CHAPTER 14 – NERVOUS SYSTEM

OBJECTIVES

On completion of this chapter, you will be able to:

• Describe the tissues of the nervous system.
• Describe nerve fibers, nerves, and tracts.
• Describe the transmission of nerve impulses.
• Describe the central nervous system.
• Describe the peripheral nervous system.
• Describe the autonomic nervous system.
• Analyze, build, spell, and pronounce medical words.
• Comprehend the drugs highlighted in this chapter.
• Describe diagnostic and laboratory tests related to the nervous system.
• Identify and define selected abbreviations.
• Describe each of the conditions presented in the Pathology Spotlights.
• Review the Pathology Checkpoint.
• Complete the Study and Review section and the Chart Note Analysis.

OUTLINE

I. Anatomy and Physiology Overview (Fig. 14–1, p. 448)

The nervous system is usually described as having two interconnected divisions. The CNS or central nervous system, which includes the brain and spinal cord, is enclosed by the bones of the skull and spinal column. The PNS or peripheral nervous system, the second portion, consists of a network of nerves and neural tissues branching throughout the body from 12 pairs of cranial nerves and 31 pairs of spinal nerves.

A. Tissues of the Nervous System (Fig. 14–2, p. 450) – there are two principal tissue types in the nervous system. These tissues are made up of neurons or nerve cells and their supporting tissues, collectively called neuroglia. Neurons are the structural and functional units of the nervous system. These cells are specialized conductors of impulses that enable the body to interact with its internal and external environments. There are several types of neurons:

1. **Motor Neurons** – cause contractions in muscles and secretions from glands and organs. They also act to inhibit the actions of glands and organs, thereby controlling most of the body’s functions. Motor neurons can be described as being *efferent processes*, as they transmit impulses away from the neural cell body to the muscles or organs to be innervated. Motor neurons consist of a nucleated cell body with protoplasmic processes extending away from it in several directions. These processes are known as:
a. **Axon** – long and covered with a fatty substance, the myelin sheath, which acts as an insulator and increases the transmission velocity of the nerve fiber it surrounds. Axons may be as long as several feet and reach from the cell body to the area to be activated.

b. **Dendrites** – resemble the branches of a tree and are short, or unsheathed, and transmit impulses to the cell body. Neurons usually have several dendrites and only one axon.

2. **Sensory Neurons** – differ in structure from motor neurons because they do not have true dendrites. The processes transmitting sensory information to the cell bodies of these neurons are called **peripheral processes**. These structures are sheathed and resemble axons. They are attached to sensory receptors and transmit impulses to the central nervous system (CNS). In turn, the CNS may stimulate motor neurons in response to this sensory information. Sensory neurons are sometimes referred to as **afferent nerves**, as they carry impulses to the cell body and the central nervous system.

3. **Interneurons** – also called **central** or **associative neurons**; interneurons are located entirely within the central nervous system. They function to mediate impulses between sensory and motor neurons.

B. **Nerve Fibers, Nerves, and Tracts** – these terms are used to describe neuronal processes conducting impulses from one location to another.

1. **Nerve Fibers** – a single elongated process, usually a long axon or a peripheral process from a sensory neuron.

a. **Peripheral Nervous System Nerve Fibers** – these fibers are wrapped by protective membranes called **sheaths**. There are two types of sheaths, which are formed by accessory cells, to include:

   - **Myelinated Fibers** – have an inner sheath of **myelin**, a thick fatty substance, as well as an outer sheath, or **neurilemma** composed of Schwann cells.
   - **Unmyelinated Fibers** – lack myelin and are only sheathed by the neurilemma.

b. **Central Nervous System Nerve Fibers** – the nerve fibers of the CNS do not contain Schwann cells, which is necessary for regeneration of a damaged nerve fiber. Therefore, damage to fibers of the CNS is permanent, whereas damage to a peripheral nerve may be reversible.

2. **Nerves** – bundles of nerve fibers, located outside the brain and spinal cord that connects to various parts of the body. Nerves are usually described as being:
   - **Afferent** – also referred to as **sensory nerves**, they conduct to the CNS.
• **Efferent** – also referred to as **motor nerves**, they conduct to muscles, organs, and glands.

• **Mixed Nerves** – some nerves contain a mixture of afferent and efferent fibers.

3. **Tracts** – groups of nerve fibers within the central nervous system that have the same origin, function, and termination. The spinal cord contains afferent sensory tracts ascending to the brain and efferent motor tracts descending from the brain. The brain itself contains numerous tracts, the largest of which is the **corpus callosum** joining the left and right hemispheres.

