...........................513
and
...........................519
ıtosis ▪
...........................529
Rabies ▪
is ▪
al Spastic
▪ Parasitic
...........................541
...........................544
gressive
▪ Chorea
...........................556
...........................561
▪
▪
itis ▪
egeneration
...........................568
...........................575
▪
ders ▪
ononeuritis
me ▪
...........................588
es That
l's Palsy ▪
...........................594

Merck Manual 2nd Home Edn, 2003

Biology of the Nervous System

The nervous system has two distinct parts: the central nervous system (the brain and spinal cord) and the peripheral nervous system (the nerves outside the brain and spinal cord).

The basic unit of the nervous system is the nerve cell (neuron). Nerve cells consist of a large cell body and nerve fibers—one elongated extension (axon) for sending impulses and usually many branches (dendrites) for receiving impulses. Normally, nerves transmit impulses electrically in one direction—from the impulse-sending axon of one nerve cell to the impulse-receiving dendrites of the next nerve cell. At contact points between nerve cells (synapses), the axon secretes tiny amounts of chemical messengers called neurotransmitters. Neurotransmitters trigger the receptors on the next nerve cell's dendrites to start up a new electrical current. Different types of nerves use different neurotransmitters to convey impulses across the synapses.

The nervous system is an extraordinarily complex communication system that can send and receive voluminous amounts of information simultaneously. However, the system is vulnerable to diseases and injuries. For example, nerves can degenerate, causing Alzheimer's disease or Parkinson's disease. Bacteria or viruses can infect the brain or spinal cord, causing encephalitis or meningitis. A blockage in the blood supply to the brain can cause a stroke. Injuries or tumors can cause structural damage to the brain or spinal cord.

Brain

The brain's functions are both mysterious and remarkable. From the brain come all thoughts, beliefs, memories, behaviors, and moods. The brain is the site of thinking and the control center for the rest of the body. The brain coordinates the abilities to move, touch, smell, taste, hear, and see. It enables people to form words, understand and manipulate numbers, compose and appreciate music, recognize and understand geometric shapes, communicate with others, plan ahead, and even fantasize.

The brain reviews all stimuli—from the internal organs, surface of the body, eyes, ears, nose, and mouth. It then reacts to these stimuli by correcting the position of the body, the movement of limbs, and the rate at which the internal organs function. The brain can also adjust mood and levels of consciousness and alertness.

No computer has yet come close to matching the capabilities of the human brain. However, this sophistication comes with a price. The brain needs constant nourishment; it demands an extremely high and continuous flow of blood and oxygen—about 20% of the blood flow from the heart. A loss of blood flow to the brain for more than about 10 seconds can cause loss of consciousness. Lack of oxygen, abnormally low sugar (glucose) levels in the blood, or toxic substances can cause the brain to malfunction within minutes. However, the brain is defended by several mechanisms that can usually prevent these problems. For example, if blood flow to the brain decreases, the brain immediately signals the heart to beat faster and more forcefully and thus to pump more blood. If the sugar level in the blood becomes too low, the brain signals the adrenal glands to release epinephrine (adrenaline), which stimulates the liver to release stored sugar.

In spite of its high demand for oxygen and nutrients supplied by the blood, the brain is separated from the blood by a thin barrier called the blood-brain barrier. In the brain, unlike in most of the body, the cells that form the walls of the capillaries are tightly sealed, forming the blood-brain barrier. (Capillaries are the smallest of the body's blood vessels, where the exchange of nutrients and oxygen between the blood and tissues of the body occurs.) The blood-brain barrier limits the types of substances that can pass into the brain and thus protects brain cells from some potentially toxic substances. For example, penicillin, many chemotherapy drugs, and most proteins (such as albumin—the most abundant protein in blood) cannot pass into the brain except in very tiny amounts. On the other hand, alcohol, caffeine, nicotine, and antidepressants can pass into the brain. Some substances needed by the brain, such as sugar and amino acids, do not readily pass through the barrier. However, the blood-brain barrier has transport systems that move substances the brain needs across the barrier to brain tissue.

The activity of the brain results from electrical impulses generated by nerve cells (neurons), which process and store information. The impulses pass along the nerve fibers within the brain. How much and what type of brain activity occurs and where in the brain it is initiated depend on a person's level of consciousness and the specific activity that the person is performing.

