The Business of Brain-Based Learning

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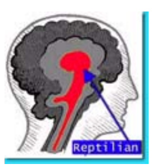
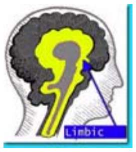
Brain Basics

The Reptilian Brain - the "Preverbal"



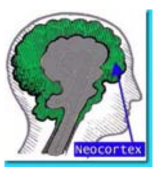
- It is the oldest and smallest region in the evolving human brain.
- It is "preverbal," but controls life itself, such as autonomic brain, lung and heart functions.
- Lacking language, its impulses are instinctual and ritualistic.
- It is concerned with fundamental needs such as food, physical maintenance, preening and mating.

The Limbic Brain - the "Emotional" Brain



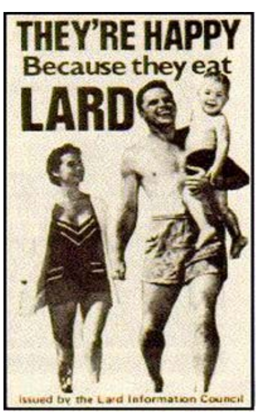
- Common to all mammals, it developed about 60 million years ago, after the dinosaurs perished.
- It's involved in bonding needs, including emotions linked to attachment.
- It acts as the brain's emotion factory, creating the chemical messages that connect information into memory.
- Retention of information can be significantly increased when it's presented in an emotionally charged context.

The Neocortex Brain - the "Thinking" Brain



- It constitutes five-sixths of the total brain mass, which has evolved over the last million years, to produce the human brain.
- It controls such high-level processes as logic, creative thought, language, and the integration of sensory information.
- The neocortex is divided into the left and right cerebral hemispheres, described in Left/Right Brain Theory.

So…



...who cares?

The Triune Brain Theory and Education

Traditional education was designed for predominantly neocortex functions. However, this misses a basic brain fact: the reptilian brain is an interconnected pathway to the limbic brain which is an interconnected pathway to the neocortex -- you can't skip a brain function!

Therefore, long-term memory is created by paying attention to the power of the whole brain by simultaneously:

- Recognizing your own reptilian brain, i.e., your personal learning style and how to apply skills and techniques that will promote your own learning process
- Recognizing your own limbic brain and creating activities and study strategies that link your emotions to the acquisition of new information
- Designing study strategies that appeal to both the left and right sides of the thinking brain

Sensory Preferences

When you..	Visual	Auditory	Kinesthetic & Tactile
Spell	Do you try to see the word?	Do you sound out the word or use a phonetic approach?	Do you write the word down to find if it feels right?
Talk	Do you sparingly but dislike listening for too long? Do you favor words such as *see*, *picture*, and *imagine*?	Do you enjoy listening but are impatient to talk? Do you use words such as *hear*, *tune*, and *think*?	Do you gesture and use expressive movements? Do you use words such as *feel*, *touch*, and *hold*?
Concentrate	Do you become distracted by untidiness or movement?	Do you become distracted by sounds or noises?	Do you become distracted by activity around you?
Meet someone again	Do you forget names but remember faces or remember where you met?	Do you forget faces but remember names or remember what you talked about?	Do you remember best what you did together?
Contact people on business	Do you prefer direct, face-to-face, personal meetings?	Do you prefer the telephone?	Do you talk with them while walking or participating in an activity?
Read	Do you like descriptive scenes or pause to imagine the actions?	Do you enjoy dialog and conversation or hear the characters talk?	Do you prefer action stories or are not a keen reader?
Do something new at work	Do you like to see demonstrations, diagrams, slides, or posters?	Do you prefer verbal instructions or talking about it with someone else?	Do you prefer to jump right in and try it?
Need help with a computer application	Do you seek out pictures or diagrams?	Do you call the help desk, ask a neighbor, or growl at the computer?	Do you keep trying to do it or try it on another computer?

remembering. The brain is performing these functions, as most other organs are performing theirs, even before birth. For example, recent research finds that a newborn recognizes the mother's voice, showing that the fetus, innately and naturally, without instruction or example, hears and then remembers this particular voice.

