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# Brain-Based Learning: Fact or Fiction?

**N**inety percent of all neuroscientists who have ever lived are alive today.<sup>1</sup> As a result, we have learned more in the past several decades than from all previous brain research throughout the history of the world. Humans are fascinated by the brain and have developed all sorts of psychological and physiological means to examine and test it.

Almost daily, articles in the popular media and on television describe with breathless hyperbole some new and revolutionary “finding” based on brain research.

The challenge for teachers and principals is to discover how this research can be intelligently applied to teaching and learning. Because their everyday work deals with the physical and psychological development of the brain, educators need to understand the use and the misuse of brain research in education.

“Researchers. . .caution educators to resist the temptation to adopt policies on the basis of a single study or to use neuroscience as a promotional tool for a pet program. . .Brain research does not—and may never—tell us specifically what we should do in a classroom. At this

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point it does not ‘prove’ that a particular strategy will increase student understanding. That is not currently the purpose of neuroscience research. Its purpose is to learn how the brain functions. . . We need to critically read and analyze the research in order to separate the wheat from the chaff. If educators do not develop a functional understanding of the brain and its processes, we will be vulnerable to pseudoscientific fads, inappropriate generalizations, and dubious programs.”<sup>2</sup>

## **Using Brain Research Intelligently**

Based on her 35 years of research on the brain, neuroanatomist Marian Diamond presents a compelling argument for legitimate connections between brain research and education in her

book, *Magic Trees of the Mind: How to Nurture Your Child’s Intelligence, Creativity, and Healthy Emotions From Birth Through Adolescence*.<sup>3</sup> With co-author Janet Hopson, Diamond describes the development and function of the brain in humans and in animals.

Diamond’s study included a comparison of rats in different environments. First, she placed rodents in an enriched environment—a large cage with lots of toys, other rats to play with, and mazes to work through. Then she

put some rats in an impoverished environment—alone in a small cage with little or nothing to play with. The enriched rats' brains developed a thicker cortex with cell bodies farther apart than in the impoverished rats' brains. This thickened cortex resulted from the development of more dendritic branches or connections between the neurons, or nerve cells.<sup>4</sup>

Ralph Holloway found that neurons sent out more dendritic branches in response to environmental stimulation, and that this branching, at least in part, caused the cortex to grow thicker.<sup>5</sup> A thicker cortex and more dendritic branches meant a smarter animal.<sup>6</sup>

Does this research prove anything other than how to produce a smarter rat? Can we apply animal research on brain enrichment to humans? Neuroscientist Bob Jacobs says that we can. His autopsy studies revealed that the brains of graduate students had more than three-fifths as many neuronic connections as the brains of high school dropouts; and graduate students who were involved in more challenging activities had at least 25 percent greater overall "brain growth" than the control group.<sup>7</sup>

Arnold Schreibel, a brain researcher at University of California-Los Angeles, is convinced that the human brain responds to stimulation. His studies showed "a correlation between dendritic complexity and the length and levels of education and of vocation in life," which indicated that enhancing environmental stimulation and challenge will increase the branching of the dendrites and the thickness of the human cortex.<sup>8</sup>

Challenging sensory stimulation has been compared to a "brain nutrient."<sup>9</sup> Experience determines which synapses are shed—and more important—which are retained. This forms the "wiring diagram" upon which subsequent development builds.<sup>10</sup>

### Enrichment

At birth, human brains have all the neurons they will ever have. In fact, some pruning of neurons occurs even before birth. Because of this, and the fact that neurons inevitably dwindle and die during one's

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lifespan, early researchers viewed the brain as static and unchangeable. They assumed that intelligence was fixed and thinking capacity inevitably deteriorated with age.

**N**ew research has revealed the exciting finding that the brain, with its complex architecture and limitless potential, is a highly plastic, constantly changing entity that is powerfully shaped by our experiences in childhood and throughout life. The brain's outer layer can grow if a person or animal lives in stimulating surroundings, while the zone can shrink if the environment is dull or unchanging.<sup>11</sup>

# Challenging sensory stimulation has been compared to a “brain nutrient.”

response to experiential input. Just as the muscles grow smaller and weaker with disuse, the dendritic trees will shrivel and the cortex grow thinner with lack of mental activity.