C. **Transmission of Nerve Impulses** – Stimulation of a nerve occurs at a receptor. Sensory receptors are of different types, ranging from the simplest, which are free nerve endings for pain, to the most complex, as in the retina of the eye for vision. Receptors are generally specialized to specific types of stimulation such as heat, cold, light, pressure, or pain and react by initiating a chemical change or impulse. The transmission of an impulse by a nerve fiber is based on the **all-or-none principle**, which means that no transmission occurs until the stimulus reaches a set minimum strength, which may vary with different receptors. Once the minimum stimulus or threshold is reached, a maximum impulse is produced. The impulse is then transmitted via a **synapse**, a specialized knoblike branch ending, with the help of certain chemical agents, across a space separating the axon’s end knobs from the dendrites of the next neuron or from a motor end plate attached to a muscle. This space is called a **synaptic cleft**, and the **chemical agents** released are called **neurotransmitters**.

D. **Central Nervous System** – consisting of the brain and spinal cord, the CNS:

• Receives impulses from throughout the body.

• Processes the information.

• Responds with an appropriate action.

This activity may be at the conscious or unconscious level, depending on the source of the sensory stimulus. Both the brain and spinal cord can be divided into two parts:

• **Gray Matter** – consists of unsheathed cell bodies and dendrites.

• **White Matter** – composed of myelinated nerve fibers.

In the spinal cord, the arrangement of white and gray matter results in an H-shaped core of gray cell bodies surrounded by tracts of nerve fibers interconnected to the brain. The reverse is generally true of the brain where the surface layer or cortex is gray matter and most of the internal structures are white matter.
1. **Brain (Fig. 14–3, p. 452)** – the brain’s nervous tissue consists of millions of nerve cells and fibers. It is the largest mass of nervous tissue in the body. When developed, the brain fills the cranial cavity and is enclosed by three membranes known collectively as the **meninges**, named from the outside in:

- **Dura Mater** – the outermost, toughest, and most fibrous membrane covering the brain and spinal cord.
- **Arachnoid** – serous membrane forming the middle of the three coverings of the brain and spinal cord.
- **Pia Mater** – delicate innermost membrane enveloping the brain and spinal cord.

The major structures of the brain are as follows:

a. **Cerebrum (Table 14–1, p. 453)** – represents seven-eighths of the brain’s total weight, the cerebrum contains nerve centers that govern all sensory and motor activity, including sensory perception, emotions, consciousness, memory, and voluntary movements. It is divided by the longitudinal fissure into two cerebral hemispheres, the right and left, that are joined the **corpus callosum** that allows information to pass from one hemisphere to the other. The surface or **cortex** of each hemisphere is arranged in folds creating bulges and shallow furrows named as followed:

- **Gyrus or Convolution** – each bulge of the cerebrum.
- **Sulcus** – each shallow furrow of the cerebrum.
- **Cerebral Cortex** – the surface of the cerebrum, which is composed of gray, unmyelinated cell bodies, and is further divided into lobes as a means of identifying certain locations. Electrical stimulation of the various areas of the cortex during neurosurgery has identified specialized cell activity within the different lobes, which are named for the corresponding bone in which they reside (Fig. 14–4, p. 454):
  - **Frontal Lobe** – location of the brain’s major motor area and the site for personality and speech.
  - **Parietal Lobe** – contains centers for sensory input from all parts of the body and is known as the *somesthetic area* and the site for the interpretation of language, temperature, pressure, touch, and awareness of muscle control.
  - **Temporal Lobe** – contains centers for hearing, smell, and language input.
o **Occipital Lobe** – the lower rear part of the cerebrum beneath the parietal lobe and posterior to the temporal lobe; it is considered to be the primary sensory areas for vision.

b. **Cerebellum (Table 14–1, p. 453)** – the second largest part of the brain, the cerebellum occupies a space in the back of the skull, inferior to the cerebrum and dorsal to the pons and medulla oblongata. It is oval in shape and divided into lobes by deep fissures. Its has a cortex of gray cell bodies and its interior contains nerve fibers and white matter connecting it to every part of the central nervous system. The cerebellum plays an important part in the coordination of voluntary movement.

c. **Diencephalon (Table 14–1, p. 453)** – means second portion of the brain and refers to the thalamus and hypothalamus.

- **Thalamus** – the larger of the two divisions of the diencephalon; actually two large masses of gray cell bodies joined by a third or intermediate mass. Serves as a relay enter for all sensory impulses (except olfactory) being transmitted to the sensory areas of the cortex. The thalamus also relays motor impulses from the cerebellum and the basal ganglia to motor areas of the cortex. Some impulses related to emotional behavior are also passed from the hypothalamus, through the thalamus, to the cerebral cortex.

