ARTICLES

KILLING THEM SOFTLY: NEUROSCIENCE REVEALS HOW BRAIN CELLS DIE FROM LAW SCHOOL STRESS AND HOW NEURAL SELF-HACKING CAN OPTIMIZE COGNITIVE PERFORMANCE

*Debra S. Austin, J.D., Ph.D.**

ABSTRACT

Law is a cognitive profession, and the legendary stressors in legal education and the practice of law can take a tremendous toll on cognitive capacity. Lawyers suffer from depression at triple the rate of non-lawyers. This Article provides a groundbreaking synthesis on the neuroscience of achieving optimal cognitive fitness for all law students, law professors, and lawyers.

A number of innovative companies have instituted programs designed to enhance the bottom line. Research shows that perks such as onsite gyms, stress management classes, and mindfulness training produce vibrant workplaces and thriving employees. Forward-looking law schools have created wellness programs designed to relieve law student stress and improve well-being.

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* J.D., Ph.D., Lawyering Process Professor, University of Denver Sturm College of Law. Many thanks to LWI-ALWD-LexisNexis for funding this research with a 2012 Legal Writing Scholarship Grant. Thank you for inviting me to speak on this topic: Chief Justice Lawton Nuss of the Kansas Supreme Court; the Legal Writing Institute; the Implications of Tiger Parenting on Legal Education Conference; the Rocky Mountain Legal Writing Conference; the Central States Legal Writing Conference; the Psychology and Lawyering Conference; Kansas Judicial Conference; and The Association of Reporters of Judicial Decisions. Thank you for your scholarship mentoring: Dr. Tom Russell; Professors Robin Wellford Slocum, Kathryn Stanchi, Nantiya Ruan, Corie Rosen Felder, Jan Jacobowitz, KK DuVivier, and Deborah Borman; and the Rocky Mountain Legal Writing Scholarship Group. Thank you for reading drafts: Gary Alexander and Dale Pugh, and for your cheerful and unflinching support: Research Assistants Kelsey Feldkamp and Keri Friedman.

This Article explains the neurobiological reasons these programs enhance employee performance and improve student achievement.

Law school admissions are down, students are questioning the value of legal education, and the Carnegie Report is pressuring law schools to make legal education more practical. Learning about the neuroscience of cognitive wellness is critical to protecting brain function and enhancing cognitive performance. Legal educators have the power to bring this information to the attention of their law students and to create a neuroscience-powered achievement culture in law schools. Law students should not wait for institutional change to alleviate the impact a stressful law school learning environment has on their learning. Their professional identity, along with their capacity to build practice skills and a legal knowledge base, are at risk. Law students, law faculty, and lawyers should be educated and proactive about mitigating stress-related damage to the hippocampus, improving memory formation with adequate sleep, and enhancing cognitive function with exercise and contemplative practices.

Neural self-hacking is likely to be the newest fitness movement. Law schools and law firms that want to support robust cognitive performance for their constituents will follow the lead of companies like Google and create achievement cultures designed to optimize cognitive wellness and limit sources of stress. In doing so, they will curate desirable learning and working environments by enhancing the formation of more complete and competent lawyers. With fresh insights into the complex world of brain function, this Article explains brain structure; describes the parts of the brain used in cognition; and details how stress damages and kills brain cells. Neuroscience-based recommendations uncover the power of self-directed neuroplasticity in every law student, law professor, and lawyer to optimize cognition.

I. INTRODUCTION

"If we treat people as they are, we make them worse.
If we treat people as they ought to be,
we help them become what they are capable of becoming."[1]
J. W. Goethe

Neuroscience shows that the aggregate educative effects of training to become a lawyer under chronically stressful conditions may undermine the efforts of legal educators by weakening the learning capacities of law students. Stress in legal education may

1. DANIEL THEYAGU, GRAVITATING TOWARD SUCCESS 37 (2012) (quoting J. W. Goethe); *Inspirational Quotes: Johann Wolfgang von Goethe*, ENTHEOS, http://www.entheos.com/quotes/by_teacher/johann+wolfgang+von+goethe (last visited Jan. 29, 2014) ("I have come to the frightening conclusion that I am the decisive element. It is my personal approach that creates the climate. It is my daily mood that makes the weather. I possess tremendous power to make life miserable or joyous. I can be a tool of torture or an instrument of inspiration, I can humiliate or humor, hurt or heal. In all situations, it is my response that decides whether a crisis is escalated or de-escalated, and a person is humanized or dehumanized. If we treat people as they are, we make them worse. If we treat people as they ought to be, we help them become what they are capable of becoming.").

also set the stage for abnormally high rates of anxiety and depression among lawyers.

The stresses of attending law school are legendary. After peppering seventy-five first year law students with questions about their experiences in their 1L year at the University of Memphis law school, Andrew J. McClurg asked students about their dominant feeling at the end of the year.[2] The answers were disproportionately focused on anxiety and stress.[3] Students reported grave concerns over upcoming finals, grades, and failing law school.[4] They described suffering from "sheer, unrelenting exhaustion" and a "level of mental exhaustion I did not know existed."[5] One student admitted to not sleeping in bed more than three nights since beginning law school due to consistently dropping off to sleep either at the computer or in the living room while studying.[6]

Douglas Litowitz argues that "most lawyers hate[d] law school," describing it as a "hazing ritual" that yields law graduates with more mental problems than they had when they started school.[7] He complains that law school is not a transformative educational experience, but one that traumatizes and breaks people: "When I say that law school *breaks* people I mean that almost nobody comes out of law school feeling better about themselves, although many come out much worse—caustic, paranoid, and overly competitive."[8] Some lawyers feel law school boosted their confidence and self-esteem.[9] They also enjoyed developing a network of friends and peers.[10] However, many also "cite competition, grades, and workload as major stressors."[11]

Law schools often define student success in terms of grades,

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2. ANDREW J. MCCLURG, 1L OF A RIDE: A WELL-TRAVELED PROFESSOR'S ROADMAP TO SUCCESS IN THE FIRST YEAR OF LAW SCHOOL 368-89 (2009).

3. *Id.* at 385.

4. *Id.*

5. *Id.* at 386.

6. *Id.*

7. DOUGLAS LITOWITZ, THE DESTRUCTION OF YOUNG LAWYERS: BEYOND ONE L 10, 19 (2006).

8. *Id.* at 30.

9. REBECCA NERISON, LAWYERS, ANGER, AND ANXIETY: DEALING WITH THE STRESSES OF THE LEGAL PROFESSION 68 (2010).

10. *Id.*

11. *Id.*

class standing, and journal participation.[12] Students are introduced to "these prizes" as early as the first day of orientation, and they feel significant pressure to perform.[13] They respond by trying to "obtain high grades as a form of credentialing," marginalizing the development of domain knowledge and skill mastery in the process.[14]

The Carnegie Report (Carnegie) parses legal education into three apprenticeships: the intellectual apprenticeship, where students build a knowledge base; the practice apprenticeship, where students develop practical legal skills; and the professional identity apprenticeship, where students learn the attitudes and values of the legal profession.[15] Carnegie argues that deeply rooted aspects of the hidden legal curriculum may cripple legal education.[16] The context in which law students are trained encourages a "single-minded focus on competitive achievement."[17] A student's professional identity is shaped by the socialization process of legal education.[18] Carnegie states:

> In their passage through law school, students apprentice to a variety of teachers, but they also apprentice to the aggregate educative effects of attending a particular professional school and program. That is, they are formed, in part, by the formal curriculum but also by the informal or 'hidden' curriculum of unexamined practices and interaction among faculty and students and of student life itself.[19]

Major obstacles to legal education reform enumerated in Carnegie are also significant sources of chronic stress for law students:

- the competitive classroom climate,
- the competitive atmosphere of most law schools, and

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12. NANCY LEVIT & DOUGLAS O. LINDER, THE HAPPY LAWYER: MAKING A GOOD LIFE IN THE LAW 125 (2010).

13. LEVIT & LINDER, *supra* note 12.

14. *Id.*

15. WILLIAM M. SULLIVAN ET AL., EDUCATING LAWYERS: PREPARATION FOR THE PROFESSION OF LAW 28 (2007) (providing the most recent critique of legal education suggesting reforms based on a three apprenticeship model).

16. *Id.* at 31-32.

17. *Id.* at 31.

18. *Id.*

19. *Id.* at 29.

- the grade curve.[20]

The term "hidden curriculum" was coined in 1968 by Philip W. Jackson, Education Professor at the University of Chicago.[21] The *Online Dictionary of the Social Sciences* defines hidden curriculum as "[t]he norms, values, and social expectations indirectly conveyed to students."[22] Elliot Eisner, Professor Emeritus of Education and Art of Stanford University, wrote extensively about the explicit official curriculum and the implicit or hidden curriculum.[23] He argued that schools teach much more than they intend to teach via the hidden curriculum.[24] The hidden curriculum is part of the culture of both classroom and school, and it socializes learners to the values of the education environment.[25]

In his book about how educational apprenticeships form professionals, David Willamson Shaffer proposes that a curriculum of professional education should be designed to transmit the skills, knowledge, identities, and values of the profession.[26] Learning how to think like a professional means "learning to value the things professionals think of as important, interesting, and meaningful,"[27] and seeing oneself as that kind of professional.[28] Knowledge, skills, and values transmitted in legal education shape the professional identity development of law students. Law students osmose the culture in legal education and transfer it to law practice.

The stresses facing law students and lawyers result in a significant decline in their well-being, including anxiety, panic

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20. SULLIVAN ET AL., *supra* note 15, at 31.

21. PHILIP W. JACKSON, LIFE IN CLASSROOMS 33-34 (1968) ("[T]he crowds, the praise, and the power that combine to give a distinctive flavor to classroom life collectively form a hidden curriculum which each student (and teacher) must master if he is to make his way satisfactorily through the school.").

22. Robert Drislane & Gary Parkinson, *Alphabetical List of Terms: H*, ONLINE DICTIONARY OF THE SOC. SCIS., http://bitbucket.icaap.org/dict.pl?alpha=H (last visited Jan. 29, 2014).

23. ELLIOT W. EISNER, THE EDUCATIONAL IMAGINATION: ON THE DESIGN AND EVALUATION OF SCHOOL PROGRAMS 87-97 (3d ed. 1994).

24. *Id.* at 87.

25. *See id.* at 88.

26. DAVID WILLIAMSON SHAFFER, HOW COMPUTER GAMES HELP CHILDREN LEARN 12 (2006).

27. *Id.* at 105.

28. *Id.* at 135.

attacks, depression, substance abuse, and suicide.[29] Neuroscience now shows that this level of stress also diminishes cognitive capacity.[30] The intricate workings of the brain, the ways in which memories become part of a lawyer's body of knowledge, and the impact of emotion on this process indicate that stress can weaken or kill brain cells needed for cognition.[31]

Cognition, Latin for "the faculty of knowing," describes the process by which humans perceive stimuli, extract key information to hold in memory, and generate thoughts and actions to achieve goals.[32] The disciplines of neuroscience, psychology, and education study human cognition to improve the understanding of how the brain enables the mind.[33] The learning-focused intersection of these fields is known either as Educational Neuroscience[34] or Mind, Brain, and Education (MBE).[35] Scientists and educators collaborate in organizations such as Brain, Neurosciences and Education[36] and the

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29. *See* LEVIT & LINDER, *supra* note 12, at 6-8; LITOWITZ, *supra* note 7, at 16-26; MCCLURG, *supra* note 2, at 315-318; NERISON, *supra* note 9, at 15-39; Lawrence S. Krieger, *Institutional Denial About the Dark Side of Law School, and Fresh Empirical Guidance for Constructively Breaking the Silence*, 52 J. LEGAL EDUC. 112, 113-15 (2002); Corie Rosen, *The Method and the Message*, 12 NEV. L.J. 160, 161 (2011).

30. *See* SANDRA AAMODT & SAM WANG, WELCOME TO YOUR BRAIN 86 (2008); DANIEL G. AMEN, CHANGE YOUR BRAIN CHANGE YOUR BODY 248 (2010); RITA CARTER, MAPPING THE MIND 96 (rev. ed. 2010) [hereinafter CARTER, MAPPING THE MIND]; NORMAN DOIDGE, THE BRAIN THAT CHANGES ITSELF 240 (2007); JOHN MEDINA, BRAIN RULES: 12 PRINCIPLES FOR SURVIVING AND THRIVING AT WORK, HOME, AND SCHOOL 179 (2008); FUNDAMENTAL NEUROSCIENCE 804 (Larry R. Squire et al. eds., 4th ed. 2012).

31. *See* citations *supra* note 30.

32. DALE PURVES ET AL., PRINCIPLES OF COGNITIVE NEUROSCIENCE 2 (2d ed. 2013).

33. Daniel Ansari, Donna Coch & Bert De Smedt, *Connecting Education and Cognitive Neuroscience: Where will the Journey Take us?*, *in* EDUCATIONAL NEUROSCIENCE: INITIATIVES AND EMERGING ISSUES 36 (2011), *available at* http://zung.zetamu.net/Library/Education/Education_Neuroscience/Patten_EducationalNeuroscience_2011.pdf.

34. Stephen R. Campbell, *Educational Neuroscience: Motivations, methodology, and implications*, *in* EDUCATIONAL NEUROSCIENCE: INITIATIVES AND EMERGING ISSUES, *supra* note 33, at 8.

35. TRACEY TOKUHAMA-ESPINOSA, MIND, BRAIN, AND EDUCATION SCIENCE: A COMPREHENSIVE GUIDE TO THE NEW BRAIN-BASED TEACHING 14 (2010); SOUSA, ET AL., MIND, BRAIN, AND EDUCATION: NEUROSCIENCE IMPLICATIONS FOR THE CLASSROOM 9 (2010).

36. The American Education Research Association SIG was launched in 1988. *About the BNE-SIG*, BRAIN, NEUROSCIENCES, & EDUC., http://www.aera-brain-education.org/About.aspx (last visited on Jan. 29, 2014).

International Mind, Brain and Education Society (IMBES) to improve teaching and learning.[37] A number of innovative companies such as Google, Whole Foods Market, and Cisco Systems have created programs designed to enhance the bottom line.[38] Research shows that perks such as onsite gyms, work/life balance programs, stress management classes, mindfulness training, and nutrition coaching promote cognitive health and produce vibrant workplaces and thriving employees.[39] Neural self-hacking, a class taught at Google, teaches employees about the power of neuroplasticity.[40]

The brain has the power to change itself through the personal effort and choices of its owner.[41] Brain plasticity is competitive; we keep the skills we practice and we lose the ones we do not.[42] Legal educators engage in scholarship on lawyer and law student well-being and are active in the Balance in Legal Education section of The Association of American Law Schools.[43] The godfather of this movement is Lawrence S. Krieger of Florida State University College of Law.[44] Law schools have instituted programs to improve student wellness and teach stress management to law students.[45]

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37. Marc Schwartz & Jeanne Gerlach, *The Birth of a Field and the Rebirth of the Laboratory School*, *in* EDUCATIONAL NEUROSCIENCE: INITIATIVES AND EMERGING ISSUES, *supra* note 33, at 66. The IMBES was initiated in 2004 and its journal, Mind, Brain and Education, was started in 2007. Zachary Stein & Kurt W. Fischer, *Directions for Mind, Brain, and Education: Methods, Models, and Morality*, *in* EDUCATIONAL NEUROSCIENCE: INITIATIVES AND EMERGING ISSUES, *supra* note 33, at 55; *see* INTERNATIONAL MIND, BRAIN & EDUCATION SOCIETY (IMBES), http://www.imbes.org/ (last visited Jan. 29, 2014).

38. EDWARD M. HALLOWELL, SHINE: USING BRAIN SCIENCE TO GET THE BEST FROM YOUR PEOPLE 31 (2011); Noah Shachtman, *Enlightenment Engineer*, WIRED (June 18, 2013, 6:30 AM), http://www.wired.com/business/2013/06/meditation-mindfulness-silicon-valley/all/.

39. HALLOWELL, *supra* note 38, at 31; Shachtman, *supra* note 38.

40. Shachtman, *supra* note 38.

41. DOIDGE, *supra* note 30, at 47.

42. *Id.* at 59-60; HALLOWELL, *supra* note 38, at 28.

43. *See AALS Section on Balance in Legal Education*, FLA. ST. U., http://www.law.fsu.edu/academic_programs/humanizing_lawschool/ (last visited Jan. 29, 2014); *Section on Balance in Legal Education*, ASS'N AM. L. SCH., https://memberaccess.aals.org/eWeb/dynamicpage.aspx?webcode=ChpDetail&chp_cst_key=9fb324e8-e515-4fd3-b6db-a1723feeb799 (last visited Jan. 29, 2014).

44. Lawrence S. Krieger is Clinical Professor and Director of Clinical Externships at Florida State University College of Law. *Faculty*, FLA. ST. U., http://www.law.fsu.edu/faculty/lkrieger.html (last visited Jan. 29, 2014).

45. Susan Swaim Daicoff, *Expanding the Lawyer's Toolkit of Skills and Competencies: Synthesizing Leadership, Professionalism, Emotional Intelligence,*

Each law student, law professor, and lawyer has the power to alter brain processes to achieve states more conducive to learning.[46] Rule 1.1 of the American Bar Association Model Rules of Professional Conduct requires lawyers to be competent in completing their duties on behalf of their clients.[47] Law students, law professors, and lawyers can benefit from developing a neuroscience-based understanding of how to optimize their own cognition.[48] Developments in neuroscience identify areas of cognition in the brain and indicate recommendations that enhance cognitive effectiveness, performance, and productivity. Steps taken to increase cognitive fitness can strengthen lawyer creativity and well-being. In addition to bolstering cognitive competence, cognitive wellness initiatives may also provide a lawyer with a competitive advantage. Knowledge of these neuroscience findings will empower law students, law professors, and lawyers to enhance their cognitive wellness. Law faculty can implement neuropedagogy, teaching practices grounded in the latest MBE findings, by reflecting on stress in legal education and the impacts of the hidden curriculum.[49] Law schools and law firms, like many cutting-edge companies, can curate a culture of cognitive wellness.