What does this mean for education? Clearly, if an enriched environment contributes to the growth of the cortex and dendritic connections, then teachers should sup-

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Diamond says that while humans may be unable to grow more neurons, they have an almost unlimited capacity to make connections between the ones they already have. Even after adolescence, the dendrites “retain their ability to grow and branch, and it is this lifetime growing potential that enables us to continue learning and adapting.”<sup>12</sup> Underused synapses will go on disappearing, even after the major pruning years are over at ages 16 to 18. “But as long as new ideas, sensations, and experiences continue to stimulate the brain, the growth and loss of connections is at least a zero-sum game. At best, lifelong enrichment will promote continued branching and growth of dendrites and with that, continual thickening of the cerebral cortex.”<sup>13</sup>

The cortex can expand and contract in

ply an enriched environment. According to Diamond, an enriched environment includes stimulation, repetition, novelty, and feedback.<sup>14</sup>

**E**ducators can find numerous ways to challenge students’ thinking processes by incorporating activities that involve problem solving, critical thinking, the arts, and working in cooperative and multi-age groups. They should also make the classroom a friendly and visually interesting place. Optimal learning occurs in a non-threatening yet stimulating atmosphere where students are helped to connect new learning with previous information and personal experience. Small groups can provide the emotionally safe cli-

mate that fosters learning and feedback.

## Other Findings of Brain Research

To summarize, what do we know for sure about the brain and education? Pat Wolfe and Ron Brandt list four things:<sup>15</sup>

1. Although all the neurons a person will ever have are present at birth, nevertheless, the brain changes as it interacts with the environment.

2. IQ is not fixed at birth. Craig Ramey’s research on an “intervention program for impoverished children” showed that IQ could be raised by offering an enriched environment.

3. Certain abilities, such as language, are more easily acquired during “windows of opportunity.”

4. “Learning is strongly influenced by emotion.”

Other researchers stress the connection between the physical body and brain function. Students are not just brains floating around four feet above the ground. They are whole people whose physical, emotional, and spiritual lives affect their mental capacity and willingness to learn. Teaching is most productive when it incorporates techniques and practices that are consistent with the wholistic nature of human beings.

When educators understand the effects of emotion and physical health on learning, they will be able to use the principles of brain research to design more effective instruction.<sup>16</sup> They can do this by

- eliminating threat and stress,
- incorporating research about interaction between the mind and body as they plan the daily schedule—having students regularly drink water, take breaks, and engage in exercise;
- making sure that the classroom is comfortable and well lighted;
- alternating intensive work with time for processing and review;
- scheduling subjects based on students’ attentional states; and
- teaching students (and parents!) about the principles of health and child development.

Administrators, too, should understand these principles and use them as they plan the school schedule and establish expectations for teachers and students.

## Cautions

Because brain research is so exciting and

suggests so many possibilities, the popular media and even some educators have made unsupported claims about activities that will increase intelligence. The unfortunate result is a discrediting of legitimate applications of brain research to learning.

**O**ne of the most articulate calls for caution comes from John Bruer, who says that his “assessment of recent articles about brain research is that well-founded educational applications of brain science may come eventually, but right now, brain science has little to offer education practice or policy.”<sup>17</sup> He warns against the following errors in the use of brain research:

1. *Inappropriate applications.* On the basis of their reading about the early development of synapses in the brain, some parents have tried to pressure young children to learn. Bruer argues that while the brain does grow rapidly during the first three years, there is no evidence that early synaptic activity in the brain results in long-term synaptic density.<sup>18</sup>

2. *Simplistic or inaccurate assumptions about the parts of the brain and learning styles.* According to Bruer, one of the most irrationally applied notions is the right-brain/left-brain argument. People who believe in brain laterality think the right-brain is the emotional, sensitive, artistic side, and that the left-brain is the logical, intellectual, mathematical side. “The fundamental problem with the right-brain versus left-brain claims that one finds in the education literature is that they rely on our intuitions and folk theories about the brain. . . . [which] are too crude and imprecise to have any scientific, predictive, or instructional value. What modern brain science is telling us—and what brain-based educators fail to appreciate—is that it makes no scientific sense to map gross, unanalyzed behaviors and skills—reading, arithmetic, spatial reasoning—onto one brain hemisphere or another.”<sup>19</sup>

3. *Unsupported cross-species applications.* Just because juvenile rats run a maze more quickly or grow more dendritic connections after a particular type of enrichment activity, this does not necessarily mean that a similar activity will make all or even some children smarter.

