

# Developing Brains- Ideas for Parenting and Education From the New Brain Science

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## Some Brain Basics

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Revised July 10, 2010

### Introduction:

When we try to understand the findings and discoveries of the new brain science, we have to understand a little about the brain itself, how it is put together and how it works. So, this is the intent of this brief article.

"The human brain is a network of more than 100 billion individual nerve cells interconnected in systems that construct our perceptions of the external world, fix our attention, and control the machinery of our actions."<sup>1</sup>

### The Nervous System and its Parts:

The central nervous system, which includes the brain and the spinal cord, is composed of 2 cell types: neurons and glial cells. Let's start with neurons.

Neurons are individual cells in the brain (and throughout the nervous system) that receive information from other neurons as well as the senses (sight, hearing, touch, taste, and smell) and transmit or send the information on to other neurons or to the muscles or glands. Neurons come in different shapes and sizes, with particular types of neurons making up specialized areas of the brain.

The neuron has several parts to it (see illustration below):

1. It has a cell body (or soma) that has the cell "machinery" to run the work it does. The cell body has a nucleus (seen below in purple) which contains the DNA. The rest of the neuron is specialized to receive and send information.

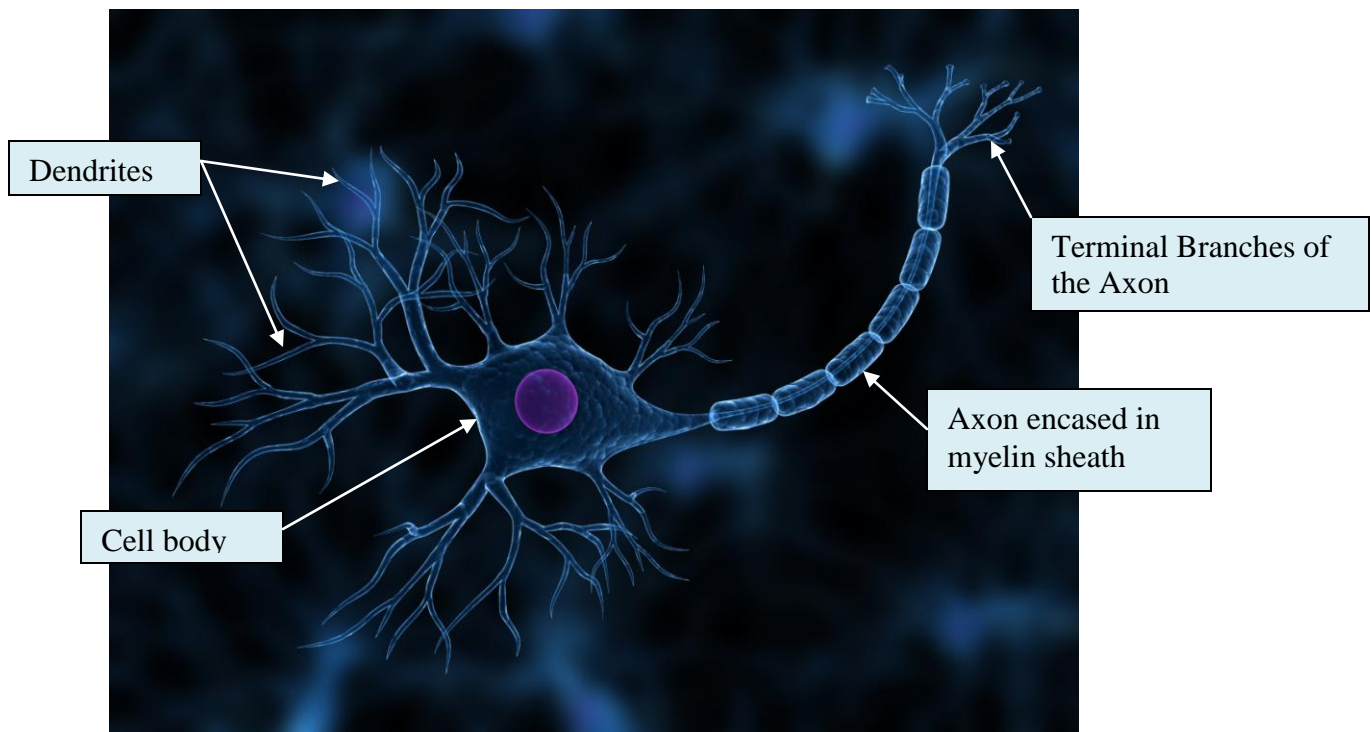
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<sup>1</sup> Kandel, Eric R., Schwartz, James H., and Jessell, Thomas M., Eds. Principles of Neural Science, 4<sup>th</sup> Edition, New York: McGraw Hill, 2000, 3..

