



SELECTED KEY TERMS


The following terms and other boldface terms in the chapter are defined in the Glossary

aphasia
brain stem
cerebellum
cerebral cortex
cerebrospinal fluid (CSF)
cerebrum
concussion
diencephalon
electroencephalograph (EEG)
gyrus (pl. gyri)
hematoma
hypothalamus
medulla oblongata
meninges
midbrain
pons
stroke
sulcus (pl. sulci)
thalamus
ventricle



LEARNING OUTCOMES

After careful study of this chapter, you should be able to:

1. Give the location and functions of the four main divisions of the brain
 2. Name and describe the three meninges
 3. Cite the function of cerebrospinal fluid and describe where and how this fluid is formed
 4. Name and locate the lobes of the cerebral hemispheres
 5. Cite one function of the cerebral cortex in each lobe of the cerebrum
 6. Name two divisions of the diencephalon and cite the functions of each
 7. Locate the three subdivisions of the brain stem and give the functions of each
 8. Describe the cerebellum and cite its functions
 9. Name some techniques used to study the brain
 10. Cite the names and functions of the 12 cranial nerves
 11. List some disorders that involve the brain, its associated structures, or the cranial nerves
 12. Show how word parts are used to build words related to the nervous system (see Word Anatomy at the end of the chapter)
- 

chapter

10

The Nervous System: The Brain and Cranial Nerves

10



► The Brain

The brain occupies the cranial cavity and is covered by membranes, fluid, and the bones of the skull. Although the brain's various regions communicate and function together, the brain may be divided into distinct areas for ease of study (Fig. 10-1, Table 10-1):

- ▶ The **cerebrum** (SER-e-brum) is the largest part of the brain. It is divided into right and left **cerebral** (SER-e-bral) **hemispheres** by a deep groove called the **longitudinal fissure** (Fig. 10-2). Each hemisphere is further subdivided into lobes.
- ▶ The **diencephalon** (di-en-SEF-ah-lon) is the area between the cerebral hemispheres and the brain stem. It includes the thalamus and the hypothalamus.
- ▶ The **brain stem** connects the cerebrum and diencephalon with the spinal cord. The superior portion of the brain stem is the **midbrain**. Inferior to the midbrain is the **pons** (ponz), followed by the **medulla oblongata** (meh-DUL-lah ob-long-GAH-tah). The pons connects the midbrain with the medulla, whereas the medulla connects the brain with the spinal cord through a large opening in the base of the skull (foramen magnum).
- ▶ The **cerebellum** (ser-eh-BEL-um) is located immediately below the posterior part of the cerebral hemispheres and is connected with the cerebrum, brain stem,

and spinal cord by means of the pons. The word *cerebellum* means “little brain.”

Each of these divisions is described in greater detail later in this chapter.

Checkpoint 10-1 What are the main divisions of the brain?

► Protective Structures of the Brain and Spinal Cord

The **meninges** (men-IN-jez) are three layers of connective tissue that surround both the brain and spinal cord to form a complete enclosure (Fig. 10-3). The outermost of these membranes, the **dura mater** (DU-rah MA-ter), is the thickest and toughest of the meninges. (*Mater* is from the Latin meaning “mother,” referring to the protective function of the meninges; *dura* means “hard.”) Around the brain, the dura mater is in two layers, and the outer layer is fused to the bones of the cranium. In certain places, these two layers separate to provide venous channels, called **dural sinuses**, for the drainage of blood coming from the brain tissue.

The middle layer of the meninges is the **arachnoid** (ah-RAK-noyd). This membrane is loosely attached to the deepest of the meninges by weblike fibers, allowing a space for the movement of cerebrospinal fluid (CSF) between the two

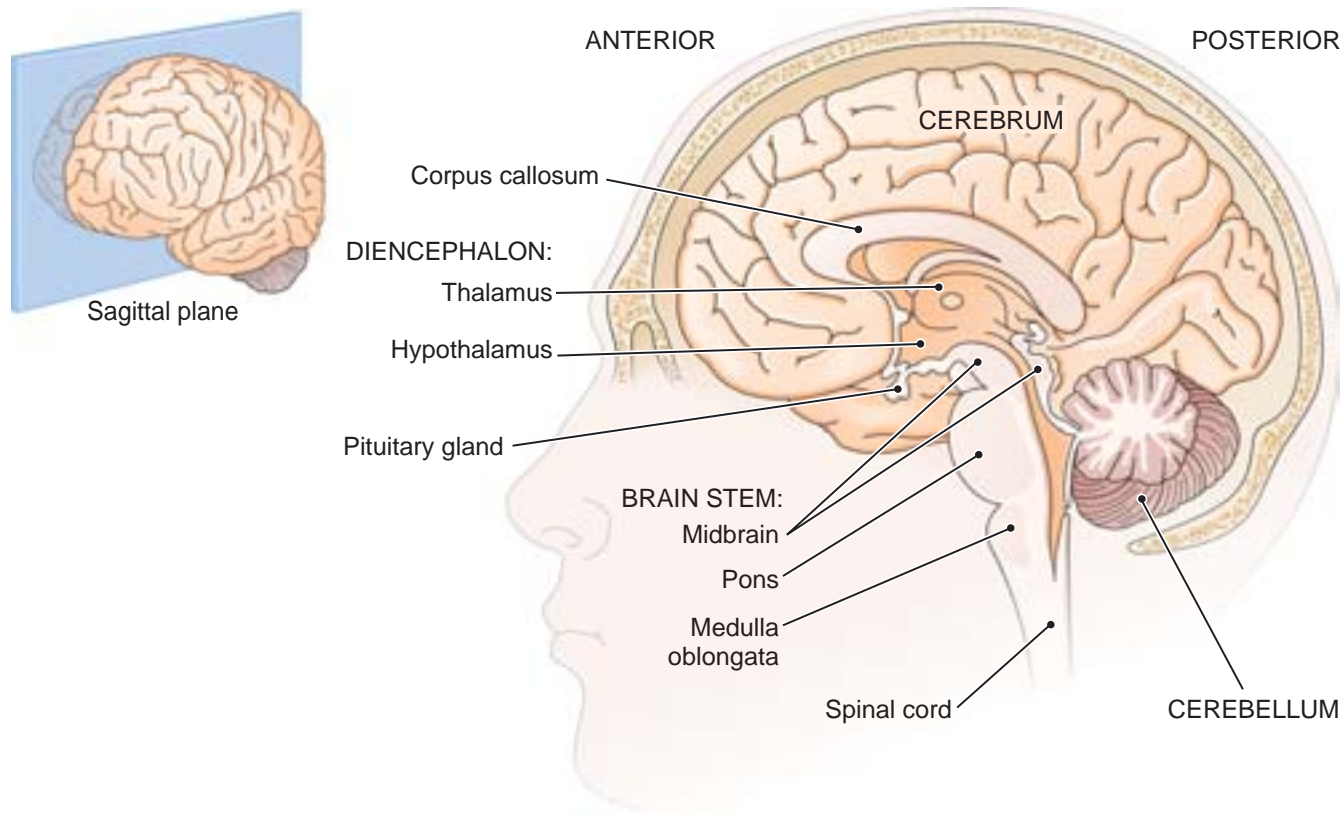


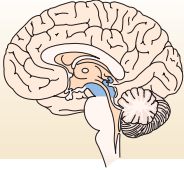
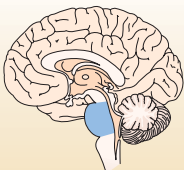
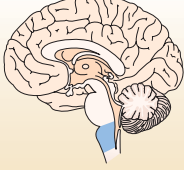



Figure 10-1 Brain, sagittal section. Main divisions are shown.

Table 10•1 Organization of the Brain

DIVISION	DESCRIPTION	FUNCTIONS
Cerebrum 	Largest and uppermost portion of the brain Divided into two hemispheres, each subdivided into lobes	Cortex (outer layer) is site for conscious thought, memory, reasoning, and abstract mental functions, all localized within specific lobes
Diencephalon 	Between the cerebrum and the brain stem Contains the thalamus and hypothalamus	Thalamus sorts and redirects sensory input; hypothalamus maintains homeostasis, controls autonomic nervous system and pituitary gland
Brain stem Midbrain 	Anterior region below the cerebrum Below the center of the cerebrum	Connects cerebrum and diencephalon with spinal cord Has reflex centers concerned with vision and hearing; connects cerebrum with lower portions of the brain
Pons 	Anterior to the cerebellum	Connects cerebellum with other portions of the brain; helps to regulate respiration
Medulla oblongata 	Between the pons and the spinal cord	Links the brain with the spinal cord; has centers for control of vital functions, such as respiration and the heartbeat
Cerebellum 	Below the posterior portion of the cerebrum Divided into two hemispheres	Coordinates voluntary muscles; maintains balance and muscle tone

membranes. (The arachnoid is named from the Latin word for spider because of its weblike appearance).

The innermost layer around the brain, the **pia mater** (PI-ah MA-ter), is attached to the nervous tissue of the brain and spinal cord and follows all the contours of these structures (see Fig. 10-3). It is made of a delicate connective tissue (*pia* meaning “tender” or “soft”). The pia mater

holds blood vessels that supply nutrients and oxygen to the brain and spinal cord.

Checkpoint 10-2 The meninges are protective membranes around the brain and spinal cord. What are the names of the three layers of the meninges from the outermost to the innermost?

