's Guide to the Brain*. New York: Pantheon. 2000.

48 **a two-month-old infant lies in his crib watching in endless fascination as his own hand moves in space:** See Gerber M, ed. 1979. *The RIE Manual for Parents and Professionals*. Los Angeles: Resources for Infant Educarers. See also Rochat P. 2003. Five levels of self-awareness as they unfold early in life. *Consciousness and Cognition* 12: 717–31.

49 **the little boy has to pay attention to his movements:** When goals are blocked, the emotion they raise and the attention they demand provide a rich set of conditions for learning to occur. Lewis MD, Todd RM. 2005. Getting emotional—A neural perspective on emotion, intention and consciousness. *Journal of Consciousness Studies* 12(-8–10): 213–38.

52 **Think of Movement with Attention as bringing about a virtual explosion of activity in the brain:** Scans showed high levels of activity in the prefrontal cortex during new learning but not once the performance became routine. Jueptner M, Stephan K, Frith CD, et al. 1997. Anatomy of motor learning. I. Frontal Cortex and attention to Action. *Journal of Neurophysiology* 77(3): 1313–24. Johansen-Berg H, Matthews PM. 2002. Attention to movement modulates activity in sensori-motor areas, including primary motor cortex. *Experimental Brain Research* 142(1): 13–24.

53 **At such times, the quality of information that the brain generates is very high, creating order from disorder:** Creating order from disorder is a major focus of the science of chaos theory and complexity. Edelmann G.M, Tononi,G. 2000. *A Universe of Consciousness: How Matter Becomes Imagination*. New York: Basic Books.

53 **brain connections created through one activity can be applied in infinite and predictable and unpredictable ways in developing other skills:** As a child learns, different elements will come together to produce something entirely new and surprising. Levels of constructions of movements. Latash ML, Tuvey MT, eds. *On Dexterity and Its Development*. Translated by ML Latash. Mahwah, NJ: Lawrence Erlbaum. Bernstein NA. 1996b.On exercise and Motor Skill. In Latash ML, Tuvey MT, eds. *On Dexterity and Its Development*. Translated by ML Latash. Mahwah, NJ: Lawrence Erlbaum. See also Thelen E, Smith LB. 1996. *A Dynamic Systems Approach to the Development of Cognition and Action*. Cambridge, MA: MIT Press.

58 **"The practice of intentional, nonjudgmental awareness of moment to moment experience has been practiced since ancient times":** Siegel, D. The science of mindfulness. Available at http://mindful.org/the-science/medicine/the-science-of-mindfulness. Awareness as an action has been practiced and developed for centuries in the Buddhist tradition and is now the subject of intense scientific scrutiny. Barinaga M. 2003. Studying the well-trained mind: Buddhist monks and Western scientists are comparing notes on how the mind works and collaborating to test insights gleaned from meditation. *Science* 302(5642): 44–46. Lutz A, Greischar LL, Rawlings NB, Davidson R. 2004. Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences, USA* 16: 16369–73.

58 **"adults and adolescents with attentional problems achieved more executive function improvements (sustaining attention, diminishing distractibility) than are accomplished with medication for this condition."** Siegel DJ. The science of mindful awareness and the human capacity to cultivate mindsight and neural integration. Available at www.instituteofcoaching.org/images/ARticles/Mindful%20Awareness.pdf. Recent scientific findings demonstrate the benefits of practicing mindfulness in many areas of life. See Hanson R, Mendius R. 2009. *Buddha's Brain: The Practical Neuroscience of Happiness, Love & Wisdom*. Oakland, CA: New Harbinger. Siegel D. 2010. *Mindsight: The New Science of Personal Transformation*. New York: Bantam.

58 **In experiments with owl monkeys:** Recanzone, G.H, Merzenich MM, Jenkins WM, et al. 1992. Topographic reorganization of the hand representation in cortical area 3b of owl monkeys trained in a frequency discrimination task. *Journal of Neurophysiology* 67: 1031–56. Nudo RJ, Milliken G.W, Jenkins WM, Merzenich MM. 1996 Use-dependent alterations of movement representations in primary motor cortex of adult squirrel monkeys. *Journal of Neuroscience* 16: 785–807.

59 **"Experience coupled with attention leads to physical changes in the structure and functioning of the nervous system":** Merzenich MM, deCharms RC. 1996. Neural representations, experience and change." In Llinàs R, Churchland PS, eds. *The Mind-Brain Continuum*. Cambridge, MA: MIT Press.

61 **Scientific research demonstrates the importance of playfulness, joy and fun for successful growth and learning:** Play contributes to the growth and development of the brain. Byers JA, Walker C. 1995. Refining the motor training hypothesis for the evolution of play. *American Naturalist* 146(1): 25–40. Play actually shapes the brain. Gordon NS, Burke S, Akil H, Panksepp J. 2003. Socially-induced brain "fertilization": Play promotes brain derived neurotrophic factor in the amygdala and dorsolateral frontal cortex in juvenile rats. *Neuroscience Letters* 341: 17–20. See also Pellis SM, Pellis VC. 2010. *The Playful Brain: Venturing to the Limits of Neuroscience*. Oxford: Oneworld.