Other research shows that infants are able to think soon after birth. In *How People Learn: Brain, Mind, Experience, and School*, Bransford et al. (1999) found in their 2-year evaluation of new developments in the science of learning that even 5- to 12-week-old infants are

> capable of perceiving, knowing, and remembering. . . . The answers about infant understanding of physical and biological causality, number, and language have been quite remarkable. These studies have profoundly altered scientific understanding of how and when humans begin to grasp the complexities of their worlds. (p. 72)

Learners are "biologically driven to make sense of their world" (Caine & Caine, 1991, p. 50). Perhaps this is what impels 2-year-old children to want to find out about everything and do everything by themselves. Some people see this innate and natural desire to understand and to be empowered ("How does the world work and how can I make it work for me?") as the defining characteristic of the misnamed "terrible twos."

My two-year-old grandson was visiting us, and I took his hand to help him up our front steps. Part way up, he pushed me away and said, "Jesse do it!" Then he climbed back down to the bottom and started up the steps again on his own. My daughter put her head in her hands and exclaimed, "Oh no, the terrible twos are here!" But, no, these are the twos that guarantee that civilization—its art, science, and technology—will continue to develop.

HOW THE BRAIN LEARNS

One challenge for educators is to learn about the brain's innate and natural learning, thinking, and remembering processes if they are to teach the way the brain naturally functions.

Brain Facts

Figure 3.1 shows how the brain, which is soft, like intestines, sits in the skull. The adult brain weighs about 3 pounds and could be held in one hand. Figure 3.2 shows the sections (lobes) of the brain.