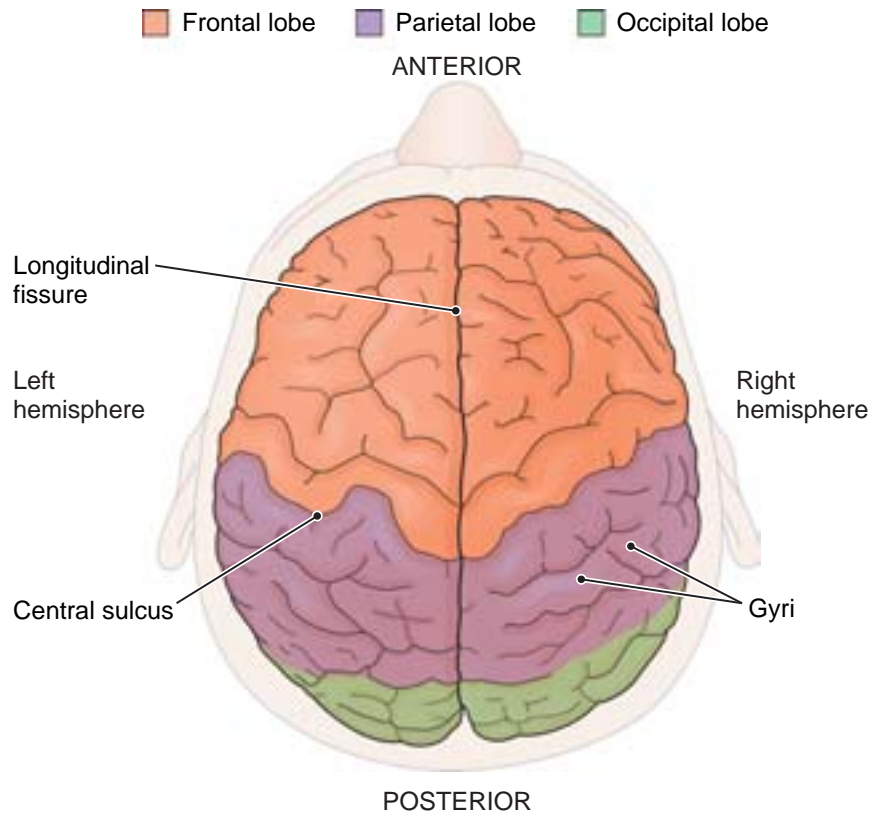


Figure 10-2 External surface of the brain, superior view. The division into two hemispheres and into lobes is visible.

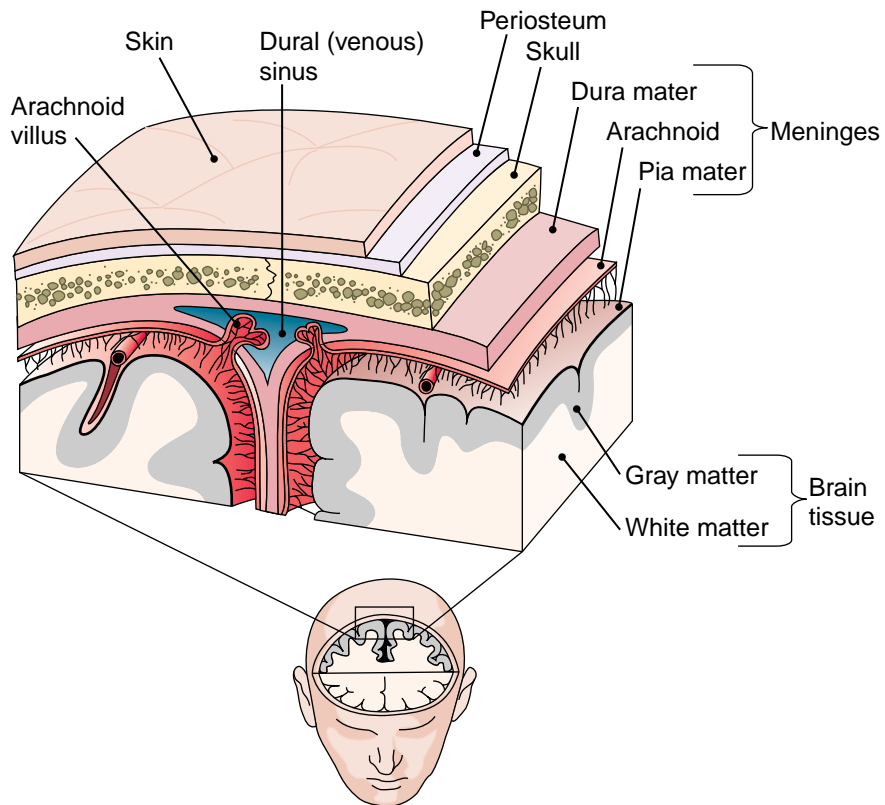


Figure 10-3 Frontal (coronal) section of the top of the head. The meninges and related parts are shown. **ZOOMING IN ♦** What is located in the spaces where the dura mater divides into two layers?

Cerebrospinal Fluid

Cerebrospinal (ser-e-bro-SPI-nal) **fluid** is a clear liquid that circulates in and around the brain and spinal cord (Fig. 10-4). The function of the CSF is to support nervous tissue and to cushion shocks that would otherwise injure these delicate structures. This fluid also carries nutrients to the cells and transports waste products from the cells.

CSF flows freely through passageways in and around the brain and spinal cord and finally flows out into the subarachnoid space of the meninges. Much of the fluid then returns to the blood through projections called *arachnoid villi* in the dural sinuses (see Figs. 10-3 and 10-4).

Ventricles CSF forms in four spaces within the brain called **ventricles** (VEN-trih-klz) (Fig. 10-5). A vascular network in each ventricle, the **choroid** (KOR-oyd) **plexus**, forms CSF by filtration of the blood and by cellular secretion.

The four ventricles that produce CSF extend somewhat irregularly into the various parts of the brain. The largest are the lateral ventricles in the two cerebral hemispheres. Their extensions into the lobes of the cerebrum are called **horns**. These paired ventricles communicate with a mid-

line space, the third ventricle, by means of openings called **foramina** (fo-RAM-in-ah). The third ventricle is surrounded by the diencephalon. Continuing down from the third ventricle, a small canal, called the **cerebral aqueduct**, extends through the midbrain into the fourth ventricle, which is located between the brain stem and the cerebellum. This ventricle is continuous with the central canal of the spinal cord. In the roof of the fourth ventricle are three openings that allow the escape of CSF to the area that surrounds the brain and spinal cord.

Box 10-1, The Blood-Brain Barrier: Access Denied, presents information on protecting the brain.

Checkpoint 10-3 In addition to the meninges, CSF helps to support and protect the brain and spinal cord. Where is CSF produced?

► The Cerebral Hemispheres

Each cerebral hemisphere is divided into four visible **lobes** named for the overlying cranial bones. These are the frontal, parietal, temporal, and occipital lobes (Fig. 10-6). In addition, there is a small fifth lobe deep within each hemisphere

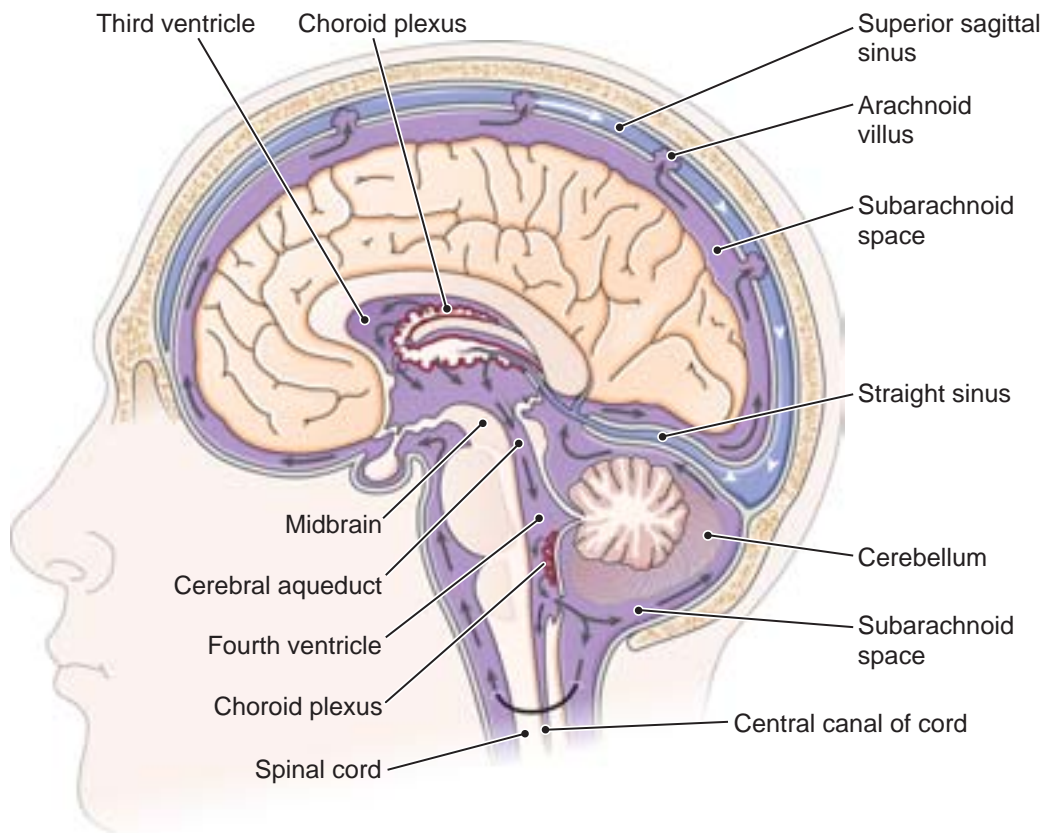


Figure 10-4 **Flow of cerebrospinal fluid (CSF).** Black arrows show the flow of CSF from the choroid plexuses and back to the blood in dural sinuses; white arrows show the flow of blood. (The actual passageways through which the CSF flows are narrower than those shown here, which have been enlarged for visibility.) **ZOOMING IN ♦ Which ventricle is continuous with the central canal of the spinal cord?**