The brain has three main parts: the cerebrum, the brain stem, and the cerebellum.

The **cerebrum** consists of dense, convoluted masses of tissue. The outer layer is the cerebral cortex (gray matter). In adults, the cerebral cortex contains most of the nerve cells in the nervous system. Underneath the cortex is the white matter, which consists mainly of nerve fibers that connect the nerve cells in the cortex with other parts of the nervous system.

The cerebrum is divided into two halves—the left and right cerebral hemispheres. The hemispheres are connected in the middle by nerve fibers called the corpus callosum. Each hemisphere is further divided into a frontal, parietal, occipital, and temporal lobe.

The frontal lobes initiate many voluntary actions, ranging from looking toward an object of interest, to crossing a street, to relaxing the bladder to urinate. The frontal lobes control learned motor skills, such as writing, playing musical instruments, and tying shoelaces. They also control complex intellectual processes, such as speech, thought, concentration, problem-solving, and planning for the future. They control facial expressions and hand and arm gestures and coordinate expressions and gestures with mood and feelings. Particular areas of the frontal lobes control specific movements, typically of the opposite side of the body. In most people, the left frontal lobe controls most language functions.

The parietal lobes interpret sensory information from the rest of the body and control body movement. They combine impressions of form, texture, and weight into general perceptions. These lobes influence mathematical and language skills, which are controlled more specifically by adjacent areas of the temporal lobes. The parietal lobes store spatial memories that enable people to orient themselves in space (know where they are) and to maintain a sense of direction (know where they are going). The parietal lobes also process information that helps people know the position of their body parts.

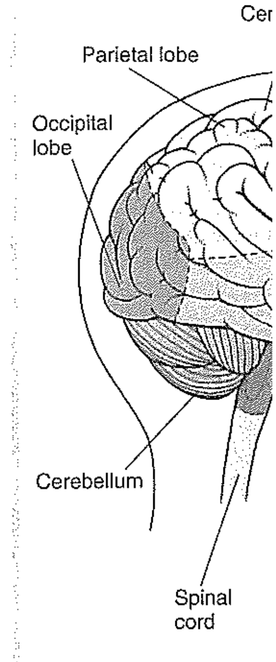
The occipital lobes process and interpret vision, enable people to form visual memories, and integrate visual perceptions with the spatial information provided by the adjacent parietal lobes.

The temporal lobes generate memory and emotions. They process immediate events into recent and long-term memory as well as store and retrieve long-term memories. They also comprehend sounds and images, enabling people to recognize other people and objects and to integrate hearing and speech.

Collections of nerve cells—the basal ganglia, thalamus, and hypothalamus—are located at the base of the cerebrum. The basal ganglia coordinate and smooth out movements. The thalamus generally organizes sensory messages to and from the highest levels of the brain (cerebral cortex), providing a general awareness of such sensations as pain, touch, and temperature. The hypothalamus coordinates some of the more automatic functions of the body, such as control of sleep and wakefulness, maintenance of body temperature, and regulation of appetite and the balance of water within the body.

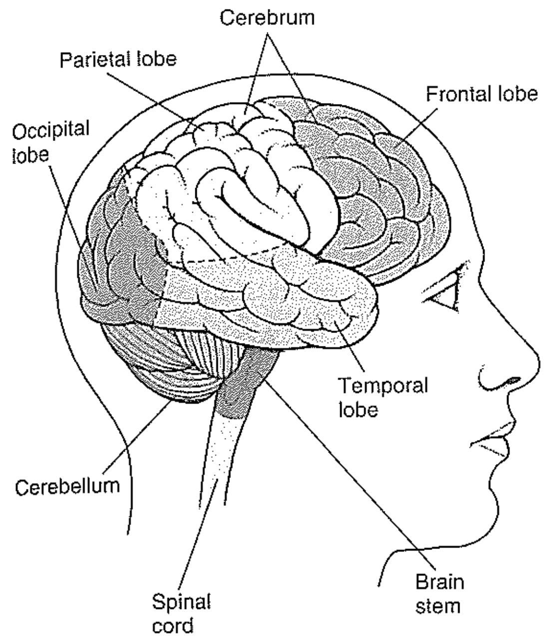
A system of nerve fibers—called the limbic system—connects the hypothalamus with other areas of the frontal and temporal lobes, which include the hippocampus and amygdala. The limbic system controls the experience and expression of emotions, as well as automatic functions of the body. By producing emotions (such as fear, anger, pleasure, and sadness), the limbic system enables people to behave in ways that help them communicate and survive physical and psychologic upsets. The hippocampus is also involved in the formation and retrieval of memories. Through the limbic system, memories that are emotionally charged are easier to recall than those that are not.