2. The dendrites (that look like branches coming off the cell body) are the parts of the neuron that receive information from many other cells - which is why there are extensive dendrite "trees". The dendrites have little spines on them, which increases the amount of surface area available for connections. The dendrite trees expand a lot after birth and there is a great increase in dendritic spines. Information comes into the dendrite and through the cell body and down the axon.

3. The axon (coming off the cell body to the right in the illustration below) is a long thin fiber (sometimes up to a yard long) that transmits the signal from the cell body to other neurons or muscles or glands. Bundles of axons are what we call "nerves".

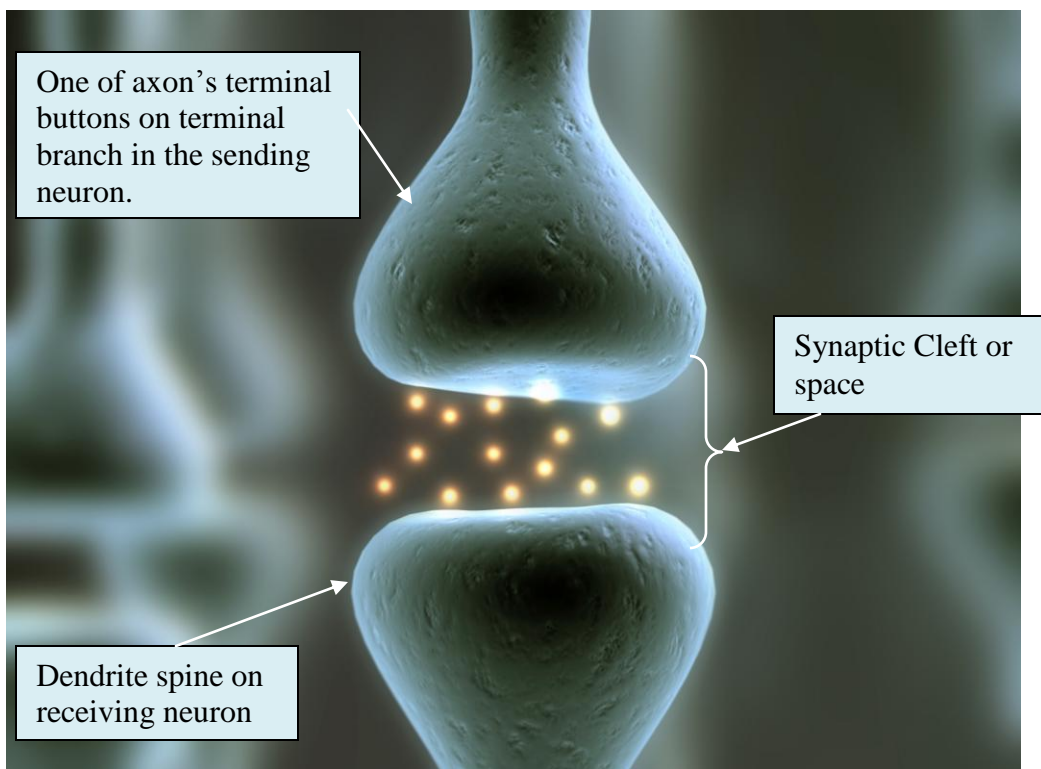
For example, when you sense something frightening, like a loud noise, your brain sends a signal to your adrenal glands (located near the kidneys) and the adrenals secrete chemicals such as adrenaline.



Cell body with purple nucleus, dendrites branching off of cell body, and axon projecting out to the right of the cell body. Illustration by eraxion.

The end of the axon has "branches" with terminal buttons at the ends. The places where the terminal buttons come *very* close to their target (usually dendrites of other neurons) are called the synapses.

4. The synapse is the space (tiny, microscopic space, called the synaptic cleft) between the axon's terminal button and the dendrite of the receiving neuron, which is the next one in the network. The terminal button completes sending the message to another neuron by releasing chemicals, called neurotransmitters, which float across this space and "fit" into receptor sites on the receiving cell - like a "lock and key".



Release of Neurotransmitter from the terminal button to a spine on a dendrite of the receiving neuron. Illustration by eraxion .

Anti-depressant medications target the neurotransmitters by changing how much neurotransmitter is released, how much is received, or how much is "vacuumed" back up into the terminal button for recycling.