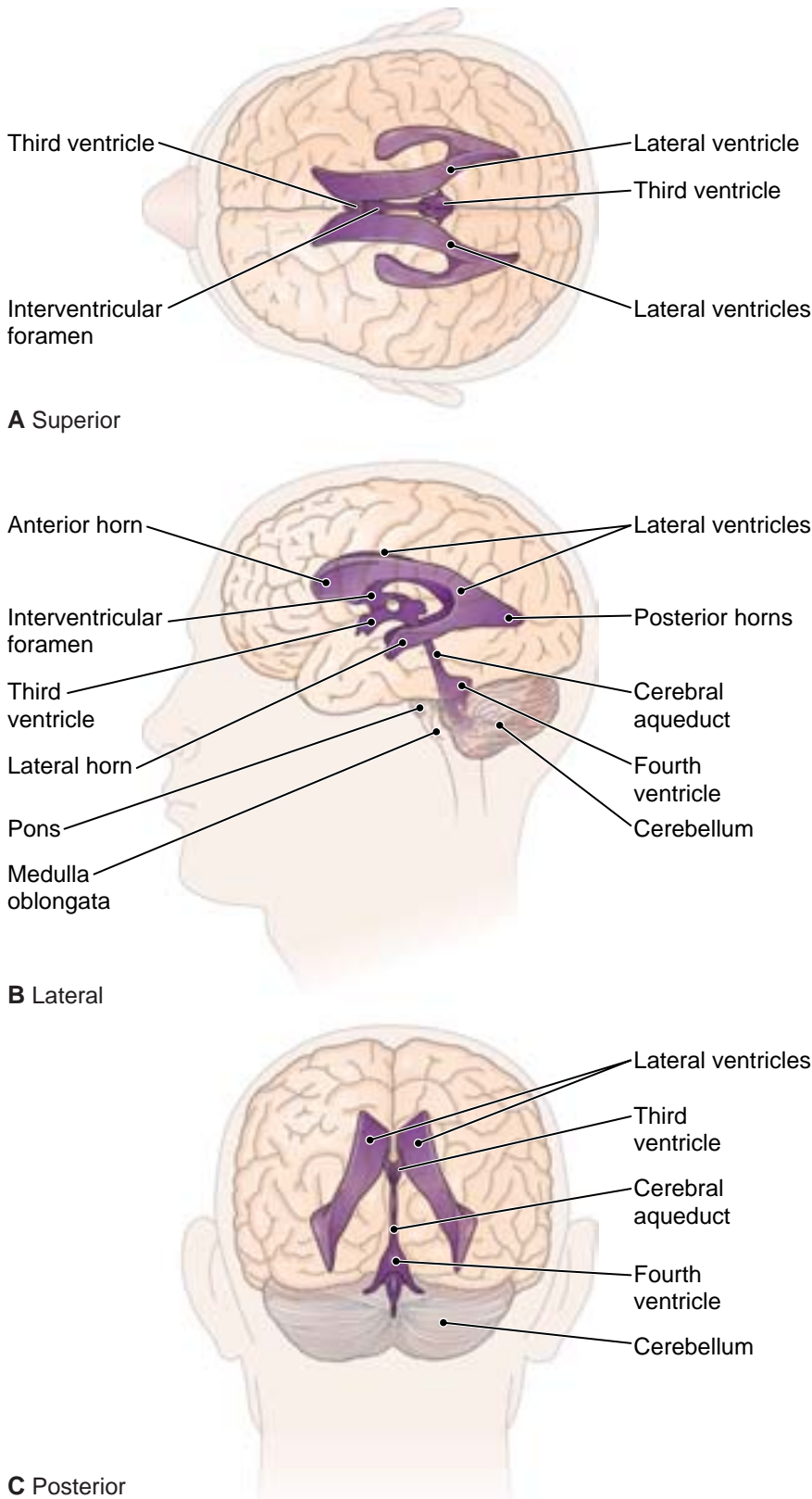


Figure 10-5 Ventricles of the brain. Three views are shown. **ZOOMING IN** ♦ Which are the largest ventricles?

that cannot be seen from the surface. Not much is known about this lobe, which is called the **insula** (IN-su-lah).

The outer nervous tissue of the cerebral hemispheres is gray matter that makes up the **cerebral cortex** (see Fig. 10-3). This thin layer of gray matter (2–4 mm thick) is the most highly evolved portion of the brain and is responsible for conscious thought, reasoning, and abstract mental functions. Specific functions are localized in the cortex of the different lobes, as described in greater detail later.

The cortex is arranged in folds forming elevated portions known as **gyri** (JI-ri), singular *gyrus*. These raised areas are separated by shallow grooves called **sulci** (SUL-si), singular *sulcus* (Fig. 10-7). Although there are many sulci, the following two are especially important landmarks:

- ▶ The **central sulcus**, which lies between the frontal and parietal lobes of each hemisphere at right angles to the longitudinal fissure (see Figs. 10-2 and 10-6)
- ▶ The **lateral sulcus**, which curves along the side of each hemisphere and separates the temporal lobe from the frontal and parietal lobes (see Fig. 10-6)

Internally, the cerebral hemispheres are made largely of white matter and a few islands of gray matter. The white matter consists of myelinated fibers that connect the cortical areas with each other and with other parts of the nervous system.

Basal nuclei, also called **basal ganglia**, are masses of gray matter located deep within each cerebral hemisphere. These groups of neurons work with the cerebral cortex to regulate body movement and the muscles of facial expression. The neurons of the basal nuclei secrete the neurotransmitter **dopamine** (DO-pah-mene).

The **corpus callosum** (kah-LO-sum) is an important band of white matter located at the bottom of the longitudinal fissure (see Fig. 10-1). This band is a bridge between the right and left hemispheres, permitting impulses to cross from one side of the brain to the other.

Box 10-1 A Closer Look

The Blood-Brain Barrier: Access Denied

Neurons in the central nervous system (CNS) function properly only if the composition of the extracellular fluid bathing them is carefully regulated. The semipermeable blood-brain barrier helps maintain this stable environment by allowing some substances to cross it while blocking others. Whereas it allows glucose, amino acids, and some electrolytes to cross, it prevents passage of hormones, drugs, neurotransmitters, and other substances that might adversely affect the brain.

Structural features of CNS capillaries create this barrier. In most parts of the body, capillaries are lined with simple squamous epithelial cells that are loosely attached to each other. The small spaces between cells let materials move between the bloodstream and the tissues. In CNS capillaries, the simple squamous epithelial cells are joined by tight junctions that limit passage of materials between them. Astrocytes—specialized neuroglial cells that wrap around capillaries and limit their permeability—also contribute to this barrier.

The blood-brain barrier excludes pathogens, although some viruses, including poliovirus and herpesvirus, can bypass it by traveling along peripheral nerves into the CNS. Some streptococci also can breach the tight junctions. Disease processes, such as hypertension, ischemia (lack of blood supply), and inflammation, can increase the blood-brain barrier's permeability.

The blood-brain barrier is an obstacle to delivering drugs to the brain. Some antibiotics can cross it, whereas others cannot. Neurotransmitters also pose problems. In Parkinson disease, the neurotransmitter dopamine is deficient in the brain. Dopamine itself will not cross the barrier, but a related compound, L-dopa, will. L-dopa crosses the blood-brain barrier and is then converted to dopamine. Mixing a drug with a concentrated sugar solution and injecting it into the bloodstream is another effective delivery method. The solution's high osmotic pressure causes water to osmose out of capillary cells, shrinking them and opening tight junctions through which the drug can pass.

