The human brain is an amazing structure. At birth, it is equipped with over 100 billion nerve cells designed to collect information and learn the skills necessary to keep its owner alive. Although comparatively slow in its growth and development compared to the brains of other mammals, it can learn complex skills, master any of over 6,000 languages, store memories for a lifetime, and marvel at the glory of a radiant sunset. Early in life, the brain's cells grow and connect with each other—at the rate of thousands per second—to store information and skills. Most of the connections result in the development of neural networks that will help the individual successfully face life's challenges. But sometimes, certain connections go awry, setting the stage instead for problems.

To understand the complexity of human brain growth and development, let's review some basic information about its structure. For our purposes, we will first look at major parts of the outside of the brain (Figure 1.1): the frontal, temporal, occipital, and parietal lobes; the motor cortex; and the cerebellum. Although the minor wrinkles are unique in each brain, several major wrinkles and folds are common to all brains. These folds form a set of four lobes in the largest part of the brain, called the cerebrum (Latin for brain). Each lobe specializes in performing certain functions.

The frontal lobe contains almost 50 percent of the volume of each cerebral hemisphere and is often referred to as the executive control center. The temporal lobe is the speech center. Visual processing is the main function of the occipital lobe, while the parietal lobe is responsible for sensory integration and orientation. Table 1.1 lists the functions of the four lobes as well as of the motor cortex.
HOW THE SPECIAL NEEDS BRAIN LEARNS

Motor Cortex

Parietal Lobe

Frontal Lobe

Occipital Lobe

Temporal Lobe

Cerebellum

Figure 1.1 This diagram shows the four major lobes of the brain (cerebrum) as well as the motor cortex and the cerebellum.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>Frontal Lobe</td>
<td>Personality, curiosity, planning, problem solving, higher-order thinking, and emotional restraint</td>
</tr>
<tr>
<td>Temporal Lobe</td>
<td>Interpretation of sound, speech (usually on the left side only), and some aspects of long-term memory</td>
</tr>
<tr>
<td>Occipital Lobe</td>
<td>Visual processing</td>
</tr>
<tr>
<td>Parietal Lobe</td>
<td>Orientation, calculation, and certain types of recognition</td>
</tr>
<tr>
<td>Motor Cortex</td>
<td>Control of body movements</td>
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</tbody>
</table>

Table 1.1 Some Exterior Parts of the Brain

Next, we will look at the inside of the brain and at some of its major structures (see Figure 1.2). Table 1.2 lists the functions of some of the interior parts of the brain: the brain stem, limbic area, cerebrum, and cerebellum.
Figure 1.1 This diagram shows the four major lobes of the brain (cerebrum) as well as the motor cortex and the cerebellum.

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How the Brain Learns

Figure 1.2 A cross section of the human brain.

Table 1.2 Some Interior Parts of the Brain

<table>
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<td>Brain Stem</td>
<td>The oldest and deepest area of the brain, this is often referred to as the reptilian brain because it resembles the entire brain of a reptile. Here is where vital body functions (such as respiration, body temperature, blood pressure, and digestion) are monitored and controlled. The brain stem also houses the reticular activating system (RAS), responsible for the brain's alertness.</td>
</tr>
</tbody>
</table>
| Limbic Area     | Above the brain stem lies the limbic area, whose structures are duplicated in each hemisphere of the brain. Three parts of the limbic area are important to learning and memory:  

  **Thalamus.** All incoming sensory information (except smell) goes first to the thalamus. From here it is directed to other parts of the brain for additional processing.  

  **Hippocampus.** Named for the Greek word for a sea monster resembling a seahorse, because of its shape, it plays a major role in consolidating learning and in converting information from working memory via electronic signals to the long-term storage regions, a process that may take from days to months. This brain area constantly checks information relayed to working memory and compares it to stored experiences. This process is essential for the creation of meaning.  

  **Amygdala.** Attached to the end of the hippocampus, the amygdala (Greek for almond) plays an important role in emotions, especially fear. Because of its proximity to the hippocampus and its activity on PET scans, researchers believe that the amygdala encodes an emotional message, if one is present, whenever a memory is tagged for long-term storage. |
The cerebrum represents over 80 percent of the brain by weight. For some still unexplained reason, the nerves from the left side of the body cross over to the right hemisphere, and those from the right side of the body cross over to the left hemisphere. The two hemispheres are connected by a thick cable, called the corpus callosum, composed of over 250 million nerve fibers. The hemispheres use this bridge to communicate with each other and to coordinate activities.

The hemispheres are covered by a thin but tough laminated cortex (Latin for free bark). The cortex is composed of six layers of cells meshed in approximately 10,000 miles of connecting fibers per cubic inch! Here is where thinking, memory, speech, and muscular movement are controlled.

The cerebellum (Latin for little brain) coordinates every movement. Because the cerebellum monitors impulses from nerve endings in the muscles, it is important in the learning, performance, and timing of complex motor tasks, including speaking. The cerebellum may also store the memory of rote movements, such as touch-typing and tying a shoelace. A person whose cerebellum is damaged cannot coordinate movement, has difficulty with speech, and may display the symptoms of autism.