This groundbreaking synthesis on the neuroscience of how to achieve optimal cognitive fitness is a must-read for all law students, law professors, and lawyers. Section II of this Article identifies the areas of the brain involved in cognition and explains the unique structure of neural communication networks. Section III discusses the neuroscience of memory formation and how learning occurs. Section IV describes the relationship between the brain and body during the stress response, examines the impact of negative emotions on learning, and details how brain research results from rodent studies are being confirmed in

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Conflict Resolution, and Comprehensive Law, 52 SANTA CLARA L. REV. 795, 813 (2012). *See generally* Gretchen Duhaime, *Practicing on Purpose: Promoting Personal Wellness and Professional Values in Legal Education*, 28 TOURO L. REV. 1207 (2012).

46. *See* Campbell, *supra* note 34, at 8.

47. MODEL RULES OF PROF'L CONDUCT R. 1.1 (2012), *available at* http://www.americanbar.org/groups/professional_responsibility/publications/model_rules_of_professional_conduct/rule_1_1_competence.html.

48. *See* MARGARET GLICK, THE INSTRUCTIONAL LEADER AND THE BRAIN: USING NEUROSCIENCE TO INFORM PRACTICE 13 (2011).

49. *See* Kathryn E. Patten, *The Somatic Appraisal Model of Affect: Paradigm for Educational Neuroscience and Neuropedagogy*, *in* EDUCATIONAL NEUROSCIENCE: INITIATIVES AND EMERGING ISSUES, *supra* note 33, at 86.

studies on live humans with brain-scanning technology. Section V presents a plan for neural self-hacking. It connects the neuroscience to recommendations to optimize law student and lawyer cognitive function and to create a culture of cognitive wellness in law schools and firms. Section V concludes with a challenge to individual law students and lawyers to embrace the promise of neuroplasticity and develop a plan for cognitive wellness. Section VI challenges legal educators to adopt the neuroscience-based innovations of achievement cultures that could transform the law school experience. Finally, the Appendix summarizes the neuroscience vocabulary used in this Article.

II. THE BRAIN

"What flows through your mind sculpts your brain."[50]
Rick Hanson

A. STRUCTURE OF THE BRAIN

A law student's brain weighs three pounds,[51] is the size of a coconut, is shaped like a walnut, and has the consistency of chilled butter,[52] Jell-O,[53] or for the vegetarians, tofu.[54] Despite assumptions to the contrary, a law professor's brain is the same size. The eight bones that make up the cranium protect the brain.[55] It requires about 25% of the calories consumed, 20% of the oxygen breathed, and 25% of the body's total blood flow.[56] The brain evolved from the top of the spine up into three general functional areas:[57] the primitive brain, the emotional brain,[58] and the thinking brain.[59]

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50. RICK HANSON, BUDDHA'S BRAIN: THE PRACTICAL NEUROSCIENCE OF HAPPINESS, LOVE, & WISDOM 6 (2009).

51. GERALD M. EDELMAN, WIDER THAN THE SKY: THE PHENOMENAL GIFT OF CONSCIOUSNESS 15 (2004).

52. CARTER, MAPPING THE MIND, *supra* note 30, at 14.

53. DAVID M. EAGLEMAN, INCOGNITO: THE SECRET LIVES OF THE BRAIN 2 (2011).

54. AMEN, *supra* note 30, at 18.

55. ERIC H. CHUDLER, THE LITTLE BOOK OF NEUROSCIENCE HAIKUS 113 (2013).

56. AMEN, *supra* note 30, at 17.

57. BARRY J. GIBB, THE ROUGH GUIDE TO THE BRAIN 6-8 (Duncan Clark & Ruth Tidball eds., 2007); DAVID PERLMUTTER & ALBERTO VILLOLDO, POWER UP YOUR BRAIN: THE NEUROSCIENCE OF ENLIGHTENMENT 16-21 (2011).

58. JUDITH HORSTMAN, THE SCIENTIFIC AMERICAN: DAY IN THE LIFE OF YOUR BRAIN 4-6 (2009) [hereinafter HORSTMAN, DAY IN THE LIFE].

59. JUDITH HORSTMAN, THE SCIENTIFIC AMERICAN: BRAVE NEW BRAIN 4 (2010) [hereinafter HORSTMAN, BRAVE NEW BRAIN].

The primitive brain sits on top of the spine and is also known as the brain stem, hindbrain,[60] or reptilian brain.[61] The primitive brain governs some of the body's basic motor functions,[62] such as breathing, digestion, heartbeat, sleeping,[63] and balance.[64] Major parts of this region include the brain stem, midbrain, and cerebellum.[65] If you are struggling for survival, you are using your primitive brain.[66]

The emotional brain lies deep within the skull, is situated around the primitive brain, and is also called the limbic system[67] or inner brain.[68] The emotional brain is the sentry between spinal cord and primitive brain below and the thinking brain above it.[69] The emotional brain manages circadian rhythm, hunger, sex hormones, addiction, and emotions.[70] Most of its parts "come in pairs, one in each hemisphere."[71] The major components of the limbic system are the amygdala, hippocampus, hypothalamus, thalamus, nucleus accumbens, and ventral tegmental, surrounded by the limbic lobe.[72] When law students experience an emotional response or create new memories, their emotional brains are engaged.[73]

The thinking brain is the wrinkly top layer known as the cerebral cortex.[74] The cortex is "wafer-thin" and approximately

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60. *Id.* at 3.

61. *See* PERLMUTTER & VILLOLDO, *supra* note 57, at 17, 27.

62. GIBB, *supra* note 57, at 37.

63. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 3.

64. GIBB, *supra* note 57, at 37 (stating that the cerebellum or "little brain" is located behind the brain stem and has the "primary functions of movement and balance").

65. *Id.* at 36-37.

66. PERLMUTTER & VILLOLDO, *supra* note 57, at 27.

67. CARTER, MAPPING THE MIND, *supra* note 30, at 15.

68. HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 4.

69. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 4.

70. GIBB, *supra* note 57, at 38; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 4; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 4.

71. HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 4.

72. RITA CARTER, THE HUMAN BRAIN BOOK: AN ILLUSTRATED GUIDE TO ITS STRUCTURE, FUNCTION, AND DISORDERS 64, 128 (Tony Phipps et al. eds., 2009) [hereinafter CARTER, THE HUMAN BRAIN]; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 4-5.

73. GIBB, *supra* note 57, at 39.

74. *Id.*; MICHAEL S. SWEENEY, BRAIN, THE COMPLETE MIND: HOW IT DEVELOPS, HOW IT WORKS, AND HOW TO KEEP IT SHARP 20 (Amy Briggs ed., 2009).

324 square inches,[75] about the size of a full-page newspaper[76] or baby blanket if flattened.[77] The thinking brain has two hemispheres linked together by a bundle of nerves, the corpus callosum, which allows information to pass between them.[78] The left hemisphere is analytical, logical, detail oriented, and associated with reasoning, language and speech functions, and convergent thinking.[79] The right hemisphere processes information "in a holistic way," is intuitive, imaginative, and associated with emotion, spatial cognition, and divergent thinking.[80] The thinking brain is also divided into four major lobes:

- the frontal lobe (reasoning, planning, language);
- the occipital lobe (vision);
- the temporal lobe (hearing and some aspect of memory); and
- the parietal lobe (movement, taste, temperature, touch).[81]

The outer layer of the thinking brain is gray matter, consisting of densely packed neurons responsible for information processing, and the inner layer is white matter, where information is transported between parts of the brain.[82] When law students use reasoning and logic to conduct "higher-order thinking," such as applying the law to a fact pattern, they are using their thinking brains.[83]

All parts of the primitive, emotional, and thinking brain are

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75. CHUDLER, *supra* note 55, at 25.

76. *Id.*

77. MEDINA, *supra* note 30, at 102.

78. GIBB, *supra* note 57, at 41; SWEENEY, *supra* note 74, at 20.

79. CARTER, MAPPING THE MIND, *supra* note 30, at 36; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 130; SWEENEY, *supra* note 74, at 20.

80. *See* citations *supra* note 79.

81. CARTER, THE HUMAN BRAIN, *supra* note 72, at 66; CARTER, MAPPING THE MIND, *supra* note 30, at 14; GIBB, *supra* note 57, at 40; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 6.

82. CARTER, MAPPING THE MIND, *supra* note 30, at 14-15; GIBB, *supra* note 57, at 40, 118-22.

83. *See* PERLMUTTER & VILLOLDO, *supra* note 57, at 19-20 (discussing the thinking brain, otherwise known as "the neocortex, which is . . . responsible for speech, writing, and higher-order thinking in humans" and where "reasoning, and logic take place").

made up of communication nerve cells called neurons and support cells called glial cells.[84] Chains of neurons send messages around the brain and between the brain and the body.[85] Glial cells insulate neurons and aid their information exchanges.[86] Approximately 90% of the cells in the brain are glial cells and 10% are neurons.[87]

Neurons, the communication cells that transport information around the law student brain, are shaped like trees with long trunks called axons, a cell body bulb at the top of the trunk, and branches called dendrites.[88] The cell body stores genetic material and makes proteins.[89] Axons and dendrites are limbs of nerve fibers, reaching out from the cell body, which conduct communication throughout the brain.[90] Axons are the output channels that carry messages to other cells.[91] They are insulated by myelin, which aids the transmission of information.[92] Dendrites are the input channels that receive information from the axons.[93] Information travels on a path from the branch dendrites, down the axon trunk, across the synapses, and on to the next group of dendrite branches.[94] The brain is made up of approximately 100 billion neurons that form networks and make trillions of connections.[95]

The communication site where information-sending axons (trunks) meet information-receiving dendrites (branches) is a tiny gap called the synapse.[96] Information moves along the neural path as an electrical impulse when travelling through the neuron and a chemical when jumping across the synapse.[97] A message

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84. CARTER, THE HUMAN BRAIN, *supra* note 72, at 69.

85. SWEENEY, *supra* note 74, at 11.

86. *Id.* at 10.

87. CARTER, THE HUMAN BRAIN, *supra* note 72, at 69.

88. *Id.* at 68; SWEENEY, *supra* note 74, at 10-11.

89. JOSEPH LEDOUX, SYNAPTIC SELF: HOW OUR BRAINS BECAME WHO WE ARE 40 (2002).

90. SWEENEY, *supra* note 74, at 11-12.

91. LEDOUX, *supra* note 89, at 40.

92. SWEENEY, *supra* note 74, at 12.

93. LEDOUX, *supra* note 89, at 40-41.

94. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 39 (explaining how memories or "bits of specific information" are created through this process).

95. NAT'L GEOGRAPHIC SOC'Y, YOUR BRAIN: A USER'S GUIDE 27 (2012).

96. CARTER, THE HUMAN BRAIN, *supra* note 72, at 69; LEDOUX, *supra* note 89, at 40-42.

97. NAT'L GEOGRAPHIC SOC'Y, *supra* note 95, at 28.

moving from neuron to neuron is electrical–chemical–electrical.[98] The chemicals that carry messages over the synaptic gap are called neurotransmitters.[99] Over 100 neurotransmitters have been identified and some of the important ones are:

- Dopamine (motivation, pleasure, meaning);
- Endorphins (reduce pain, increase pleasure);
- Serotonin (mood, anxiety, sleep);
- Oxytocin (bonding);
- Acetylcholine (attentiveness, memory);
- Glutamate (learning, memory);
- Gamma-aminobutyric acid or GABA (slows and balances system); and
- Norepinephrine (mood, arousal, attention, perception, motivation).[100]

Neurotransmitters leave the axon of the first neuron, move across the synapse, and dock in the dendrite of the next neuron.[101] Each neurotransmitter can dock only in the appropriate place in the dendrite receptor cell's surface.[102] Neurotransmitters either encourage the receptor cell to fire or inhibit neural activity.[103] "About 80 percent of the signaling in the brain is carried out by two neurotransmitters:" glutamate excites neurons into action and gamma-aminobutyric acid (GABA) suppresses them.[104] Like a transit system connects neighborhoods in a city, these electrochemical neuron data

98. LEDOUX, *supra* note 89, at 47 ("[*E*]*lectrical* signals coming down axons get converted into *chemical* messages that help trigger *electrical* signals in the next cell.").

99. CARTER, MAPPING THE MIND, *supra* note 30, at 16, 28-29; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 6.

100. CARTER, MAPPING THE MIND, *supra* note 30, at 29 (referring to the same chemical by its other name, noradrenaline); HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 8; JOHN J. RATEY, SPARK: THE REVOLUTIONARY NEW SCIENCE OF EXERCISE AND THE BRAIN 37 (2008); SWEENEY, *supra* note 74, at 15.

101. NAT'L GEOGRAPHIC SOC'Y, *supra* note 95, at 28.

102. *Id.*; SWEENEY, *supra* note 74, at 15.

103. CARTER, MAPPING THE MIND, *supra* note 30, at 28-29; SWEENEY, *supra* note 74, at 15.

104. RATEY, *supra* note 100, at 37.

pathways link brain regions.[105]

B. MAPPING THE BRAIN

Neuroscientists, psychologists, and educators strive to understand the relationship between the brain and human behavior.[106] While there is still much to be learned about the complex nuances of brain function,[107] brain scans have expanded research into how the brain operates.[108]

The earliest brain drawing, on Egyptian papyrus, dates from 3,000 to 2,500 B.C.[109] While Christopher Columbus Langdell's model of legal education using the casebook method is about 142 years old, modern brain mapping began approximately 350 years ago.[110] After studying the brain for many years, Oxford physiologist Thomas Willis published the first illustrated manual of the brain, *Cerebri Anatome*, in 1664.[111] Willis meticulously dissected post-mortem human brains and coined the terms neurology, lobe, and hemisphere.[112]

Brain research has been greatly enhanced by increasingly sophisticated scanning technologies that allow study of the brains of live subjects.[113] Brain scanning can provide anatomical imaging of the structure of the brain or functional scanning indicating how the brain is working during various tasks.[114]

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105. CARTER, MAPPING THE MIND, *supra* note 30, at 28.

106. Joy Hirsch, *From Brain Structure to Brain Function*, *in* PORTRAITS OF THE MIND: VISUALIZING THE BRAIN FROM ANTIQUITY TO THE 21ST CENTURY 200 (2010).

107. *See* HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 79-80.

108. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12.

109. CARTER, MAPPING THE MIND, *supra* note 30, at 25.

110. MCCLURG, *supra* note 2, at 89-90; CARTER, THE HUMAN BRAIN, *supra* note 72, at 8; GIBB, *supra* note 57, at 17-19.

111. CARTER, THE HUMAN BRAIN, *supra* note 72, at 8; GIBB, *supra* note 57, at 17-19.

112. GIBB, *supra* note 57, at 18. His illustrator was Christopher Wren, who later designed St. Paul's Cathedral in London. SWEENEY, *supra* note 74, at 8. Early brain research highlights include: the discovery of the two language centers by Broca in 1861 and Wernicke in 1876; the silver nitrate staining process of Camillo Golgi and the discovery of the neuron and the theory that information travels between neurons in a chemical process by Ramón y Cajal, for which they won the Nobel Prize in 1906; Korbinian Brodmann's cortex map of types of brain cells in fifty-two cortical areas in 1909; and the isolation of the first neurotransmitter, one of the chemicals that allows information to be passed between neurons, by Henry Hallett Dale in 1914. CARTER, THE HUMAN BRAIN, *supra* note 72, at 9, 10, 67, 73; SWEENEY, *supra* note 74, at 11.

113. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 72.

114. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12-13; GIBB, *supra* note 57, at

Brain structure scanning tools include: X-Ray; CT or CAT scan; and MRI.[115] Brain function and activity scanning tools include: EEG; fMRI; MEG; PET; DTI; and NIRS.[116] Neuroscientists use brain imaging to study a range of human activities and they have identified the brain regions involved in perception, language, memory, emotion, and movement.[117] Although human brain regions function the same way in each person, the location of human memory is individualized.[118]

C. EACH BRAIN IS ONE OF A KIND

The brains of all healthy law students are comprised of the triune structure: the primitive, emotional, and thinking brains.[119] The critical unit of communication within each brain is the tree-shaped neuron, which relies on the electrochemical process of transmitting information through the brain and between brain and body.[120] Every law student has a multitude of neuronal networks operating within the brain.[121] But each student's transit system map of neuron data pathways, referred to as the connectome,[122] is unique.[123]

"You are your synapses,"[124]and your brain is a "work in progress" because your connectome is continuously rewiring itself.[125] The brain is in a constant state of change. It has the capacity to produce new neurons in the hippocampus and the olefactory bulbs (parts of the emotional brain) in a process called

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26-27; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 73-74, 78; SWEENEY, *supra* note 74, at 29.

115. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12-13; GIBB, *supra* note 57, at 26-27; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 73-74; SWEENEY, *supra* note 74, at 29.

116. *See* citations *supra* note 114.

117. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12.

118. DEAN BUONOMANO, BRAIN BUGS: HOW THE BRAIN'S FLAWS SHAPE OUR LIVES 33 (2011).

119. SWEENEY, *supra* note 74, at 69.

120. CARTER, THE HUMAN BRAIN, *supra* note 72, at 41.

121. SWEENEY, *supra* note 74, at 13; Mark I. Sirkin, *Managing Your Brain – A User's Guide*, 82-SEP N.Y. ST. B.J. 38, 39 (2010) (referring to these networks as "maps").

122. PRINCIPLES OF NEURAL SCIENCE 1523-24 (Eric R. Kandel et al. eds., 5th ed. 2013); SEBASTIAN SEUNG, CONNECTOME: HOW THE BRAIN'S WIRING MAKES US WHO WE ARE xiii (2012).