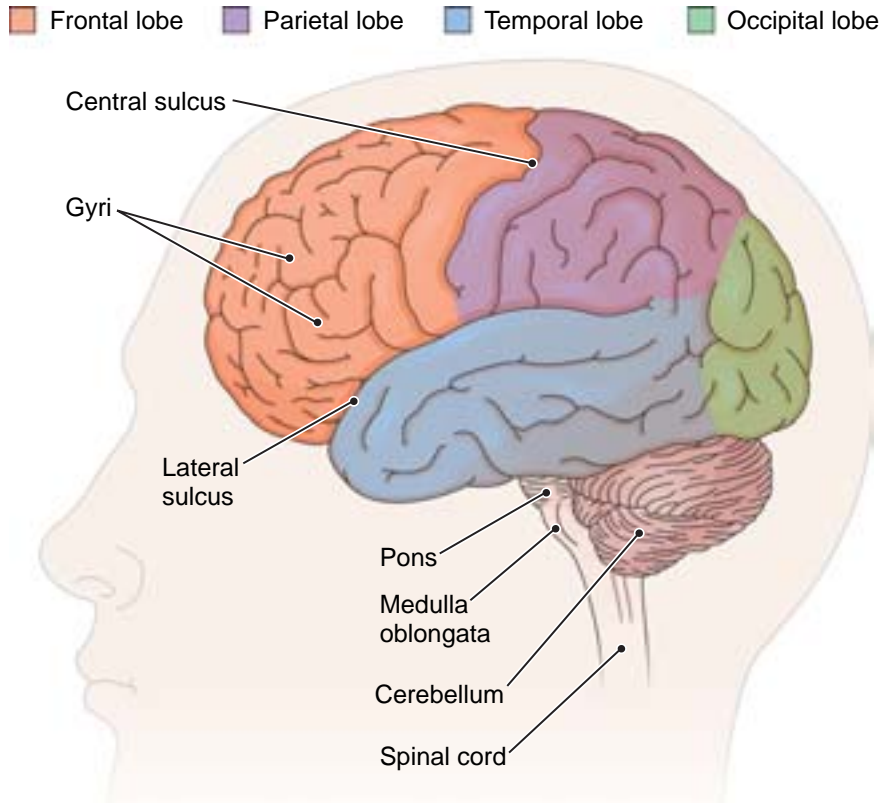


Figure 10-6 External surface of the brain, lateral view. The lobes and surface features of the cerebrum are visible. **ZOOMING IN** ♦ What structure separates the frontal from the parietal lobe?

The **internal capsule** is a compact band of myelinated fibers that carries impulses between the cerebral hemispheres and the brain stem. The vertical fibers that make up the internal capsule travel between the thalamus and some of the basal nuclei on each side and then radiate toward the cerebral cortex.

Checkpoint 10-4 What are the four surface lobes of each cerebral hemisphere?

Functions of the Cerebral Cortex

It is within the cerebral cortex, the layer of gray matter that forms the surface of each cerebral hemisphere, that impulses are received and analyzed. These activities form the basis of knowledge. The brain “stores” information, much of which can be recalled on demand by means of the phenomenon called *memory*. It is in the cerebral cortex that thought processes such as association, judgment, and discrimination take place. Conscious deliberation and voluntary actions also arise from the cerebral cortex.

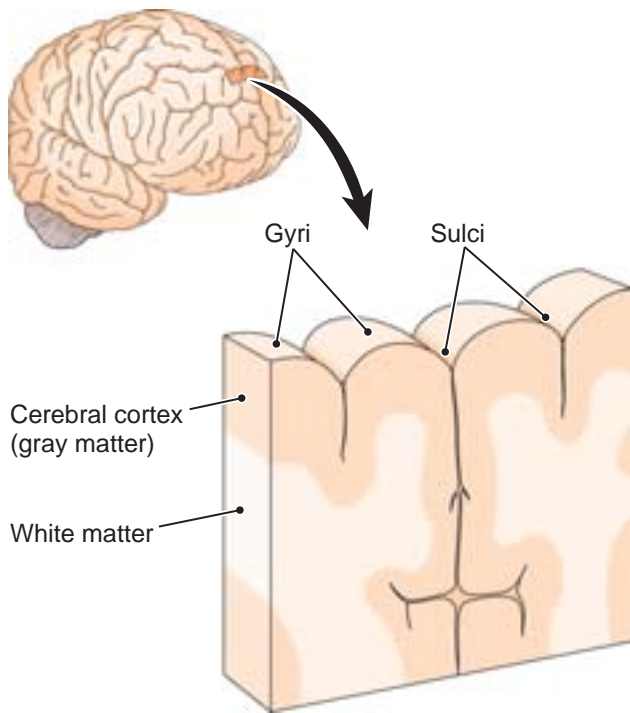


Figure 10-7 Section of the cerebrum. Labels point out surface features, the cerebral cortex, and the white matter. **ZOOMING IN** ♦ How is the cortex provided with increased surface area?

Frontal lobe Parietal lobe Temporal lobe Occipital lobe

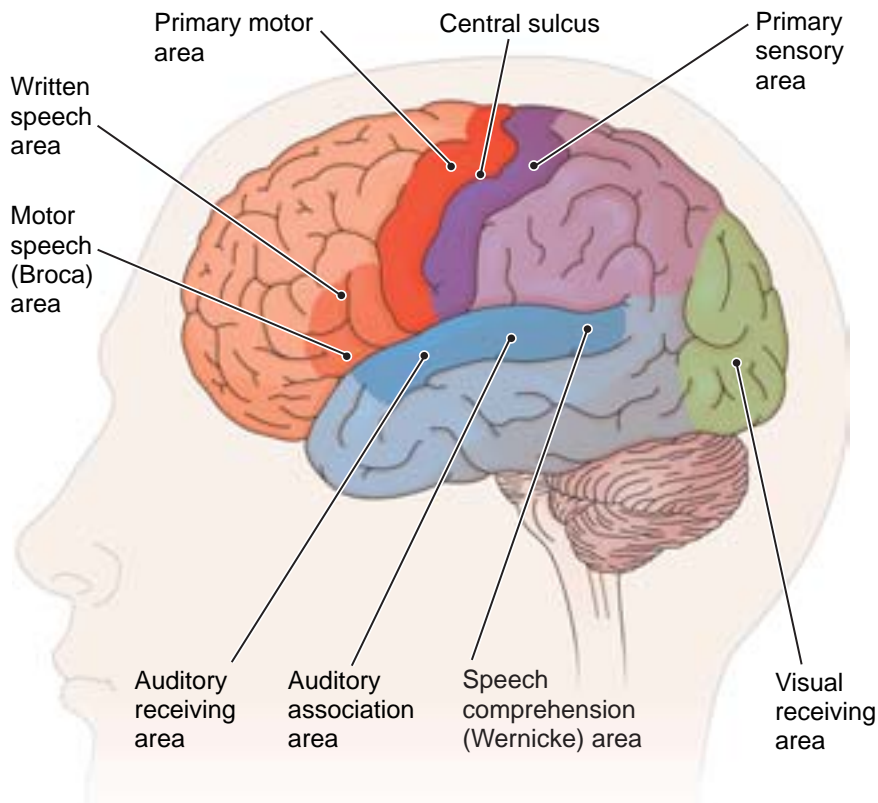


Figure 10-8 Functional areas of the cerebral cortex. **ZOOMING IN** ♦ What cortical area is posterior to the central sulcus? What area is anterior to the central sulcus?

Although the various brain areas act in coordination to produce behavior, particular functions are localized in the cortex of each lobe (Fig. 10-8). Some of these are described below:

- The **frontal lobe**, which is relatively larger in humans than in any other organism, lies anterior to the central sulcus. The gyrus just anterior to the central sulcus in this lobe contains a **primary motor area**, which provides conscious control of skeletal muscles. Note that the more detailed the action, the greater the amount of cortical tissue involved (Fig. 10-9). The frontal lobe also contains two areas important in speech (the speech centers are discussed later).
- The **parietal lobe** occupies the superior part of each hemisphere and lies posterior to the central sulcus. The gyrus just behind the central sulcus in this lobe contains the **primary sensory area**, where impulses from the skin, such as touch, pain, and temperature, are interpreted. The estimation of distances, sizes, and shapes also takes place here. As with the motor cortex, the greater the intensity of sensation from a particular area, the tongue or fingers, for example, the more area of the cortex is involved.
- The **temporal lobe** lies inferior to the lateral sulcus and folds under the hemisphere on each side. This lobe contains the **auditory area** for receiving and interpreting impulses from the ear. The **olfactory area**, concerned

with the sense of smell, is located in the medial part of the temporal lobe; it is stimulated by impulses arising from receptors in the nose.

- The **occipital lobe** lies posterior to the parietal lobe and extends over the cerebellum. The visual area of this lobe contains the **visual receiving area** and the **visual association area** for interpreting impulses arising from the retina of the eye.

Checkpoint 10-5 Higher functions of the brain occur in a thin layer of gray matter on the surface of the cerebral hemispheres. What is the name of this outer layer of gray matter?

Communication Areas

The ability to communicate by written and verbal means is an interesting example of the way in which areas of the cerebral cortex are interrelated (see Fig. 10-8). The development and use of these areas are closely connected with the process of learning.