Figure 3.2 The Sections of the Brain

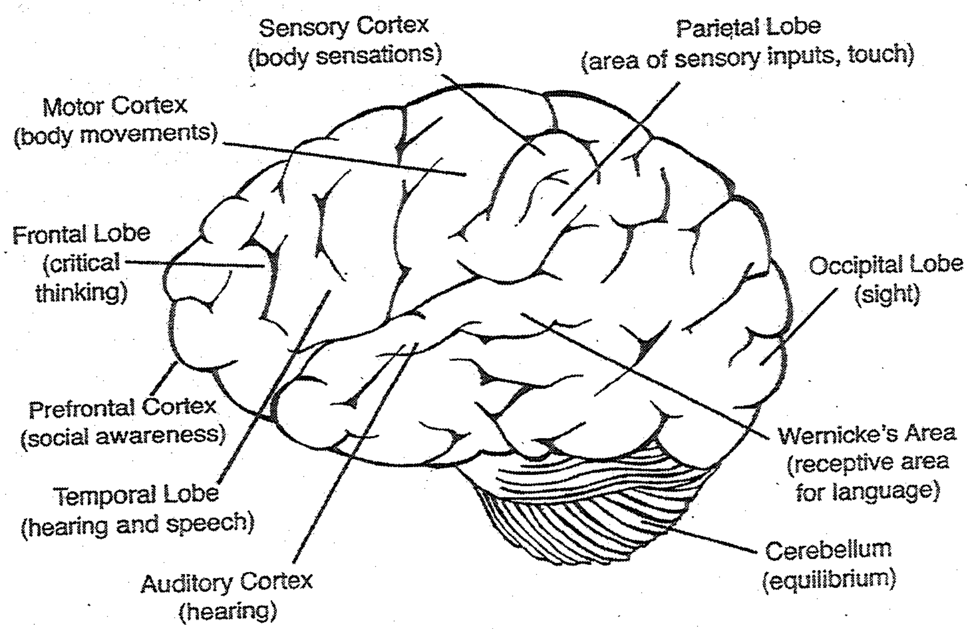


Figure 3.3 A Neuron

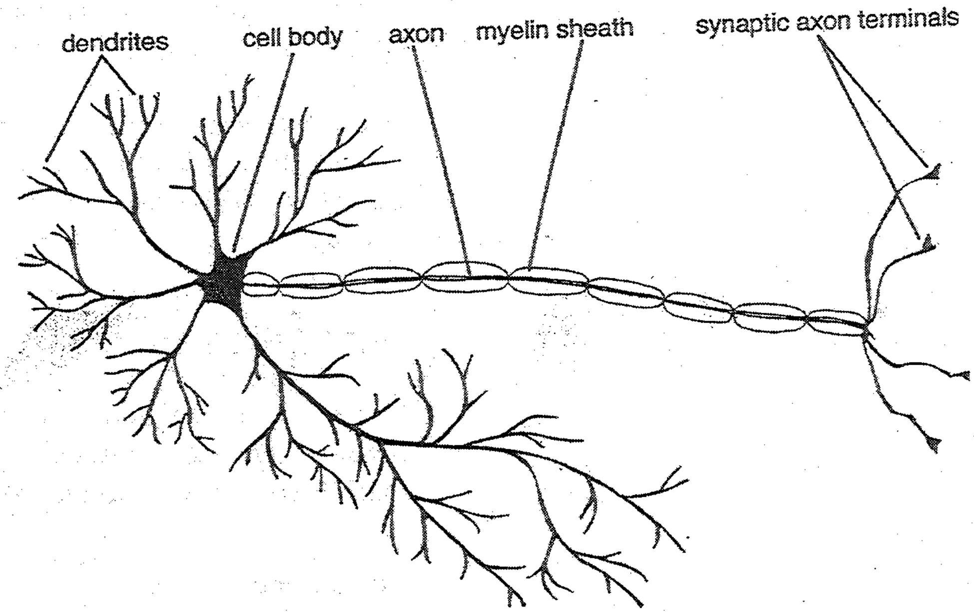


Figure 3.4 Neuron Magnified 1,000 Times

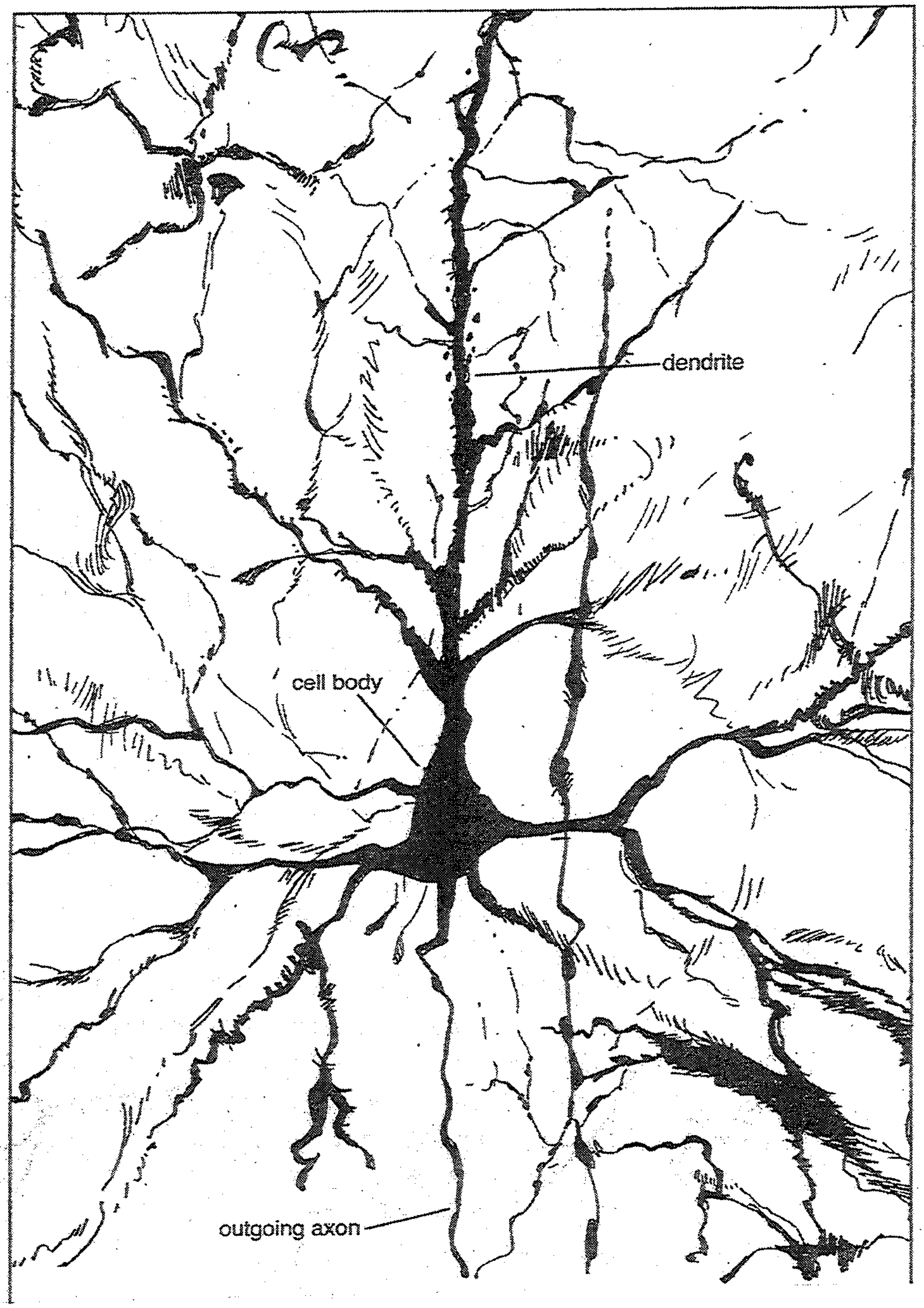
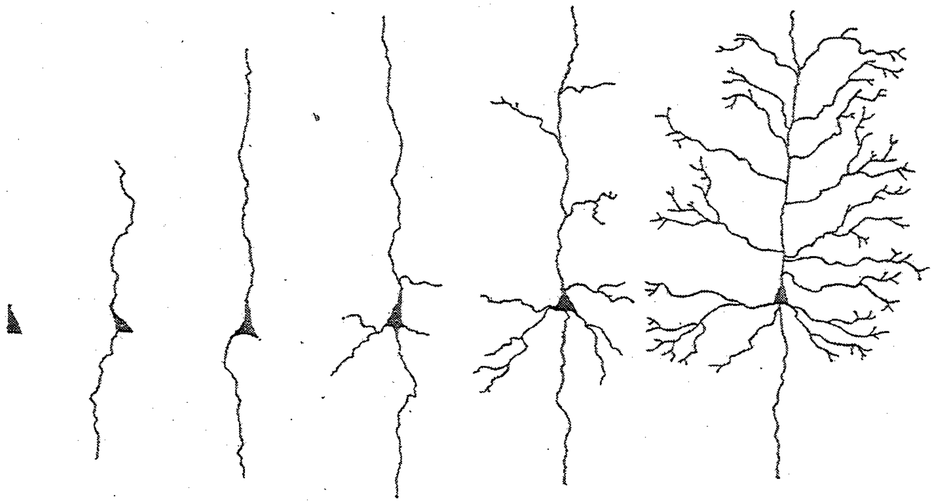


Figure 3.5 Growing Dendrites = Learning



Also from the neuron's body grows one long fiber called the axon. At the end of the axon are dendrite-like fibers called teledendrites or processes. At the end of each process is a tiny bulb, called a synaptic terminal. Synaptic terminals are filled with chemicals (neurotransmitters). These structures are discussed further in the sections that follow.

Dendrites and Learning

Figure 3.5 is a picture of dendrites growing. This is a picture of learning because, as we are learning, specific neurons are growing specific new dendrites for that specific new object of learning. Then other neurons' axons connect with these dendrites, as well as with other neurons' bodies, at connection points called synapses (Figures 3.6A, 3.6B, and 3.6C). Synapses are discussed in the "How the Brain Thinks and Remembers."

The growing and connecting of dendrites *are* learning (e.g., Borklund, 2000; Gopnik et al., 1999; Greenfield, 1997; Restak, 2001; S. Rose, 1992; Sylwester, 1995). In fact, as we feel ourselves learning, instead of saying, "I feel I'm getting it; I'm learning it," we could more accurately say, "I feel my dendrites growing and my synapses connecting."