61 **These are also manifestations of attentioning that elevate the quality of the functioning of your child's brain:** The novelty that accompanies play sparks exploration and learning. Bunzeck N, Duzel E. 2006. Absolute coding of stimulus novelty

in the human substantia nigra/VTA. *Neuron* 51: 369–79. See also Anonymous. 2006. Pure novelty spurs the brain. *Medical News Today*, August.

61 **are always associated with an increased sense of well-being:** Free, imaginative play is crucial for normal social, emotional, and cognitive development and our well-being. When free play is lacking the results can be disastrous. Wenner M. 2009. The serious need for play. *Scientific American Mind*, February March: 22–29.

65 **Then if you have some inkling about what he's trying to communicate, ask him: "Are you asking about———?":** For thought-provoking research into how speech develops, see Bronson P, Merryman A. 2009. *Nurtureshock: New Thinking About Children*. New York: Twelve/Hachette Book Group.

65 **when touch is lacking, it can have serious consequences for the child's development:** Deprivation of normal social experience or maternal contact has damaging effects in a number of areas, the more deprivation the more disastrous. Harlow HF, Suomi SJ. 1971. Social recovery by isolation-reared monkeys. *Proceedings of the National Academy of Sciences, USA* 68(7): 1534–38.

5. Essential Two: Slow

74 ***Fast we can do only what we already know*:** See Libet B, Gleason CA, Wright EW, and Pearl DK. 1983. Time of conscious intention to act in relation to onset of cerebral activity (readiness potential): The unconscious intention of a freely voluntary act. *Brain* 106: 623–42.

74 **And it is important to hold off on fast until the brain has formed the necessary connections and patterns for performing that skill:** Then we can speed up successfully and even develop strong intuition in that area. Kahnman D. 2003. A perspective on judgement and choice: Mapping bounded rationality. *American Psychologist* 58: 697–720.

76 ***The feeling of what happens* is at the core of everything we do:** Emotions are critical in ensuring our survival and allowing us to think. Eakin E. 2003. I feel therefore I am. *New York Times*, April 19. Damasio AR. 1994. Descartes' Error: Emotion, Reason, and the Human Brain. New York: Grosset/Putnam.

76 **When we go fast, the brain has no option but to revert to already existing patterns:** Scientific research shows that we can either react automatically with a short reaction time of 0.25 second or less or act consciously with a delayed reaction time of 0.5 second or more. See Norretranders T. 1998. *The User Illusion: Cutting Consciousness Down to Size*. New York: Viking/Penguin. Norretranders's writings are based on an interview with Libet that took place on March 26–27, 1991, in San Francisco. See Libet B, Gleason CA, Wright EW, and Pearl DK. 1983. Time of conscious intention to act in relation to onset of cerebral activity (readiness potential): The unconscious intention of a freely voluntary act. *Brain* 106: 623–42.

77 **Slow is a great tool for getting there:** The learning of any skill involves putting together elements that have been formed by learning to do something else previously.

Going slowly allows the brain to figure out what in its existing repertoire may be useful, allowing the new skill to emerge. Bernstein NA. 1996. On exercise and motor skill, In Latash ML, Tuvey MT, eds. *On Dexterity and Its Development.* Translated by ML Latash. Mahwah, NJ: Lawrence Erlbaum. See also Thelen E, Smith LB. 1996. *A Dynamic Systems Approach to the Development of Cognition and Action*. Cambridge, MA: MIT Press.

79 **Current brain science confirms . . . the critical importance of Slow:** When developing his Fast ForWord program, Michael Merzenich saw the underlying problem of children with language and learning impairment as one of signal and noise—that is, the inability to filter out or generate meaningful information from background stimuli rather than a lack of stimulation per se. Merzenich MM, Tallal P, Miller SL, et al.1996. Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science* 271(5245): 81–84.

83 **Parents are told to place infants as young as two weeks old on their bellies—what is called "tummy time":** Despite the fact that many infants are distressed by it, the advice to put young infants on their belly while awake arose after the findings of the connection between children sleeping on their bellies and sudden infant death syndrome (SIDS). Anonymous. 1992. Positioning and SIDS AAP Task Force on Infant Positioning and SIDS. *Pediatrics* 89: 1120–26. Anonymous. 1996. Positioning and sudden infant death Ssndrome (SIDS): Update—Task Force on Infant Positioning and SIDS. *Pediatrics* 98:1216–18. Davis BE, Moon RY, Sachs HC, and Ottolini MC. 1998. Effects of sleep position on infant motor development. *Pediatrics* 102(5): 1135–40.