4. *Limiting or inappropriately scheduling various types of instruction due to in-*

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# New research has revealed...that the brain, with its complex architecture and limitless potential, is a highly plastic, constantly changing entity that is powerfully shaped by our experiences in childhood and throughout life.

accurate assumptions about "windows of opportunity." Because researchers have discovered critical periods for brain development, some educators theorize that certain interventions must be undertaken during these periods, or the child will never be able to "make up for lost time." A variety of processes, like the development of vision, occur during a certain period, with or without special help from education. Overemphasizing specific time periods may cause educators to ignore research on the plasticity of the brain at all ages, and the importance of an enriched environment and learning opportunities throughout life.

5. *Applying knowledge about the physical brain to areas in education that deal primarily with socialization and interpersonal skills.* Bruer thinks that brain research offers few insights into the best time to teach culturally and socially transmitted skills such as reading, mathematics, or music.<sup>20</sup> Furthermore, it may be appropriate to teach certain skills differently in different cultures. People of any age can benefit from instruction in a variety of areas and can increase their intelligence and expertise throughout their lifetimes.<sup>21</sup>

## Evaluating Claims

Brain research is revealing many things about the brain. Credible scientists are working with educators to make appropriate connections between education and science. Marian Diamond is a prime example. But we must take care not to read into the research things that are not there.

One example of the misuse of brain re-

search has been extravagant claims about the "Mozart effect." From limited and very specific research, the popular media and some educators have asserted that listening to Mozart increases brain function. It is always important to find out what the research really showed and then apply it rationally, not mak-

ing unwarranted assumptions. Does music affect the brain? Much research suggests that it does through emotional reactions and other responses. Does specifically listening to Mozart make the brain smarter, long-term? So far, the evidence does not support that claim.

It has become clear that enriched envi-

## Elements of an Enriched Environment

Essentially, the question is: What is an appropriate enriched environment in which the brain can reach its fullest potential? Marian Diamond and Janet Hopson suggest the following as an enriched environment:

- Includes a steady source of positive emotional support;
- Provides a nutritious diet with enough protein, vitamins, minerals, and calories;
- Stimulates all the senses (but not necessarily all at once);
- Has an atmosphere free of undue pressure and stress but suffused with a degree of pleasurable intensity;
- Presents a series of novel challenges that are neither too easy nor too difficult for the child at his or her stage of development;
- Allows for social interaction for a significant percentage of activities;
- Promotes the development of a broad range of skills and interests that are mental, physical, aesthetic, social, and emotional;
- Gives the child an opportunity to choose many of his or her own activities;
- Gives the child a chance to assess the results of his or her efforts and to modify them;
- Provides an enjoyable atmosphere that promotes exploration and the fun of learning;
- Above all, enriched environments allow the child to be an active participant rather than a passive observer (Marian Diamond and Janet Hopson, *Magic Trees of the Mind*, pp. 107, 108).

## Bibliography of Brain-Based Learning Books

Diamond, Marian, and Janet Hopson. *Magic Trees of the Mind: How to Nurture Your Child's Intelligence, Creativity, and Healthy Emotions From Birth Through Adolescence*. New York: Penguin Putnam, Inc., 1999. This book contains a good science foundation about the brain. It ties the research on the brain to education and gives activities and books that are age-appropriate.

Caine, Renate Nummela, and Sam Crowell. *MindShifts: A Brain-Compatible Process for Professional Development and Renewal of Education*. Tucson, Ariz.: Zephyr Press, 1999. This book is intended to help educators better understand the brain and to provide them with tools and procedures to develop their own effective learning environments.

Caine, Renate Nummela, and Geoffrey Caine. *Making Connections: Teaching and the Human Brain*. Menlo Park, Calif.: Addison-Wesley, 1994. The authors tie brain research to brain-based learning with specific ways to think about brain-based learning.

Goleman, Daniel. *Emotional Intelligence*. New York: Bantam, 1995. Goleman gives a detailed description of Emotional Intelligence with suggestions for emotional health.

Howard, Pierce. *Owner's Manual for the Brain*. Austin, Texas: Leonard Press, 1994. This book contains details on brain function and makes many connections to learning.

Jensen, Eric. *Teaching With the Brain in Mind*. Alexandria, Va.: Association for Supervision and Curriculum Development (ASCD), 1998. A highly readable, foundational book that makes a strong connection between the brain and education.

\_\_\_\_\_. *Brain-Based Learning*. San Diego: The Brain Store, 2000. A treasure of specific applications for using brain research in a classroom setting.

Konikak, Ronald. *Inside the Brain: Revolutionary Discoveries of How the Mind Works*. St. Louis: Andrew McMeely, 1996. A treasure-house of information on the brain that explains in lay language how the brain works, what can go wrong with it, and its remarkable power to heal itself.