123. *See* MEDINA, *supra* note 30, at 66; Sirkin, *supra* note 121, at 39.

124. LEDOUX, supra note 89, at ix.

125. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 7.

neurogenesis.[126] The modification of neural networks in response to experience, such as legal education, is neuroplasticity.[127] Humans have struggled to find a metaphor for human memory. Plato thought it similar to a wax tablet,[128] and more recently, memory has been compared to hard drive storage in a computer.[129] Memories are not stored in a central location in the brain, but are stored in the neural pathways distributed across the cortex in the exclusive transit map connectome of each law student and lawyer.[130]

III. THE NEUROBIOLOGY OF COGNITION

"Sixty minutes of thinking of any kind is bound to lead to confusion and unhappiness."[131]
James Thurber

A. THE EMOTIONAL AND THINKING BRAIN LOOP

Connecting specific regions of the brain to the human experience continues to engage scientists,[132] and much of the focus has been on processes such as learning and memory.[133] Learning is the acquisition of new information and memory is how the information is stored.[134] Learning includes cognitive components, such as memorizing rules of civil procedure; motor components, such as the typing necessary to take notes on a laptop; and affective components, such as feeling embarrassed if unprepared when called on in class.[135] When learning something new, the brain is processing information and establishing fresh neural connections as networks of neurons fire together.[136]

For law professors to help students learn and encode

126. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 8; SWEENEY, *supra* note 74, at 294.

127. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 11; *see* LEDOUX, *supra* note 89, at 9.

128. SEUNG, *supra* note 122, at 77.

129. MEDINA, *supra* note 30, at 112-13.

130. *Id.* at 112; *see* SEUNG, *supra* note 122, at 79-80.

131. *James Thurber Quotes*, BRAINYQUOTE, http://www.brainyquote.com/quotes/authors/j/james_thurber.html (last visited Jan. 29, 2014).

132. *See* CARTER, MAPPING THE MIND, *supra* note 30, at 18.

133. LEDOUX, *supra* note 89, at 9-10.

134. SWEENEY, *supra* note 74, at 236 (referring to a statement made by Eric R. Kandel).

135. *See* NAT'L GEOGRAPHIC SOC'Y, *supra* note 95, at 21.

136. GLICK, *supra* note 48, at 88-89.

memories for storage, the law student thinking brain and emotional brain must work together in a complex communication process. Information comes into the thinking brain via the senses.[137] Visual information is processed by the occipital lobe; sound is processed by the temporal lobe; language is processed by the frontal lobe; and information about movement, touch, or taste is processed in the parietal lobe.[138] From the senses in the thinking brain, information moves through the emotional brain when the thalamus focuses the brain's attention, screens and sorts this sensory information, and relays it to the hippocampus.[139] The hippocampus is both "the starting point and ending point of the loop" that is necessary for storing new memories.[140] Before the information circuit goes back to the thinking brain, the amygdala is checked for emotional content.[141] The amygdala becomes part of the memory storage capacity for emotionally-charged experiences, and those memories are encoded more powerfully in the brain than emotionally-neutral information.[142] The information loops back to the thinking brain, to the specific lobe of the original sensory input, and returns to the hippocampus.[143] Information travels this entire memory-encoding ring via law student neurons and their neurotransmitters.[144]

For law students, classroom experiences and reading material start to become part of long-term memory when the information is iterated through the circuit from the hippocampus in the emotional brain to the thinking brain and back to the hippocampus.[145] Neurons fire along the way, increasing in sensitivity and the likelihood that they will fire again along the same path, in a process called long-term potentiation (LTP).[146]

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137. SWEENEY, *supra* note 74, at 248.

138. CARTER, THE HUMAN BRAIN, *supra* note 72, at 66; GIBB, *supra* note 57, at 40; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 6.

139. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 60; EDELMAN, *supra* note 51, at 19-21.

140. SWEENEY, *supra* note 74, at 252.

141. *See id* at 242.

142. CARTER, THE HUMAN BRAIN, *supra* note 72, at 158-59; SWEENEY, *supra* note 74, at 242.

143. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 159.

144. *See* CARTER, MAPPING THE MIND, *supra* note 30, at 159.

145. *See* SWEENEY, *supra* note 74, at 246-49.

146. CARTER, MAPPING THE MIND, *supra* note 30, at 159-60; SWEENEY, *supra* note 74, at 248.

Canadian psychologist Donald Hebb described this connectome-building synaptic process: "Cells that fire together wire together."[147] Synaptic plasticity supports memory systems, which are distributed assemblies of interconnected neurons.[148] The brains of law students and lawyers are continuously being rewired and everything they do, think, and feel is governed by their neural networks.[149]

B. MEMORY TYPES

A memory trace, such as the first five minutes of an introductory lecture on the Rule Against Perpetuities, is the initial sensory information received by the brain during a law student learning experience. The ability to store information depends on working memory, which consists of visual, auditory, motor, and emotion memory traces, mediated by executive control processes.[150] "[A] memory trace is fragile, labile, subject to amendment, and at risk for extinction."[151] The brain can use working memory to begin converting memory traces into long-term memory or it can forget them.[152]

Long-term memory can be classified as implicit or explicit, and these memory types are stored in different regions of the brain.[153] Implicit memories are also called nondeclarative memories because they "cannot be experienced in our conscious awareness."[154] Nondeclarative memories include procedural and fear memories, which are unconscious and stored in the primitive or emotional brain.[155] Procedural memories are motor skills or how-to memories, and they are stored in the cerebellum (primitive brain).[156] These are learned habits and skills such as skiing, dancing, and driving.[157] Fear memories are phobias and flashbacks, such as fear of snakes or humiliations at the hands of

147. LEDOUX, *supra* note 89, at 79.

148. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 1029.

149. RATEY, *supra* note 100, at 36.

150. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1442. Executive control is decision-making by monitoring a situation and applying the appropriate rule for behavior within a particular context. PURVES ET AL., *supra* note 32, at 431.

151. MEDINA, *supra* note 30, at 125.

152. *Id.* at 103; SWEENEY, *supra* note 74, at 240-43.

153. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1445-47.

154. *Id.* at 1446; MEDINA, *supra* note 30, at 101.

155. SWEENEY, *supra* note 74, at 240-43.

156. *Id.* at 242-43.

157. *Id.* at 242.

vicious law professors or legal employers, and they are stored in the amygdala (emotional brain).[158]

Explicit memories are called declarative memories because they require conscious thought in order to be recalled, and they are stored in both the emotional and thinking brain.[159] Episodic memories are of autobiographical personal experiences, such as the memory of meeting your best law school friend at the Orientation Week picnic.[160] Semantic memories, those especially important in legal education, are "learned knowledge," such as facts, concepts, and words.[161] Episodic and semantic memories are stored in the hippocampus (emotional brain) and the cerebral cortex (thinking brain).[162]

Scientists learned much about the relationship between working memory and long-term memory because of an historic case involving a man who had surgery to treat epileptic seizures. In 1953, patient H.M. had a substantial amount of his temporal lobes removed on both sides of his brain.[163] The temporal lobes are part of the emotional brain and include the hippocampus.[164] The surgery improved his seizures, but he was left with severe memory impairment and his capacity for new learning was nearly extinguished.[165]

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158. CARTER, MAPPING THE MIND, *supra* note 30, at 162.

159. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 158; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1446.

160. CARTER, MAPPING THE MIND, *supra* note 30, at 162; GIBB, *supra* note 57, at 69.

161. GIBB, *supra* note 57, at 69; SWEENEY, *supra* note 74, at 243.

162. CARTER, MAPPING THE MIND, *supra* note 30, at 162; SWEENEY, *supra* note 74, at 243.

163. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 1031.

164. SWEENEY, *supra* note 74, at 241.

165. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1442-45; MEDINA, *supra* note 30, at 101-03; SEUNG, *supra* note 122, at 187; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 1031. H.M. was the subject of extensive research until his death in 2008. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1442. Because H.M. remembered how to talk and his IQ was unchanged, scientists learned that memory could be separated from perception and intelligence. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 1031. H.M. could remember his name, his job, and his childhood, so the medial temporal lobes were not the site of long-term memory storage. *Id.* at 1031. When asked to learn a new telephone number, H.M. could rehearse and repeat it for seconds to minutes, indicating his working memory was intact. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1445. H.M. could learn new motor skills, which indicated nondeclarative memory formation did not rely on the temporal lobes. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 1031. What H.M. could not do was recognize people he met after the surgery, learn the names of his caretakers, recite

Nondeclarative memory became defined as any unconscious memory system that is not substantially altered when the hippocampus is damaged.[166] Declarative memory, the kind of memory that is critical to legal education, has been refined to mean "any conscious memory system that is altered when the hippocampus and various surrounding [brain] regions become damaged."[167] Neuroscientists have used fMRI scanning in studies on live subjects to further demonstrate that a healthy hippocampus is critical to the encoding and retrieval of declarative memory.[168]

C. MEMORY FORMATION

Memories have different life spans, some lasting minutes, the undergrad who cut you off in the law school parking lot, and others a lifetime—the time you got called on the first week of school and the professor would not move on to another student even though you never came up with a satisfactory response.[169] The process of converting memory traces into long-term memory is called consolidation.[170] Consolidation makes information more stable in the brain. The first step of consolidation is encoding.[171]

Encoding is the processing of physical sensory information—sights, sounds, language, and emotions—as it enters the brain.[172] Automatic processing is the type of memory encoding that requires "minimal attentional effort."[173] Memories encoded in this way, such as episodic memories of autobiographical experiences, are easy to recall.[174] And if memories of travel, special events, or law school degradation are discussed at length with law school friends, they are fluently consolidated in long-

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current events, or understand where he was every morning when he woke up. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1445. These memory problems convinced scientists that the hippocampus was integral to declarative memory formation. *See* MEDINA, *supra* note 30, at 102-03.

166. MEDINA, *supra* note 30, at 103.

167. *Id.*

168. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 1035.

169. MEDINA, *supra* note 30, at 100.

170. *Id.* at 125; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1447.

171. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1447; MEDINA, *supra* note 30, at 125-27.

172. CARTER, THE HUMAN BRAIN, *supra* note 72, at 156; TOKUHAMA-ESPINOSA, *supra* note 35, at 261.

173. MEDINA, *supra* note 30, at 106.

174. *Id.*

term memory.[175]

The life cycle of declarative memory, of critical importance in legal education and law firm training programs, involves four stages: encoding, storing, retrieving, and forgetting.[176] Encoding declarative memory information requires the application of conscious attention known as effortful processing.[177] In the initial moments of encoding, when memory traces enter the thinking brain via the senses, electrical activity is discharged through millions of neurons in the brain regions associated with those senses.[178] Data from salient experiences break out of working memory and travel to the hippocampus in the emotional brain for further processing.[179] The hippocampal neurons start to encode this information for permanent storage along chains of firing neurons.[180] This temporarily strengthened synaptic interaction, which lasts an hour or two, is called early LTP.[181] If the sensory input is repeated after a period of time has elapsed (like when law students consolidate class notes into outlines each week), the same neurons fire together more often and late LTP occurs.[182] The strongest information is sent back to the thinking brain, distributed to the parts of the cortex where it was first registered by the senses.[183] The learning process, memory encoding and consolidation, alters the structure of the brain by forging new connections of neurons and expanding the connectome of every law student.[184]

Consolidation (enhanced by creating and studying law class outlines) makes temporarily stored fragile information (from reading and class lectures) more stable for later retrieval (on law school exams) by strengthening neural connections of the information circuit between the hippocampus and the cortex.[185]

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175. MEDINA, *supra* note 30, at 131-32.

176. *Id.* at 103.

177. *Id.* at 107.

178. *Id.* at 103, 109.

179. CARTER, THE HUMAN BRAIN, *supra* note 72, at 159.

180. *Id.* at 156, 159; SWEENEY, *supra* note 74, at 248-49.

181. MEDINA, *supra* note 30, at 134-35.

182. *Id.* at 135.

183. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 159; MEDINA, *supra* note 30, at 138.

184. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 156, 158; *see* SEUNG, *supra* note 122, at 123-24.

185. CARTER, MAPPING THE MIND, *supra* note 30, at 164; CARTER, THE HUMAN

This dialogue between the hippocampus and the cerebral cortex takes place largely during sleep.[186] Researchers believe the memory consolidation process, the electrochemical marriage between the emotional brain and the thinking brain, can take from two to ten years to complete.[187] Once consolidation is completed, the hippocampus lets go of its relationship with the cortex.[188] Consolidated long-term memories, such as the expertise lawyers develop from school courses and practice experience, are distributed throughout the cortex in the brain regions where they initially entered the brain.[189]

The memory retrieval process used by law students during an exam relies on the same neural pathways that they used for memory encoding while they studied and slept.[190] Physical skills, such as typing or bike riding, are implicitly transferred through repetition.[191] Emotional learning experiences, demeaning or encouraging, are also implicitly and powerfully encoded as memories by the amygdala.[192] If emotion is an element of a memory, it increases the intensity of the perception and it enhances consolidation.[193]

For law students, the consolidation necessary for recall of declarative memories on assessments can be enhanced by rehearsal, practice, study, and analysis to imbue the information with meaning and link it to other important information.[194] If there is enough iteration between the hippocampus and the cerebral cortex, the memory is firmly established in the thinking brain and the hippocampus is no longer needed for retrieval of the memory.[195]

BRAIN, *supra* note 72, at 159.

186. CARTER, MAPPING THE MIND, *supra* note 30, at 162, 166; CARTER, THE HUMAN BRAIN, *supra* note 72, at 159; GIBB, *supra* note 57, at 68; SWEENEY, *supra* note 74, at 246.

187. CARTER, THE HUMAN BRAIN, *supra* note 72, at 159; *see* CARTER, MAPPING THE MIND, *supra* note 30, at 162; MEDINA, *supra* note 30, at 138, 140.

188. MEDINA, *supra* note 30, at 138.

189. CARTER, THE HUMAN BRAIN, *supra* note 72, at 159; MEDINA, *supra* note 30, at 140-41; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1448.

190. SWEENEY, *supra* note 74, at 249.

191. *Id.* at 247.

192. *Id.*

193. CARTER, THE HUMAN BRAIN, *supra* note 72, at 158; CARTER, MAPPING THE MIND, *supra* note 30, at 164.

194. *See* SWEENEY, *supra* note 74, at 246-47.

195. CARTER, MAPPING THE MIND, *supra* note 30, at 162.

Forgetting memories allows law students to prioritize and survive law school by eliminating unneeded information, such as the irritating undergraduate driver.[196] Rather than store irrelevant information, the brain forgets it.[197] Because the processes of learning, memory storage, and memory retrieval involve both the emotional and thinking brains, law students, legal educators, and lawyers should develop an understanding of the impact of emotion on cognition and the nexus between brain and body.

IV. YOUR BRAIN ON EMOTION

"An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissues."[198]
William James

A. EMOTIONS AND THE BRAIN-BODY LINK

The thinking brain and the emotional brain of the law student and lawyer must work in concert to encode declarative memories, such as learning the law, and consolidate them for future retrieval on law exams, in legal memos, or during arguments in court.[199] Sensory information in the form of emotional memory traces often accompanies visual, auditory, and language information as it first enters the brain.[200] The nature of this emotional information can impact memory formation.[201]

An emotion is an unconscious and automatic response to an emotional stimulus that results in physical changes, such as the pounding heart or sweaty palms you experienced during your first moot court oral argument.[202] Emotions are physiological and largely unconscious behavioral and cognitive responses that occur within both the brain and the body, when the brain detects a positively or negatively charged stimulus.[203] "Emotions manifest

196. MEDINA, *supra* note 30, at 143.

197. *Id.*

198. 1 WILLIAM JAMES, THE PRINCIPLES OF PSYCHOLOGY 670 (1890).

199. *See* MEDINA, *supra* note 30, at 108-09.

200. CARTER, THE HUMAN BRAIN, *supra* note 72, at 158; TOKUHAMA-ESPINOSA, *supra* note 35, at 143-49.

201. CARTER, THE HUMAN BRAIN, *supra* note 72, at 158; SWEENEY, *supra* note 74, at 212.

202. GIBB, *supra* note 57, at 96.

203. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079.

themselves outwardly in visible changes to the body."[204] Physical responses to emotions include blushing, muscle contractions, facial expressions, increased heart rate, and heightened blood pressure.[205]

The six primary emotions are fear, anger, sadness, disgust, surprise, and joy.[206] Brain scan technologies have led researchers to assign negative emotions to the right hemisphere and positive emotions to the left hemisphere, and therefore, lawyers with more activity in the left would tend to be happier than those with more activity in the right hemisphere.[207]

Emotions are experienced as "powerful feelings" that add meaning to our lives.[208] Feelings are the conscious perceptions of automatic bodily emotional responses.[209] Feelings are "inward and private[,]" and the awareness of feelings "provide[s] incentives to adapt and act."[210] A feeling is "the representation in working memory of the various elements" of an emotion.[211]

Emotional information travels through the law student brain along two parallel processing routes.[212] The fastest route goes straight to the amygdala, which assesses it as either a threat—I didn't do the reading and may get called on—or as an opportunity—I am prepared to be called on and want to impress the professor so she will hire me as a research assistant—and then "prime[s] the body to act appropriately."[213] This "quick and dirty" route allows law students to take instant action to survive

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204. SWEENEY, *supra* note 74, at 208.

205. CARTER, THE HUMAN BRAIN, *supra* note 72, at 124; CARTER, MAPPING THE MIND, *supra* note 30, at 82; SWEENEY, *supra* note 74, at 208.

