7:6 Nervous System

Objectives
After completing this section, you should be able to:

- Identify the four main parts of a neuron
- Name the two main divisions of the nervous system
- Describe the function of each of the five main parts of the brain
- Explain three functions of the spinal cord
- Name the three meninges
- Describe the circulation and function of cerebrospinal fluid
- Contrast the actions of the sympathetic and parasympathetic nervous systems
- Describe at least five diseases of the nervous system
- Define, pronounce, and spell all key terms

KEY TERMS

autonomic nervous system
brain
central nervous system (CNS)
cerebellum (seh'-rah-bell'-um)
cerebrospinal fluid (seh-ree'-broh-spy'-nal fluid)
cerebrum (seh-ree'-brum)
diencephalon
hypothalamus
medulla oblongata (meh'-due'-la ob-lawn-got'-ah)
meninges (singular: meninx) (meh-nin'-jeez)
midbrain
nerves
nervous system
neuron (nur'-on)
parasympathetic (par'-ah-sim'-ik)
peripheral nervous system (PNS) (peh-rif'-eh-ral)
pons (ponz)
somatic nervous system
spinal cord
sympathetic
thalamus
ventricles

Related Health Careers

- Acupressurist
- Acupuncturist
- Anesthesiologist
- Chiropractor
- Diagnostic Imager
- Doctor of Osteopathic Medicine
- Electroencephalographic Technologist
- Electroneurodiagnostic Technologist
- Mental Health Technician
- Neurologist
- Neurosurgeon
- Nurse Anesthetist
- Physical Therapist
- Polysomnographic Technologist
- Psychiatrist
- Psychologist

The nervous system is a complex, highly organized system that coordinates all the activities of the body. This system enables the body to respond and adapt to changes that occur both inside and outside the body.

The basic structural unit of the nervous system is the neuron, or nerve cell (Figure 7-31). It consists of a cell body containing a nucleus; nerve fibers, called dendrites (which carry impulses toward the cell body);
Nerves are a combination of many nerve fibers located outside the brain and spinal cord. Afferent, or sensory, nerves carry messages from all parts of the body to the brain and spinal cord. Efferent, or motor, nerves carry messages from the brain and spinal cord to the muscles and glands. Associative, or internuncial, nerves carry both sensory and motor messages.

There are two main divisions to the nervous system: the central nervous system and the peripheral nervous system (Figure 7-32). The central nervous system (CNS) consists of the brain and spinal cord. The peripheral nervous system (PNS) consists of the nerves and has two divisions: the somatic nervous system and the autonomic nervous system. The somatic nervous system carries messages between the CNS and the body. The autonomic nervous system contains the sympathetic and parasympathetic nervous systems, which work together to control involuntary body functions.

Central Nervous System

The brain is a mass of nerve tissue well protected by membranes and the cranium, or skull (Figure 7-33). The main sections include:

- **Cerebrum**: the largest and highest section of the brain. The outer part is arranged in folds, called convolutions, and separated into lobes. The lobes include the frontal, parietal, temporal, and occipital, named from the skull bones that surround them (Figure 7-34, p. 167). The cerebrum is responsible for reasoning, thought, memory, judgment, speech, sensation, sight, smell, hearing, and voluntary body movement.

- **Cerebellum**: the section below the back of the cerebrum. It is responsible for muscle coordination, balance, posture, and muscle tone.

- **Diencephalon**: the section located between the cerebrum and midbrain. It contains two structures: the thalamus and hypothalamus. The thalamus acts as a relay center and directs sensory impulses to the cerebrum. It also allows conscious recognition of pain and temperature. The hypothalamus regulates and controls the autonomic nervous system, temperature, appetite, water balance, sleep, and blood vessel constriction and dilation. The hypothalamus is also involved in emotions such as anger, fear, pleasure, pain, and affection.

- **Midbrain**: the section located below the cerebrum at the top of the brainstem. It is responsible for conducting impulses between brain parts and for certain eye and auditory reflexes.
- **Pons:** the section located below the midbrain and in the brainstem. It is responsible for conducting messages to other parts of the brain; for certain reflex actions including chewing, tasting, and saliva production; and for assisting with respiration.

- **Medulla oblongata:** the lowest part of the brainstem. It connects with the spinal cord and is responsible for regulating heartbeat, respiration, swallowing, coughing, and blood pressure.

