

Biology of the Nervous System

.....513
 and

.....519
 itosis ■

.....529
 Rabies ■
 is ■
 al Spastic
 ■ Parasitic

.....541

.....544
 gressive
 ■ Chorea

.....556

.....561
 ■
 ■
 itis ■
 egeneration

.....568

.....575
 ■
 ders ■
 onneuritis
 me ■

.....588
 es That
 l's Palsy ■

.....594

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 informa-

tion that helps people know the position of their body parts.

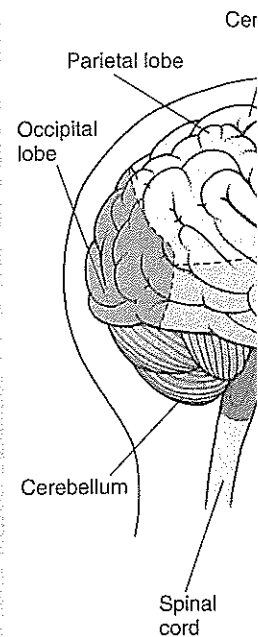
The occipital lobes process and interpret vision, enable people to form visual memories, and integrate visual perceptions with the spatial information provided by the adjacent parietal lobes.

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**, which sits just above the brain stem, controls the body's movements. It receives information from the cerebral cortex about the position of the body and helps the brain coordinate movements smoothly and accurately. It does this by adjusting muscle tone and posture. The cerebellum interacts with areas in the brain called the vestibular nuclei, which are the organs of balance (located in the inner ear). Together, they provide a sense of balance and store memories of past movements, enabling highly coordinated actions, such as a ballet dancer's pirouette, with speed and balance.

Both the brain and spinal cord are covered by three layers of tissue. The innermost layer is the pia mater, which adheres to the brain and spinal cord. The middle layer is the arachnoid mater, a spider web-like layer. The space between the arachnoid mater and the pia mater (called the subarachnoid space) is a channel through which cerebrospinal fluid flows.