- **Hypothalamus** – lies beneath the thalamus and is a principal regulator of autonomic nervous activity that is associated with behavior and emotional expression. It also produces neurosecretions for the control of water balance, sugar and fat metabolism, regulation of body temperature, and other metabolic activities. Additionally, the hypothalamus produces hormones for the posterior pituitary gland and exerts control over secretions from both the anterior and posterior pituitary. The pituitary gland is attached to the hypothalamus by a narrow stalk called the **infundibulum**.

d. **Brainstem (Table 14–1, p. 453)** – consists of three structures: the **mesencephalon** or **midbrain**, the **pons**, and the **medulla oblongata**, which contain centers that, along with other important functions, process visual, auditory and sensory data and relay information to and from the cerebrum.
• **Midbrain or Mesencephalon** – located below the cerebrum and above the pons. It has four small masses of gray cells known collectively as the **corpora quadrigemina**. The upper two of these masses, called the **superior colliculi**, are associated with visual reflexes such as the tracking movements of the eyes. The lower two, or **inferior colliculi**, are involved with the sense of hearing.

• **Pons** – broad band of white matter located anterior to the cerebellum and between the midbrain and the medulla oblongata. It contains fiber tracts linking the cerebellum and medulla to higher cortical areas. Plays a role in somatic and visceral motor control.

• **Medulla Oblongata** – that part of the brainstem that connects the pons and the rest of the brain to the spinal cord. All the afferent and efferent tracts from the spinal cord either pass through or terminate in the medulla oblongata. It also contains nerve centers instrumental to the regulation and control of breathing, swallowing, coughing, sneezing, and vomiting. Other centers in the medulla regulate heartbeat and arterial blood pressure, thereby exerting control over the circulation of blood.

2. **Spinal Cord (Fig. 14–5, p. 456)** – has an H-shaped gray area of cell bodies encircled by an outer region of white matter. Its functions are to conduct sensory impulses to the brain, to conduct motor impulses from the brain, and to serve as a reflex center for impulses entering and leaving the spinal cord without involvement of the brain. Various areas of the spinal cord are:
   • **White Matter** – consists of nerve tracts of fibers providing sensory input to the brain and conducting motor impulses from the brain to spinal neurons.
   • **Other Fibers** – connect nerve cells within the spinal cord with other areas of the cord. It extends down the vertebral canal from the medulla to terminate near the junction of the L1 and L2.
   • **Conus Medullaris** – the area of the spinal cord located between the T-12 and L-1, where it becomes conically tapered.
   • **Filum Terminale** – also known as the terminal thread of fibrous tissue extends from the conus medullaris to the second sacral vertebra.

3. **Cerebrospinal Fluid** – colorless fluid that surrounds the brain and spinal cord. It is produced by the **choroid plexuses** within the ventricles of the brain and circulates through the ventricles, the central canal, and the subarachnoid space. Cerebrospinal fluid is removed from circulation by the **arachnoid villi**, which are small
projections of the arachnoid membrane that penetrate the tough outer membrane, the dura mater. The arachnoid villi allow fluid to drain into the superior sagittal sinus. The purpose of the fluid is to:

- Serve as a cushion to the brain and cord from shocks.
- Help support the brain by allowing it to float within the supporting liquid.
- Carry neurotransmitters.

E. Peripheral Nervous System (PNS) – network of nerves branching throughout the body from the brain and spinal cord. There are 12 pairs of cranial nerves that attach to the brain and 31 pairs of spinal nerves connected to the spinal cord.

1. Cranial Nerves (Fig. 14–6, p. 457) (Table 14–2, p. 458) – nerves that attach to the brain and provide sensory input, motor control, or a combination of these functions. They are arranged symmetrically, 12 to each side of the brain, and generally are named for the area or function they serve:

   a. Olfactory Nerve (I) – provides sensory input only and carries impulses for smell to the brain. The cell bodies of these nerve fibers are located in the nasal mucous membrane and serve as receptors for the sense of smell.

   b. Optic Nerve (II) – provides sensory input only and carries impulses for vision to the brain. The rods and cones of the eyes are receptors and transmit images through the cells of the retina to processes that form the optic nerve. The optic nerves from each eye unite after entering the cranial cavity to form the optic chiasm from which tracts, carrying images from both eyes, connect to the brain.

   c. Oculomotor Nerve (III) – conducts motor impulses to four of the six external muscles of the eye and to the muscle that raises the eyelid. The cell bodies of motor nerves are located in the brain.

   d. Trochlear Nerve (IV) – conducts motor impulses to control the superior oblique muscle of the eyeball.