206. CARTER, THE HUMAN BRAIN, *supra* note 72, at 127 (discussing anger, fear, sadness, disgust, and surprise); RITA CARTER, MAPPING THE MIND 83 (1998) (explaining that some researchers have found the primary emotions to be disgust, fear, anger, and parental love); SWEENEY, *supra* note 74, at 208 ("Most scientists recognize either four or six basic emotions. The four most elemental are fear, anger, sadness, and joy.").

207. CARTER, THE HUMAN BRAIN, *supra* note 72, at 126; SWEENEY, *supra* note 74, at 208.

208. CARTER, THE HUMAN BRAIN, *supra* note 72, at 126 (quotation marks omitted).

209. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079.

210. SWEENEY, *supra* note 74, at 210.

211. LEDOUX, *supra* note 89, at 225.

212. CARTER, MAPPING THE MIND, *supra* note 30, at 83.

213. *Id.*; SWEENEY, *supra* note 74, at 215 (discussing this process in relation to experiencing fear).

via flight, fight, or appeasement.[214] On the slow and deliberative route, the information is processed by the cortex in the thinking brain and the hippocampus in the emotional brain.[215] If no threat is found—the professor does not engage students randomly so I know how to prepare for class—the thinking brain overrules the amygdala in the emotional brain and inhibits the fight-or-flight response.[216]

Joseph LeDoux of New York University, the neuroscientist who put the amygdala on the map, has shown that more neural traffic travels up from the emotional brain to the thinking brain than down from the thinking brain to the emotional brain; thus, he believes that the emotional brain has more power to influence law student behavior than the thinking brain.[217]

B. STRESS AND BRAIN-BODY EQUILIBRIUM

"Our brain is the factory of the emotions."[218]
Don Miguel Ruiz

Four of the six universally recognized emotions are negative: fear, anger, sadness, and disgust.[219] Stress involves some combination of these adverse emotions.[220] Stress, a concept borrowed from engineering, "can be defined as the amount of resistance a material offers to being reshaped and reformed."[221] If too great a load is placed on the beam supporting a structure or the law student trying to learn the law, it/he is damaged or collapses.[222] Walter B. Cannon and Hans Selye were key

214. CARTER, THE HUMAN BRAIN, *supra* note 72, at 125; SUSAN GREENFIELD, THE PRIVATE LIFE OF THE BRAIN: EMOTIONS, CONSCIOUSNESS, AND THE SECRET OF THE SELF 18 (2000).

215. CARTER, THE HUMAN BRAIN, *supra* note 72, at 125; CARTER, MAPPING THE MIND, *supra* note 30, at 83.

216. SWEENEY, *supra* note 74, at 215.

217. CARTER, MAPPING THE MIND, *supra* note 30, at 98 (quoting JOSEPH LEDOUX, THE EMOTIONAL BRAIN (1996)); ROBERT M. SAPOLSKY, WHY ZEBRAS DON'T GET ULCERS 323 (Henry Holt & Co. 3d ed. 2004).

218. DON MIGUEL RUIZ, THE FOUR AGREEMENTS: A PRACTICAL GUIDE TO PERSONAL FREEDOM 102 (1997).

219. CARTER, THE HUMAN BRAIN, *supra* note 72, at 127; SWEENEY, *supra* note 74, at 208.

220. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 232; CARTER, MAPPING THE MIND, *supra* note 30, at 96-97.

221. PERLMUTTER & VILLOLDO, *supra* note 57, at 57.

222. *Id.*

researchers in stress physiology.[223] Cannon developed the fight-or-flight phenomenon to describe the stress response,[224] and Selye used the term stress to describe the general unpleasantness his lab rats were experiencing when he would routinely drop, chase, and recapture them during his experiments.[225] Selye noticed that the rats had a similar set of responses to a broad array of stressors and that extended exposure to general unpleasantness made them sick.[226]

Jeansok Kim and David Diamond developed a three-part definition of stress in humans:

- There must be a physiological response to the stressor and it must be measurable by another party;
- The stressor must be perceived as aversive; and
- The person must feel she has no control over the stressor.[227]

A law student's reaction to stress depends upon the individual and the length and severity of the stressor.[228] Like Selye's lab rats, when law students are subjected to a broad array of stressors in the legal education environment, that general unpleasantness is likely to make them sick.[229] Law students and lawyers have reported a response to law school conditions that meet the stress definition of Kim and Diamond: they suffer physiological responses to negative stressors over which they have no control.[230] Bruce McEwen coined the term allostasis to provide a framework for understanding the various ways humans respond to stress.[231] Allostasis is the process the brain uses to

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223. *See* SAPOLSKY, *supra* note 217, at 7-12.

224. *Id.* at 12.

225. *Id.* at 8.

226. *Id.*

227. MEDINA, *supra* note 30, at 173-74.

228. *See id.* at 182.

229. *See* SAPOLSKY, *supra* note 217, at 8.

230. LITOWITZ, *supra* note 7, at 10, 19; *see* MEDINA, *supra* note 30, at 173-74.

231. MEDINA, *supra* note 30, at 182. Of Greek origin, "allo" means variable and "stasis" means a condition of balance. *Id.* Allostasis is an expansion of the concept homeostasis which had been used to describe the body's stable internal state. *Id.*; CARTER, THE HUMAN BRAIN, *supra* note 72, at 112; SAPOLSKY, *supra* note 217, at 9-10. This idea was grounded in the theory that there is a single optimal level, number, or amount for any given quantifiable measure in the body. SAPOLSKY, *supra* note 217, at 9. This theory does not account for differing set points during various

coordinate body-wide changes.[232] The brain helps maintain stability in the body with the process of allostatic regulation.[233] McEwen called the wear-and-tear from the stress response—the tipping point at which stress becomes toxic—"allostatic load."[234] When the law student reaches this allostatic load, "the stress-response can become [even] more damaging than the stressor."[235]

The autonomic nervous system (ANS) is the neural circuitry that works with the brain to direct the law student's physiology and maintain allostatic balance.[236] Walter B. Cannon called this stability system, working to balance the right amount of alertness with relaxation and anxiety with calm, the "wisdom of the body."[237] The ANS maintains allostatic equilibrium with two divisions: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS).[238] The SNS is activated by the hypothalamic–pituitary–adrenal axis (HPAA) of the endocrine system.[239] The SNS/HPAA directs fight-or-flight behaviors, and the PNS controls rest-and-digest functions.[240] The SNS/HPAA arousal system is the body's accelerator, and the PNS is its brake.[241]

C. LIGHTING UP THE FIGHT-OR-FLIGHT SNS/HPAA

When the law student brain detects an emotional stimulus, it sends signals to three systems that control the physiological expression of emotional states: the endocrine, autonomic, and skeletal motor systems.[242] "The endocrine system is responsible for the secretion and regulation of hormones into the

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activities, such as the difference in blood pressure when sleeping, relaxing, or exercising. SAPOLSKY, *supra* note 217, at 9.

232. SAPOLSKY, *supra* note 217, at 9.

233. *See id.* at 9-10; MEDINA, *supra* note 30, at 182.

234. MEDINA, *supra* note 30, at 182; SAPOLSKY, *supra* note 217, at 14, 70.

235. SAPOLSKY, *supra* note 217, at 13.

236. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 729; *see* PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1066-67.

237. GAYATRI DEVI, A CALM BRAIN: HOW TO RELAX INTO A STRESS-FREE, HIGH-POWERED LIFE 37 (2012); FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 729.

238. PURVES ET AL., *supra* note 32, at 326; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 730.

239. HANSON, *supra* note 50, at 51; *see* RATEY, *supra* note 100, at 63.

240. PURVES ET AL., *supra* note 32, at 326.

241. LINDA GRAHAM, BOUNCING BACK: REWIRING YOUR BRAIN FOR MAXIMUM RESILIENCE AND WELL-BEING 201 (2013).

242. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079.

bloodstream."[243] The autonomic system mediates physiological changes in the body, including the cardiovascular system.[244] The skeletal motor system controls behaviors such as freezing, flight, fight, and facial expressions.[245]

The human response to stress enables the fight-or-flight reaction necessary for survival and is known as the SNS/HPAA.[246] This response was highly adaptive during the period of time when humans needed to flee from predators, but it can be destructive in law school and legal practice.[247] Psychologists have identified two kinds of stress: acute and chronic stress.[248] Acute stress is short-lived and can be helpful in dealing with situations such as a novel intellectual problem or a significant physical challenge.[249] Chronic stress is long lasting and is caused by experiences such as a troubled intimate relationship, financial struggles, job loss, treatment for a life-threatening illness, or attending law school.[250]

When stress persists for a few hours or days, a law student may experience a bad mood.[251] Longer-term stress can cause stress-related disorders such as panic attacks, anxiety, or depression; the physical effects include increased blood pressure, heart palpitations, breathlessness, dizziness, irritability, chest pain, abdominal discomfort, sweating, chills, or increased muscle tension.[252] These symptoms are caused by the stress response originating in the emotional brain, which activates the endocrine and autonomic systems, together the SNS/HPAA.[253]

The law student SNS/HPAA is ignited by "the brain's panic button," the amygdala.[254] The amygdala is alert to threats—I might fail this final exam and blow my GPA—and to opportunities—I want to impress the cute girl in my class with

243. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1080.
244. *Id.*
245. *Id.*
246. *See id.* at 1066.
247. *See* FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 803.
248. PERLMUTTER & VILLOLDO, *supra* note 57, at 59.
249. *Id.*
250. *Id.*; *see* LITOWITZ, *supra* note 7, at 10, 19.
251. *See* CARTER, THE HUMAN BRAIN, *supra* note 72, at 127.
252. *Id.* at 232.
253. *See* PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079.
254. RATEY, *supra* note 100, at 62.

my intellectual prowess—and initiates the quick and dirty route to the body's fight-or-flight response.[255] The amygdala signals two other parts of the emotional brain: the thalamus to focus attention and the hypothalamus to release stress hormones.[256]

The two main stress hormones secreted by the endocrine system are adrenalin (also known as epinephrine) and glucocorticoids (the main glucocorticoid is cortisol).[257] Cortisol indicates to the SNS/HPAA to elevate heart rate and blood pressure, mobilize energy, slow digestion, and suppress immune responses.[258] The evolutionary purpose for these responses is to allow the skeletal motor system to respond to ensure survival.[259]

Our stress responses were shaped to help humans manage immediate predator threats and address problems that could be resolved within seconds or minutes.[260] The purpose was to mobilize our muscles to escape harm.[261] When chronic stress causes a lengthy stress response in the law student, both the brain and body suffer.[262] Too much adrenaline causes surges in blood pressure and scarring in the blood vessels, which increases the risk of stroke and heart attack.[263] Chronic stress reduces and impairs the white blood cells necessary to fight infection and eventually cripples the immune system.[264]

Law student and lawyer stress-related diseases are caused by problems in allostatic regulation where the stress response is

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255. *See* citations *supra* note 214.

256. HANSON, *supra* note 50, at 52.

257. CARTER, THE HUMAN BRAIN, *supra* note 72, at 232; MEDINA, *supra* note 30, at 174; PERLMUTTER & VILLOLDO, *supra* note 57, at 60; SWEENEY, *supra* note 74, at 40; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409. The pituitary gland and the hypothalamus in the emotional brain tell the adrenal gland sitting atop the kidneys to release adrenalin and glucocorticoids. CARTER, THE HUMAN BRAIN, *supra* note 72, at 232; PERLMUTTER & VILLOLDO, *supra* note 57, at 60. Glucocorticoids are steroid hormones, and the major glucocorticoid is cortisol. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804.

258. PERLMUTTER & VILLOLDO, *supra* note 57, at 60; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804; *see* SAPOLSKY, *supra* note 217, at 13.

259. *See* PERLMUTTER & VILLOLDO, *supra* note 57, at 60; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079.

260. MEDINA, *supra* note 30, at 175.

261. *Id.*

262. *See id.* at 176.

263. *Id.*

264. *Id.*

either repeatedly turned on or cannot be turned off.[265] Long-term elevated levels of glucocorticoids resulting from chronic stress have been associated with the following physical conditions:

- Impaired immune response;
- Increased appetite and food cravings;
- Increased body fat;
- Increased symptoms of PMS and menopause;
- Decreased muscle mass;
- Decreased bone density; and
- Decreased libido.[266]

Chronic stress also produces the following emotional conditions:

- Increased mood swings, irritability, and anger;
- Increased anxiety; and
- Increased depression.[267]

Because the panic button amygdala is hardwired to react to trouble, the law student brain suffers from a negativity bias,[268] where the mind can trigger the stress response by simply imagining a threating situation.[269] Executive control within the thinking brain is diminished during SNS/HPAA arousal, so it becomes difficult for the anxious law student to put the brakes on worries that may or may not come to pass.[270] Law school and law practice are filled with sources of stress that initiate the SNS/HPAA response, such as intense workload, the expectation of 24/7 availability, technology overload, and a loss of the intimacy of face-to-face connections.[271] The legal workplace is a

265. *See* SAPOLSKY, *supra* note 217, at 16; SHAWN TALBOTT, THE CORTISOL CONNECTION: WHY STRESS MAKES YOU FAT AND RUINS YOUR HEALTH-AND WHAT YOU CAN DO ABOUT IT 30-33 (2007).

266. TALBOTT, *supra* note 265, at 22.

267. *Id.*

268. HANSON, *supra* note 50, at 42, 53; RATEY, *supra* note 100, at 62.

269. RATEY, *supra* note 100, at 63 (referring to a statement made by neuroscientist, Bruce McEwen).

270. *See* HANSON, *supra* note 50, at 50-53

271. *See* DEVI, *supra* note 237, at 22-33.

common stressor for lawyers,[272] and emotional responses to problems spark the SNS/HPAA response more often than the presence of actual peril.[273]

Activation of the SNS/HPAA stress response causes circular damage in the emotional brain of the stressed-out law student or lawyer.[274] It heightens stimulation of the terror-prone amygdala, which produces more cortisol.[275] The cortisol suppresses the hippocampus, which normally curbs the amygdala, leading to more cortisol production.[276] The amygdala is over-sensitized, and the hippocampus is compromised.[277]

Many law students and lawyers spend their lives lit up in SNS/HPAA overdrive, believing their performance is enhanced by the adrenaline rush.[278] This predicament may be fueled by caffeine and other substances.[279] Living in chronic SNS/HPAA arousal redirects resources away from building a strong immune system and maintaining cognitive well-being.[280] Neuroscientists have proven that cognitive performance is diminished during the SNS/HPAA state, but thanks to neuroplasticity, it can be reversed when law students and lawyers develop greater PNS control.[281]

D. CHILLING OUT: THE REST-AND-DIGEST PNS

The other half of the law student brain–body equilibrium system is the parasympathetic nervous system (PNS).[282] The "rest-and-digest" PNS conserves energy and produces a feeling of calm and contentment.[283] It promotes digestion and nutrient absorption, slows the heart rate, lowers blood pressure, and curbs

272. RATEY, *supra* note 100, at 83.

273. HANSON, *supra* note 50, at 50.

274. *Id.* at 52-53; *see* RATEY, *supra* note 100, 66-67.

275. HANSON, *supra* note 50, at 52-53.

276. *Id.* at 53.

277. *Id.* at 57 (calling this a "bad combination").

278. *See* DEVI, *supra* note 237, at 7.

279. *See id.*

280. HANSON, *supra* note 50, at 55-56.

281. *Id.* at 52-60; RATEY, *supra* note 100, at 67-71; *see* DEVI, *supra* note 237, at 83-86.

282. HANSON, *supra* note 50, at 58-59; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 734.

283. CHUDLER, *supra* note 55, at 35; HANSON, *supra* note 50, at 59.

the release of adrenaline.[284] The PNS limits heat loss and promotes rest.[285] Where the SNS stimulates arousal, defense, and escape, the PNS supports nourishment and procreation and also restores allostatic equilibrium after SNS activation.[286]

Law students and lawyers can enhance the PNS, cultivate the neurology of calm, and foster resilience in the face of stress.[287] Strengthening the PNS requires practicing deep relaxation, contemplative practices, and guided imagery.[288]

Researchers began studying the impact of stress on cognition using mice and rats.[289] These little creatures advanced our knowledge and helped us learn about how to protect the human brain against stress until scanning technologies made non-invasive research on the human brain possible.[290]

E. STRESS AND COGNITION—OF RODENTS AND MEN

Because it is much more difficult to study the human brain than the animal brain, extensive brain research has been done using mice and rats.[291] Topics of keen interest to researchers include learning[292] and emotional response.[293] Brain imaging technologies have been used in recent years to study the learning and emotional processes in brain-damaged humans.[294] Because so many parallel discoveries have been made in brain research on both rats and humans, findings from rodent research should be assumed to apply to law students, law professors, and lawyers.[295]

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284. WILLIAM J. BROAD, THE SCIENCE OF YOGA: THE RISKS AND THE REWARDS 90 (2012); DEVI, *supra* note 237, at 53; SWEENEY, *supra* note 74, at 41; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 734.

285. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 736.

286. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 353, 1066.

287. *See* DEVI, *supra* note 237, at 37; GRAHAM, *supra* note 241, at 208.

288. AMEN, *supra* note 30, at 167; HANSON, *supra* note 50, at 110; NERISON, *supra* note 9, 154-55.

289. LEDOUX, *supra* note 89, at 218; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

290. *See* LEDOUX, *supra* note 89, at 218.

291. LEDOUX, *supra* note 89, at 218; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

292. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 15-16; SAPOLSKY, *supra* note 217, at 232.

293. *See* LEDOUX, *supra* note 89, at 218.