- The auditory areas lie in the temporal lobe. One of these areas, the **auditory receiving area**, detects sound

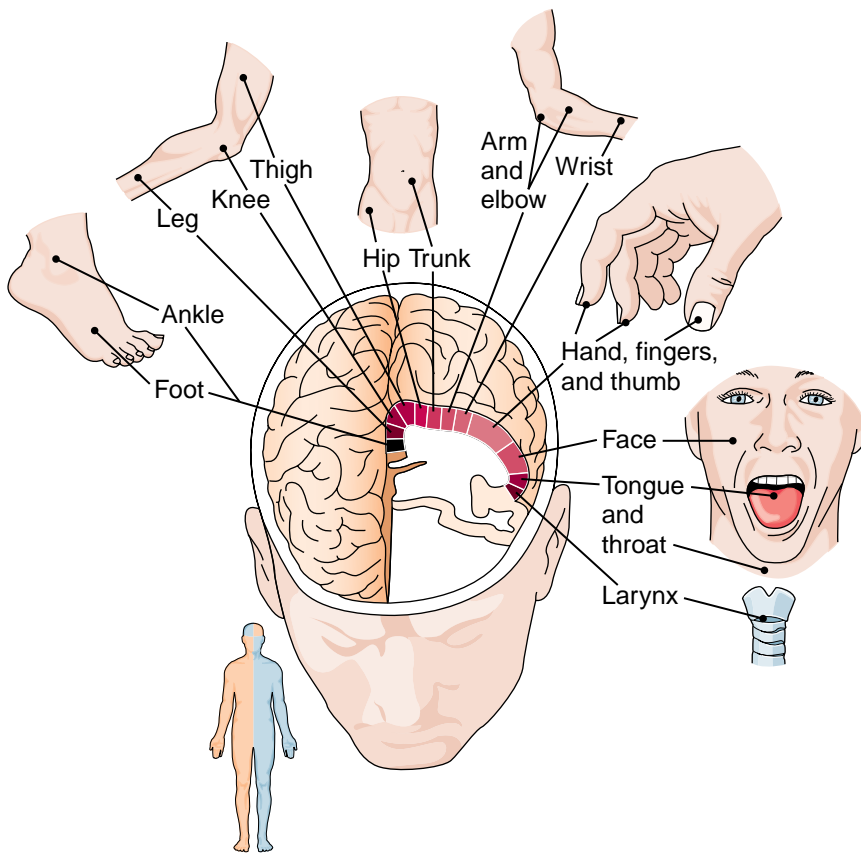


Figure 10-9 Motor areas of the cerebral cortex (frontal lobe). The amount of cortex involved in control of a body part is proportional to the degree of coordination needed in movement. The small figure indicates that control is contralateral. The right hemisphere controls the left side of the body and the left hemisphere controls the right side of the body.

impulses transmitted from the environment, whereas the surrounding area, the **auditory association area**, interprets the sounds. Another region of the auditory cortex, the **speech comprehension area**, or **Wernicke (VER-nih-ke) area**, functions in speech recognition and the meaning of words. Someone who suffers damage in this region of the brain, as by a stroke, will have difficulty in understanding the meaning of speech. The beginnings of language are learned by hearing; thus, the auditory areas for understanding sounds are near the auditory receiving area of the cortex. Babies often appear to understand what is being said long before they do any talking themselves. It is usually several years before children learn to read or write words.

- The **motor areas** for spoken and written communication lie anterior to the most inferior part of the frontal lobe's motor cortex. The speech muscles in the tongue, the soft palate, and the larynx are controlled here, in a region named the **motor speech area**, or **Broca (bro-KAH) area** (see Fig. 10-8). A person who suffers damage to this area may have difficulty in producing speech (motor aphasia). Similarly, the written speech center lies anterior to the cortical area that controls the arm

and hand muscles. The ability to write words is usually one of the last phases in the development of learning words and their meanings.

- The **visual areas** of the occipital lobe's cortex are also involved in communication. Here, visual images of language are received. The visual area that lies anterior to the receiving cortex then interprets these visual impulses as words. The ability to read with understanding also develops in this area. You might see writing in the Japanese language, for example, but this would involve only the visual receiving area in the occipital lobe unless you could also *understand* the words.

There is a functional relation among areas of the brain. Many neurons must work together to enable a person to receive, interpret, and respond to verbal and written messages as well as to touch (tactile stimulus) and other sensory stimuli.

Memory and the Learning Process

Memory is the mental faculty for recalling ideas. In the initial stage of the memory process, sensory signals (e.g., visual, auditory) are retained for a very short time, perhaps only fractions of a second. Nevertheless, they can be used for further processing. **Short-term memory** refers to the retention of bits of information for a few seconds or perhaps a few minutes, after which the information is lost unless reinforced. **Long-term memory** refers to the storage of information that can be recalled at a later time. There is a tendency for a memory to become more fixed the more often a person repeats the remembered experience; thus, short-term memory signals can lead to long-term memories. Furthermore, the more often a memory is recalled, the more indelible it becomes; such a memory can be so deeply fixed in the brain that it can be recalled immediately.

Careful anatomic studies have shown that tiny extensions called *fibrils* form at the synapses in the cerebral cortex, enabling impulses to travel more easily from one neuron to another. The number of these fibrils increases with age. Physiologic studies show that rehearsal (repetition) of the same information again and again accelerates and potentiates the degree of transfer of short-term memory into long-term memory. A person who is wide awake memorizes far better than does a person who is in a state of mental fatigue. It has also been noted that the brain is able to organize information so that new ideas are stored in the same areas in which similar ones had been stored before.

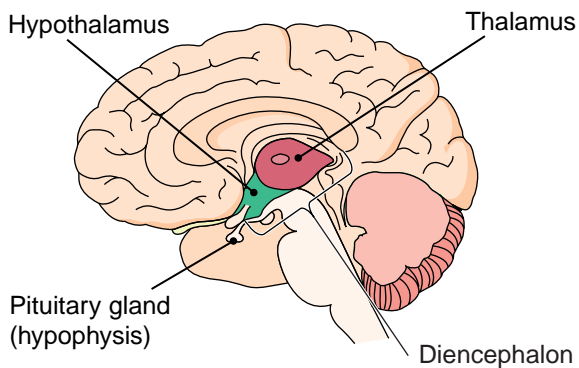


Figure 10-10 Regions of the diencephalon. The figure shows the relationship among the thalamus, hypothalamus, and pituitary gland (hypophysis). **ZOOMING IN** ♦ *To what part of the brain is the pituitary gland attached?*

► The Diencephalon

The **diencephalon**, or interbrain, is located between the cerebral hemispheres and the brain stem. One can see it by cutting into the central section of the brain. The diencephalon includes the **thalamus** (THAL-ah-mus) and the **hypothalamus**. (Fig. 10-10.)

The two parts of the thalamus form the lateral walls of the third ventricle (see Figs. 10-1 and 10-5). Nearly all sensory impulses travel through the masses of gray matter that form the thalamus. The role of the thalamus is to sort out the impulses and direct them to particular areas of the cerebral cortex.

The hypothalamus is located in the midline area inferior to the thalamus and forms the floor of the third ventricle. It helps to maintain homeostasis by controlling body temperature, water balance, sleep, appetite, and some emotions, such as fear and pleasure. Both the sympathetic and parasympathetic divisions of the autonomic nervous system are under the control of the hypothalamus, as is the pituitary gland. The hypothalamus thus influences the heart-beat, the contraction and relaxation of blood vessels, hormone secretion, and other vital body functions.

Checkpoint 10-6 What are the two main portions of the diencephalon and what do they do?

The Limbic System

Along the border between the cerebrum and the diencephalon is a region known as the **limbic system**. This system is involved in emotional states and behavior. It includes the **hippocampus** (shaped like a sea horse), located under the lateral ventricles, which functions in learning and the formation of long-term memory. It also includes regions that stimulate the **reticular formation**, a network that extends along the brain stem and governs wakefulness and sleep. The limbic system thus links the conscious functions of the cerebral cortex and the automatic functions of the brain stem.

► The Brain Stem

The brain stem is composed of the midbrain, the pons, and the medulla oblongata (see Fig. 10-1). These structures connect the cerebrum and diencephalon with the spinal cord.

The Midbrain

The **midbrain**, inferior to the center of the cerebrum, forms the superior part of the brain stem. Four rounded masses of gray matter that are hidden by the cerebral hemispheres form the superior part of the midbrain. These four bodies act as centers for certain reflexes involving the eye and the ear, for example, moving the eyes in order to track an image or to read. The white matter at the anterior of the midbrain conducts impulses between the higher centers of the cerebrum and the lower centers of the pons, medulla, cerebellum, and spinal cord. Cranial nerves III and IV originate from the midbrain.

The Pons

The **pons** lies between the midbrain and the medulla, anterior to the cerebellum (see Fig. 10-1). It is composed largely of myelinated nerve fibers, which connect the two halves of the cerebellum with the brain stem as well as with the cerebrum above and the spinal cord below. (Its name means “bridge.”)

The pons is an important connecting link between the cerebellum and the rest of the nervous system, and it contains nerve fibers that carry impulses to and from the centers located above and below it. Certain reflex (involuntary) actions, such as some of those regulating respiration, are integrated in the pons. Cranial nerves V through VIII originate from the pons.

The Medulla Oblongata

The **medulla oblongata** of the brain stem is located between the pons and the spinal cord (see Fig. 10-1). It appears white externally because, like the pons, it contains many myelinated nerve fibers. Internally, it contains collections of cell bodies (gray matter) called **nuclei**, or **centers**. Among these are vital centers, such as the following:

- The **respiratory center** controls the muscles of respiration in response to chemical and other stimuli.
- The **cardiac center** helps regulate the rate and force of the heartbeat.
- The **vasomotor** (vas-o-MO-tor) **center** regulates the contraction of smooth muscle in the blood vessel walls and thus controls blood flow and blood pressure.

The ascending sensory fibers that carry messages through the spinal cord up to the brain travel through the medulla, as do descending motor fibers. These groups of fibers form tracts (bundles) and are grouped together according to function.

The motor fibers from the motor cortex of the cerebral hemispheres extend down through the medulla, and most of them cross from one side to the other (decussate) while going through this part of the brain. The crossing of motor fibers in the medulla results in contralateral control—the right cerebral hemisphere controls muscles in the left side of the body and the left cerebral hemisphere controls muscles in the right side of the body, a characteristic termed *contralateral* (opposite side) control.

The medulla is an important reflex center; here, certain neurons end, and impulses are relayed to other neurons. The last four pairs of cranial nerves (IX through XII) are connected with the medulla.