83 **"Man has absolutely the most protracted period of infancy, childhood and juvenility of all forms of life":** Nearly 30 percent of a human's life is devoted to growing. Quoted in Gould SJ. 2007. *Ever Since Darwin.* Rev. ed. New York: W. W. Norton. See also, Krogman WM. 1972. *Child Growth*. Ann Arbor. MI: University of Michigan Press.

83 **When we compare the speed at which humans reach developmental milestones with that of chimpanzees:** Sources consulted during the composition of this passage include the following: Chevalier-Skolnikoff S. 1983. Sensorimotor development in orangutans and other primates. *Journal of Human Evolution* 12: 545–61. Domingo Balcells C, Veà Baró JJ. 2009. Developmental stages in the howler monkey, subspecies *Alouatta palliata mexicana*: A new classification using age-sex categories. *Neotropical Primates* 16(1): 1–8. Gerber M, ed. 1979. *The RIE Manual for Parents and Professionals*. Los Angeles: Resources for Infant Educarers. Gesell A. 1940. *The First Five Years of Life: A Guide to the Study of the Pre-School Child.* New York: Harper & Brothers. Eisenberg A, Murkoff H, Hathaway S. 1989. *What to Expect the First Year.* New York: Workman. Reynolds V. 1967. *The Apes: The Gorilla, Chimpanzee, Orangutan and Gibbon: Their History and Their World*. London: Cassell. Schaller GB. 1963. *The Mountain Gorilla; Ecology and Behavior.* Chicago: University of Chicago Press. Schultz AH. 1969. *The Life of Primates.* New York: Universe Books. Van Lawick-Goodall J. 1971. *In the Shadow of Man*. Boston: Houghton Mifflin. Watts ES. 1985. Adolescent growth and development of monkeys, apes and humans. In

Watts ES, ed. *Nonhuman Primate Models for Human Growth and Development*. New York: Alan R. Liss.

86 **Stephen Jay Gould writes: "Human babies are born as embryos":** Gould SJ. 1977. *Ever Since Darwin*. New York: W. W. Norton.

87 **What does matter is the underlying process that leads the child to accomplish that milestone:** "Do not look for linear increases in a single . . . function but for progressive patterns of maturity. Nor should we look for static absolutes. Nothing *is*. Everything is *becoming*." Gesell A. 1940. *The First Five Years of Life: A Guide to the Study of the Pre-School Child*. New York: Harper & Brothers.

89 **Merzenich, using the principle of slowing the child and the process down, developed a software program called Fast ForWord;** Merzenich MM, Tallal P, Miller SL, et al. 1996. Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science* 271(5245): 81–84.

89 **children with autism were showing improvements in listening, attention, and focus; in handwriting; and in general mental processing, indicating that their brains improved as a whole:** One study showed that Fast ForWord quickly moved autistic children from severe language impairment to the normal range. Merzenich MM, Saunders G, Jenkins WM, et al. 1999. Pervasive developmental disorders: Listening training and language possibilities. In Broman SH, Fletcher JM, eds. *The Changing Nervous System: Neurobehavioral Consequences of Early Brain Disorders*. New York: Oxford University Press. Another pilot study of 100 autistic children showed that Fast ForWord had a significant impact on their autistic symptoms. Melzer M, Poglitsch G. November 1998. Functional changes reported after Fast ForWord training for 100 children with autistic spectrum disorders. Paper presentation to the American Speech Language and Hearing Association, San Francisco. See also Tallal P, Merzenich M, Miller S, Jenkins W. 1998. Language learning impairment: Integrating research and remediation. *Scandinavian Journal of Psychology* 39: 197–99. Rubenstein JL, Merzenich MM, et al. 2003. Model of autism: Increased ratio of excitation/inhibition in key neural systems. *Genes, Brain and Behavior* 2: 255–67.

6. Essential Three: Variation

95 **In the first three years of life, the brain grows fourfold, reaching 80 percent of its adult weight:** Gould SJ. 1977. *Ever Since Darwin*. New York: W. W. Norton..

96 **The brain itself creates variation all the time:** "Thus, and this is the most important note that we are going to make, the motor skill involved in even a very simple and monotonous movement cannot be a movement formula. . . . It is the ability to find a solution across a range of variations." Bernstein NA. 1996. On exercise and motor skill. In Latash ML, Tuvey MT, eds. *On Dexterity and Its Development.* Translated by M L Latash. Mahwah, NJ: Lawrence Erlbaum. Furthermore, no one learns a skill directly through practicing that skill: "A human starts learning a movement because he cannot do it. . . . The essence and objective of exercise is to improve the move-

ments, that is, to change them. Therefore, correct exercise is in fact a repetition without repetition." Ibid.