294. *Id.*

295. *Id.* at 220. The Allen Brain Atlas is a research project of the Allen Institute for Brain Science designed to advance human brain research through the study of

Considerable research has been conducted on the hippocampus and amygdala—components of the emotional brain—in rats.[296] In rodents, new neurons born in the hippocampus are integrated into neural circuits.[297] The presence of glucocorticoids suppresses normal rates of neurogenesis in rodent hippocampi.[298] Damage to the hippocampus can create a destructive cycle where greater amounts of glucocorticoids are released, producing additional hippocampal atrophy.[299] "[T]he tendency of glucocorticoids to damage the hippocampus increases the over-secretion of glucocorticoids" causing more hippocampal damage.[300]

In the law student brain, stress responses are coordinated by glucocorticoid receptors in the hippocampus.[301] There are abundant glucocorticoid receptors in the hippocampus making it very responsive to stress,[302] and chronic high glucocorticoid exposure leads to hippocampal neurodegeneration and cell

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the mouse brain. Sara Ball et al., *The Human Brain Online: An Open Resource for Advancing Brain Research*, 10 PLOS BIOLOGY, Dec. 27, 2012, at 1-3, *available at* http://www.plosbiology.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pbio.1001453&representation=PDF; *see* ALLEN BRAIN ATLAS, http://www.brain-map.org/ (last visited Jan. 29, 2014); *Publications*, ALLEN INST. FOR BRIAN SCI., http://www.alleninstitute.org/science/publications/index.html (last visited Jan. 29, 2014). A recent study shows a 79% similarity in the expression of approximately 1,000 genes in the visual cortex of both mouse and human. Ball et al, *supra*, at 2 (citing Zeng Hongkui et al., *Large-Scale Cellular-Resolution Gene Profiling in Human Neocortex Reveals Species-Specific Molecular Signatures* (2012), *available at* http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3328777/). In his 2013 State of the Union Address, President Obama proposed the Brain Activity Map (BAM) project, a ten-year research agenda designed to map the human connectome and provide a greater understanding of the function of the neural wiring in the human brain. *See* Barack Obama, Address Before a Joint Session of Congress on the State of the Union 3 (Feb. 12, 2013), *available at* http://www.whitehouse.gov/the-press-office/2013/02/12/president-barack-obamas-state-union-address-prepared-delivery; John Markoff, *Obama Seeking to Boost Study of Human Brain*, N.Y. TIMES, Feb. 18, 2013, *available at* 2013 WLNR 3995035; Maia Szalavitz, *Brain Map: President Obama Proposes First Detailed Guide of Human Brain Function*, TIME MAG. (Feb. 19, 2013), http://healthland.time.com/2013/02/19/brain-map-president-obama-proposes-first-detailed-guide-of-human-brain-function/?hpt=hp_t2.

296. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 15-16; LEDOUX, *supra* note 89, at 218-25.

297. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

298. *Id.*; *see* SWEENEY, *supra* note 74, at 294.

299. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

300. SAPOLSKY, *supra* note 217, at 387.

301. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1320.

302. MEDINA, *supra* note 30, at 177; FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804.

death.[303] Remaining hippocampal neurons "no longer work as well."[304] The complexity of neural networks is diminished as they weaken or get disconnected at the synapse.[305] Glucocorticoids kill cells in the hippocampus, impairing its ability to make synaptic connections in neural networks that make law student learning and consolidation of declarative memory possible.[306] When hippocampal neurons die, learning is nearly impossible for law students.[307]

The impact of stress on law student cognition includes deterioration in memory, concentration, problem-solving, math performance, and language processing.[308] Curiosity is dampened, and creativity is diminished.[309] A paralysis sets in, limiting motivation and the ability to break out of repetitive behavior patterns.[310] Research has shown that hippocampi shrink in size in people with major depression.[311] Exercise, healthful sleep, and antidepressants can reverse law student and lawyer hippocampal atrophy and increase the rate of neurogenesis, new brain cell development.[312]

That neurons in the hippocampus—the brain region so important to learning and memory formation and one of only two places in the brain where neurogenesis occurs–can be harmed or killed by exposure to stress hormones creates significant implications for law students, legal educators, law schools, and legal employers.[313] Neuroplasticity allows every law student and

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303. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 57; SWEENEY, *supra* note 74, at 124.

304. SAPOLSKY, *supra* note 217, at 215.

305. *Id.* at 217.

306. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804; DOIDGE, *supra* note 30, at 240; MEDINA, *supra* note 30, at 179; *see* AAMODT & WANG, *supra* note 30, at 86; AMEN, *supra* note 30, at 248; CARTER, MAPPING THE MIND, *supra* note 30, at 96; DAVID A. SOUSA, HOW BRAIN SCIENCE CAN MAKE YOU A BETTER LAWYER 25 (2009).

307. PERLMUTTER & VILLOLDO, *supra* note 57, at 61.

308. MEDINA, *supra* note 30, at 178.

309. PERLMUTTER & VILLOLDO, *supra* note 57, at 61.

310. *Id.*

311. SAPOLSKY, *supra* note 217, at 221. Hippocampi also shrink in those with post-traumatic stress disorder and for those who experience repeated jet lag. *Id.*

312. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409; MEDINA, *supra* note 30, at 163, 179; SWEENEY, *supra* note 74, at 294; *see* PERLMUTTER & VILLOLDO, *supra* note 57, at 87 (discussing a protein called brain-derived neurotrophic factor (BDNF) which aids in creating new neurons).

313. DOIDGE, *supra* note 30, at 248; LEDOUX, *supra* note 89, at 223; MEDINA, *supra* note 30, at 179; PERLMUTTER & VILLOLDO, *supra* note 57, at 61; SAPOLSKY, *supra*

lawyer to self-fashion a cognitive wellness plan.[314] The practice of law demands maximum cognitive function, and the profession is notoriously stressful.[315] Law students, law professors, and lawyers have the capacity to enhance their brains and augment their parasympathetic nervous systems in order to improve performance.[316] Researchers should seek to:

- identify sources of stress in legal education and legal work environments,
- limit these stressors, and
- implement cognitive wellness training programs and practices.

V. RECOMMENDATIONS FOR NEURAL SELF-HACKING

Your brain is the most modifiable part of your whole body, and you can rewire your brain by how you use it every single day.[317]
Sandra Bond Chapman

A. THRIVE, NOT SURVIVE

Many innovative companies promote wellness to provide vibrant workplaces and thriving employees.[318] Research shows that perks such as onsite gyms, work/life balance programs, stress management classes, mindfulness training, and nutrition coaching improve the bottom line.[319] These corporate amenities foster a preeminent achievement culture. There have been achievement cultures throughout history.[320] The objective of the ancient Greeks was to assist every male citizen in achieving the

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note 217, at 215-23.

314. *See* KATHLEEN TAYLOR, THE BRAIN SUPREMACY: NOTES FROM THE FRONTIERS OF NEUROSCIENCE 3 (2012).

315. *See* Krieger, *supra* note 29, at 113-15; Rosen, *supra* note 29, at 161-62; *see also* LITOWITZ, *supra* note 7, at 16-26; NERISON, *supra* note 9, at 15-39; LEVIT & LINDER, *supra* note 12, at 6-8; MCCLURG, *supra* note 2, at 315-18.

316. *See* HALLOWELL, *supra* note 38, at 29.

317. SANDRA BOND CHAPMAN, MAKE YOUR BRAIN SMARTER: INCREASE YOUR BRAIN'S CREATIVITY, ENERGY, AND FOCUS 4 (2013).

318. HALLOWELL, *supra* note 38, at 31 (referring to companies like Google, SAS, Whole Foods Market, the Cleveland Clinic, and Cisco Systems).

319. *Id.*; *see* CHADE-MENG TAN, SEARCH INSIDE YOURSELF: THE UNEXPECTED PATH TO ACHIEVING SUCCESS, HAPPINESS (AND WORLD PEACE) 3 (2012).

320. DAVID SHENK, THE GENIUS IN ALL OF US: WHY EVERYTHING YOU'VE BEEN TOLD ABOUT GENETICS, TALENT, AND IQ IS WRONG 118 (2010).

human ideal, and Greek society fostered this achievement culture with robust public education, mentoring, contests, and an emphasis on the journey rather than the outcome.[321] Development of an achievement culture requires healthy competition, imbued with a deep undercurrent of respect, concern, and admiration for all participants.[322]

Neuroscience can explain the success of achievement cultures. Achievement cultures provide brain-boosting benefits and promote environments rich with cognitive power. Leaders in achievement cultures have made cognitive well-being a priority, reaping benefit at both the individual and institutional levels.[323] Learning about the neuroscience of cognitive wellness is critical to protecting brain function and enhancing cognitive performance. Legal educators have the power to bring this information to the attention of their law students and to create a neuroscience-powered achievement culture in law schools. Law students need not wait for institutional change to alleviate the impact a stressful law school learning environment has on their learning. Their professional identity, along with their capacity to build practice skills and a legal knowledge base, are at risk. Law students must make cognitive wellness a priority by engaging in some of the recommended practices in this Article. This will require subordinating other activities in favor of exercise, more sleep, and contemplative practices. Going to the gym with classmates will provide long-lasting cognitive benefit. Taking a mindfulness or meditation seminar will activate the PNS and calm the amygdala. Replacing less healthful activities such as cocktail hour, playing video games, or watching television could yield the time law students and lawyers require to optimize cognitive performance.

Carnegie declared that the competitive learning environment and grade curve are obstacles to legal education reform,[324] and neuroscience reveals the impact of the hidden curriculum is likely brain damage to law students, resulting in obstacles to their learning.[325] Law practice stressors cause increased anxiety,

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321. SHENK, *supra* note 320, at 119.

322. *See id.*

323. HALLOWELL, *supra* note 38, at 31.

324. SULLIVAN ET AL., *supra* note 15, at 31.

325. *See* MEDINA, *supra* note 30, at 178; *see also* SULLIVAN ET AL., *supra* note 15, at 29-32.

depression, substance abuse, and suicide.[326] Law students, law faculty, and lawyers should be educated about mitigation of stress-related damage to the hippocampus, the role of sleep in memory formation, and enhancing PNS rest-and-digest function with contemplative practices.[327]

Cognitive wellness initiatives can improve neurobiological brain function and enhance PNS performance. Aerobic exercise and adequate sleep nourish and heal the brain,[328] and the PNS is augmented with mindfulness, meditation, yoga, relaxation, and gratitude practices. Law students, law professors, and lawyers cannot only manage their brains for personal and professional benefit, but also to enhance their impact on society.[329] Law schools and law firms can make the culture shift to supportive and democratized achievement cultures. This type of legal education innovation could result in high demand for law school admissions, similar to the desire for employment at workplaces that offer wellness perks. Neuroplasticity, the most promising of human features, allows every brain to become what is demanded of it.[330]

We are what we repeatedly do. Excellence, then, is not an act, but a habit.[331]
Aristotle

B. EXERCISE

Overworked lawyers make sacrifices to meet billable hour requirements, client needs, and court deadlines. Law students are no different. Most of them probably prefer to get exercise on a daily basis, but they may abandon their commitment to exercise under the strain of considerable reading and writing assignments, especially during their first year of law school. The

326. LITOWITZ, *supra* note 7, at 16-26; NERISON, *supra* note 9, at 15-39; LEVIT & LINDER, *supra* note 12, at 6-8.

327. *See* PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409; MEDINA, *supra* note 30, at 163, 179; NERISON, *supra* note 9, 154-55; PERLMUTTER & VILLOLDO, *supra* note 57, at 87.

328. *See* MEDINA, *supra* note 30, at 15, 159-63; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 15; RATEY, *supra* note 100, at 49-50.

329. *See* NIKOLAS ROSE & JOELLE M. ABI-RACHED, NEURO: THE NEW BRAIN SCIENCES AND THE MANAGEMENT OF THE MIND 22-23, 222 (2013).

330. SHENK, *supra* note 320, at 30.

331. *Aristotle*, BRAINYQUOTE, http://www.brainyquote.com/quotes/quotes/a/aristotle145967.html#RDF6OpSpxdEA47Mc.99 (last visited Jan. 29, 2014).

same may be true for law faculty juggling the responsibilities of teaching and scholarship. Exercise is the wrong activity to eliminate.

Research has shown exercise provides cognitive restoration in people of all ages, from children to the elderly.[332] Getting at least thirty minutes of aerobic exercise two or three times per week, plus some strength training, will provide a cognitive benefit to law students and lawyers.[333] In rodent studies, scientists have found that neurogenesis results in five thousand to ten thousand new neurons born in rat hippocampi every day.[334] Rats that spend time on a running wheel generate twice the new brain cells as those that are sedentary.[335]

A school district in a suburb of Chicago has been testing the academic benefits of aerobic exercise since the early 1990s.[336] Naperville District 203 has turned 19,000 students into some of the fittest and smartest in the United States with a fitness-oriented physical education (PE) program where students are assessed based on time spent with an increased heart rate.[337] The most compelling data from the program is from the 1999 Trends in International Mathematics and Science Study (TIMSS), designed to compare the science and math knowledge of students from different countries.[338] Typically about half the students from Asian countries, but only 7% of American students, score in the top tier.[339] However, approximately 97% of the Naperville 203 eighth-graders took the test, and on science they scored first, just ahead of Singapore.[340] On math, they scored sixth—behind Singapore, Korea, Taiwan, Hong Kong, and Japan.[341] All U.S. students combined ranked 18th in science and 19th in math.[342]

The Naperville program has influenced others through

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332. MEDINA, *supra* note 30, at 13-18; PERLMUTTER & VILLOLDO, *supra* note 57, at 148.
333. MEDINA, *supra* note 30, at 15.
334. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 15.
335. *Id.*; RATEY, *supra* note 100, at 49-50.
336. RATEY, *supra* note 100, at 9, 14-15.
337. *Id.* at 10-13.
338. *Id.* at 13.
339. *Id.*
340. *Id.* at 14.
341. RATEY, *supra* note 100, at 14.
342. *Id.*

PE4life, an organization that trains PE educators about the fitness-academic performance link.[343] A teacher in Titusville, Pennsylvania converted his PE program, and since 2000, the standardized test scores of Titusville students have gone from below state average to 17% above the average in reading and 18% above the average in math.[344] In 2001, the California Department of Education found that "fit kids scored twice as well on academic tests as their unfit peers."[345] In 2004, a multi-disciplinary panel of researchers reviewed more than 850 studies on the impact of physical activity on school kids that confirmed the academic benefits demonstrated by the California study and showed that exercise has a positive influence on memory and concentration.[346]

Exercise benefits the law student brain in three ways: it enhances blood and oxygen flow; it elevates the levels of key neurotransmitters; and it stimulates the production of brain cell building blocks such as Brain Derived Neurotropic Factor (BDNF).[347] Exercise prompts blood vessels to produce nitric oxide, which in turn improves blood flow deeper into body tissues.[348] The more exercise, the greater the benefits provided by the bloodstream.[349] This includes distribution of food and elimination of waste.[350] The entire body benefits from the improved functioning that increased blood flow renders.[351] In the brain, exercise increases blood volume in the dentate gyrus, a layer of the hippocampus.[352] The increase in blood flow helps to maintain the health and functioning of the hippocampus.[353]

Three powerful neurotransmitters are increased by exercise: serotonin, norepinephrine, and dopamine.[354] Serotonin

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343. RATEY, *supra* note 100, at 31.

344. *Id.* at 31-32.

345. *Id.* at 21.

346. *Id.* at 22.

347. AMEN, *supra* note 30, at 110; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 29; MEDINA, *supra* note 30, at 22; PERLMUTTER & VILLOLDO, *supra* note 57, at 87-97; RATEY, *supra* note 100, at 38.

348. MEDINA, *supra* note 30, at 21.

349. *Id.* at 21-22.

350. *Id.* at 22.

351. *Id.*

352. CARTER, THE HUMAN BRAIN, *supra* note 72, at 65; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 349; MEDINA, *supra* note 30, at 22.

353. MEDINA, *supra* note 30, at 22.

354. RATEY, *supra* note 100, at 37-38.

modulates brain activity and "influences mood, impulsivity, anger, and aggressiveness."[355] Norepinephrine amplifies brain signals that activate attention, motivation, and perception.[356] Dopamine increases reward and satisfaction and influences learning.[357] Exercise not only elevates the levels of these neurotransmitters, but also restores their delicate balance in the brain.[358]

BDNF is a protein that acts like a fertilizer for hippocampal neurons.[359] BDNF helps create new neurons, protects existing neurons, and encourages synapse formation—the connection between neurons vital for thinking and learning.[360] Exercise creates new brain cells and enhances the production of BDNF.[361] "When [the] brain doesn't create as many new cells as it loses, aging occurs."[362] The gene that turns on BDNF is activated by exercise,[363] calorie reduction, intellectual stimulation, curcumin, and the omega-3 fat known as docosahexaenoic acid (DHA).[364]

Lab rats that voluntarily choose to spend time on a running wheel produce significantly more BDNF than sedentary rats.[365] Researchers have shown a direct relationship between the elevated levels of BDNF in the fit rats and their ability to learn.[366] An examination of the impact of exercise on human cognition shows results similar to the rodent studies. A study on elderly individuals who exercised twenty minutes per day for twenty-four weeks showed a 1,800% improvement in attention, language ability, and memory compared to the control group.[367]

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355. RATEY, *supra* note 100, at 37.

356. *Id.*

357. *Id.* at 38.

358. *Id.*

359. AMEN, *supra* note 30, at 110; MEDINA, *supra* note 30, at 22.

360. AAMODT & WANG, *supra* note 30, at 89; DEEPAK CHOPRA & RUDOLPH E. TANZI, SUPER BRAIN: UNLEASHING THE EXPLOSIVE POWER OF YOUR MIND TO MAXIMIZE HEALTH, HAPPINESS, AND SPIRITUAL WELL-BEING 35 (2012); PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1202-03; PERLMUTTER & VILLOLDO, *supra* note 57, at 87.

361. AMEN, *supra* note 30, at 110; PERLMUTTER & VILLOLDO, *supra* note 57, at 88.

362. AMEN, *supra* note 30, at 110.

363. DOIDGE, *supra* note 30, at 254-55; MEDINA, *supra* note 30, at 22; PERLMUTTER & VILLOLDO, *supra* note 57, at 88-89.