The **brain stem** connects the cerebrum with the spinal cord. A system of nerve cells and fibers (called the reticular activating system) located deep within the upper part of the brain stem controls levels of consciousness and alertness. The brain stem also automatically regulates critical body functions, such as breathing, swallowing, blood pressure, and heartbeat, and it helps adjust posture. If the entire brain stem becomes severely damaged, consciousness is lost, and these automatic body functions cease. Death soon follows.



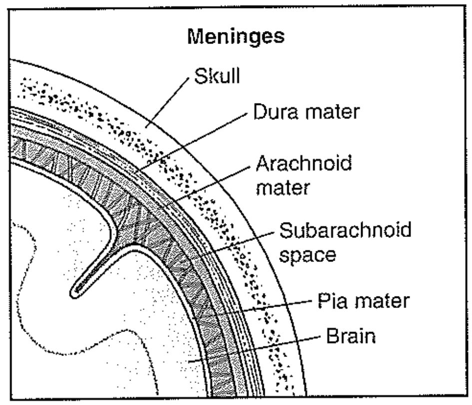
The **cerebellum**, whic
brum just above the bı
the body's movements.
receives from the cerebı
ganglia about the posit
cerebellum helps the l
and accurately. It does s
ing muscle tone and po
interacts with areas in
vestibular nuclei, whic
the organs of balance (s
the inner ear. Together
vide a sense of balance
stores memories of prac
abling highly coordinat
a ballet dancer's pirou
with speed and balance.

Both the brain and s
by three layers of tissu
pia mater is the inner
heres to the brain and
cate, spider web–like a
middle layer. The spac
noid mater and the pia
noid space) is a channel
which helps protect the
Cerebrospinal fluid flo



Viewing the Brain

The brain consists of the cerebrum, brain stem, and cerebellum. Each half (hemisphere) of the cerebrum is divided into lobes. Within the skull, the brain is covered by three layers of tissue called the meninges.



The **cerebellum,** which lies below the cerebrum just above the brain stem, coordinates the body's movements. With information it receives from the cerebral cortex and the basal ganglia about the position of the limbs, the cerebellum helps the limbs move smoothly and accurately. It does so by constantly adjusting muscle tone and posture. The cerebellum interacts with areas in the brain stem called vestibular nuclei, which are connected with the organs of balance (semicircular canals) in the inner ear. Together, these structures provide a sense of balance. The cerebellum also stores memories of practiced movements, enabling highly coordinated movements, such as a ballet dancer's pirouette, to be performed with speed and balance.

Both the brain and spinal cord are covered by three layers of tissue (meninges). The thin pia mater is the innermost layer, which adheres to the brain and spinal cord. The delicate, spider web–like arachnoid mater is the middle layer. The space between the arachnoid mater and the pia mater (the subarachnoid space) is a channel for cerebrospinal fluid, which helps protect the brain and spinal cord. Cerebrospinal fluid flows over the surface of the brain between the meninges, fills internal spaces within the brain (the four ventricles), and cushions the brain against sudden jarring and minor injury. The leathery dura mater is the outermost and toughest layer. The brain and its meninges are contained in a tough, bony protective structure, the skull.

Spinal Cord

The spinal cord is a long, fragile tubelike structure that begins at the end of the brain stem and continues down almost to the bottom of the spine (spinal column). The spinal cord consists of nerves that carry both incoming and outgoing messages between the brain and the rest of the body. It is also the center for reflexes, such as the knee jerk reflex.▲ Like the brain, the spinal cord is covered by three layers of tissue (meninges). The spinal cord and meninges are contained in the spinal canal, which runs through the center of the spine. In most adults, the spine is composed of 26 vertebrae, which are the individual bones of the back. Just as the skull protects the

▲ see art on page 442