96 **If we eliminated all variation in our environment we would actually be unable to function:** Eliminating variation has such a powerful effect on us that paranoid psychosis has been reported in prisoners in solitary confinement, in communication-deprived refugees, and in the hard of hearing. Ziskind E. 1964. A second look at sensory deprivation. *Journal of Nervous and Mental Disease* 138:223–32. Recent research has shown that as little as 15 minutes of near complete deprivation of sight and sound leads to increases in several aspects of psychotic-like experience. Mason O, Brady F. 2009. The psychotomimetic effects of short-term sensory deprivation. *Journal of Nervous and Mental Disease* 197(10): 783–85.

97 **known as developmental dysplasia of the hip (DDH):** For more information about this condition and its surgical treatment, visit the Lucile Packard Children's Hospital at Stanford website, www.lpch.org.

99 **I was very aware of his phantom cast; for Michael, even though the cast was no longer there, it was real:** The phenomenon known as *phantom limb* is felt by amputees, who sense that missing arm or leg is still present and in many cases can even feel pain. It is relatively easy to generate such illusions in otherwise normal individuals, and experiments suggest that inanimate objects may be assimilated into a person's own body image. Ramachandran VS, Hirstein W. 1998. The perception of phantom limbs. *Brain* 121: 1603–30.

101 **In 1990 a group of brain scientists set up a very interesting research project with four separate groups of adult rats:** Black JE, Isaacs KR, Anderson BJ, et al. 1990. Learning causes synaptogenesis, whereas motor activity causes angiogenesis, in cerebellar cortex of adult rats. *Proceedings of the National Academy of Sciences, USA* 87: 5568–72.

103 **Researcher Melissa A. Schilling and colleagues state:** Schilling, MA, Vidal P, Ployhart RE, Marangoni A. 2003. Learning by doing something else: Variation, relatedness, and the learning curve. *Management Science* 49(1): 39–56.

7. Essential Four: Subtlety

114 **what Ernst Heinrich Weber, a psychophysiologist, discovered more than a century ago:** The Weber-Fechner law emphasizes that the greater the intensity of the background sensory stimulus, the harder it is to perceive a change. See Uppsala University. 2004. The Weber Fechner law. Available at www.neuro.uu.se/fysiologi/gu/nbb/lectures/WebFech.html. Guyton AC. 1981. *Textbook of Medical Physiology*. Philadelphia: Saunders.

123 **"Thinking is the same fundamental process in the brain as organizing movement."** Merzenich M. April 2009. Lecture on brain plasticity to students in the Anat Baniel Method Professional Training Program. Anat Baniel Method Center, San Rafael, CA.

127 **Researchers have found that babies' ability to recognize differences followed the same Weber-Fechner law:** Infants as young as six month olds perceive differences in number in accordance with the Weber-Fechner law. Lipton JS, Spelke ES. 2003. Origins of number sense: Large-number discrimination in human infants. *Psychological Science* 14(5): 396–401. Subsequent research suggests that all information that can be conceptualized in ordinal (more vs. less) terms may share representational mechanisms in the brain, including number, space, and time; among other possible candidate dimensions are speed, loudness, luminance, and even less obvious sources of magnitude information, such as emotional expression. Lourenco SF, Longo MR. 2010. General magnitude representation in human infants. *Psychological Science* 21(6): 873–81.

8. Essential Five: Enthusiasm

133 **Think of enthusiasm as a skill:** Enthusiasm amplifies our experience, and amplification is a characteristic of many biological systems. Guyton AC. 1981. *Textbook of Medical Physiology.* Philadelphia: Saunders. Murphy BK, Miller KD. 2009. Balanced amplification: A new mechanism of selective amplification of neural activity patterns. *Neuron* 61: 635–48. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25: 252–77.

134 **In 1996 Giacomo Rizzolatti, a neuroscientist at the University of Parma, discovered the activity of mirror neurons in the brain:** As early as the 1980s Rizzolatti and his colleagues identified a type of brain cell that fires when observing the actions of another. Rizzolatti G, Fadiga L, Gallese V, Fogassi, L. 1996. Premotor cortex and the recognition of motor actions. *Cognitive Brain Research* 3: 131–41. Recent research suggests the mirror neuron system to be key in the learning of language, empathy, and emotions. Craighero L, Metta G., Sandini G., Fadiga L. 2007. The mirror-neurons system: Data and models. *Progress in Brain Research* 164(3): 39–59. However, the exact level of involvement and indeed the involvement of other as yet unknown mechanisms are still matters for debate. Debes R. 2009. Which empathy? Limitations in the mirrored "understanding" of emotion. *Synthese* 175(2): 219–39. Oberman LM, Ramachandran VS. 2007. The simulating social mind: The role of the mirror neuron system and simulation in the social and communicative deficits of autism spectrum disorders. *Psychology Bulletin* 133: 310–27. Singer T, Seymour B, O'Doherty J, et al. 2004. Empathy for pain involves the affective but not the sensory components of pain. *Science* 303(5661): 1157–62. Singer T. 2006. The neuronal basis and ontogeny of empathy and mind reading. *Neuroscience and Biobehavioral Reviews* 30(6): 855–63. Niedenthal P. 2007. Embodying emotion. *Science* 316(5827): 1002–05. Gallagher H, Frith C. 2003. Functional imaging of "theory of mind." *Trends in Cognitive Sciences* 7: 77–83. See Hanson R, Mendius R. 2009. *Buddha's Brain: The Practical Neuroscience of Happiness, Love & Wisdom*. Oakland, CA: New Harbinger.