364. PERLMUTTER & VILLOLDO, *supra* note 57, at 88-97.

365. *Id.* at 88; RATEY, *supra* note 100, at 44-45.

366. *See* citations *supra* note 365.

367. PERLMUTTER & VILLOLDO, *supra* note 57, at 88.

A large study of elderly women demonstrated exercise lowered the risk of cognitive impairment by about 20%.[368] BDNF also improves the rate of learning.[369] In 2007, German researchers discovered that people learned vocabulary words 20% faster after exercise than before and that the rate of learning correlated directly with BDNF levels in the brains of the subjects.[370]

BDNF encourages neurogenesis, neuroplasticity, and protects neurons from trauma and environmental toxins.[371] In addition to exercise, there are two dietary elements that enhance BDNF production: curcumin and DHA.[372] Curcumin, the active ingredient in the spice turmeric, activates a genetic switch that turns on the genes that produce antioxidants and increase BDNF production.[373] In India, where turmeric is used in curry, the incidence of Alzheimer's disease is only about 25% as common as in the United States.[374] "Inflammation is responsible for a number of brain [diseases], including Alzheimer's, Parkinson's, attention deficit hyperactivity disorder (ADHD), and multiple sclerosis."[375] DHA is a brain fat responsible for aiding synaptic connection, regulating inflammation, and enhancing gene expression for the production of BDNF.[376]

Learning requires strengthening of the affinity between neurons through repeated activation.[377] The presence of BDNF at the synapse enhances long-term potentiation (LTP), the process that is required to store memories.[378] BDNF, the key link between movement and learning, is crucial for maximizing law student and lawyer cognition.[379]

Three other hormones work closely with BDNF to build and maintain brain cell circuitry: IGF-1 (insulin-like growth factor); VEGF (vascular endothelial growth factor); and FGF-2 (fibroblast

368. PERLMUTTER & VILLOLDO, *supra* note 57, at 89.
369. RATEY, *supra* note 100, at 45.
370. *Id.*
371. PERLMUTTER & VILLOLDO, *supra* note 57, at 95.
372. *Id.* at 93-95.
373. *Id.* at 93.
374. *Id.*
375. *Id.* at 94.
376. PERLMUTTER & VILLOLDO, *supra* note 57, at 94.
377. RATEY, *supra* note 100, at 39.
378. *See id.*
379. *Id.* at 40-43.

growth factor).[380] During exercise, BDNF helps the brain increase the uptake of IGF-1, which activates the production of glutamate and encourages new BDNF receptors, which supports long-term memory formation.[381] VEGF builds capillaries in the body and brain, and FGF-2 helps tissue growth and aids long-term potentiation.[382] Aging, stress, and depression cause a drop in the three growth factors and BDNF, but activity increases them and enhances neurogenesis at the same time.[383] A lifestyle that includes regular exercise will encourage production of BDNF and these important growth factors and provide a powerful boost to the brains of law students and lawyers.[384]

Exercise also has a unique capacity to engage the law student SNS and improve the connectome. The SNS is activated by aerobic activity when breathing becomes more rapid and heart rate increases.[385] Instead of fueling the SNS fight-or-flight response, exercise beneficially retools the law student brain by creating neural networks that produce BDNF and growth factors, as well as by increasing key neurotransmitters: serotonin, norepinephrine, dopamine, and GABA.[386]

In addition to the brain benefits of aerobic exercise, scientists are just starting to investigate the role of complex motor movements that involve skill building.[387] The cerebellum in the primitive brain coordinates motor movement, and the neurons connecting the cerebellum to the thinking brain are "proportionally thicker in humans than in monkeys."[388] One study compared running rats with rats that were taught complex motor skills such as walking on balance beams and rope ladders.[389] After two weeks, "the acrobatic rats had a 35 percent increase of BDNF in the cerebellum," while the running rats had none in that brain region.[390]

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380. RATEY, *supra* note 100, at 51.
381. *Id.* at 52.
382. *Id.*
383. *Id.* at 53.
384. PERLMUTTER & VILLOLDO, *supra* note 57, at 89; RATEY, *supra* note 100, at 72-73.
385. RATEY, *supra* note 100, at 107.
386. *Id.* at 37, 107.
387. *Id.* at 246-47.
388. *Id.* at 41.
389. *Id.* at 55.
390. RATEY, *supra* note 100, at 55.

While aerobic exercise increases and balances neurotransmitters, creates new blood vessels that elevate growth factors, and generates and strengthens new neurons in the hippocampus, complex movement strengthens and expands neural networks.[391] Even though these networks are created by movement, they can be coopted for cognition.[392] Practicing complex motor skills with activities such as tennis, dance, martial arts, and yoga also thicken the myelin protecting the neurons and ramping up the speed and quality of the signals in the connectome.[393] For law students and lawyers, the most effective cognitive fitness plan should include activities that require complex physical skill building.[394]

When creating a plan to optimize brain function, each law student and lawyer must decide how much exercise to incorporate into their daily regimen. Research shows that the more fit the body, the greater brain resilience and cognitive and psychological function.[395] A normal body mass index (BMI) and a robust cardiovascular system is a great start.[396] The National Heart, Blood, and Lung Institute website has a BMI calculator that can assist in evaluating individual fitness.[397] Our genes are coded for consistent activity from a time when we had to spend most of our time foraging or hunting for food.[398] To fully engage our endurance metabolism, law students and lawyers should find time to participate in low or moderate-intensity activity every day and high-intensity activity a couple of times per week.[399]

C. SLEEP

Law students, law faculty, and lawyers require adequate and restful sleep to maximize their cognitive capacity. In addition to exercise, improving sleep is an important strategy for enhancing

391. RATEY, *supra* note 100, at 55-56.

392. *Id.* at 56.

393. *Id.*

394. *See id.*

395. *See id.* at 245-51.

396. RATEY, *supra* note 100, at 247.

397. *See Calculate Your Body Mass Index*, NAT'L INST. OF HEALTH, http://www.nhlbi.nih.gov/guidelines/obesity/BMI/bmicalc.htm (last visited Dec. 23, 2013).

398. RATEY, *supra* note 100, at 248.

399. *See id.* at 248-49.

the brain's learning potential and mind-body connection.[400] Sufficient sleep is critical for memory consolidation.[401]

Sleep occurs in cycles in which the brain transitions through five different stages of sleep.[402] When falling asleep, law students surrender a state of conscious awareness to Stage 1 light sleep.[403] During Stage 2, brain waves slow, while Stage 3 is a mix of fast and slow brain waves.[404] The body reaches Stage 4, which is slow brain waves, and then reverses the cycle through sleep Stages 3, 2, and 1.[405] After this initial pattern, the brain enters its first Stage 5 REM sleep, which takes ninety minutes to two hours.[406] After completing two full cycles, the brain only returns to Stage 3 for the third cycle and Stage 2 for the 4th cycle before entering into REM sleep.[407] People who manage to get the recommended eight hours of sleep have the benefit of four REM sleep cycles.[408] Adults spend about 50% of their sleep in Stage 2 and about 30% in Stage 5 REM sleep.[409] An infant spends about 50% of his sleep in Stage 5 REM sleep.[410]

The hippocampus and the amygdala are among the most active parts of the brain during REM sleep.[411] Communication between neurons happens at rates that are equal to or higher than when the brain is awake.[412] Bruce McNaughton tracked the activity of hippocampal neurons in rats while learning "new explicit information."[413] The patterns of activation in specific neurons that were very active during the learning were repeated when the rat was sleeping, indicating memory consolidation of

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400. TOKUHAMA-ESPINOSA, *supra* note 35, at 219.

401. *Id.* at 26, 123; DEVI, *supra* note 237, at 165-66.

402. CARTER, THE HUMAN BRAIN, *supra* note 72, at 184; SWEENEY, *supra* note 74, at 188-89.

403. *See* citations *supra* note 402.

404. *See* citations *supra* note 402.

405. CARTER, THE HUMAN BRAIN, *supra* note 72, at 184; SWEENEY, *supra* note 74, at 188.

406. *See* citations *supra* note 402.

407. CARTER, THE HUMAN BRAIN, *supra* note 72, at 184; SWEENEY, *supra* note 74, at 189.

408. *See* citations *supra* note 407.

409. SWEENEY, *supra* note 74, at 188.

410. *Id.*

411. CARTER, THE HUMAN BRAIN, *supra* note 72, at 185; *see* SAPOLSKY, *supra* note 217, at 229.

412. HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 158-59.

413. SAPOLSKY, *supra* note 217, at 232.

the new information.[414] Brain imaging studies in humans have shown similar hippocampal activity and have demonstrated that during REM sleep, memory consolidation genes that help form new connections between neurons are activated.[415] Law students need sufficient time in REM sleep to consolidate the material they are learning in the law classes.

Stage 5 REM sleep is believed by scientists to play a key role in memory consolidation, in part because of a study where human subjects who were routinely awakened during REM sleep lost their ability to learn new information.[416] A sleep deprivation study on military subjects demonstrated that a loss of one night's sleep resulted in about a 30% loss in cognitive skill, and a loss of two night's sleep amounted to a 60% cognitive decline.[417] Regularly shortchanging sleep is equally damaging. A study showed that sleeping less than six hours each night, for a span of five nights, resulted in a diminished cognitive performance similar to missing two continuous nights of sleep.[418] Law students who short-change sleep in favor of studying will likely perform less effectively than law students who get sufficient sleep before taking exams.

Temporary cognitive loss is not the only damage sleep deprivation causes; the aging process is accelerated as well.[419] Sleep deprivation also impairs the ability to utilize the fuel that food provides,[420] while stress hormones become increasingly deregulated, compromising allostatic balance.[421] One study limited thirty-year-old subjects to only four hours of sleep per night for six nights, and their body chemistry began to operate with the reduced function of a sixty-year-old.[422] It took almost a week for subjects to return to normal thirty-year-old allostatic equilibrium.[423] Chronically elevated stress hormones caused by sleep deprivation are also responsible for increased appetite and diminished control over healthy blood-sugar levels, creating a

414. SAPOLSKY, *supra* note 217, at 232.
415. *Id.*
416. *Id.* at 227, 231; SWEENEY, *supra* note 74, at 192.
417. MEDINA, *supra* note 30, at 162.
418. *Id.*
419. *Id.*
420. *Id.*
421. *Id.* at 162.
422. MEDINA, *supra* note 30, at 162-63.
423. *Id.*

higher risk of diabetes and obesity.[424] Adequate sleep is the way lawyers and law professors can avoid this kind of cognitive aging.

Sleep patterns are controlled by the allostatic regulation system known as circadian rhythm.[425] The circadian arousal system (Process C), a group of neurons, hormones, and chemicals, works to keep the body awake.[426] The homeostatic sleep drive (Process S), different neurons, hormones, and chemicals, puts the body to sleep.[427] Process C maintains active consciousness for about sixteen hours, when the body begins to give way to Process S to fall asleep.[428]

About 10% of humans are early chronotypes, larks who are most productive early in the day and who want to go to bed around 9 PM.[429] Approximately 20% are late chronotypes, owls who are most alert late in the day and rarely want to retire before 3 AM.[430] The other 70% of the population are hummingbirds who operate somewhere in the middle, with some sleeping more like larks and some more like owls.[431] Processes C and S flat-line in the afternoon, causing a desire to nap.[432] While some people crave a siesta more than others, studies have shown that a twenty-six minute nap improved NASA pilot performance by 34% and a forty-five minute nap improved cognition for at least six hours.[433]

Because sleep deprivation causes loss in cognitive skill—diminished attention, working memory capacity, executive function, quantitative skills, logical reasoning ability, mood, and both fine and gross motor control—law students, law professors, and lawyers should make adequate regular sleep a priority.[434]

D. CONTEMPLATIVE PRACTICES

Incorporating a contemplative practice into a cognitive

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424. TALBOTT, *supra* note 265, at 248.
425. SWEENEY, *supra* note 74, at 176; MEDINA, *supra* note 30, at 155.
426. MEDINA, *supra* note 30, at 155.
427. *Id.*
428. *Id.* at 155-56.
429. *Id.* at 157.
430. *Id.*
431. MEDINA, *supra* note 30, at 157.
432. *Id.* at 159-60.
433. *Id.* at 159.
434. *See id.* at 162.

wellness regimen strengthens the PNS rest-and-digest system and enables law students and lawyers to induce calm on demand.[435] Common contemplative practices include mindfulness, meditation, yoga, relaxation, and gratitude. Harvard physician Herbert Benson studied the effects of meditation, yoga, and other contemplative practices and found that they allowed practitioners to cut their heart and respiratory rates, reduce oxygen consumption, and lower high blood pressure.[436] Benson's 1975 book, *The Relaxation Response*, became a classic on dealing with stress.[437] The goal of contemplative practice is to become an "amygdala whisperer."[438]

1. MINDFULNESS

The best cognitive approach to dealing with stress is mindfulness.[439] Research on mindfulness indicates that it:

- strengthens the insula in the thinking brain (the early detection system of well-being);
- increases gray matter and connections between brain regions;
- improves immune function;
- decreases distraction; and
- equips the brain to notice patterns and events before responses become overly-reactive.[440]

Although mindfulness has its roots in a spiritual practice, originating from the experiences and teachings of Buddha, modern Western mindfulness practice is a secular endeavor.[441] Buddha, the original amygdala whisperer, was trying to fully

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435. *See* AMEN, *supra* note 30, at 167.

436. BROAD, *supra* note 284, at 95-96.

437. *Id.* at 95.

438. TAYLOR CLARK, NERVE: POISE UNDER PRESSURE, SERENITY UNDER STRESS, AND THE BRAVE NEW SCIENCE OF FEAR AND COOL 81 (2011).

439. *Id.* at 78.

440. DEVI, *supra* note 237, at 143; GRAHAM, *supra* note 241, at 256; SCOTT L. ROGERS & JAN L. JACOBOWITZ, MINDFULNESS & PROFESSIONAL RESPONSIBILITY: A GUIDE BOOK FOR INTEGRATING MINDFULNESS INTO THE LAW SCHOOL CURRICULUM 22-23 (2012).

441. *See* CLARK, *supra* note 438, at 80; ROGERS & JACOBOWITZ, *supra* note 440, at 19.

experience the world.[442] He fled his home in search of himself, and he realized his mind scurried like a monkey, where his darting thoughts were the branches of trees his mind would grasp and release.[443] Buddha learned to distance himself from his "monkey mind" and enter a state of non-judgmental awareness.[444]

Secular mindfulness is attention without labels, ideas, thoughts, or opinions.[445] Mindfulness means "being fully aware of something" and paying attention to the moment, with acceptance and without judgment or resistance.[446] It requires "emotion-introspection rather than cognitive self-reflection," and specifically does not involve the analysis of thoughts or feelings.[447] Mindfulness is a form of self-understanding involving self-awareness rather than thinking.[448] Law students and lawyers may become amygdala whisperers by becoming mindful.[449]

An elegant application of expert mindfulness involves being able to "just drive" after another driver cuts you off.[450] If you are able to "just drive" after the SNS lights up when you are startled by a distracted or aggressive driver, you feel the steering wheel, hear the engine, see the road ahead, and hold your focus on your destination.[451] You remain calm and your senses are focused on driving, rather than resenting the anonymous driver.[452] When faced with law school stress, "just drive" is also an effective mantra and reminder for law student mindfulness.

Mindfulness improves information processing and decision-making.[453] It provides space between awareness, and judgments

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442. CLARK, *supra* note 438, at 81.

443. *Id.* at 79-80.

444. *Id.* at 80.

445. *Id.*

446. GRAHAM, *supra* note 241, at 52; HANSON, *supra* note 50, at 83; SRINIVASAN S. PILLAY, YOUR BRAIN AND BUSINESS: THE NEUROSCIENCE OF GREAT LEADERS 48 (2011).

447. PILLAY *supra* note 446, at 48-49.

448. *Id.* at 50.

449. *See* CLARK, *supra* note 438, at 157, 275.

450. JULIAN FORD & JON WORTMANN, HIJACKED BY YOUR BRAIN: HOW TO FREE YOURSELF WHEN STRESS TAKES OVER 80-81 (2013).

451. *Id.* at 81.

