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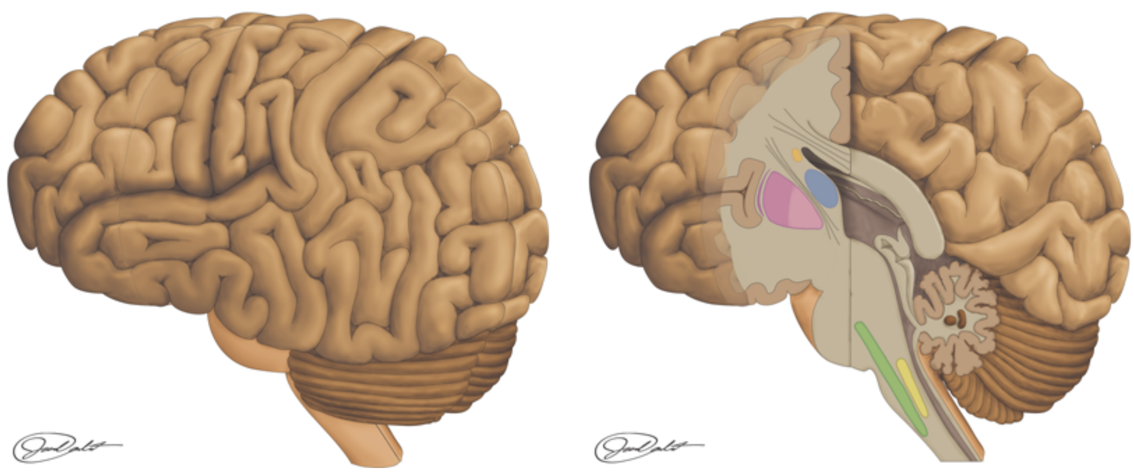
BRAIN OVERVIEW AND CEREBRUM

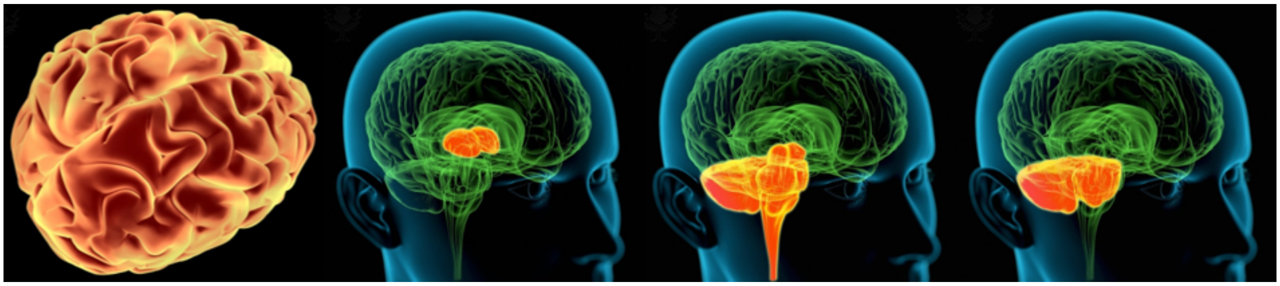


The Brain. *Image created by BYU-Idaho student Jared Cardinet Spring 2015*

The human brain is an incredible organ. In a Scientific American article published Oct 12, 2011, Mark Fischetti compared the human brain to the largest super computers. In the article he states: "For decades computer scientists have strived to build machines that can calculate faster than the human brain and store more information. The contraptions have won. The world's most powerful supercomputer, the K from Fujitsu, computes four times faster and holds 10 times as much data. And of course, many more bits are coursing through the Internet at any moment. Yet the Internet's servers worldwide would fill a small city, and the K sucks up enough electricity to power 10,000 homes. The incredibly efficient brain consumes less juice than a dim light bulb and fits nicely inside our head." The brain is the center of the nervous system and its functions include receiving, evaluating and responding to sensory input, storing information, planning future activities, reasoning and abstract thought. These functions are carried about by neurons, over 100 billion, which use action potentials as a means of communicating to other parts of the brain or to the rest of body. In order to generate the large number of neurons, our fetal brains had to produce about 500,000 neurons per minute during the early days of development. Each of us has about the same number of neurons in adulthood as they did at birth but the neurons grew and reached a maximum size at about age six. Synapses and brain organization continue through age 20 and perhaps beyond. How neurons send and receive action potential signals is well understood, but the way that neurons give rise to conscious awareness is still a mystery. It appears that a thought is a physical pathway of neurons in the brain. The more you use that pathway the easier it becomes to use, this is why repetition is so important in learning. This is also why having the thought "I'm so ugly," or "I'm a bad test taker" is never a good idea. Amazingly, aside from brain disease, your brain never loses the ability to learn and change. It is an urban legend that you only use 10% of the brain, we use it all!