134 **"The human brain has multiple mirror neuron systems":** Blakeslee S. Cells that read minds. 2006. *New York Times*, January 10.

139 **His experience itself is the reinforcement:** The spontaneous excitement of doing something new essentially gets his brain to select the relevant connections that are being formed. LeDoux J. 2002. *Synaptic Self: How Our Brains Become Who We Are*. New York: Viking/Penguin. The emotional arousal facilitates learning by increasing neural excitation and consolidating synaptic change. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25: 252–77.

141 **I have also observed that when pressure was placed on a child to repeat his performance of a newly acquired skill, this new skill often seems to disappear:** See Siegel D. 2003. *Parenting from the Inside Out*. New York: Tarcher/Penguin.

143 **Others' emotions as well as our own can affect us, even when we are not consciously aware of it:** The way people behave around us has a direct influence on us without requiring our full attention or requiring that the visual stimulus be consciously seen. Sinke CBA, Kret ME, de Gelder B. 2011. Body language: Embodied perception of emotion. In Berglund B, Rossi GB, Townsend JT, Pendrill LR, eds.. *Measurements with Persons: Theory, Methods and Implementation Areas*. Abingdon, Oxfordshire, UK: Psychology Press/Taylor & Francis. Kret ME, Sinke CBA, de Gelder B. 2011. Emotion perception and health. In Nyklicek I, Vingerhoets A, Zeelenberg M, eds. *Emotion Regulation and Well-Being*. New York: Springer.

143 **And these emotions can initiate synaptic changes, activating new neural connections:** Current research and theory point ever more clearly to the link between our emotions and our brain's ability and tendency to learn. Ikemoto S, Panksepp J. 1999. The role of nucleus accumbens dopamine in motivated behavior: A unifying interpretation with special reference to reward-seeking. *Brain Research Reviews* 31(1): 6–41.

143 **it is easy for him to acquire feelings of learned helplessness:** See Seligman M. 2006. *Learned Optimism: How to Change Your Mind and Your Life*. New York: Free Press.

143 **A fearful face is fast-tracked to the amygdala:** Yang E, Zald DH, Blake R. 2007. Fearful expressions gain preferential access to awareness during continuous flash suppression. *Emotion* 7(4): 882–86.

143 **Studies have shown that even when researchers made fearful faces that were invisible to conscious awareness:** Jiang Y, He S. 2006, Cortical responses to invisible faces: Dissociating subsystems for facial-information processing. *Current Biology* 16: 2023–29.

143 **places the child's brain in a "motive state," coordinating information processing in the brain:** LeDoux J. 2002. *Synaptic Self: How Our Brains Become Who We Are*. New York: Viking/Penguin.

144 **These emotions are generally manifest as stress:** Too much cortisol can damage receptors in the hypothalamus, amygdala, and prefrontal cortex, affecting mood and memory and leading to hyperreactivity to stress. Fogel A. 2009. *The Psychophysiology of Self-Awareness: Rediscovering the Lost Art of Body Sense*. New York: W. W. Norton. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25: 252–77.

147 **Focusing on these feelings increases the release of dopamine:** Dopamine and oxytocin (the bonding hormone) mediate strong pleasant, rewarding situations like falling in love and cause the human brain to expand its neural model of the self. Nicolelis M. 2011. *Beyond Boundaries: The New Neuroscience of Connecting Brains with Machines—And How It Will Change Our Lives*. New York: Times Books. Young L. 2009. Being human; Love; Neuroscience reveals all. *Nature* 457(7226): 148. Young L, Zuoxin W. 2004. The neurobiology of pair bonding. *Nature Neuroscience* 7(10): 1048–54.

149 **recalling, strengthening, and accessing feelings in this way . . . has been shown to lead to measurable changes in neural structures in our brains:** The longer something is held in awareness and the more emotionally stimulating it is, the more neurons that fire and thus wire together, and the stronger the trace in the memory. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25(3–4): 252–77. Hanson R, Mendius R. 2009. *Buddha's Brain: The Practical Neuroscience of Happiness, Love & Wisdom*. Oakland, CA: New Harbinger.