The Frontal Lobe

The frontal lobe is the executive control center of the brain, monitoring higher-order thinking, directing problem solving, and regulating the excesses of the emotional system. Because emotions drive attention, the efficiency of this area is linked to the limbic centers. The frontal lobe also contains our self-will area—what some might call our personality. Trauma to the frontal lobe can cause dramatic—and sometimes permanent—behavior and personality changes. (One wonders why we allow 10-year-olds to play football and soccer where the risk of trauma to the frontal lobe is so high.)

Because most of the working memory is located in the frontal lobe, it is the area where focus occurs. The frontal lobe, however, matures slowly. MRI studies of postadolescents reveal that the frontal lobe continues to mature into early adulthood. Thus, the emotional regulation capability of the frontal lobe is not fully operational during adolescence (Sowell, Thompson, Holmes, Jernigan, and...
This is one reason why adolescents are more likely than adults to submit to their emotions and may resort to high-risk behavior.

**Brain Cells**

The control functions and other activities of the brain are carried out by signals traveling along brain cells. The brain is composed of a trillion cells of at least two known types: nerve cells and their support cells. Nerve cells are called neurons and represent about one-tenth of the total number of cells—roughly 100 billion. Most of the cells are support cells, called glial (Greek for glue) cells, that hold the neurons together and act as filters to keep harmful substances out of the neurons.

Neurons are the functioning core for the brain and the entire nervous system. They come in different sizes, but it takes about 30,000 brain neurons to fit on the head of a pin. Unlike other cells, the neuron (Figure 1.3) has tens of thousands of branches or dendrites (from the Greek word for tree) emerging from its center. The dendrites receive electrical impulses from other neurons and transmit them along a long fiber, called the axon (Greek for axis). Each neuron has only one axon. A layer called the myelin (related to the Greek word for marrow) sheath surrounds each axon. The sheath insulates the axon from the other cells and increases the speed of impulse transmission. The impulse travels along the neurons through an electrochemical process and can move the entire length of a 6-foot adult in 2/10ths of a second. A neuron can transmit between 250 and 2,500 impulses per second.

Neurons have no direct contact with each other. Between each dendrite and axon is a small gap of about a millionth of an inch called a synapse (from the Greek meaning to join together). A typical neuron collects signals from others through the dendrites. The neuron sends out spikes of electrical activity (impulses) through the axon to the synapse where the activity releases chemicals stored in sacs (called synaptic vesicles) at the end of the axon.

The chemicals, called neurotransmitters, either excite or inhibit the neighboring neuron. Nearly 100 different neurotransmitters have been discovered so far. Some of the common neurotransmitters are acetylcholine, epinephrine, serotonin, and dopamine.

**Learning and Retention**

Learning occurs when the synapses make physical and chemical changes so that the influence of one neuron on another also changes. For instance, a set of neurons "learns" to fire together. Repeated firings make successive firings easier and, eventually, automatic under certain conditions. Thus, a memory is formed.
Neurons, or nerve cells, transmit impulses along an axon and across the synapse to the dendrites of the neighboring cell. The impulse is carried across the synapse to receptor sites by chemicals called neurotransmitters that lie within synaptic vesicles (Sousa, 2001, p. 21).

For all practical purposes, the capacity of the brain to store information is unlimited. That is, with about 100 billion neurons, each with thousands of dendrites, the number of potential neural pathways is incomprehensible. The brain will hardly run out of space to store all that an individual learns in a lifetime. Learning is the process by which we acquire new knowledge and skills; memory is the process by which we retain knowledge and skills for the future.
Investigations into the neural mechanisms required for different types of learning are revealing more about the interactions between learning new information, memory, and changes in brain structure. Just as muscles improve with exercise, the brain seems to improve with use. Although learning does not increase the number of brain cells, it does increase their size, their branches, and their ability to form more complex networks.

The brain goes through physical and chemical changes when it stores new information as a result of learning. Storing gives rise to new neural pathways and strengthens existing pathways. Hence, every time we learn something, our long-term storage areas undergo anatomical changes that, together with our unique genetic makeup, constitute the expression of our individuality (Beatty, 2001).

Learning and retention also occur in different ways. Learning involves the brain, the nervous system, and the environment, and the process by which their interplay acquires information and skills. Sometimes, we need information for just a short period of time, like the telephone number for a pizza delivery, and then the information decays after just a few seconds. Thus, learning does not always involve long-term retention.

A good portion of the teaching done in schools centers on delivering facts and information to build concepts that explain a body of knowledge. We teach numbers, arithmetic operations, ratios, and theorems to explain mathematics. We teach about atoms, momentum, gravity, and cells to explain science. We talk about countries and famous leaders and discuss their trials and battles to explain history, and so on. Students may hold on to this information in working memory just long enough to take a test, after which the knowledge readily decays and is lost. Retention, however, requires that the learner not only give conscious attention but also build conceptual frameworks that have sense and meaning for eventual consolidation into long-term storage networks.

Implications for Students With Learning Disabilities. Because students with learning disabilities can have difficulty focusing for very long, they are even more likely to perceive learning facts as a temporary effort just to please the teacher or to pass a test. It becomes increasingly important, then, for teachers of these students to emphasize why they need to learn certain material. Meaning (or relevancy) becomes the key to focus, learning, and retention.

Retention is the process whereby long-term memory preserves a learning in such a way that the memory can be located, identified, and retrieved accurately in the future. This is an inexact process influenced by many factors including the degree of student focus, the length and type of rehearsal that occurred, the critical attributes that may have been identified, the student’s learning style, any learning disabilities, and, of course, the inescapable influence of prior learning.