Checkpoint 10-7 What are the three subdivisions of the brain stem?

The Cerebellum

The **cerebellum** is made up of three parts: the middle portion (vermis) and two lateral hemispheres, the left and right (Fig. 10-11). Like the cerebral hemispheres, the cerebellum has an outer area of gray matter and an inner portion that is largely white matter. However, the white matter is distributed in a treelike pattern. The functions of the cerebellum are as follows:

- Help coordinate voluntary muscles to ensure smooth, orderly function. Disease of the cerebellum causes muscular jerkiness and tremors.
- Help maintain balance in standing, walking, and sitting as well as during more strenuous activities. Messages from the internal ear and from sensory receptors in tendons and muscles aid the cerebellum.

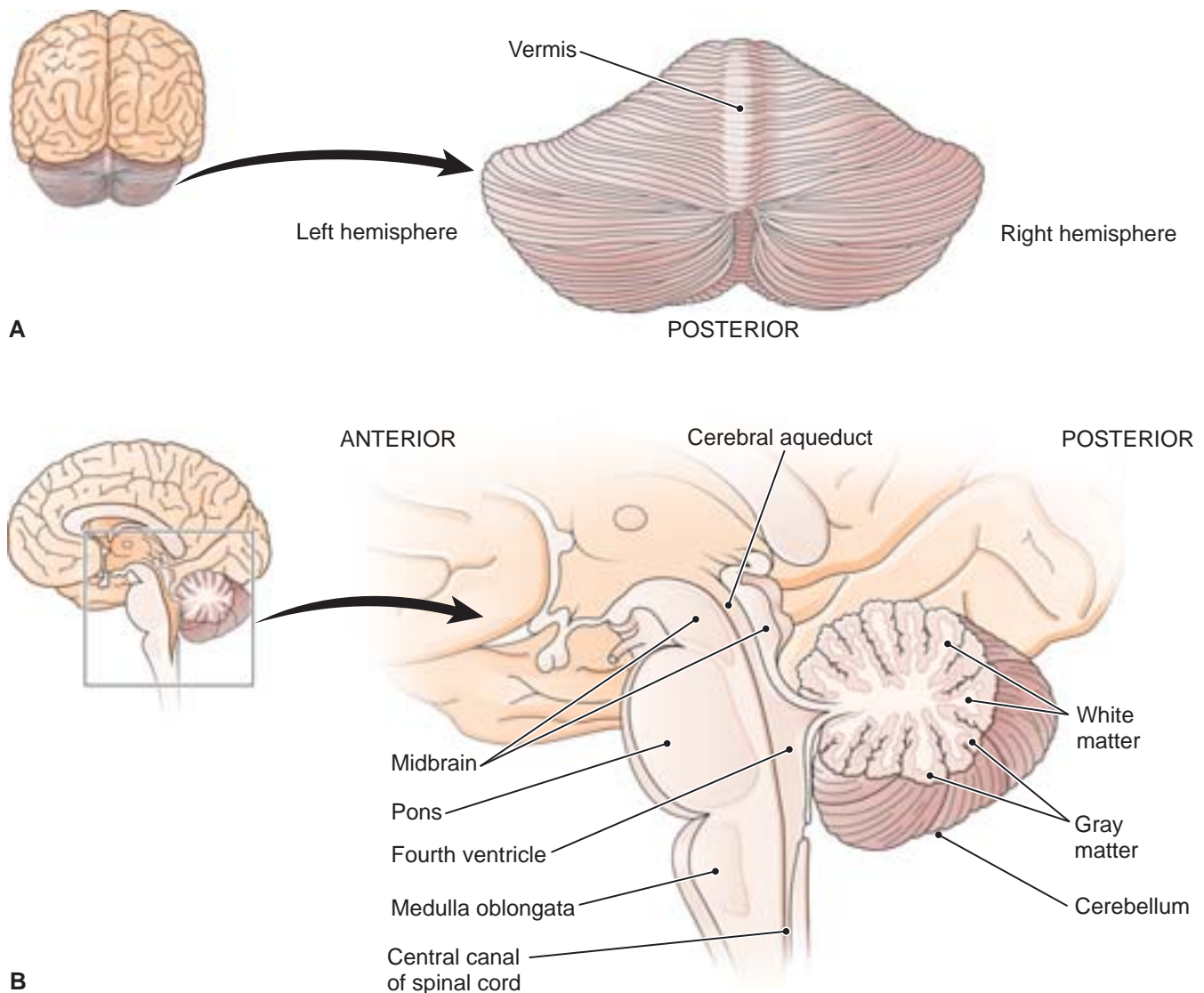


Figure 10-11 The cerebellum. (A) Posterior view showing the two hemispheres. (B) Midsagittal section showing the distribution of gray and white matter. The three parts of the brain stem (midbrain, pons, and medulla oblongata) are also labeled.

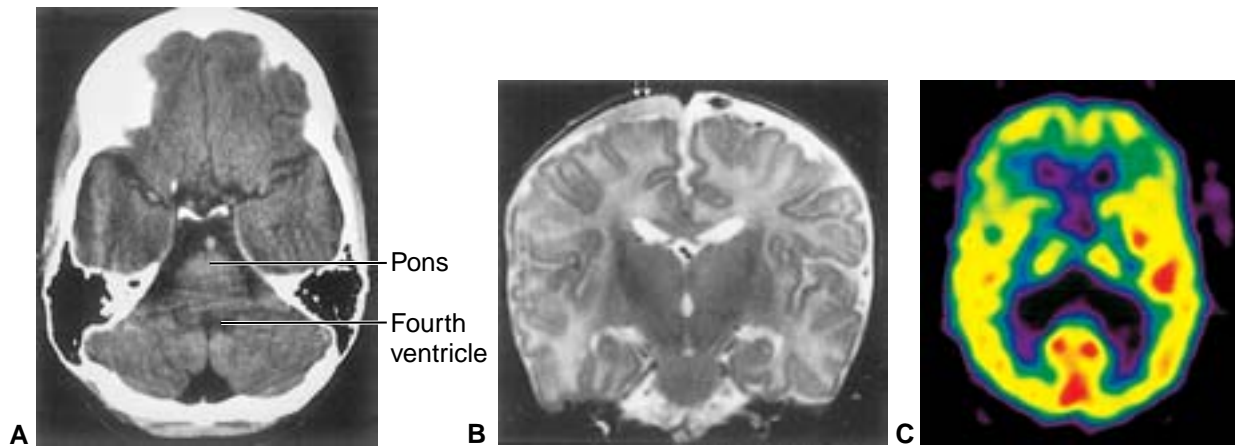


Figure 10-12 Imaging the brain. (A) CT scan of a normal adult brain at the level of the fourth ventricle. (B) MRI of the brain showing a point of injury (arrows). (C) PET scan. (A and B, reprinted with permission from Erkonen WE. *Radiology* 101. Philadelphia: Lippincott Williams & Wilkins, 1998. C, Courtesy of Newport Diagnostic Center, Newport Beach, CA.)

- ▶ Help maintain muscle tone so that all muscle fibers are slightly tensed and ready to produce changes in position as quickly as necessary.

Checkpoint 10-8 What are some functions of the cerebellum?

Brain Studies

Some of the imaging techniques used to study the brain are described in Box 1-2, Medical Imaging: Seeing Without Making a Cut, in Chapter 1. These techniques include:

- ▶ CT (computed tomography) scan, which provides photographs of the bone, soft tissue, and cavities of the brain (Fig. 10-12 A). Anatomic lesions, such as tumors or scar tissue accumulations, are readily seen.
- ▶ MRI (magnetic resonance imaging), which gives more views of the brain than CT and may reveal tumors, scar tissue, and hemorrhaging not shown by CT (see Fig. 10-12 B).
- ▶ PET (positron emission tomography), which visualizes the brain in action (see Fig. 10-12 C).

The Electroencephalograph

The interactions of the brain's billions of nerve cells give rise to measurable electric currents. These may be recorded using an instrument called the **electroen-**