   e. Trigeminal Nerve (V) – has both sensory and motor fibers, which form three sensory divisions, the ophthalmic, maxillary, and mandibular. These fibers provide sensory input from the face, nose, mouth, forehead, and top of the head. The mandibular division also contains motor fibers to the muscles of the jaw.

   f. Abduces Nerve (VI) – conducts motor impulses to the lateral rectus muscle of the eyeball.

   g. Facial Nerve (VII) – has both sensory and motor fibers, which control the muscles of the face and scalp, thereby providing for facial expression. It also provides efferent fibers to control the lacrimal glands of the eyes as well as...
the submandibular and sublingual salivary glands. Sensory fibers of the facial nerve provide input from the forward two thirds of the tongue for the sense of taste.

h. Vestibulocochlear Nerve (Acoustic or Auditory) (VIII) – provides sensory input for hearing and equilibrium. Fibers of the cochlear division connect with receptors in the cochlea of the ear for hearing and fibers of the vestibular division connect to receptors in the semicircular canals and vestibule located in the ear for the sense of equilibrium.

i. Glossopharyngeal Nerve (IX) – has both sensory and motor fibers in which the sensory fibers provide for the general sense of taste and attach to the back of the tongue and pharynx. Motor fibers innervate the stylopharyngeous muscle and are important to the act of the swallowing. Other efferent fibers control the secretion of saliva from the parotid gland.

j. Vagus Nerve (X) – contains both sensory and motor fibers and is the longest of the cranial nerves. The motor fibers innervate palatal and pharyngeal muscles and branch to the heart, lungs, stomach, and intestines. The sensory fibers provide input from the pharynx, the external ear, the diaphragm, and the organs of the thoracic and abdominal cavities.

k. Accessory Nerve (XI) – conducts motor impulses for the control of the trapezius and sternocleidomastoid muscles, permitting movement of the head and shoulders.

l. Hypoglossal Nerve (XII) – conducts motor impulses for control of the muscles of the tongue.

2. Spinal Nerves (Fig. 14–5, p. 456) (Fig. 14–7, p. 459) – 31 pairs of spinal nerves are distributed along the length of the spinal cord and emerge from the vertebral canal on either side through the intervertebral foramina. At the point of attachment, each nerve divides into the following:
   - Dorsal or Sensory Root – composed of afferent fibers, which carry impulses to the cord.
   - Ventral Root – contains motor fibers carrying efferent impulses to muscles and organs.

These nerves are named for the region of the vertebral column from which they exit; they are:

- Cervical Spinal Nerves – 8 pairs.
- Thoracic Spinal Nerves – 12 pairs.
- Lumbar Spinal Nerves – 5 pairs.
- Sacral Spinal Nerves – 5 pairs.
- Coccygeal Spinal Nerves – 1 pair.
A short distance from the cord, the fibers of the two roots unite to form a single spinal nerve composed of afferent and efferent fibers. Each spinal nerve then branches into several smaller nerves. The two primary branches from each spinal nerve are the:

- **Dorsal Rami** – carries motor and sensory fibers to the muscles and skin of the back and serve an area from the back of the head to the coccyx.
- **Ventral Rami** – serves a much larger area, carrying both motor and sensory fibers to the muscles and organs of the body, including the arms, legs, hands, and feet.

E. **Autonomic Nervous System (ANS) (Fig. 14–8, p. 460)** – a part of the peripheral nervous system, the ANS controls involuntary bodily functions such as sweating, secretions of glands, arterial blood pressure, smooth muscle tissue, and the heart. The autonomic nervous system is primarily composed of efferent fibers from certain cranial and spinal nerves and can be functionally divided into two divisions, which counteract each other’s activity to keep the body in a state of homeostasis. The divisions are:

1. **Sympathetic Division (Fig. 14–9, p. 461)** – consists of branches from the ventral roots of the 12 thoracic and the first 3 lumbar spinal nerves. The cell bodies of these nerve fibers are located in the gray matter of the spinal cord. Just outside the spinal cord, axons of these nerve cells leave the spinal nerves and enter almost immediately into masses of nerve cell bodies, the **sympathetic ganglia**, which form a chain that runs next to the vertebral column. This chain of about 23 ganglia runs from the base of the head to the coccyx and is known as the **sympathetic trunk**. Within the ganglia of the sympathetic trunk, fibers from the spinal nerves synapse with **ganglionic nerve cell bodies**, which produce long axons that reach to the parts of the body to be innervated thus creating a two-neuron chain as opposed to single-neuron control of regular motor nerves:

- **Fight-or-Flight Response** – the condition that occurs when the sympathetic system stimulates the adrenal gland to release epinephrine (adrenaline), the hormone that causes the familiar adrenaline rush. Because of the arrangement in which sympathetic fibers from spinal nerves synapse with many cell bodies in the sympathetic ganglia, they tend to produce widespread innervation when activated.