151 **"Moment by moment we choose and sculpt how our ever changing minds will work":** Merzenich MM, deCharms RC. 1996. Neural representations, experience and change. In Llinàs R, Churchland PS, eds. *The Mind-Brain Continuum*. Cambridge, MA: MIT Press.

9. Essential Six: Flexible Goals

154 **Baboons in the Kalahari Desert have excellent caches of water:** This story is presented in the 1975 documentary film *Animals Are Beautiful People*, written, produced, and directed by J. Uys.

161 **ways for her brain to differentiate and produce small changes at the edges of what she was already able to do:** Thanks to science and technology, we can now see and hear this process of a young child learning speech in action. Deb Roy: The birth of a word [TED]. Available at www.youtube.com/watch?v=VwgkT34g61w.

163 **Play It as It Lays:** Didion J. 1970. *Play It as It Lays*. New York: Farrar Straus & Giroux.

164 **One example of imposing a rigid goal is the practice called tummy time:** It is true that babies who are subject to such efforts do tend to reach some of the earlier milestones a bit sooner. Dudek-Shriber L, Zelazny S. 2007. The effects of prone positioning on the quality and acquisition of developmental milestones in four-month-old infants. Research report. *Pediatric Physical Therapy* 19(1): 48–55.

164 **A number of followup studies:** Kuo YL, Liao HF, Chen PC, et al. 2008. The influence of wakeful prone positioning on motor development during the early life. *Journal of Developmental and Behavioral Pediatrics* 29(5): 367–76. See also Davis BE, Moon RY, Sachs HC, Ottolini MC. 1998. Effects of sleep position on infant motor development. *Pediatrics* 102(5): 1135–40.

165 **One of the studies of tummy time focused on infants with low birth weight:** Monterosso L, Kristjanson L, Cole J. 2002. Neuromotor development and the physiologic effects of positioning in very low birth weight infants. *Journal of Obstetric Gynecologic and Neonatal Nursing* 31(2): 138–46.

165 **"parents and other persons engaged in childcare":** Strassburg HM, Bretthauer Y, Kustermann W. 2006. Continuous documentation of the development of infants by means of a questionnaire for the parents. *Early Child Development and Care* 176(5): 493–504. See also Pikler E. 1988. *Lasst mir Zeit: die sebstaendige Bewegungsentwicklung des Kindes bis zum freien Gehen* (Give me time: The independent movement development of a child up to free walking). Munich: Pflaum-Verlag. Pikler E. 1997. *Miteinander vertraut werden* (To gain trust with one another). Freiburg/Breisgau: Herder-Vertlag. Pikler E. 1999. *Friedliche Babys, zufriedene Muetter* (Peaceful babies, contented mothers). Freiburg/Breisgau: Herder-Vertlag.

166 **"Not only did the children learn to sit stand and walk by themselves":** Pikler E. 1968. Some contributions to the study of gross motor development of children. *Journal of Genetic Psychology* 113: 27–39.

166 **"We regard the secure and well balanced movements of the children reared in our institute as significant":** Pikler E. 1972. Data on gross motor development on the infant. *Early Child Development and Care* 1: 297–310.

166 **among the fourteen hundred children who were raised in her institute:** Pikler E 1968. Some contributions to the study of gross motor development of children. *Journal of Genetic Psychology* 113: 27–39. Strassburg HM, Bretthauer Y, Kustermann W. 2006. Continuous documentation of the development of infants by means of a questionnaire for the parents. *Early Child Development and Care* 176(5): 493–504.

10. Essential Seven: The Learning Switch

171 **It is an actual change in the way your brain is working:** "We all know that the brain can be in a learning mode or a non-learning mode; we just don't fully understand what that mechanism is." Mark Latash, personal communication, 2007. Latash is the author of *Neurophysiological Basis of Human Movement* (Champaign, IL: Human Kinetics, 1998) and distinguished professor of kinesiology at the Pennsylvania State University.

172 **Using an electroencephalogram to measure brain waves:** Certain patterns characteristic of childhood become less common in adulthood but are seen in dreaming, in creative states, and during meditation. Oken B, Salinsky M. 1992. Alertness and attention: Basic science and electrophysiologic correlates. *Journal of Clinical Neurophysiology* 9(4): 480–94.

172 **When it is turned on, the brain is receptive:** Anticipation can affect perception. By directing our attention we can alter what we perceive of our environment. Kanwisher N, Downing P. 1998. Separating the wheat from the chaff. *Science* 282(5386): 57–58.

176 **in areas that are not directly or obviously connected to the known problems:** The Fast ForWord program designed to help with language learning has been shown to provide general improvements in mental processing. Merzenich MM, Saunders G, Jenkins WM, et al. 1999. Pervasive developmental disorders: Listening training and language possibilities. In Broman SH, Fletcher JM, eds. *The Changing Nervous System: Neurobehavioral Consequences of Early Brain Disorders.* New York: Oxford University Press. Fast ForWord has also had a significant impact on autistic symptoms. Melzer M, Poglitsch G. November 1998. Functional changes reported after Fast ForWord training for 100 children with autistic spectrum disorders. Paper presented to the American Speech Language and Hearing Association, San Francisco. See Doidge N. 2007. *The Brain That Changes Itself.* New York: Viking/Penguin.