The **spinal cord** continues down from the medulla oblongata and ends at the first or second lumbar vertebrae. It is surrounded and protected by the vertebrae. The spinal cord is responsible for many reflex actions and for carrying sensory (afferent) messages up to the brain and motor (efferent) messages from the brain to the nerves that go to the muscles and glands. The **meninges** are three membranes that cover and protect the brain and spinal cord. The **dura mater** is the thick, tough, outer layer. The middle layer is delicate and weblike, and is called the **arachnoid membrane.** It is loosely attached to the other meninges to allow space for fluid to flow between the layers. The innermost layer, the **pia mater,** is closely attached to the brain and spinal cord, and contains blood vessels that nourish the nerve tissue.

The brain has four **ventricles,** hollow spaces that connect with each other and with the space under the arachnoid membrane (the subarachnoid space). The ventricles are filled with a clear, colorless fluid called **cerebrospinal fluid.** This fluid circulates continually between the ventricles and through the subarachnoid space. It serves as a shock absorber to protect the brain and spinal cord. It also carries nutrients to some parts of the brain and spinal cord and helps remove metabolic products and wastes. The fluid is produced in the ventricles of the brain by the special structures called **choroid plexuses.** After circulating, it is absorbed into the blood vessels of the dura mater and returned to the bloodstream through special structures called **arachnoid villi.**

**Peripheral Nervous System**

The peripheral nervous system consists of the somatic and the autonomic nervous systems.

**SOMATIC NERVOUS SYSTEM**

The somatic nervous system consists of 12 pairs of cranial nerves and their branches, and 31 pairs of spinal nerves and their branches. Some of the cranial nerves are responsible for special senses such as sight, hearing, taste, and smell (Figure 7-35, p. 168). Others receive general sensations
such as touch, pressure, pain, and temperature, and send out impulses for involuntary and voluntary muscle control. The spinal nerves carry messages to and from the spinal cord and are mixed nerves, both sensory (afferent) and motor (efferent). There are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 pair of coccygeal spinal nerves (Figure 7-36, p. 170). Each nerve goes directly to a particular part of the body or networks with other spinal nerves to form a plexus that supplies sensation to a larger segment of the body.

**AUTONOMIC NERVOUS SYSTEM**

The autonomic nervous system is an important part of the peripheral nervous system. It helps maintain a balance in the involuntary functions of the body and allows the body to react in times of emergency. There are two divisions to the autonomic nervous system: the sympathetic and parasympathetic nervous systems. These two systems usually work together to maintain a balanced state, or homeostasis, in the body and to control involuntary body functions at proper rates. In times of emergency, the sympathetic nervous system prepares the body to act by increasing heart rate, respiration, and blood pressure, and by slowing activity in the digestive tract. This is known as the fight or flight response. After the emergency, the parasympathetic nervous system counteracts the actions of the sympathetic system by slowing heart rate, decreasing respiration, lowering blood pressure, and increasing activity in the digestive tract.
Diseases and Abnormal Conditions

AMYOTROPHIC LATERAL SCLEROSIS

Amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig’s disease, is a chronic, degenerative neuromuscular disease. The cause is unknown, but genetic or viral-immune factors are suspected. Nerve cells in the CNS that control voluntary movement degenerate, resulting in a weakening and atrophy (wasting away) of the muscles they control. Initial symptoms include muscle weakness, abnormal reflexes, tripping and falling, impaired hand and arm movement, and difficulty in speaking or swallowing. As the disease progresses, more muscles are affected, resulting in total body paralysis. In the later stages, the patient loses all ability to communicate, breathe, eat, and move. Mental acuity is unaffected, so an active mind is trapped inside a paralyzed body. No treatment exists, but drugs such as Riluzole may slow the progress of the disease. Supportive care that includes physical therapy, occupational therapy, and speech therapy is used to relieve symptoms and improve quality of life. ALS life expectancy is 2 to 5 years from time of diagnosis, but some patients with slower rates of progression have survived 10–20 years after the diagnosis of the disease. Only 5 percent live longer than 20 years.
CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome is a progressively painful hand and arm condition that occurs when the medial nerve and tendons that pass through a canal or "tunnel" on their way from the forearm to the hands and fingers are pinched. Repetitive movement of the wrist causes swelling around this tunnel, which puts pressure on the nerves and tendons. Symptoms include pain, muscle weakness in the hand, and impaired movement. A classic symptom is pain, numbness, and tingling in the thumb, ring finger, and middle finger. Initially, carpal tunnel is treated with activity modification, anti-inflammatory medications, analgesics for pain, and splinting to immobilize the joint. Severe cases that do not respond to this treatment may require surgery to enlarge the "tunnel" and relieve the pressure on the nerves and tendons.