2. **Parasympathetic Division** – works to conserve energy and innervate the digestive system. When activated, it stimulates the salivary and digestive glands, decreases the metabolic rate, slows the heart rate, reduces blood pressure, and promotes the passage of material through the intestines along with absorption of nutrients by the blood. It consist of very long fibers branching from cranial
nerves 3, 7, 9, and 10 along with long fibers of sacral nerves 2, 3, and 4. Cell bodies for these long fibers are located in the brain and spinal cord. The long fibers extend to ganglia located close by the organs to be innervated. The process includes:

- Fibers of the cranial and sacral nerves synapse with ganglionic cell bodies.
- An impulse is conducted over short axons to the gland, smooth muscle tissue, or organ to be innervated.
- Fibers from the cranial nerves serve the iris and ciliary muscles of the eye, lacrimal glands, and salivary glands through four ganglia located in the head.
- Cranial nerve fibers extend via the vagus nerve to ganglia serving the thoracic, abdominal, and pelvic viscera.
- The fibers of the sacral spinal nerves form the pelvic nerve, which branches to synapse with small ganglia near or within the organs to be innervated. The cell bodies of these ganglia serve the lower colon, rectum, bladder, and reproductive organs.

II. Life Span Considerations
   A. The Child – neural tube development occurs about the third to fourth week of embryonic life. This development becomes the central nervous system. At 6 weeks a developing baby’s brain waves are measurable. At 28 weeks the fetal nervous system begins some regulatory functions. At 32 weeks the fetal nervous system is continuing to mature, so that rhythmic respirations and regulation of body temperature are possible if delivery of the fetus occurs at this time. Brain and nerve cell growth are most rapid from birth until about 4 years of age. A baby’s brain has three main structural parts:

- **Cerebrum** – serves as a control center as it receives, processes, and acts on information.
- **Cerebellum** – helps coordinate muscle activities and maintains posture and balance.
- **Brainstem** – maintains vital body functions, such as breathing, heartbeat, blood pressure, digestion, and swallowing.

In an infant, the right and left hemispheres of the brain have not yet developed their own specific tasks. At about four to six weeks of life, motor function is the main connection taking place in the brain. The initial movements characteristic of an infant soon give way to the repetition of smoother, deliberate ones as the brain’s motor cortex process new signals and strengthens connections. Over the next 12 months, a baby’s brain focuses first on gross-motor skills.

B. The Older Adult – experiences a decrease in the number of nerve cells and a reduction in brain mass. Loss may occur in different areas of the brain and to varying degrees; however, in many older adults there is very
little change in function, because a person has more nerve cells than needed. There are decreasing levels of neurotransmitters in synapses between nerve cells, which generally affects short-term memory, motor coordination and control. The older adult has slower response time and decreased reflexes. Loss of cells in the brainstem changes sleep patterns resulting in a shorter and more restless nights. As one ages, however, the learning of new information and skills continues.

III. Building Your Medical Vocabulary
A. Medical Words and Definitions – this section provides the foundation for learning medical terminology. Medical words can be made up of four types of word parts:
  1. Prefix (P)
  2. Root (R)
  3. Combining Forms (CF)
  4. Suffixes (S)
By connecting various word parts in an organized sequence, thousands of words can be built and learned. In the text, the word list is alphabetized so one can see the variety of meanings created when common prefixes and suffixes are repeatedly applied to certain word roots and/or combining forms. Words shown in pink are additional words related to the content of this chapter that have not been divided into word parts. Definitions identified with an asterisk icon (*) indicate terms that are covered in the Pathology Spotlights section of the chapter.

IV. Drug Highlights
A. Analgesics – inhibit ascending pain pathways in the central nervous system. They increase pain threshold and alter pain perception. They are available in narcotic and non-narcotic forms.
B. Analgesics–Antipyretics – act to relieve pain (analgesic effect) and reduce fever (antipyretic effect).
C. Sedatives and Hypnotics – work to depress the central nervous system by interfering with the transmission of nerve impulses. Depending upon the dosage, barbiturates, benzodiazepines, and certain other drugs can produce either a sedative or a hypnotic effect. When used as a sedative, the dosage is designed to produce a calming effect without causing sleep. Used as a hypnotic, the dosage is sufficient to cause sleep.
D. Antiparkinsonism Drugs – used for palliative relief from such major symptoms as bradykinesia, rigidity, tremor, and disorder of equilibrium and posture. Therapy involves an attempt to replenish dopamine levels and/or inhibit the effects of the neurotransmitter acetylcholine.
E. Anticonvulsants – inhibit the spread of seizure activity in the motor cortex.
F. Cholinesterase Inhibitors – increase the brain’s levels of acetylcholine, which helps to restore communication between brain cells. These medications may be used to improve global functioning (including
activities of daily living, behavior, and cognition) in some patients with Alzheimer’s disease.