179 **While the term *Learning Switch* does not describe a mechanical device in the brain:** When arousal is sufficient, the brain is responsive to stimuli and learning can take place. LeDoux J. 2002. *Synaptic Self: How Our Brains Become Who We Are.* New York: Viking/Penguin. Emotional arousal facilitates learning by increasing neural excitation and consolidating synaptic change. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25: 252–77. Forebrain arousal and motivational controls have been shown to modulate reorganization of the auditory cortex in response to new learning experiences. Kilgard MP, Merzenich MM. 1998. Cortical map reorganization enabled by nucleus basalis activity. *Science* n.s. 279(5357): 1714–18; Research findings suggest that events that are not emotionally significant may not maintain arousal or attention long enough for learning to take place. Lewis MD. 2005. Bridging emotion theory and neurobiology through dynamic systems modeling. *Behavioral and Brain Sciences* 28: 169–245.

179 **there are chemicals in the brain, called neuromodulators:** Neuromodulators are neurotransmitters and neuropeptides manufactured in the brainstem and hypothalamus that are released in large volumes, at many synapses simultaneously, far from their sites of origin. Izquierdo I. 1997. The biochemistry of memory formation and its regulation by hormones and neuromodulators. *Psychobiology* 25: 1–9. The effects of neuromodulators are global rather than local, providing a key mechanism by which motivational concerns influence cognitive and perceptual processes and hence learning. Lewis MD. 2005. Bridging emotion theory and neurobiology through dynamic systems modeling. *Behavioral and Brain Sciences* 28: 169–245.

180 **Emotions, most brain researchers agree, also guide our attention, which is necessary for any new learning to occur:** Cognition in general and attention in particular are assumed to be guided by emotional relevance. Isen AM. 1984. Toward understanding the role of affect in cognition. In Wyer, RS, Srull TK, eds. *Handbook of Social Cognition*. Hillsdale, NJ: Erlbaum. Dodge KA. 1991. Emotion and social information processing. In Garber J, Dodge KA, eds. *The Development of Emotion Regulation and Dysregulation*. Cambridge, UK: Cambridge University Press. Renninger KA, Hidi S, Krapp A. 1992. *The Role of Interest in Learning and Development*. Hillsdale, NJ: Erlbaum. See Lewis MD, Todd RM. 2005. Getting emotional—A neu-

ral perspective on emotion, intention and consciousness. *Journal of Consciousness Studies* 12(8–10): 213–38.

180 **"The ability to respond to threat and to seek safety is the most important job of our nervous system":** Fogel A. 2009. *The Psychophysiology of Self-Awareness: Rediscovering the Lost Art of Body Sense*. New York: W. W. Norton.

180 A **prolonged stress response to threat (perceived or real) is particularly damaging:** The stress response to threat is mediated by cortisol, which can damage receptors in the brain and affect mood, memory, and hyperreactivity to stress. Fogel A. 2009. *The Psychophysiology of Self-Awareness: Rediscovering the Lost Art of Body Sense*. New York: W. W. Norton. Lewis MD. 2005. Self-organizing individual differences in brain development. *Developmental Review* 25: 252–77.

180 **Safety, connection with the parent, playfulness, joy, comfort, acceptance, and love:** Isen AM. 1990. The influence of positive and negative affect on cognitive organization: Some implications for development. In Stein N, Leventhal B, Trabasso T, eds. *Psychological and Biological Processes in the Development of Emotion*. Hillsdale, NJ: Erlbaum. Conversely, anxiety narrows attention to specific themes or perceptions. Mathews A. 1990. Why worry? The cognitive function of anxiety. *Behavior Research and Therapy* 28: 455–68.

183 **Researchers have discovered that the ideal span of time for learning is no more than twenty minutes:** The study assessed student's recall of chemistry information following a lecture. Ralph A. May 22–25, 1985. Information impact and factors affecting recall. Paper presented at the Seventh Annual National Conference on Teaching Excellence and Conference of Administrators, Austin, TX.

11. Essential Eight: Imagination and Dreams

190 **Research shows that adults who practiced playing the piano in their imagination:** "mental practice alone led to the same plastic changes in the motor system as those occurring with the acquisition of the skill by repeated physical practice. . . . Mental practice alone seems to be sufficient to promote the modulation of neural circuits involved in the early stages of motor skill learning." Pascual-Leone A, Nguyet D, Cohen LG, et al. 1995. Modulation of muscle responses evoked by transcranial magnetic stimulation during the acquisition of new fine motor skills. *Journal of Neurophysiology* 74: 1037–45. See also Pascual-Leone A, Amedi A, Fregni, F, Merabet LB. 2005. The plastic human brain cortex. *Annual Review of Neuroscience* 28: 377–401.