452. *Id.*

453. PILLAY, *supra* note 446, at 50.

and reactions, which may encourage the onset of flow.[454] Flow is a term coined by psychologist Mihaly Csikszentmihalyi to describe the state of effortless concentration when humans are so engaged in a task they lose track of time.[455]

Being mindful allows you to have control over your attention so that you can place it where you want and shift it to something else when you want to.[456] When attention is steady, it cannot be appropriated by whatever intrudes on awareness, but remains grounded and stable.[457] Developing greater control over attention is a powerful way for law students and lawyers to sculpt their brains.[458]

One of the most supportive achievement workplace cultures can be found at Google. The master of ceremonies, and developer of Google's Search Inside Yourself (SIY) emotional intelligence curriculum, is Chade-Meng Tan.[459] The benefits of developing emotional intelligence competence include strong work performance, excellent leadership skills, and the capacity for sustainable happiness.[460] Happiness as defined by Matthieu Ricard, is an optimal state of flourishing resulting from an "exceptionally healthy mind."[461]

The SIY curriculum is comprised of three components:

- Attention training;
- Self-knowledge and self-mastery; and
- Creating useful mental habits.[462]

Attention training can improve law student amygdala regulation.[463] Both mindfulness and meditation improve attention.[464] A practitioner of mindfulness places attention on

454. GRAHAM, *supra* note 241, at 59-60.
455. DANIEL KAHNEMAN, THINKING FAST AND SLOW 40 (2011).
456. HANSON, *supra* note 50, at 177.
457. *Id.*
458. *Id.*
459. *See* TAN, *supra* note 319, at 3.
460. *Id.* at 12-16.
461. *Id.* at 15.
462. *Id.* at 7.
463. *Id.* at 20-21.
464. HANSON, *supra* note 50, at 177.

the present moment without judgment.[465] A meditator focuses mindful attention on breathing.[466] Research has shown that when expert meditators were subjected to negative sounds, they showed less activation of the amygdala than novice meditators.[467] Attention training at Google begins with mindfulness.[468] Tan describes two levels of mindfulness: the Easy Way (bring gentle and consistent attention to your breath for two minutes, and when your attention wanders, bring it back) and the Easier Way (sit without an agenda for two minutes, shifting from doing to being).[469] This mindfulness practice develops an appreciation for each moment in a law student's life.[470]

Breathing is a core practice in meditation and yoga—practiced for over 3,500 years—that activates the calming PNS.[471] This involves being aware of inhalation, exhalation, the rise and fall of the belly, and the return of attention when it wanders.[472] The objective is to stay with the sensations of each breath from beginning to end.[473] Sustaining attention to breathing is challenging, but meditation can increase concentration and insight in practitioners.[474]

Google's Tan describes meditation as mental training that can bring law students to a state where the mind is both relaxed and alert at the same time.[475] Meditation also trains meta-attention, the ability to know when attention has wandered.[476] Meditation is training for the mind to enhance mental abilities such as attention and perception.[477] Like weight training, growth in meditation comes from resistance.[478] When your mind wanders and you bring it back, your attention grows stronger.[479]

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465. HANSON, *supra* note 50, at 83.

466. *Id.* at 86-87.

467. TAN, *supra* note 319, at 20-21; PILLAY, *supra* note 446, at 112.

468. TAN, *supra* note 319, at 25.

469. *Id.* at 26-27.

470. *Id.* at 27.

471. GRAHAM, *supra* note 241, at 215; DEVI, *supra* note 237, at 64-65.

472. ROGERS & JACOBOWITZ, *supra* note 440, at 17.

473. HANSON, *supra* note 50, at 87.

474. ROGERS & JACOBOWITZ, *supra* note 440, at 17-18; HANSON, *supra* note 50, at 191-93.

475. TAN, *supra* note 319, at 30-31.

476. *Id.*

477. *Id.* at 33-35.

478. *Id.* at 34.

479. *Id.* at 35.

The lesson: "[T]here is no such thing as a bad meditation."[480]

2. MEDITATION

Meditation stimulates the PNS and dampens the SNS/HPAA stress response.[481] Research indicates that regular meditation practice:

- Increases gray matter in the thinking brain (prefrontal cortex, insula) and emotional brain (hippocampus);
- Expands the power of brain waves produced by large numbers of neurons firing together;
- Reduces prefrontal cortical thinning due to aging;
- Improves psychological functions such as attention, compassion, and empathy;
- Increases left frontal lobe activation, improving mood;
- Strengthens the immune system;
- Improves cardiovascular disease, asthma, type II diabetes, PMS, chronic pain, insomnia, anxiety, phobias, and eating disorders; and
- Decreases stress-related cortisol.[482]

The insula is a region in the thinking brain that is active when law students feel unwell, whether from physical illness or psychological angst.[483] The insula sends preconscious signals of the state of well-being, much like the amygdala is the quick assessor of danger and the trigger of the SNS/HPAA stress response.[484] The insula is also active during complex positive emotions, such as joy and feelings of compassion and pride, and this type of beneficial insula activation is enhanced by mediation.[485]

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480. TAN, *supra* note 319, at 35.

481. HANSON, *supra* note 50, at 85; *see* DEVI, *supra* note 237, at 64; AMEN, *supra* note 30, at 167, 174.

482. AAMODT & WANG, *supra* note 30, at 186; AMEN, *supra* note 30, at 224; HANSON, *supra* note 50, at 85-86; TAN, *supra* note 319, at 49.

483. DEVI, *supra* note 237, at 141-42.

484. *Id.* at 143; *see supra* notes 273-74 and accompanying text.

485. DEVI, *supra* note 237, at 142-43.

The brains of domain experts[486] differ from the brains of novices, and expert brains show greater focus, attention, and neural efficiency.[487] Meditators also have these strengths.[488] Serial tasking is the ability to sit still and focus on just one thing.[489] A serial tasker is present in the moment, can listen actively to others, can work in the flow zone to accomplish tasks, and can ignore the false sense of urgency that multi-tasking can create.[490] "Experienced meditators are [effective] serial taskers."[491] The ability to serial task provides focus for law studies and enhanced concentration for law practice.

The first major study of meditation in a business setting was conducted by Richard Davidson and Jon Kabat-Zinn, pioneers in contemplative neuroscience.[492] The research showed that after eight weeks of meditation, the participants showed decreased anxiety, increased brain activity associated with positive emotions, and an increased immune response to a flu shot.[493]

Chade-Meng Tan argues that meditation must become widely accessible to average people, and he points to the success of exercise as a model.[494] Researchers in 1927 demonstrated that a fit individual was physiologically different from someone who was unfit.[495] This started an exercise revolution with four results: everyone now knows that exercise is good for you; anyone who wants to exercise can learn how to; workplaces understand that healthy employees are good for business; and exercise is so aligned with modern life, it is taken for granted.[496] Tan wants to see meditation treated like exercise where everyone understands that meditation is good for them; anyone who wants to meditate can learn to meditate; workplaces understand that meditation is good for business, and some workplaces support it; and

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486. Domain experts possess domain knowledge, specialized skills, and unique vocabulary that they use to solve problems in their field of expertise. SHAFFER, *supra* note 26, at 58-61.

487. PILLAY, *supra* note 446, at 112.

488. *Id.*

489. DEVI, *supra* note 237, at 123-24.

490. *Id.*

491. *Id.* at 123.

492. TAN, *supra* note 319, at 47.

493. *Id.*

494. *Id.* at 232-33.

495. *Id.* at 233.

496. *Id.* at 233-34.

meditation is aligned with modern life and taken for granted.[497]

The neuroscience of cognitive fitness should be widely available to law students, law professors, and lawyers. Legal professionals need to understand that a cognitive wellness regimen is good for them, and they should know how to achieve cognitive fitness. Law schools and firms must understand that cognitive fitness is good for performance, and that cognitive wellness practices are aligned with legal education and law practice.

3. YOGA

Research has established that the dominant characteristic of yoga is that "it can slow the mind, body, and overall metabolism to foster tranquility."[498] Yoga has developed a "global following" because it is so effective at reversing stress.[499] This is because yoga has the power to provide the law student or lawyer practitioner with greater control over the PNS. [500]

The first studies were conducted on advanced yogis beginning in the 1940s.[501] Researchers discovered that these experienced practitioners could slow their respiration, heart rate, and metabolism.[502] One Indian yogi, Swami Rama, could change the temperature across the length of his hand up to eleven degrees using advanced PNS control.[503]

Recent studies have been focused on the benefits yoga provides to less-experienced practitioners. In 2006, an Indian physiologist studied more than 100 men and women whose average age was thirty-three and who practiced yoga for six months.[504] She found that the subjects were able to cut their basal metabolic rate, the energy spent on bodily housekeeping, by an average of 13%.[505] The study also showed conspicuous

497. TAN, *supra* note 319, at 234.

498. BROAD, *supra* note 284, at 157-58 (emphasis omitted).

499. *Id.* at 158; AMEN, *supra* note 30, at 226.

500. BROAD, *supra* note 284, at 89; DEVI, *supra* note 237, at 56-57; HANSON, *supra* note 50, at 82-83.

501. *See* BROAD, *supra* note 284, at 89.

502. *Id.* at 89-90, 96-97.

503. *Id.* at 90.

504. *Id.* at 96.

505. *Id.*

differences in benefits by gender.[506] The men cut their resting energy by 8%, but the women attained reductions of 18%, more than double the metabolic drop of the men.[507]

Other studies have examined the presence in yogis of the GABA neurotransmitter, responsible for inhibiting neurons, producing calm, and reducing anxiety.[508] In 2007, the subjects were mostly single females with an average age of twenty-six who practice yoga at least twice per week from two to ten years.[509] These eight yoga practitioners increased their GABA neurotransmitter 27% after sixty minutes of yoga.[510] The most experienced yogis and those who practiced most had the most dramatic increases in GABA.[511] The yogi who had a decade of yoga experience had a GABA increase of 47%, and the yogi who practiced five times a week had a GABA increase of 80%.[512] In 2010, these researchers studied new yogis and found that nineteen subjects that had just started yoga raised their GABA levels 13% after only three months.[513] The study also showed that the subjects had decreased anxiety and improved moods.[514] Because depression is linked to low GABA levels and yoga increases GABA, enhances mood, and reduces anxiety, it appears to have particular promise for lawyers and law students who suffer from anxiety, depression, or both.[515]

Mel Robin, author of *A Physiological Handbook for Teachers of Yogasana*, teaches that yoga engages both the PNS and the SNS.[516] Some poses light up the SNS (headstands) and some cool the PNS (shoulder stands).[517] Activities that increase the respiration rate engage the SNS.[518] Robin believes that the most effective yoga practices cycle through poses that activate both the SNS and PNS because they give the autonomic system a

506. BROAD, *supra* note 284, at 96.
507. *Id.*
508. *Id.* at 99.
509. *Id.* at 99-100.
510. RATEY, *supra* note 100, at 259; BROAD, *supra* note 284, at 99-100.
511. BROAD, *supra* note 284, at 100.
512. *Id.*
513. *Id.*
514. *Id.*
515. *Id.* at 98-100.
516. BROAD, *supra* note 284, at 91-95.
517. *Id.* at 91.
518. *Id.* at 94.

thorough workout and result in energetic flexibility, inner balance, and harmony.[519] He also states that any kind of muscle work or exercise will excite the SNS, which gives yoga and aerobic exercise something in common—the ability to engage the SNS in a beneficial way.[520]

Yoga and aerobic exercise are uniquely suited to engage the law student SNS and train the brain that signs of the fight-or-flight stress response—increased respiration and heart rate—can mean better health, increased resilience, self-mastery, and more brain power.[521] Even though these brain circuits are created by movement, they can be recruited for cognition.[522] The law student's thinking brain can co-opt parts of the connectome built by physical activity and use it for law school learning.[523]

4. RELAXATION

Being able to activate the PNS on demand is critical to law student neural enhancement. Two simple practices are relaxation and gratitude. Relaxed muscles send feedback to the emotional brain, curbing SNS arousal.[524] These relaxation techniques can be done by law students covertly in the presence of others when stress could stimulate the SNS:

- Touch your lips (stimulates plentiful parasympathetic fibers);
- Relax your jaws and tongue;
- Bring mindful attention to tense muscles and relax them;
- Exhale slowly—the PNS is in charge of exhalation, so inhale deeply and hold for a few seconds, then slowly exhale;
- Breathe deeply—place your hand on your stomach and breathe in deeply for three to five beats, then slowly exhale for three to five beats (engages

519. BROAD, *supra* note 284, at 95.
520. *Id.* at 93-94; RATEY, *supra* note 100, at 55-56.
521. BROAD, *supra* note 284, at 93-94; RATEY, *supra* note 100, at 55-56, 107-08.
522. RATEY, *supra* note 100, at 55-56.
523. *See id.*
524. HANSON, *supra* note 50, at 80.

diaphragm and slows heart rate); or

- Replay a mental movie—bring to mind a peaceful image or activity to activate the right hemisphere and quiet self-talk.[525]

5. GRATITUDE

Another way for the law student to cultivate the PNS is to internalize the positive.[526] Cultivating a sense of appreciation enhances the impact of pleasant experiences.[527] When law students practice mindful awareness of positive events, they train their neural networks to savor them. Noticing the rewarding aspects of any environment and expressing gratitude can rewire the connectome toward a positive bias. Focusing on the reward also increases the release of dopamine.[528]

A gratitude journal is a place to note things law students are thankful for or acknowledge people who have been of assistance to them. In more than 100 studies, researchers have found that people who maintain a daily gratitude practice experience more positive emotions, accomplish more personal goals, sleep better, have lower blood pressure, live an average of seven to nine years longer, and feel more alert, enthusiastic, and energetic.[529]

E. IMPROVING ANXIETY OR DEPRESSION

Law students who enter law school with anxiety or depression should continue treatment for these conditions. Law students, law professors, or lawyers who become anxious or depressed should seek treatment without delay.

"[A]ntidepressants, including the selective serotonin reuptake inhibitors [SSRIs], increase the rate of neurogenesis."[530] Serotonin is a neurotransmitter that enhances mood and sleep and minimizes anxiety.[531] SSRIs work by blocking the reuptake of serotonin distributed into the synapse, allowing it to remain

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525. HANSON, *supra* note 50, at 80-84.

526. *Id.* at 68-69.

527. *Id.* at 68-70.

528. *Id.* at 69.

529. GRAHAM, *supra* note 241, at 274.

530. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

531. CARTER, MAPPING THE MIND, *supra* note 30, at 28; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 8; SWEENEY, *supra* note 74, at 15.

elevated.[532] "[T]he strength of any signal sent using serotonin is reinforced."[533] Getting treatment for anxiety and depression can reduce stress and reverse hippocampal atrophy.[534]

Research has shown that aerobic exercise and yoga can improve law student and lawyer anxiety and depression.[535] Aerobic exercise increases BDNF and growth factor production in the brain.[536] These neurochemicals spawn new brain cells, repair neural networks, keep cortisol in check, and balance the regulatory neurotransmitters serotonin, norepinephrine, and dopamine.[537]

Exercise triggers the release of GABA, the law student brain's main inhibitory neurotransmitter and primary target for antianxiety medications.[538] Yoga also increases GABA production.[539] In the brain, "[a]nxiety is fear," which is "the memory of danger" (being yelled at by a cranky judge).[540] Anxiety disorders cause the brain to continuously relive that memory, creating a constant fear condition (anxiety about appearing in court).[541] Normal levels of GABA help to interrupt the anxiety feedback loop in the brain.[542] MRI scans of people with anxiety disorders show that their brains cannot distinguish between danger and non-threatening situations.[543] There is a problem in the learning circuits and researchers believe that exercise improves anxiety disorders by increasing BDNF, GABA, and serotonin in the brain.[544]

While antianxiety medication will improve anxiety, combining exercise with medication helps law students learn a different response to fear.[545] Exercise works on both body and

532. Oliver R. Goodenough & Micaela Tucker, *Neuroscience Basics for Lawyers*, 62 MERCER L. REV. 945, 952 (2011); SWEENEY, *supra* note 74, at 233.

533. Goodenough & Tucker, *supra* note 532; SWEENEY, *supra* note 74, at 233.

534. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

535. *See* BROAD, *supra* note 284, at 98-100; RATEY, *supra* note 100, at 106-08.

536. RATEY, *supra* note 100, at 78.

537. *Id.* at 78-79.

538. *Id.* at 92.

539. *See* BROAD, *supra* note 284, at 98-100.

540. RATEY, *supra* note 100, at 93.

541. *Id.*

542. *Id.* at 92.

543. *Id.* at 94-95.

544. *Id.* at 95.

545. *See* RATEY, *supra* note 100, at 108.

brain to:

- Provide a distraction and put the mind elsewhere;
- Reduce muscle tension;
- Build brain resources by increasing BDNF, growth factors, serotonin, norepinephrine, and GABA;
- Improve resilience through self-mastery by preventing anxiety, panic attacks, and depression; and
- Reroute SNS neural circuitry by teaching the brain to associate physical sensations common to anxiety and exercise—increased heart rate and breathing—with something positive.[546]

Approximately 17% of American adults experience depression and about 74% of these people also experience another disorder such as anxiety or substance abuse.[547] Lawyers suffer from major depression at more than triple the rates of non-lawyers.[548] Depression research is largely responsible for the discoveries of the impacts of exercise on the brain.[549] The process of reverse engineering accidental antidepressants, drugs designed to treat other illnesses that had a positive effect on depression, led to the revelation that these medicines increase norepinephrine, dopamine, and serotonin.[550]

Several sweeping studies of Americans, Dutch, and Finnish participants have shown that exercisers are less depressed, anxious, stressed, angry, and neurotic, but more socially outgoing.[551] In 1999, researchers at Duke University conducted a sixteen-week study of exercise and the SSRI sertraline (Zoloft).[552] They divided 156 patients into three groups: medication only, exercise only, and a combination of medication and exercise.[553] The exercisers walked or jogged three times a week at 70–85% of

546. *See* RATEY, *supra* note 100, at 106-08.
547. *Id.* at 114.
548. LEVIT & LINDER, *supra* note 12, at 6.
549. RATEY, *supra* note 100, at 114.
550. *Id.* at 113-15.
551. *Id.* at 19.
552. *Id.* at 122.
553. *Id.*

their aerobic capacity for thirty minutes, plus fifteen minutes for warm-up and cool-down.[554] Researchers concluded that exercise was as effective as medication and more effective over the long term.[555] Six months after the study, about 30% of the exercise group remained depressed versus 52% of the medication group.[556]

The most significant predictor of whether a person felt better was how much he or she exercised. Every fifty minutes of weekly exercise correlated to a 50% drop in depression.[557] In 2006, a small study of eight deeply depressed patients who did not respond to antidepressants showed that where medication does not work, exercise does.[558] The participants lowered their score on a common depression test by 10.4 points on a seventeen-point scale, and five of the eight achieved full remission.[559] In Great Britain, exercise is an immediate treatment recommendation for depressed patients, but in the United States it remains underutilized even though depression is the leading cause of disability in the U.S. and Canada, ahead of heart disease, cancer, and AIDS.[560]

As previously noted, MRI technology has allowed researchers to discover that people with depression have smaller hippocampi than control participants.[561] High levels of the stress hormone cortisol kill neurons in the hippocampus, which may explain why so many people with depression suffer from learning and memory problems.[562] Research demonstrates that when chronically stressed rats are exercised, their shrunken hippocampi grow back to a normal state.[563]

Exercise and antidepressants boost BDNF production and heal the hippocampus; thus law students and lawyers suffering from depression should add exercise to their other treatment.[564] Yoga increases GABA, a neurotransmitter depleted in depressed

554. RATEY, *supra* note 100, at 122.
555. *Id.* at 122-24.
556. *Id.* at 123-24.
557. *Id.* at 124.
558. *Id.* at 125-26.
559. RATEY, *supra* note 100, at 125-26.
560. *Id.* at 114.
561. *Id.* at 128.
562. *Id.*
563. *Id.* at 79.
564. RATEY, *supra* note 100, at 78-79, 130.

individuals, and so yoga is another treatment enhancement option.[565] Because lawyers are at a high risk for depression, exercise and yoga are even more important for prevention.[566]

VI. CONCLUSION

As an irrigator guides water to his fields,
as an archer aims an arrow,
as a carpenter carves wood, the wise shape their lives.[567]
Buddha

Professor Robin Wellford Slocum argues that law schools need to provide law students with an understanding of the emotional brain so that as lawyers, they may better serve their clients.[568] She puts forth a framework of four domains of emotional intelligence necessary for a lawyer to achieve emotional competence: self-awareness, self-management, social awareness, and relationship management.[569] With these competencies, lawyers can enhance client relationships and improve the effectiveness of their legal work.[570] Cognitive competence is the responsibility of each law student, law professor, and lawyer and an understanding of neuroscience developments and self-directed neuroplasticity makes cognitive enhancement possible.[571] With an understanding of how the emotional brain and thinking brain work together during learning and when subjected to stress, law students and lawyers can improve their individual cognitive wellness and performance.