G. **Anesthetics** – interfere with the conduction of nerve impulses and are used to produce loss of sensation, muscle relaxation, and/or complete loss of consciousness. They block nerve transmission in the area to which they are applied.

1. **Local** – block nerve transmission in the area to which they are applied.

2. **General** – affects the central nervous system and produces either partial or complete loss of consciousness. They also produce analgesia, skeletal muscle relaxation, and reduction of reflex activity.

V. **Diagnostic and Lab Tests**

A. **Cerebral Angiography** – process of making an x-ray record of the cerebral arterial system. A radiopaque substance is injected into an artery of the arm or neck, and x-ray films of the head are taken. Cerebral aneurysms, tumors, or ruptured blood vessels may be visualized.

B. **Cerebrospinal Fluid (CSF) Analysis** – examination of spinal fluid for color, pressure, pH, and the level of protein, glucose, and leukocytes. Abnormal results may indicate hemorrhage, a tumor, and various disease processes.

C. **Computed Tomography (CT)** – diagnostic procedure used to study the structure of the brain. Computerized three-dimensional x-ray images allow the radiologist to differentiate between intracranial tumors, cysts, edema, and hemorrhage.

D. **Echoencephalography** – process of using ultrasound to determine the presence of a centrally located mass in the brain.

E. **Electroencephalography (EEG)** – process of measuring the electrical activity of the brain via an electroencephalograph. Abnormal results may indicate epilepsy, brain tumor, infection, abscess, hemorrhage, and/or coma. Also, brain “death” may be determined by an EEG.

F. **Lumbar Puncture (LP) (Fig. 14–20, p. 477)** – insertion of a needle into the lumbar subarachnoid space for removal of spinal fluid. The fluid is examined for color, pressure, and the level of protein, chloride, glucose, and leukocytes.

G. **Myelogram** – x-ray of the spinal canal after the injection of a radiopaque dye. Useful in diagnosing spinal lesions, cysts, herniated disks, tumors, and nerve root damage.

H. **Neurologic Examination** – assessment of a patient’s vision, hearing, sense of taste, smell, touch and pain, position, temperature, gait, muscle strength, coordination, and reflex action; used to determine a patient’s neurologic status.

I. **Positron Emission Tomography (PET)** – computer-based nuclear imaging procedure that can produce three-dimensional pictures of actual organ functioning. Useful in locating a brain lesion, in identifying blood
flow and oxygen metabolism in stroke patients, in showing metabolic changes in Alzheimer’s disease, and in studying biochemical changes associated with mental illness.

J. **Ultrasonography, Brain** – use of high-frequency sound waves to record echoes on an oscilloscope and film; used as screening test or diagnostic tool.

VI. **Abbreviations (p. 477)**

VII. **Pathology Spotlights**

A. **Alzheimer’s Disease (AD) (Table 14–3, p. 478)** – a progressive, degenerative disease of the brain that is characterized by loss of memory and other cognitive functions. The most common cause of dementia among people aged 65 or older, it seriously affects a person’s ability to carry out daily activities. AD involves the parts of the brain that control thought, memory, and language. Alzheimer’s usually begins after age 60, and risk goes up with age even though it is not a normal part of aging. Alzheimer’s begins slowly with only a possibility of mild forgetfulness. In this stage, people may have trouble remembering recent events, activities, or the names of familiar people or things. They may not be able to solve simple math problems. As the disease progresses, symptoms are more easily noticed and become serious enough to cause people with AD or their family members to seek medical help. As the disease progresses, victims may become anxious or aggressive, or wander away from home. Eventually, patients require total care. There is no cure for the disease but certain treatments may help prevent some symptoms from becoming worse for a limited time. Also, some medicines may help control behavioral symptoms of AD such as sleeplessness, agitation, wandering, anxiety, and depression. Treating these symptoms often makes patients more comfortable and makes their care easier for caregivers.