191 **George Land tested 1,500 children between the ages of three and five:** Land conducted the study beginning in the late 1960s. It employed repeated administrations of eight tests that had been used by NASA to measure the potential for creative work by its engineers and scientists. Land G, Jarman, B. 1998. *Breakpoint and Beyond: Mastering the Future Today*. Scottsdale, AZ: Leadership 2000.

193 **all physical activity is organized in the brain by images of the person moving through space:** Alain Berthoz discusses how the development of perception critically depends on movement and the information that movement provides. Decety J, Jeannerod M, Prablanc C. 1989. The timing of mentally represented actions. *Behavioral Brain Research* 34: 35–42. Berthoz A. t2000. *The Brain's Sense of Movement.* Translated by G Weiss. Cambridge, MA: Harvard University Press.

194 **That three-dimensional movie . . . contains information from all of our senses:** A stable internal model of the self is constructed from fragments of information resulting from multiple sensory systems—vision, proprioception, hearing, etc. Ramachandran VS, Hirstein W. 1998. The perception of phantom limbs. *Brain* 121: 1603–30. Dawkins, R. 1996. *Climbing Mount Improbable.* New York: W. W. Norton.

194 **A child who was raised with wolves:** In May 1972, a boy aged about four was discovered in the forest of Musafirkhana, about twenty miles from Sultanpur, India. The boy was playing with wolf cubs. Wallechinsky D, Wallace A, Basen I, Farrow J, eds. 2004. *The Book of Lists: The Original Compendium of Curious Information*. Toronto: Knopf Canada.

195 **Research shows just the opposite is the case:** Researchers observed activity within the brains of people engaged in tasks that required high levels of mental concentration, then compared those results to brain activity when the people were daydreaming. Mason MF, Norton MI, Van Horn JD, et al. 2007. Wandering minds: The default network and stimulus-independent thought. *Science* 315(5810): 393–95. Jones H. 2007. Daydreaming improves thinking. *Cosmos Online*, January 19.

196 **Steven Jay Lynn and Judith Rhue, both psychologists, studied six thousand men and women:** Lynn SJ, Rhue JW. 1988.Fantasy proneness. Hypnosis, developmental antecedents, and psychopathology. *American Psychologist* 43(1): 35–44.

196 **But it's not only in mental or cognitive functions that Imagination and Dreams make a Difference:** Crum AJ, Langer EJ. 2007. Mind-set matters: Exercise and the placebo effect. *Psychological Science* 18(2): 165–71.

197 **Children begin participating in pretend play, or make believe by their second year of life:** Pretend play is typical between fifteen months and six years of age. Piaget J. 1951. *Play, Dreams and Imitation in Childhood.* London: Heinemann. Smith PK. 2005. Social and pretend play in children. In Pellegrini A, Smith PK, eds. 2005. *The Nature of Play: Great Apes and Humans.* New York: Guildford Press.

12. Essential Nine: Awareness

209 **Philosophers have also referred to this capacity as "meta- consciousness" or "meta-awareness":** Meta-awareness is a concept that points to the possibility of taking awareness itself as an object of attention. Schooler JW. 2001. Discovering memories in the light of meta-awareness. *Journal of Aggression, Maltreatment and Trauma* 4: 105–36. Studies in mind wandering show that it is not the mind wandering per se that interferes with the ability to process knowledge and information and learning but

the lack of awareness of the mind wandering. Winkielman P, Schooler JW. 2011. Splitting consciousness: Unconscious, conscious, and metaconscious processes in social cognition. *European Review of Social Psychology* 22(1): 1–35.

210 **researchers are finding out that infants as young as seven months old demonstrate at least some capabilities of awaring:** Kovács ÁM, Téglás E, Endress AD. 2010. The social sense: Susceptibly to others' beliefs in human infants and adults. *Science* 330(6012): 1830–34. Bryner J. 2010. 7-month-old babies show awareness of others' viewpoints. Available at www.livescience.com/10924-7-month-babies-show-awareness-viewpoints.html.

210 **Scientists at MIT have shown that twelve-month-old babies can use knowledge to form surprisingly sophisticated expectations of how novel situations will unfold:** If no relevant past experience is available results suggest that infants reason by mentally simulating possible scenarios and figuring out which outcome is most likely, based on a few physical principles. Téglás E, Vul E, Girotto V, et al. 2011. Pure reasoning in 12-month-old infants as probabilistic inference. *Science* 332(6033): 1054–59.

13. Beyond Limitations

220 **"Parents and teachers should look at the child, not the child's label":** Grandin T. 2011. *The Way I See It*. Arlington, TX: Future Horizons.