CEREBRAL PALSY

Cerebral palsy is a nonprogressive, noncontagious disturbance in voluntary muscle action and is caused by brain damage. Lack of oxygen to the brain, birth injuries, prenatal rubella (German measles), and infections can all cause cerebral palsy. Of the three forms—spastic, athetoid, and atactic—spastic is the most common. Symptoms include exaggerated reflexes, tense muscles, contracture development, seizures, speech impairment, spasms, tremors, and in some cases, mental retardation. Although there is no cure, physical, occupational, and speech therapy are important aspects of treatment. Muscle relaxants, anticonvulsive drugs, casts, braces, and/or orthopedic surgery (for severe contractures) are also used. In addition, botulinum toxin (Botox) can be injected directly into a contracted muscle to relax it.
CEREBROVASCULAR ACCIDENT

A cerebrovascular accident (CVA), also called a brain attack, stroke, or apoplexy, occurs when the blood flow to the brain is impaired, resulting in a lack of oxygen and a destruction of brain tissue. It can be caused by cerebral hemorrhage resulting from hypertension, an aneurysm, or a weak blood vessel; or by an occlusion, or blockage, caused by atherosclerosis or a thrombus (blood clot). Factors that increase the risk for a CVA include smoking, a high-fat diet, obesity, and a sedentary lifestyle. Symptoms vary depending on the area and amount of brain tissue damaged. Some common symptoms of an acute CVA include loss of consciousness, weakness or paralysis on one side of the body (hemiplegia), dizziness, dysphagia (difficult swallowing), visual disturbances, mental confusion, aphasia (speech and language impairment), and incontinence. A transient ischemic attack (TIA), also known as a ministroke, is caused by the same things as a CVA and has the same symptoms, but the symptoms only last for a few minutes and they do not cause permanent damage. TIAS are often a warning sign of an impending CVA. Prompt diagnosis and treatment of the cause of the TIA is important. When a CVA occurs, immediate care during the first 3 hours can help prevent brain damage. Treatment with thrombolytic or "clot-busting" drugs such as TPA (tissue plasminogen activator) or angioplasty of the cerebral arteries can dissolve a blood clot and restore blood flow to the brain. Computerized tomography (CT) scans (noninvasive computerized X-rays that show cross-sectional views of body tissue) are used to determine the cause of the CVA. Clot-busting drugs cannot be used if the CVA is caused by a hemorrhage. Neuroprotective agents, or drugs that help prevent injury to neurons, are also used initially to prevent permanent brain damage. Additional treatment depends on symptoms and is directed toward helping the person recover from or adapt to the symptoms that are present. Physical, occupational, and speech therapy are the main forms of treatment.

ENCEPHALITIS

Encephalitis is an inflammation of the brain and is caused by a virus, bacterium, chemical agent, or as a complication of measles, chicken pox, or mumps. The virus is frequently contracted through a mosquito bite because mosquitoes can carry the encephalitis virus. Symptoms vary but usually present as flu-like, then escalate depending on severity of infection. They may include fever, extreme weakness or lethargy, visual disturbances, headaches, vomiting, stiff neck and back, disorientation, seizures, coma, and rarely, death. Treatment methods are supportive and include antiviral drugs, anti-inflammatory drugs, maintenance of fluid and electrolyte balance, antiseizure medication, and monitoring and support of respiratory and kidney function.

EPILEPSY

Epilepsy, or seizure syndrome, is a brain disorder associated with abnormal surges in electrical impulses in the neurons of the brain. Although causes can include genetics, brain injury, birth trauma, tumors, toxins such as lead or carbon monoxide, and infections,
many cases of epilepsy are idiopathic (spontaneous, or primary). Absence, or petit mal, seizures are milder and are characterized by a loss of consciousness lasting several seconds. They are common in children and frequently disappear by late adolescence. Generalized tonic-clonic, or grand mal, are the most severe seizures. They are characterized by a loss of consciousness lasting several minutes; convulsions accompanied by violent shaking and thrashing movements; hypersalivation, causing foaming at the mouth; and loss of body functions. Some individuals experience an aura, such as a particular smell, ringing in the ears, visual disturbances, or tingling in the fingers and/or toes just before a seizure occurs. Anticonvulsant drugs are effective in controlling epilepsy in most people. In conjunction with, or in place of medications, a diet high in fat and low in carbohydrates (ketogenic), or vagus nerve stimulation (VNS) may be helpful in controlling seizures. In special cases, brain surgery can be performed to remove the area of the brain causing the seizures.