B. **Encephalitis and Meningitis (Fig. 14–21, p. 479)**

1. **Encephalitis** – an inflammation of the brain. There are many types of encephalitis, many of which are caused by viral infection. The prognosis for encephalitis varies. Some cases are mild, short and relatively benign, and patients have full recovery. Other cases are severe, and permanent impairment or death is possible. The acute phase of encephalitis may last for 1 to 2 weeks, with gradual or sudden resolution of fever and neurological symptoms. Neurological symptoms may require many months before full recovery. Symptoms include:
   - Sudden fever
   - Headache
   - Vomiting
   - Photophobia (abnormal visual sensitivity to light)
   - Stiff neck and back
   - Confusion
Drowsiness  
Clumsiness  
Unsteady gait  
Irritability  
Loss of consciousness – medical emergency.
Poor responsiveness – medical emergency.
Seizures – medical emergency.
Muscle weakness – medical emergency.
Sudden severe dementia – medical emergency.
Memory loss – medical emergency.
Withdrawal from social interaction – medical emergency.
Impaired judgment – medical emergency.

Antiviral medications may be prescribed for herpes encephalitis or other severe viral infections. Antibiotics may be prescribed for bacterial infections. Anticonvulsants are used to prevent or treat seizures. Corticosteroids are used to reduce brain swelling and inflammation.

2. Meningitis – an infection of the membranes or meninges that surround the brain and spinal cord. Meningitis may be caused by many different viruses and bacteria. Viral meningitis cases are usually self-limiting to 10 days or less. Some types of meningitis can be deadly if not treated promptly. Anyone experiencing symptoms of meningitis should see a doctor immediately. Symptoms, which may appear suddenly, often include:
- High fever
- Severe and persistent headache
- Stiff neck
- Nausea and vomiting
- Confusion – behavioral change that may require emergency treatment.
- Sleepiness – behavioral change that may require emergency treatment.
- Difficulty waking up – behavioral change that may require emergency treatment.
- In infants, symptoms may include irritability or tiredness, poor feeding, and fever.

With early diagnosis and prompt treatment, most patients recover from meningitis. Individuals with bacterial meningitis are usually hospitalized for treatment. The child with bacterial meningitis assumes an opisthotonic position, with the neck and head hyperextended to relieve discomfort.

C. Epilepsy (Fig. 14–22, p. 480) – a brain disorder involving repeated seizures, which are episodes of disturbed brain functions that cause changes in attention and/or behavior, of any type. Seizures are caused by abnormal electrical excitation in the brain. In epilepsy, clusters of nerve
cells, or neurons, in the brain sometimes signal abnormally. The normal pattern of neuronal activity becomes disturbed, causing strange sensations, emotions, and behavior or sometimes convulsions, muscle spasms, and loss of consciousness. Epilepsy is either classified as **symptomatic** (cause of condition is known) or **idiopathic** (cause of the condition is unknown). The majority of cases are idiopathic, and symptoms begin during childhood or early adolescence. The types of seizures experienced by individuals with epilepsy are:

1. **Partial Seizures (Focal Seizures)** – seizures in which electrical disturbances are localized to areas of the brain near the source or focal point of the seizure.
2. **Generalized Seizures (Bilateral, Symmetrical)** – those seizures without local onset that involve both the right and left hemispheres of the brain.
3. **Unilateral Seizures** – those seizures in which the electrical discharge is predominately confined to one of the two hemispheres of the brain.
4. **Unclassified Seizures** – those seizures that cannot be placed into one of the other three categories because of incomplete data.

The objective with all types of seizures is to obtain the greatest degree of control over the seizures without the patient experiencing intolerable side effects from the prescribed medication. The following steps should be taken to ensure safety in individuals experiencing seizures:

- Protect the patient from nearby hazards by moving hazards away from the patient.
- A child who has a seizure while standing should be gently assisted to the floor and placed in a side lying position (Fig. 14–22, p. 480).
- Do not move the patient or restrain the patient.
- Do not put anything in the patient’s mouth.
- Do not try and hold the patient’s tongue; it cannot be swallowed.

D. **Multiple Sclerosis (MS)** (Fig. 14–23, p. 482) – a chronic, potentially debilitating disease that affects the brain and spinal cord that is twice as common in women as in men. The illness is probably an autoimmune disease, which means the immune system responds as if part of the body is a foreign substance. In MS, the body directs antibodies and white blood cells against proteins in the myelin sheath surrounding nerves in the brain and spinal cord. This causes inflammation and injury to the sheath and ultimately to the nerves. The damage slows or blocks muscle coordination, visual sensation and other nerve signals. The disease varies in severity, ranging from a mild illness to one that results in permanent disability, with the manifestations of the disease varying according to the areas destroyed by demyelination and the affected body system. The cause of the disease is unknown, but there seems to be a genetic link to its
occurrence. There is no cure for MS; however, therapies do exist to decrease exacerbation and delay the progress of the disease. The symptoms of MS, which may vary with each attack, include:

- Weakness
- Paralysis, and/or tremor of one or more extremities
- Muscle Spasticity (uncontrollable spasm of muscle groups)
- Numbness
- Decreased or abnormal sensation (in any area)
- Tingling
- Urinary hesitancy, urgency, and/or frequency

An estimated 400,000 Americans have MS, which is more prevalent in the between the ages of 20 to 50.