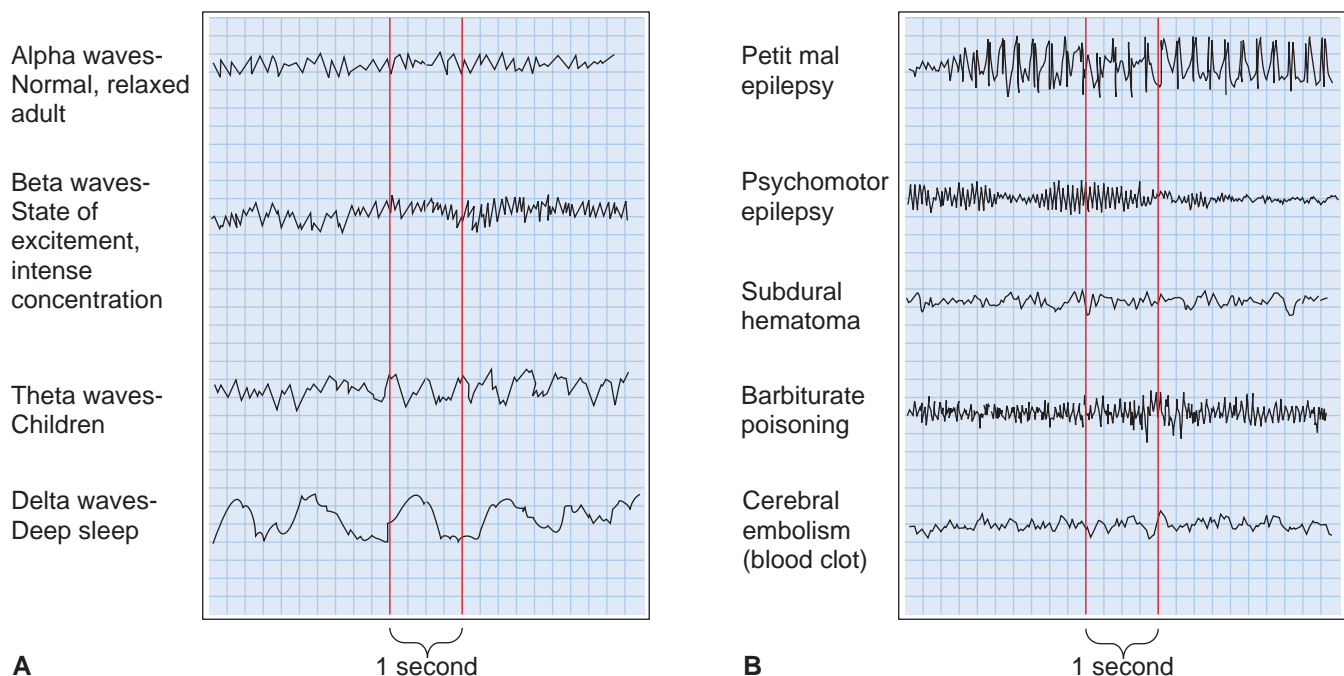


Figure 10-13 Electroencephalography. (A) Normal brain waves. (B) Abnormal brain waves.

cephalograph (e-lek-tro-en-SEF-ah-lo-graf). Electrodes placed on the head pick up the electrical signals produced as the brain functions. These signals are then amplified and recorded to produce the tracings, or brain waves, of an electroencephalogram (EEG).

The electroencephalograph is used to study sleep patterns, to diagnose disease, such as epilepsy, to locate tumors, to study the effects of drugs, and to determine brain death. **Figure 10-13** shows some typical normal and abnormal tracings.

Disorders of the Brain and Associated Structures

Infection and other factors can cause inflammation of the brain and its protective structures. **Meningitis** (men-in-JI-tis) is an inflammation of the meninges, the coverings of the brain and spinal cord. It is usually caused by bacteria that enter through the ear, nose, or throat or are carried by the blood. In many cases, an injury, invasive procedure, septicemia (blood infection), or an adjoining infection allows the entry of pathogenic organisms. One of these organisms, the meningococcus (*Neisseria meningitidis*) is responsible for epidemics of meningitis among people living in close quarters. Other causative bacteria are *Haemophilus influenzae* (Hib), *Streptococcus pneumoniae*, and *Escherichia coli*. Some viruses, including the mumps virus, can cause meningitis, but usually produce mild forms of the disease that require no treatment.

Headache, stiff neck, nausea, and vomiting are common symptoms of meningitis. Diagnosis is by lumbar puncture and examination of the CSF for pathogens and

white blood cells (pus). In cases of bacterial meningitis, early treatment with antibiotics can have good results. Untreated cases have a high death rate. Vaccines are available against some of the bacteria that cause meningitis.

Inflammation of the brain is termed **encephalitis** (en-sef-ah-LI-tis), based on the scientific name for the brain, which is *encephalon*. Infectious agents that cause encephalitis include poliovirus, rabies virus, HIV (the cause of AIDS), insect-borne viruses, such as West Nile virus, and, rarely, the viruses that cause chickenpox and measles. Less frequently, exposure to toxic substances or reactions to certain viral vaccines can cause encephalitis. Swelling of the brain and diffuse nerve cell destruction accompany invasion of the brain by lymphocytes (white blood cells) in cases of encephalitis. Typical symptoms include fever, vomiting, and coma.

Hydrocephalus

An abnormal accumulation of CSF within the brain is termed **hydrocephalus** (hi-dro-SEF-ah-lus) (**Fig. 10-14**). It may result either from overproduction or impaired drainage of the fluid. As CSF accumulates in the ventricles or its transport channels, mounting pressure can squeeze the brain against the skull and destroy brain tissue. Possible causes include congenital malformations present during development, tumors, inflammation, or hemorrhage.

Hydrocephalus is more common in infants than in adults. Because the fontanels of the skull have not closed in the developing infant, the cranium itself can become greatly enlarged. In contrast, in the adult, cranial enlargement cannot occur, so that even a slight increase in fluid results in symptoms of increased pressure within the skull and brain damage. Treatment of hydrocephalus involves

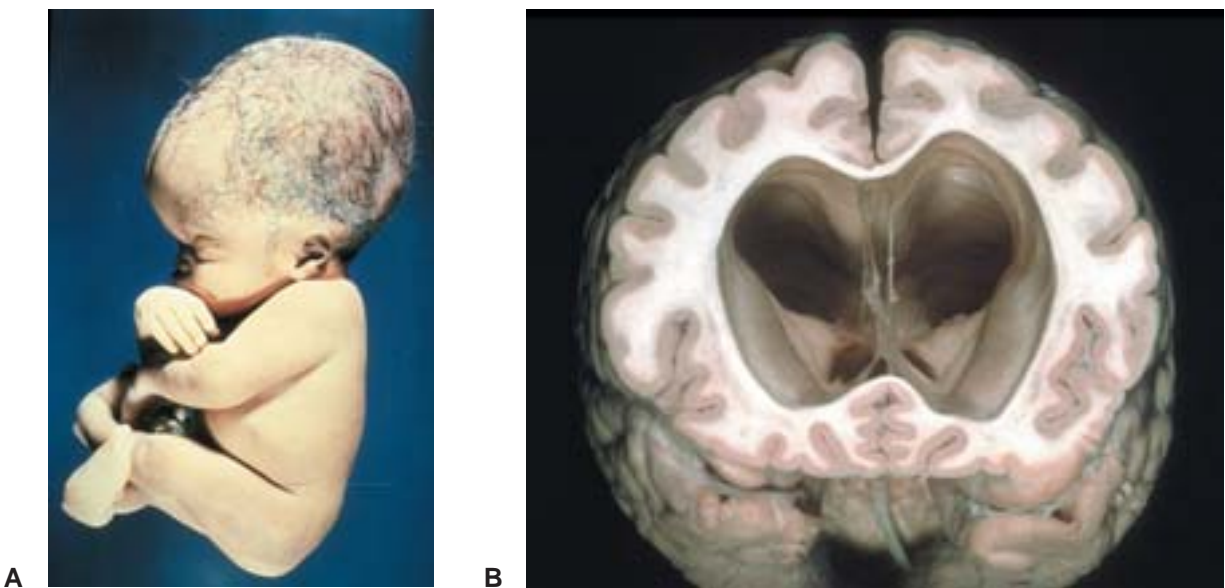


Figure 10-14 Hydrocephalus. (A) Congenital hydrocephalus causing pronounced enlargement of the head. (B) Coronal section of the brain showing marked enlargement of the lateral ventricles caused by a tumor that obstructed the flow of CSF. (Reprinted with permission from Rubin E, Farber JL. Pathology. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 1999.)

the creation of a shunt (bypass) to drain excess CSF from the brain.

Stroke and Other Brain Disorders

Stroke, or **cerebrovascular** (ser-e-bro-VAS-ku-lar) **accident** (CVA), is by far the most common kind of brain disorder. The most common cause is a blood clot that blocks blood flow to an area of brain tissue. Another frequent cause is the rupture of a blood vessel resulting in **cerebral hemorrhage** (HEM-eh-rij) and destruction of brain tissue. Stroke is most common among people older than 40 years of age and those with arterial wall damage, diabetes, or hypertension (high blood pressure). Smoking and excess alcohol consumption also increase the risk of stroke. Restoring blood flow to the affected area can reduce long-term damage. This can be done surgically or by administration of clot-dissolving medication, usually followed by medication to reduce brain swelling and minimize further damage.

The effect of a stroke depends on the location of the artery and the extent of the involvement. Damage of the white matter of the internal capsule in the inferior part of the cerebrum may cause extensive paralysis of the side opposite the affected area.

One possible aftereffect of stroke or other brain injury is **aphasia** (ah-FA-ze-ah), a loss or defect in language communication. Losses may involve the ability to speak or write (expressive aphasia) or to understand written or spoken language (receptive aphasia). The type of aphasia present depends on what part of the brain is affected. The lesion that causes aphasia in the right-handed person is likely to be in the left cerebral hemisphere.

Often, much can be done for stroke victims by care and retraining. The brain has tremendous reserves for adapting to different conditions. In many cases, some means of communication can be found even though speech areas are damaged.

Cerebral palsy (PAWL-ze) is a disorder caused by brain damage occurring before or during the birth process. Characteristics include diverse muscular disorders that vary in degree from only slight weakness of the lower extremity muscles to paralysis of all four extremities as well as the speech muscles. With muscle and speech training and other therapeutic approaches, children with cerebral palsy can be helped.

Epilepsy is a chronic disorder involving an abnormality of the brain's electrical activity with or without apparent changes in the nervous tissues. One manifestation of epilepsy is seizure activity, which may be so mild that it is hardly noticeable or so severe that it results in loss of consciousness. In most cases, the cause is not known. The study of brain waves on an EEG usually shows abnormalities and is helpful in both diagnosis and treatment (see Fig. 10-13 B). Many people with epilepsy can lead normal, active lives with appropriate medical treatment.