Neural Networks and Learning

As we are growing dendrites and making synaptic connections—that is, as we are learning—neurons are being connected into networks. In Figure 3.6C, we see several neurons connected in what is called a neural network.

Figure 3.6A Synapses

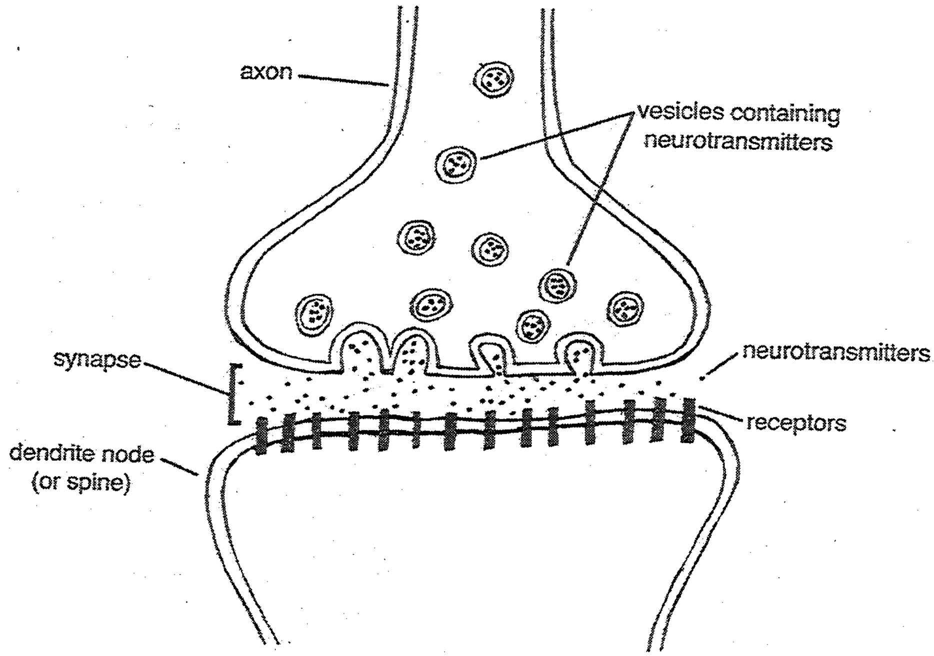
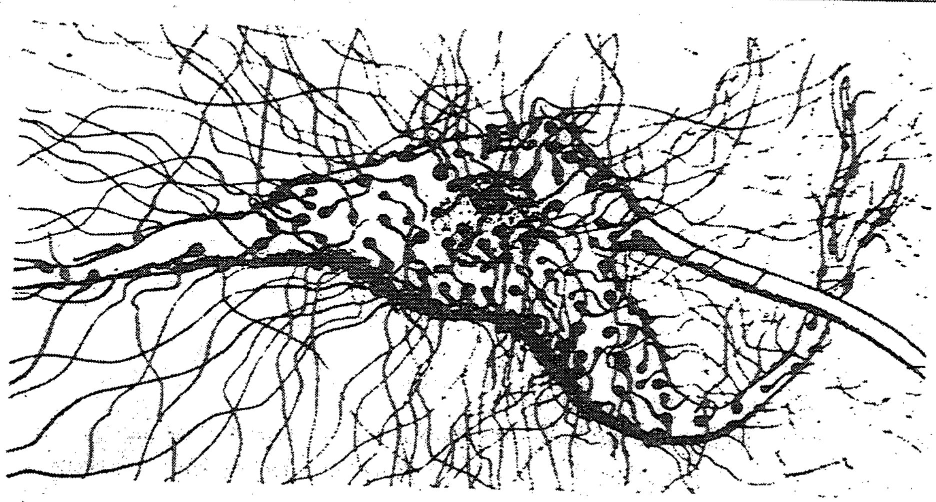
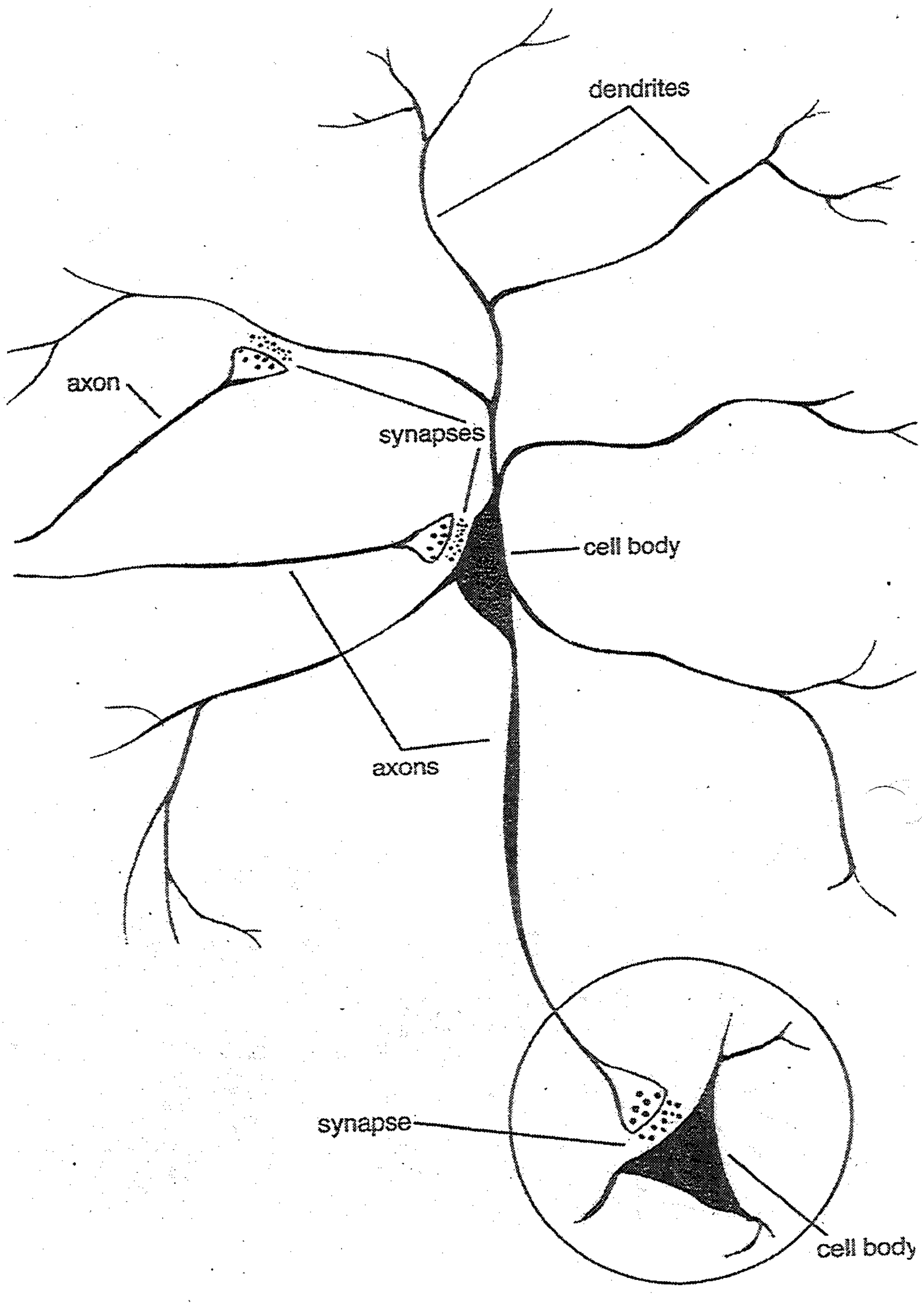


Figure 3.6B Drawing of Single Neuron With Synapses on It



In Figure 3.6C axons from two neurons are approaching another neuron (in the middle). One of these axons is putting a "synaptic terminal" next to one of the "receiver" neuron's dendrites to form a synapse. The other neuron's axon is putting a synaptic terminal next to that same "receiver" neuron's body (soma) to form another synapse. The axon from

Figure 3.6C Neural Network



the "receiver" neuron is also moving out to a fourth neuron's soma (at bottom). These four neurons are now connected in a neural network.