As we study the brain we will identify different structures that are involved in specific functions. However, it is good to keep in mind that typically a given function will involve more than one region of the brain and that each region is probably involved in more than one function at a time. A good example is muscle movement. Normal, coordinated muscle movement involves several regions in the frontal lobe of the cerebrum, the basal nuclei and the cerebellum. We will see many other examples of this as we study the brain.

Although in appearance the human brain is nothing more than an oversized wrinkled walnut with the consistency of damp oatmeal, it can be divided into four major regions: the **cerebrum**, the **diencephalon**, the **brain stem**, and the **cerebellum** (see figure below). Additionally, each of these regions can be further subdivided into multiple structures. We will be learning the basic functions of each of these regions.



*© 2013 Encyclopædia Britannica, Inc. Downloaded from Image Quest Britannica; BYU-Idaho.***Diagrams, moving from left to right, illustrating the cerebrum, the diencephalon, the brain stem, and the cerebellum.**

The cerebrum is the largest and most superior part of the brain. It is highly developed in humans and separates man from all other species. It is divided into two **hemispheres** by the **longitudinal fissure** and each hemisphere is further divided into lobes. The classic division of the lobes is based on the cranial bones that overlay the cerebrum, hence there are four lobes, the **frontal**, the **parietal**, the **temporal**, and the **occipital** lobes. A fifth region, the **insula**, lies deeper in the cerebrum (Figure 2). Originally the lobes were designated solely based on their anatomical position but it is now known that each houses neurons with a specific function (more on this later). In order to increase the amount of surface area the cerebrum is arranged with numerous grooves and mounds. The grooves are called sulci (singular = sulcus) and the mounds are called gyri (singular = gyrus). Note: if the cerebrum were smooth it would have to be about the size of a beach ball to have the same amount of surface area. The arrangement of the gyri and sulci is fairly consistent between individuals but there are subtle individual differences. The outer 2-4 millimeters of the cerebrum is the **cerebral cortex**. It is composed of **gray matter**, which is made up of neuron cell bodies and dendrites. Under the gray matter is the medulla which is composed of **white matter**. White matter is primarily myelinated axons (Figure 3).The designation grey matter comes from the observation that it looks grey in fresh brain tissue and the inner layer looks white. Other clusters of cell bodies can be found deeper in the cerebrum within the white matter. These clusters are called **nuclei**. Recall that a cluster of neuron cell bodies in the peripheral nervous system is called a ganglion. The various nuclei of the cerebrum make up two important functional units, the **basal nuclei** and the **limbic system**.

Let's take a minute and try to explain how the brain works. Recall that typical neurons have three main components, a cell body, several dendrites and one axon. It is often helpful to compare the nervous system to a computer network. Using this analogy, each neuron cell body would be comparable to a computer or CPU. This is where information is stored, data is evaluated, and decisions are made. In a computer network individual CPUs are connected by fiber optic cables that send information from one CPU to another. The fiber optics would be analogous with the dendrites and axons in the brain. Their job is solely to transmit information, in the form of action potentials, from one cell body to the next. As the signal from one neuron reaches a synapse it generally results in one of two possible responses, it either excites the neuron, EPSP, or it inhibits the neuron, IPSP. It is the combination of these EPSPs and IPSPs that create the code that the nervous system uses. This is very much like the binary system of ones and zeros that computers use to process information. Hopefully, it is somewhat clear that it is the cell bodies (i.e. the gray matter in the cortex and nuclei) that do all of the processing in the brain while the white matter simply carries messages from one neuron to the next. One last thing, in a computer network your CPU can connect to virtually every other CPU in the system. In the brain each neuron cell body is connected to up to 10,000 other neurons! It isn't hard to imagine how complex the brain circuitry must be.

Recall that in our analogy of the computer network the axons function to transmit information like the fiber optic cables in a computer network. Functionally, the white matter within the medulla of the cerebrum can be divided into three types of fibers: **association fibers**, **commissural fibers** and **projection fibers**. Association fibers connect regions within a given hemisphere allowing the right frontal lobe to communicate with the right parietal lobe, etc. Commissural fibers allow the two hemispheres to communicate with each other, hence the right temporal lobe can talk to the left temporal lobe. Commissural fibers cross from one hemisphere to the other through an area called the **corpus callosum**. Projection fibers connect the cerebrum with other parts of the brain and to the spinal cord allowing information to be sent both out of and into the cerebrum.

Cerebral Cortex