And, so the chain of information continues. This process is happening all over the brain and body at extremely rapid rates - allowing us to perceive a

glass of water, reach for it, pick it up, bring it to the mouth and take a drink, all in a smooth, mostly unconscious manner (unless you suffer from a nervous system disorder like Parkinson's disease or multiple sclerosis). Another piece of information about the neuron is that on the axons of some cells, there is a "fatty" covering, called the myelin sheath (seen as rectangles on the axon in the illustration of the neuron above), which "insulates" the axon, speeding up the transmission of signals, like the insulation on a lamp cord. During the first 5 years of life, the brain is actively in the process of laying this "fatty" sheath on the appropriate axons. This is why children up to at least age 2 must be fed full fat milk after weaning. (Breast milk, of course, has the "perfect" balance of fat and protein for brain development!)

Actually, myelin continues to be developed on axons throughout childhood and into young adulthood. The progressive insulating of axons during the early years accounts for changes such as the ever increasing muscle control we see in the small muscles of the hands and face as well as the large muscles of the arms, legs, and trunk.

Motor coordination in children is one of the set of behaviors we can easily observe in order to "peek in" on the continued development of the brain.

Glial cells are the second type of cells in the nervous system. They are much more numerous than neurons. Glial cells provide support for the neurons in many ways. They produce the myelin sheath, nourish the neuron, and provide some padding or protection for the neurons. They also play a role in learning and memory.

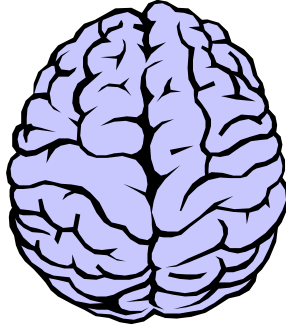
### The parts of the brain:

The human brain is divided into two hemispheres, a left and a right. Most people are aware of how the hemispheres control the movement on the opposite side of the body.

Most of the specialized structures of the brain are in pairs, with one in each hemisphere. Each hemisphere also has specialized functions and the

hemispheres "talk" to each other through the bundle of nerves called the corpus callosum, which connects the two hemispheres.

(Front of the head)



(Looking at the brain from above)

For example, if someone has a stroke in the right hemisphere, we will see the effects in the muscles of the left arm, leg, or side of the face.

The brain has various parts that control certain functions. One of these structures, the cerebellum (or the "little brain") stores information about balance and movement.

For example, once you learn to ride a bike, the cerebellum stores that information and even if you haven't been on a bike in years, when you start riding again, it comes back easily.

Another structure is the amygdala, which is involved in our emotional responses as well as our "fight, flight, flee or freeze" response to perceived dangers or threats.

Covering all these structures is the cerebral cortex, which is quite large in humans (compared to primates and other mammals in general). It is the cortex that gives us our huge memory and our ability to create and master language, to develop diverse cultures, to express our ideas through the arts or engineering or farming.

The cerebral cortex is also specialized into areas of function. The auditory cortex (near the ear) interprets sound, the visual cortex at the back is for sight, and the motor cortex area across the top is for movement. The

frontal lobe, with the prefrontal cortex, is the C.E.O. of the brain, controlling executive functions, such as planning, organizing, inhibition of behavior, and morality.

### Experience shapes the brain's structure:

Connections between neurons are strengthened by experience. Children learn what they live. In development, the prefrontal cortex continues to grow and organize itself through adolescence and into the early twenties. This part of the brain, like all the others, structures its architecture based on what the individual does. What we spend our time doing during adolescence, for example, will determine the skills that our brain will devote the most connections to. These behaviors will become the "default" setting, so to speak.

Thus, the need for guidance and mentoring from older people continues to be necessary for optimal development through the early twenties. Time spent in community service activities will promote pro-social behaviors. Segregation of people by age group is NOT good for the brain!

### Conclusion:

Kandel, et. al. summarize the relationship between brain function and behavior in the following manner:

"...All behavior is the result of brain function. What we commonly call the mind is a set of operations carried out by the brain. The actions of the brain underlie not only relatively simple motor behaviors such as walking or eating, but all the complex cognitive actions that we believe are quintessentially human, such as thinking, speaking, and creating works of art. As a corollary, all the behavioral disorders that characterize psychiatric illness - disorders of affect (feeling) and cognition (thought) - are disturbances of brain function."<sup>2</sup>

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<sup>2</sup> Ibid., 5