Neural networks can be inconceivably complex and numerous. Ag any one of a person's 100 billion neurons could be connected to as m as 10,000 other neurons. "A square centimeter of the brain's cortex, or outer layer, has a million neurons with over one billion interconnecting fibers, called dendrites" (Johnson & Brown, 1988, p. 39). Furthermore, "the theoretical number of different patterns of connections possible in a single brain is approximately 40,000,000,000,000,000—forty quadrillion" (Ratey, 2001, p. 9). These uncountable networks are interacting or parallel processing: "The 100 billion neurons in the brain all perform operations simultaneously, . . . [in an] enormous tangle of interconnections" (Johnson & Brown, 1988, p. 39). This results from learning, is how we think and remember, and, according to LeDoux (2002), is who we are.

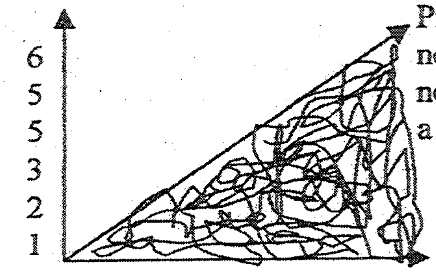
Pruning

We can surmise from the research that one of the rules of how the brain learns is that *dendrites, synapses, and neural networks grow for what is personally, actively, specifically experienced and practiced.* That is, they grow for what is processed (e.g., attended to, explored, experimented with, thought about). However, if these particular structures and connections are not used subsequently, because that skill or idea is not used or practiced, they can be "pruned." That is, the brain apparently is economical: If a dendrite or synapse is not being used for a period of time, it can be eliminated. Thus, we come to a widely acknowledged, well-documented second rule of how the brain learns (and forgets): *use it or lose it.* This and other rules are discussed later in this chapter in "Five Rules of How the Brain Learns."

Experience and Brain Growth

"Researchers have . . . accumulated a substantial amount of data indicating that the brain will grow physiologically if stimulated through interaction with the environment" (Caine & Caine, 1991, p. 28). Marion Diamond (1967, 1988) and other researchers (e.g., Greenough, Black, & Wallace, 1987; Renner & Rosenzweig, 1987) have done numerous experiments with rats, whose neurons are similar to human neurons (Ratey, 2001, p. 22). The researchers have found that rats who live even 2 weeks in what Diamond called an "enriched environment" (with other rats, toys, and mazes) have heavier and larger brains than rats who live in an "impoverished environment" (nonactive, noninteractive). Their brains are bigger because they have more dendrites, a thicker cerebral cortex, more synapses, and more and larger neural networks. The researchers' conclusion is that this disparity in brain structures results from the one variable that is different between the two groups: The rats in the enriched environment have the opportunity to experience a greater amount of activity and interactivity than the rats in the impoverished environment.

Figure 3. 8 Individual Differences

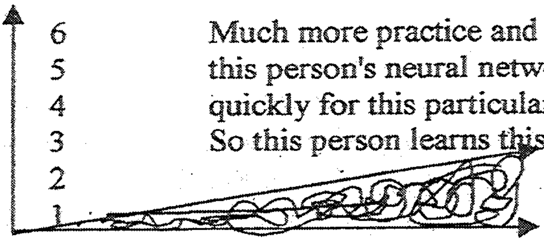


Practice and time are needed to grow new neural networks to learn a new object of learning.

The Model in general

Less practice and time are needed because this person's neural networks grow more quickly for this particular object of learning.
AND this person can learn this skill more easily and quickly than the skill below.

Someone with an aptitude for this skill



Much more practice and skill are needed because this person's neural networks do not grow quickly for this particular object of learning.
So this person learns this skill less well, even with more effort and time, than the skill above.