Springer, Marilee. *Learning and Memory: The Brain in Action*. Alexandria, Va.: ASCD, 2000. Based on biological, chemical and psychological research, this book provides a wealth of information on how the brain works and numerous suggestions for classroom application.

# Clearly, if an enriched environment contributes to the growth of the cortex and dendritic connections, then teachers should supply an enriched environment.

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Know From Brain Research?" *Educational Leadership* 56:3 (November 1998), p. 8.

2. *Ibid.*, pp. 8-10.

3. Marian Diamond and Janet Hopson, *Magic Trees of the Mind: How to Nurture Your Child's Intelligence, Creativity, and Healthy Emotions From Birth Through Adolescence* (New York: Penguin Putnam, Inc., 1999). Diamond and Hopson use the term "Magic Trees" to describe the growth of dendritic connections in the brain because they look somewhat like trees.

4. *Ibid.*, p. 23.

5. Cited in *ibid.*

6. *Ibid.*, p. 31.

7. Robert Jacobs, Matthew Schall, and Arnold B. Scheibel, "A Quantitative Dendritic Analysis of Wemicke's Area in Humans: Gender, Hemispheric, and Environmental Factors," *Journal of Comparative Neurology* 327:1 (1993), pp. 97-111, cited in Eric Jensen, *Teaching With the Brain in Mind* (Alexandria, Va.: Association for Supervision and Curriculum Development, 1998), p. 31.

8. Cited in Diamond and Hopson, p. 35.

9. *Ibid.*, p. 31.

10. Sharon Begley, "Your Child's Brain," *Newsweek* 127:6 (February 19, 1996), pp. 55-62.

11. Diamond and Hopson, p. 2.

12. *Ibid.*, p. 56.

13. *Ibid.*, p. 255.

14. *Ibid.*, pp. 29, 30.

15. Wolfe and Brandt, pp. 8-13.

16. See articles by Linda Caviness and Melvin Campbell in this issue.

17. John T. Bruer, "Brain Science, Brain Fiction," *Educational Leadership* 56:3 (November 1998), p. 14.

18. \_\_\_\_\_, "Neural Connections: Some You Use, Some You Lose," *Phi Delta Kappan* 81:4 (December 1999), pp. 264-277.

19. "In Search of . . . Brain-Based Education," *Phi Delta Kappan* (May 1999), p. 648.

20. Bruer, "Brain Science, Brain Fiction," *Educational Leadership*, p. 17.

21. W. T. Greenough, "We Can't Focus Just on Ages Zero to Three," *APA Monitor* 28 (1997), p. 19; cited in Bruer, "Brain Science, Brain Fiction," *Educational Leadership*, p. 18.

22. Renate Nummela Caine and Geoffrey Caine, *Making Connections: Teaching and the Human Brain* (Menlo Park, Calif.: Addison-Wesley, 1994), p. 8.

23. Pat Wolfe, "Revisiting Effective Teaching," *Educational Leadership* 56:3 (November 1998), p. 64.

24. Caine and Caine, p. 9.

ronments are important to growing new synapses throughout life. But what constitutes an appropriate enrichment for different humans at varying ages? One of the best books on enrichment for children and adolescents is the previously mentioned *Magic Trees of the Mind* by Marian Diamond, which urges both caution and enthusiasm in applying brain-based research.

Brain-based learning can be supported if it follows some basic principles:<sup>22</sup>

"1. Designing and orchestrating lifelike, enriching, and appropriate experiences for learners."

"2. Ensuring that students process experiences in such a way as to increase the extraction of meaning."

Although brain research is providing exciting insights about the way the brain develops and learns, many of its findings confirm what teachers have already known or at least theorized.<sup>23</sup> However, it does help to synthesize psychology and biology, and provides a much-needed reminder of the intimate interaction between body and mind.

Teachers should be suspicious of any new research used to promote extravagant claims or pet programs. However, many classroom practices, such as multiple intelligences and

cooperative learning,<sup>24</sup> which teachers already use and that have been verified through research in other fields, are also supported by brain research. Understanding how the brain works will help teachers apply them more successfully.

## Conclusion

Research on the brain continues at a rapid pace. Educators need to stay abreast of current and reputable research, applying it in responsible ways. Consulting other sources, such as the behavioral sciences, educational research, the Bible, and Ellen G. White's writings, will provide verification and suggest areas where caution is warranted. ☞

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## NOTES AND REFERENCES

1. Pat Wolfe and Ron Brandt, "What Do We