Professor Slocum also points to law professor frustration when students seem unable to absorb course lessons, work with the nuances of legal problems, and fully develop legal skills.[572] Professors who do not understand the neuroscience of cognitive wellness may unwittingly be causing their own disappointment in

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565. BROAD, *supra* note 284, at 99-100.

566. *See* LEVIT & LINDER, *supra* note 12, at 6-8; LITOWITZ, *supra* note 7, at 16-23; MCCLURG, *supra* note 2, at 335-37; NERISON, *supra* note 9, at 15-39; Krieger, *supra* note 29, at 113-15; Rosen, *supra* note 29, at 161; *see also* BROAD, *supra* note 284, at 99-100; RATEY, *supra* note 100, at 139.

567. GRAHAM, *supra* note 241, at 378.

568. Robin Wellford Slocum, *An Inconvenient Truth: The Need to Educate Emotionally Competent Lawyers*, 45 CREIGHTON L. REV. 827, 834 (2012).

569. *Id.* at 834-37.

570. *Id.* at 834-38.

571. *See* ROSE & ABI-RACHED, *supra* note 329, at 52.

572. Slocum, *supra* note 568, at 839.

student performance by conducting classes under stressful conditions or supporting policies that engender stress-saturated law school cultures. Law faculty who embrace neuropedagogy will construct the classrooms of the future and promote innovation within their institutions. Law schools and law firms can evolve into achievement cultures with programs designed to improve student and lawyer wellness and performance.

Professor Rhonda Magee argues that contemplative practices should be part of the required law school curriculum.[573] She defines contemplative practice as any activity that calms the mind with the goal of developing insight.[574] Benefits of contemplative practices include reduction of lawyer stress, improved client relationships, and more effective and ethical lawyering.[575] Mindfulness was introduced to legal professionals in 1998 when Yale Law School held one of the first law and meditation retreats.[576] Mindfulness is reaching a "tipping point" in legal education, and workshops, retreats, and courses taught for credit are held at law schools across the country.[577]

Learning something new, complex, and challenging helps rescue new neurons from death.[578] Elizabeth Gould and Tracy Stors tracked rodent new brain cell retention by staining new brain cells and then recruiting half the subject rats into a training program.[579] After four or five days of training, the rats that had learned most effectively retained the highest number of newborn neurons in the hippocampus.[580] The rats that failed to learn and the rats that were not included in the training maintained very few new brain cells.[581] These findings convinced researchers that it was the successful learning process that aided brain cell retention, not simply the exposure to the training.[582]

Intellectual activities that include "some level of challenge,

573. Rhonda V. Magee, *Educating Lawyers to Meditate?*, 79 UMKC L. REV. 535, 537 (2011).

574. *Id.* at 546.

575. *Id.* at 555-58.

576. ROGERS & JACOBOWITZ, *supra* note 440, at 3.

577. *See id.* at 4-13.

578. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 16-17.

579. *Id.* at 15.

580. *Id.* at 16.

581. *Id.*

582. *Id.*

novelty, or variety" will enhance the human brain.[583] Lawyers are life-long learners who deal with evolving laws and novel client problems throughout their careers. The profession naturally provides an intellectually stimulating environment. But legal education is infused with general unpleasantness that causes a toxic allostatic load for many law students.[584] The chronic SNS/HPAA activation continues into law practice, and lawyers suffer from abnormally high rates of anxiety and depression.[585] Legal education that embraces stress-mitigation does not go far enough. Law schools must address the hidden curriculum.

Legal education can become a transformative educational experience if the Carnegie knowledge, skill, and professional identity apprenticeships are implemented within an achievement culture that supports the cognitive development of every student. Google is not an achievement culture because it provides some unusual workplace perks. It is a tribe where employees work on projects they believe in, and the cognitive health of every employee is promoted.[586] It is a smart, flexible, and innovative organization that allowed a single heretic, Chade-Meng Tan, to change the status quo and create a remarkable workplace that would-be employees strive to enter.[587]

Law students come to law school with a desire to belong to, contribute to, and take from the tribe of lawyers.[588] They want to connect to each other and apprentice to law faculty. They want to learn in achievement cultures. Innovation is curtailed within institutions designed around the ranking and sorting of participants, and the result can be institutional failure.[589] Education designed around "prizes" that are available to only a few law students will likely succumb to market demand for legal education structured in supportive Google-esque achievement

583. CHAPMAN, *supra* note 317, at 60.

584. *See* LITOWITZ, *supra* note 7, at 16-26; MCCLURG, *supra* note 2, at 335-37; NERISON, *supra* note 9, at 15-39; Krieger, *supra* note 29, at 113-15; Rosen, *supra* note 29 at 161.

585. *See* LEVIT & LINDER, *supra* note 12, at 6-8; LITOWITZ, *supra* note 7, at 16-26; NERISON, *supra* note 9, at 32-39; Krieger, *supra* note 29, at 113-15.

586. *See* SETH GODIN, TRIBES: WE NEED *YOU* TO LEAD US, 3-9 (2008).

587. *See id.* at 35-49; *see also* Shachtman, *supra* note 38.

588. *See* GODIN, *supra* note 586, at 3.

589. LANI GUINIER, MICHELLE FINE, & JANE BALIN, BECOMING GENTLEMEN: WOMEN, LAW SCHOOL, AND INSTITUTIONAL CHANGE 17-19 (1997).

cultures.[590] Students may not accept a stress-filled, expensive, and ineffective education much longer. When they learn about the neuroscience of cognitive wellness, they are likely to lean in and demand change within legal education.[591] Law schools that address the stress-inducing obstacles to innovation in legal education cited in Carnegie, such as the competitive learning atmosphere and grade curve, will enjoy Google-like market demand by transforming into achievement cultures.[592]

Given the recent developments in neuroscience showing the brain-boosting benefits of exercise and contemplative practices and the key role of sleep in consolidating memories, law students, law professors, and lawyers should implement performance-enhancing strategies for nurturing their own brains. Law schools and legal employers should strive to create thriving achievement cultures that support optimal cognitive fitness for students and lawyers. Cognitive fitness programs do not have to impact tight law school budgets. Law faculty and local lawyers who engage in fitness regimen or contemplative practices can be recruited as speakers or trainers. Students and lawyers can form affinity groups for exercise or contemplative practices, and law schools can facilitate these relationships.

Neural self-hacking is likely to be the newest fitness movement and law students, law professors, and lawyers should be among the early adopters of a regimen of cognitive wellness.

590. *See* LEVIT & LINDER, *supra* note 12, at 125.

591. *See* GODIN, *supra* note 586, at 57.

592. *See* SULLIVAN ET AL., *supra* note 15, at 31; Shachtman, *supra* note 38.

APPENDIX

Aristotle was famous for knowing everything. He taught that the brain exists merely to cool the blood and is not involved in the process of thinking. This is true only of certain persons.[593]
Will Cuppy

Allostasis—the process the brain uses to coordinate body-wide changes and maintain stability.[594]

Allostatic load—the tipping point where stress becomes toxic, the wear-and-tear from the stress response.[595]

Amygdala—part of the emotional brain and part of memory storage capacity for emotionally-charged experiences.[596]

Autonomic System—mediates physiological changes in the body, including the cardiovascular system.[597]

Axon—part of the neuron that sends information to the dendrite of the next neuron.[598]

Cerebri Anatome—the first illustrated map of the brain by Thomas Willis and Christopher Wren.[599]

Connectome—the individual map of a brain's unique data pathways.[600]

Consolidation—the process of making information stable in the brain and the beginning of long-term memory formation.[601]

CT or CAT Scan (Computerized Axial Tomography)—A series of fine x-rays are taken from many different directions, which produce many slices of the head. It shows deeper sections of the brain in greater detail and contrast between tissues, so it is

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593. WILL CUPPY, THE DECLINE AND FALL OF PRACTICALLY EVERYBODY 40 (1950).

594. *See supra* notes 231-33 and accompanying text.

595. *See* citations *supra* note 234 and accompanying text.

596. *See* citations *supra* note 142 and accompanying text.

597. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079-80.

598. LEDOUX, *supra* note 89, at 40-41.

599. CARTER, THE HUMAN BRAIN, *supra* note 72, at 8; GIBB, *supra* note 57, at 17-19.

600. SEUNG, *supra* note 122, at xii-xiv; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1523-24.

601. MEDINA, *supra* note 30, at 103; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1447.

very helpful in diagnosing tumors and blood clots. [602]

Declarative memory—"any conscious memory system that is altered when the hippocampus is damaged"; is stored in the emotional and thinking brain; and includes semantic (facts, concepts, words) and episodic (autobiographical) memories.[603]

Dendrite—part of the neuron that receives information from the previous axon.[604]

Emotion—an unconscious and automatic response to an emotional stimulus that causes physical changes in the body.[605] The primary emotions are fear, anger, sadness, disgust, surprise, and joy.[606]

Emotional brain components—amygdala, hippocampus, hypothalamus, thalamus, nucleus accumbens, and ventral tegmental.[607]

Encoding—the processing of sensory information as it enters the brain and the first step in consolidation.[608]

Endocrine System—responsible for the secretion and regulation of hormones into the bloodstream.[609]

DTI Scan (Diffusion Tensor Imaging)—This process measures water molecules flowing within the white matter of the brain[610] White matter consists of axons insulated by myelin which carry information through the brain.[611] This technology helps illustrate the connections between different regions of the brain.[612]

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602. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12; GIBB, *supra* note 57, at 26; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 74; SWEENEY, *supra* note 74, at 29.

603. CARTER, THE HUMAN BRAIN, *supra* note 72, at 158; CARTER, MAPPING THE MIND, *supra* note 30, at 162; GIBB, *supra* note 57, at 69; MEDINA, *supra* note 30, at 103.

604. LEDOUX, *supra* note 89.

605. *See supra* note 202 and accompanying text.

606. *See supra* note 206 and accompanying text.

607. CARTER, THE HUMAN BRAIN, *supra* note 72, at 64, 128; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 4-5.

608. *See supra* note 172 and accompanying text.

609. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1080.

610. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 74.

611. *Id.*

612. *Id.*

EEG Scan (Electroencephalogram)—Electrodes placed on the scalp record electrical activity caused by nerve cells firing.[613] Unusual brain waves may indicate a brain disorder.[614]

Feelings—"the conscious perceptions of emotional responses."[615]

fMRI Scan (Functional Magnetic Resonance Imaging)—A huge magnet is used to track the magnetic properties of iron atoms in blood.[616] Because the properties of the iron change in the presence or absence of oxygen, the magnet reflects brain activity by measuring oxygenated blood traveling to different parts of the brain.[617] The more work a brain region is performing, the more oxygen and nutrients it consumes.[618] Researchers use fMRI scans to determine what parts of the brain are active during different human activities.[619]

Glucocorticoids—steroid hormones that indicate to the autonomic system to elevate heart rate and blood pressure, mobilize energy, slow digestion, and suppress immune responses.[620] They also kill hippocampal brain cells and suppress growth of new brain cells in the hippocampus.[621]

Hippocampus—the part of the emotional brain that dialogues with the thinking brain during memory formation.[622] Also the site of neurogenesis.[623]

Long-term potentiation—a process when a chain of neurons fire together multiple times, increasing in sensitivity and the likelihood they will fire together again.[624]

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613. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 73-74; SWEENEY, *supra* note 74, at 29.

614. SWEENEY, *supra* note 74, at 29.

615. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1079.

616. GIBB, *supra* note 57, at 26.

617. *Id.* at 26-27.

618. *Id.* at 27.

619. *Id.*; *see* CARTER, THE HUMAN BRAIN, *supra* note 72, at 12-13; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 74; SWEENEY, *supra* note 74, at 29.

620. FUNDAMENTAL NEUROSCIENCE, *supra* note 30, at 804; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1409.

621. *See* citations *supra* note 31.

622. SWEENEY, *supra* note 74, at 252.

623. *See* citations *infra* note 631 and accompanying text.

624. CARTER, MAPPING THE MIND, *supra* note 30, at 159-60; CARTER, THE HUMAN BRAIN, *supra* note 72, at 156; SWEENEY, *supra* note 74, at 248.

Long-term memory—memories that have been consolidated in the brain and are available for retrieval.[625]

MEG Scan (Magnetoencephalograph)—Using sensors on the scalp, MEG measures electrical activity in the brain using magnetic fields.[626] This process is used to detect tumors and record brain region functions.[627]

Memory trace—the first sensory information received by the brain and the first step to memory encoding.[628]

MRI Scan (Magnetic Resonance Imaging)—Magnetic fields are used to create a 3-dimensional map of the brain.[629] MRI produces slices of the head, but produces a better contrast between tissues than a CT scan.[630]

Neurogenesis—the birth of new brain cells in the hippocampus and olefactory bulbs.[631]

Neurons—communication cells in the brain.[632]

Neurotransmitters—chemicals such as dopamine and serotonin that carry messages between neurons and across the synaptic gap.[633]

NIRS Scan (Near-Infrared-Spectroscopy)—Low-level light waves are beamed into the brain and the light that is reflected from each area is measured.[634] It cannot access the deepest brain regions.[635] This process measures the amount of fuel used by different parts of the brain.[636]

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625. CARTER, THE HUMAN BRAIN, *supra* note 72, at 159; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1448; MEDINA, *supra* note 30, at 140-41.

626. SWEENEY, *supra* note 74, at 29.

627. *Id.*; CARTER, THE HUMAN BRAIN, *supra* note 72, at 12; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 74.

628. PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1442.

629. SWEENEY, *supra* note 74, at 29.

630. *Id.*; CARTER, THE HUMAN BRAIN, *supra* note 72, at 13; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 74.

631. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 8; SWEENEY, *supra* note 74, at 294.

632. CARTER, THE HUMAN BRAIN, *supra* note 72, at 69.

633. CARTER, MAPPING THE MIND, *supra* note 30, at 16, 28-29; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 6.

634. CARTER, MAPPING THE MIND, *supra* note 30, at 26.

635. *Id.*

636. *Id.*

Nondeclarative memory—unconscious memory systems, including procedural and fear memories, which are stored in the primitive or emotional brain and are not changed when the hippocampus is impaired.[637]

PET Scan (Positron-Emission Tomography)—A small amount of radioactive material is tracked through the brain using special cameras.[638] This process measures brain activity by monitoring blood flow, oxygen levels, and glucose metabolism.[639]

Plasticity—the constant changing of neural networks in response to experience.[640]

Primitive brain components—brain stem, midbrain, and cerebellum.[641]

Synapse—the communication site where the axon meets the dendrite and the electrical impulse travels via chemical between neurons.[642]

Thinking brain components—two hemispheres and the bundle of nerves connecting them (corpus callosum)[643] and four major lobes: the frontal lobe (reasoning, planning, language); occipital lobe (vision); temporal lobe (hearing and some aspect of memory); and parietal lobe (movement, taste, temperature, touch).[644]

X-Ray—Electromagnetic radiation is passed through the brain where different densities absorb it at different levels, creating a negative image on light-sensitive film.[645]

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637. MEDINA, *supra* note 30, at 101, 103; PRINCIPLES OF NEURAL SCIENCE, *supra* note 122, at 1382.

638. CARTER, THE HUMAN BRAIN, *supra* note 72, at 12; GIBB, *supra* note 57, at 26; HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 74.

639. SWEENEY, *supra* note 74, at 29.

640. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 11; LEDOUX, *supra* note 89, at 9.

641. GIBB, *supra* note 57, at 36-37.

642. CARTER, THE HUMAN BRAIN, *supra* note 72, at 69; LEDOUX, *supra* note 89, at 40-42.

643. GIBB, *supra* note 57, at 41; SWEENEY, *supra* note 74, at 20.

644. CARTER, THE HUMAN BRAIN, *supra* note 72, at 66; CARTER, MAPPING THE MIND, *supra* note 30, at 14; GIBB, *supra* note 57, at 40; HORSTMAN, DAY IN THE LIFE, *supra* note 58, at 6.

645. HORSTMAN, BRAVE NEW BRAIN, *supra* note 59, at 73; SWEENEY, *supra* note 74, at 29.

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