Someone who finds this skill difficult to learn

around in it.) Some infants are born sucking their thumb, another skill learned before birth. Perhaps there are even more things they have learned from their in utero experiences that we do not know about yet. By 15 months, however, babies have learned a great deal, that is grown many new dendrites, synapses, and neural networks about this new place, its

Figure 3.9 Learning Over Time

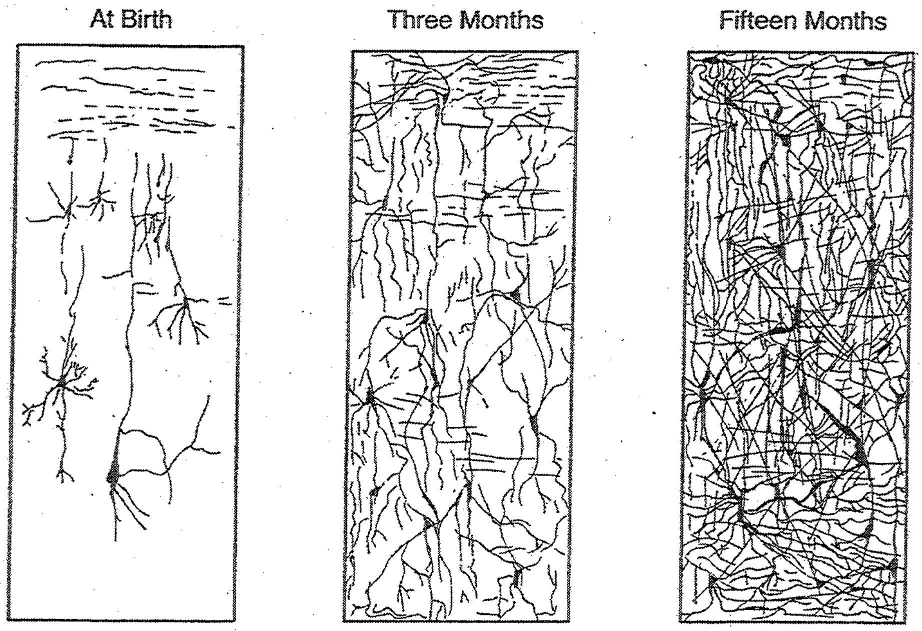
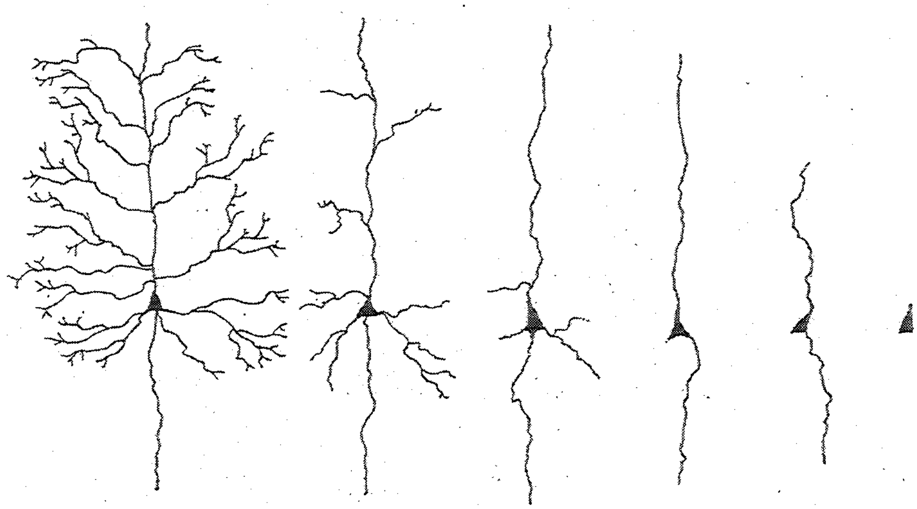


Figure 3.10 Disappearing Dendrites, as in Alzheimer's Disease = Forgetting



things and people, how it works, and how to negotiate in it (Chapter 2, "Critical and Creative Thinking by Infants and Children").

Alzheimer's Brains

In contrast to growing dendrites when learning, Figure 3.10 shows the loss of well-grown dendrites in Alzheimer's disease.