HYDROCEPHALUS

Hydrocephalus, also known as “water on the brain,” is an excessive accumulation of cerebrospinal fluid (CSF) in the ventricles and, in some cases, the subarachnoid space of the brain. It is usually caused by a congenital (at birth) defect, infection, or tumor that obstructs the flow of cerebrospinal fluid out of the brain. Symptoms include an abnormally enlarged head, prominent forehead, bulging eyes, irritability, distended scalp veins, and when pressure prevents proper development of the brain, retardation. If left untreated, it can be fatal. The condition can be treated by the surgical implantation of a shunt (tube) between the ventricles and the veins, heart, or abdominal peritoneal cavity to provide for drainage of the excess fluid. A ventriculostomy can also be performed to create a hole in the bottom of the ventricle to allow CSF to drain toward the base of the brain to be reabsorbed.

MENINGITIS

Meningitis is an inflammation of the meninges of the brain and/or spinal cord and is caused by a bacterium, virus, fungus, or toxin such as lead or arsenic. Early signs can easily be mistaken as the flu. Symptoms include high fever, headaches, back and neck pain and stiffness, nausea and vomiting, delirium, convulsions, and if untreated, coma and death. Treatment methods include antibiotics, antipyretics (for fever), anticonvulsants, and/or medications for pain and cerebral edema.

Some forms of bacterial meningitis are preventable with vaccinations.

MULTIPLE SCLEROSIS

Multiple sclerosis (MS) is a chronic, progressive, disabling condition resulting from a degeneration of the myelin sheath in the CNS. It usually occurs between the ages of 20 and 40 (Figure 7-37). The cause is unknown but genetics or an autoimmune disorder in which the body attacks its own tissue (in this case, the myelin sheath) are suspected. The disease progresses at different rates and has periods of remission. Early symptoms include visual disturbances such as diplopia (double vision), weakness, fatigue, poor coordination, and tingling and numbness. As the disease progresses, tremors, muscle spasticity, paralysis, speech impairment, emotional swings, and incontinence occur. There is no cure. Beta interferon medications are being used to slow the

**FIGURE 7-37** Multiple sclerosis usually occurs between the ages of 20 and 40. Courtesy, National Multiple Sclerosis Society.
rate at which MS progresses. Treatment methods such as physical therapy, muscle relaxants, steroids, and psychological counseling are used to maintain functional ability as long as possible.

NEURALGIA

Neuralgia is nerve pain that is experienced without stimulation of the nerve receptor. The pain is caused by nerve damage and is often very difficult to diagnose. It is a form of chronic pain affecting more women than men, and it does not respond well to traditional pain medication. The pain can be so severe that the person is unable to sleep or eat. High doses of anticonvulsant medications may be used to block the nerves from firing. Antidepressant medications, acupuncture, vitamin or nutritional therapy, hot and cold compresses, and electrical nerve stimulation may also relieve the pain.

PARALYSIS

Paralysis is the loss of voluntary muscle movement and coordination in some part of the body. It usually results from a brain or spinal cord injury that destroys neurons and results in a loss of function and sensation below the level of injury. Hemiplegia is paralysis on one side of the body and is caused by a tumor, injury, or CVA. Paraplegia is paralysis in the lower extremities or lower part of the body and is caused by a spinal cord injury. Quadriplegia is paralysis of the arms, legs, and body below the spinal cord injury. Currently, no cure exists, although much research is being directed toward repairing spinal cord damage, including nerve reconstruction. Treatment methods are supportive and include physical and occupational therapy.

PARKINSON’S DISEASE

Parkinson’s disease is a chronic, progressive condition involving degeneration of brain cells, usually in persons over 50 years of age. Symptoms include tremors, stiffness, muscular rigidity, a forward-leaning position, a shuffling gait, difficulty in stepping while walking, loss of facial expression, drooling, mood swings and frequent depression, and behavioral changes. Although no cure exists, drugs such as levodopa, dopamine agonists, and MAO-B inhibitors are used to relieve the symptoms. Deep brain stimulation (DBS) therapy uses an implantable device that has been proven to reduce some of the symptoms of Parkinson’s. In some cases, surgery can be performed to selectively destroy a small area of the brain and control involuntary movements. Physical therapy is also used to limit muscular rigidity.

SHINGLES

Shingles, or herpes zoster, is an acute inflammation of nerve cells and is caused by the herpes virus, which also causes chicken pox. A person who has shingles can pass the virus to those who have not had chicken pox. This occurs through direct contact with open sores. However, the infected person will develop chicken pox, not shingles. It characteristically occurs in the thoracic area on one side of the body and follows the path of the affected nerves (Figure 7-38). Fluid-filled vesicles appear on the skin, accompanied by severe pain, redness, itching, fever, and abnormal skin sensations. Antiviral medications should be started within 72 hours of the first sign of the rash to decrease the severity and duration of the symptoms. Treatment is directed toward relieving pain and itching until the inflammation subsides, usually in 1–4 weeks.

STUDENT: Go to the workbook and complete the assignment sheet for 7-6, Nervous System.