E. **Parkinson’s Disease** – a progressive disorder caused by degeneration of nerve cells in the part of the brain that controls movement. This degeneration creates a shortage of the brain signaling chemical (neurotransmitter) known as dopamine, causing the movement impairments that characterize the disease. The symptoms of Parkinson’s disease, which tend to worsen with time, include:

- Tremor (trembling or shaking) of a limb – especially when the body is at rest; often begins on one side of the body, frequently in one hand. This is usually the first symptom.
- Bradykinesia (slow movement)
- Akinesia (inability to move)
- Rigid limbs
- Shuffling gait
- Stooped posture
- Reduced facial expressions
- Speaking in a soft voice
- Depression
- Personality changes
- Dementia
- Sleep disturbances
- Speech impairments
- Sexual difficulties

An estimated 500,000 Americans have Parkinson’s disease, and 50,000 new cases are reported annually. The disorder appears to be slightly more common in men than women with an average age of onset at about 60. Both prevalence and incidence increase with advancing age; the rates are very low in people under 40 and rise among people in their 70s and 80s. Parkinson’s disease is diagnosed by a neurologist along with result of several brain tests to Parkinson’s disease or some other disorder that resembles it. There is no cure for the disease and treatment involves:

- **Drug Therapy** – used to replenish dopamine levels and/or inhibit the effects of the neurotransmitter acetylcholine.
- **Pallidotomy** – surgical procedure used to stop uncontrollable movements.
- **Deep Brain Stimulation (Brain Implant)** – surgical procedure used to stop uncontrollable movements

**F. Stroke (Fig. 14–24, p. 483)** – or brain attack, or cerebrovascular accident (CVA) is the death of brain tissue that occurs when the brain does not get enough blood and oxygen. If the flow of blood in an artery supplying the brain is interrupted for longer than a few seconds, brain cells can die, causing permanent damage. Stroke is the third leading cause of death in the United States and many other countries, and the leading cause of disability in adults with the risk doubling with each decade after age 35. Stroke occurs more often in men than women. The interruption of blood flow to the brain can be caused by either:

1. **Blood Clots in the Brain (Fig. 14–25, p. 484)** – a very common cause of stroke is **atherosclerosis**. Fatty deposits and blood platelets collect on the wall of the arteries, forming plaques. Over time, the plaques slowly begin to block the flow of blood. The plaque itself can block the artery enough to cause a stroke, or the plaque can cause the blood to flow abnormally, which can lead to a **thrombus** or a **blood clot**. A clot can stay at the site of the narrowing and prevent blood flow to all of the smaller arteries it supplies. In other cases, it can become an **embolus** and can travel and wedge into a smaller vessel. Strokes caused by embolisms are most commonly caused by heart disorders.

2. **Hemorrhagic Stroke or Bleeding in the Brain** – a second major cause of stroke can occur when small blood vessels in the brain become weak and burst. Some people have defects in the blood vessels of the brain that makes this more likely. The flow of blood after the break damages brain cells. This kind of stroke can also occur if a clot caused by atherosclerosis or other conditions blocks a vessel, which then breaks and damages surrounding tissue. The warning signs of a stroke may include one or all of the following:
   - **Numbness** or weakness of the face, arm, or legs, especially on one side of the body.
   - **Confusion** – trouble speaking or understanding.
   - **Trouble seeing** in one or both eyes.
   - **Trouble walking** – dizziness, loss of balance or coordination.
   - **Severe headache** with no known cause.
   - **Transient Ischemic Attack (TIA)** – also called a ministroke, is the temporary interference in the blood supply to the brain. The symptoms may last for a few minutes or for several hours. After the attack, there is usually no evidence of residual brain damage or
neurological damage. The specific signs and symptoms depend on the portion of the brain affected but include:
  o Disturbance of normal vision in one or both eyes
  o Dizziness
  o Weakness
  o Dysphasia
  o Numbness
  o Unconsciousness can occur

VIII. Pathology Checkpoint

IX. Study and Review (pp. 486–493)

X. Practical Application: SOAP: Chart Note Analysis