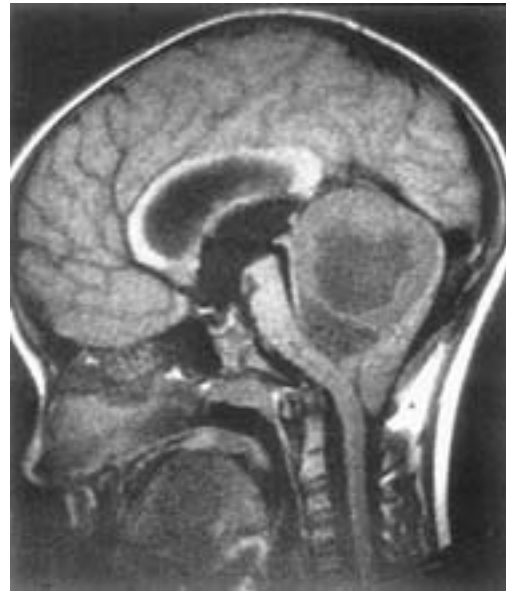


Figure 10-15 Brain tumor. MRI shows a large tumor that arises from the cerebellum and pushes the brain stem forward. (Reprinted with permission from Erkonen WE. *Radiology* 101. Philadelphia: Lippincott Williams & Wilkins, 1998.)

Tumors of the brain may develop in people of any age but are somewhat more common in young and middle-aged adults than in other groups (Fig. 10-15). Most brain tumors originate from the neuroglia (support tissue of the brain) and are called **gliomas** (gli-O-mas). Such tumors tend not to metastasize (spread to other areas), but they nevertheless can do harm by compressing brain tissue. The symptoms produced depend on the type of tumor, its location, and its degree of destructiveness. Involvement of the frontal portion of the cerebrum often causes mental symptoms, such as changes in personality and in levels of consciousness.

Early surgery and radiation therapy offer hope of cure in some cases. The blood-brain barrier, however, limits the effectiveness of injected chemotherapeutic agents (see Box 10-1). A newer approach to chemotherapy for brain tumors is to implant timed-release drugs into a tumor site at the time of surgery.

Checkpoint 10-9 What is the common term for cerebrovascular accident (CVA)?

Checkpoint 10-10 What type of cells are commonly involved in brain tumors?

Injury

A common result of head trauma is bleeding into or around the meninges (Fig. 10-16). Damage to an artery from a skull fracture, usually on the side of the head, may result in bleeding between the dura mater and the skull, an **epidural hematoma** (he-mah-TO-mah). The rapidly

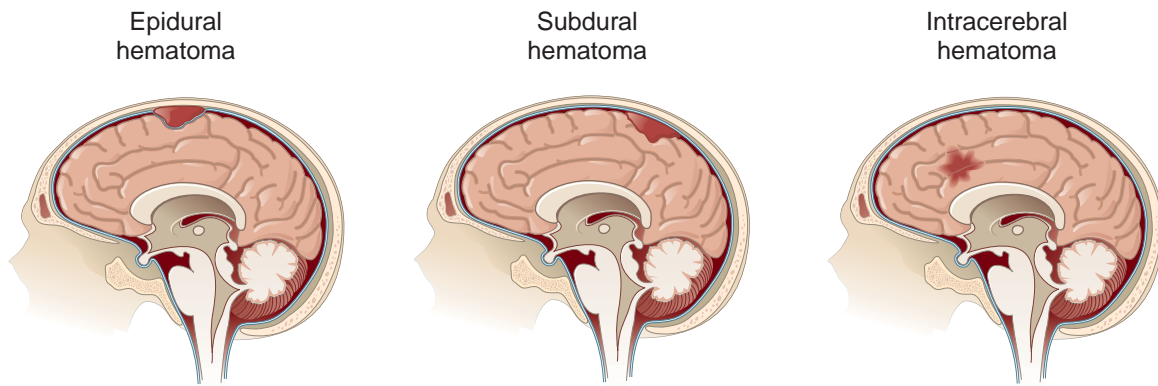


Figure 10-16 Hematomas. Compare the locations of epidural, subdural, and intracerebral hematomas. (Reprinted with permission from Cohen BJ. *Medical Terminology*. 4th ed. Philadelphia: Lippincott Williams & Wilkins, 2004.)

accumulating blood puts pressure on blood vessels and interrupts blood flow to the brain. Symptoms include headache, partial paralysis, dilated pupils, and coma. If the pressure is not relieved within a day or two, death results.

A tear in the wall of a dural sinus causes a **subdural hematoma**. This often results from a blow to the front or back of the head that separates the dura from the arachnoid, as occurs when the moving head hits a stationary object. Blood gradually accumulates in the subdural space, putting pressure on the brain and causing headache, weakness, and confusion. Death results from continued

bleeding. Bleeding into the brain tissue itself results in an intracerebral hematoma.

Cerebral **concussion** (kon-CUSH-on) results from a blow to the head or from sudden movement of the brain against the skull, as in violent shaking. The effects include loss of consciousness, headache, dizziness, vomiting, and even paralysis and impaired brain function. These vary in length and severity with the degree of damage.

Frequent observations of level of consciousness, pupil response, and extremity reflexes are important in the patient with a head injury (see Box 10-2, Brain Injury: A Heads-Up).

Box 10-2 Clinical Perspectives

Brain Injury: A Heads-Up

Traumatic brain injury is a leading cause of death and disability in the United States. Each year, approximately 1.5 million Americans sustain a brain injury, of whom about 50,000 will die and 80,000 will suffer long-term or permanent disability. The leading causes of traumatic brain injury are motor vehicle accidents, gunshot wounds, and falls. Other causes include shaken baby syndrome (caused by violent shaking of an infant or toddler) and second impact syndrome (when a second head injury occurs before the first has fully healed).

Brain damage occurs either from penetrating head trauma or acceleration-deceleration events where a head in motion suddenly comes to a stop. Nervous tissue, blood vessels, and possibly the meninges may be bruised, torn, lacerated, or ruptured, which may lead to swelling, hemorrhage, and hematoma. The best protection from brain injury is to prevent it. The following is a list of safety tips:

- ▶ Always wear a seat belt and secure children in approved car seats.
- ▶ Never drive after using alcohol or drugs or ride with an impaired driver.
- ▶ Always wear a helmet during activities such as biking, motorcycling, in-line skating, horseback riding, football, ice hockey, and batting and running bases in baseball and softball.
- ▶ Inspect playground equipment and supervise children using it. Never swing children around to play “airplane,” nor vigorously bounce or shake them.
- ▶ Allow adequate time for healing after a head injury before resuming potentially dangerous activities.
- ▶ Prevent falls by using a nonslip bathtub or shower mat and using a step stool to reach objects on high shelves. Use a safety gate at the bottom and top of stairs to protect young children (and adults with dementia or other disorienting conditions).
- ▶ Keep unloaded firearms in a locked cabinet or safe and store bullets in a separate location.

For more information, contact the Brain Injury Association of America.

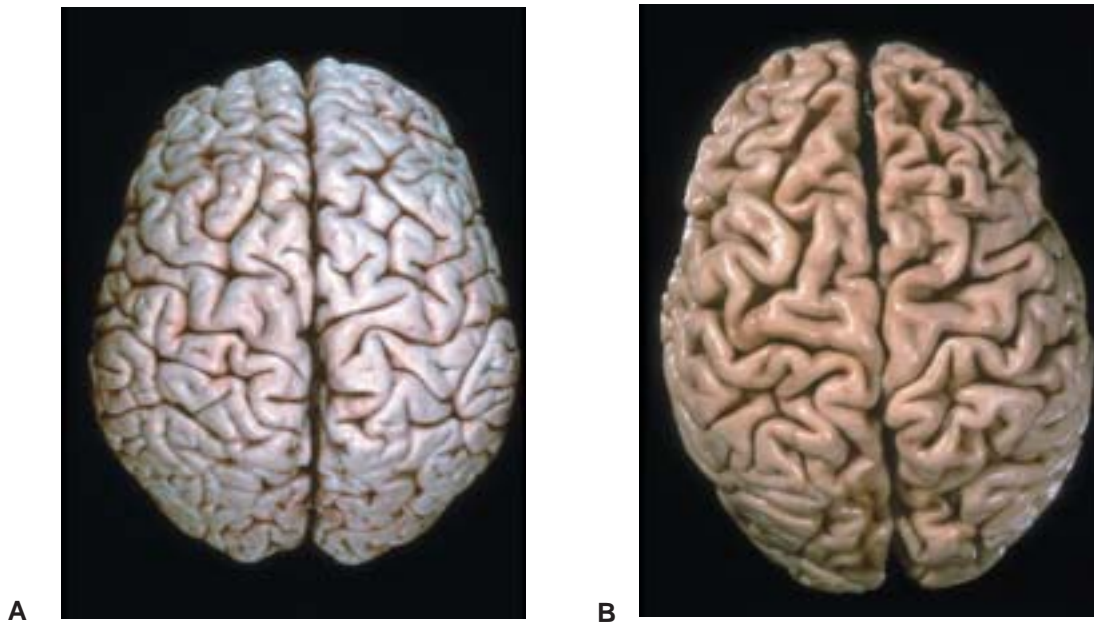


Figure 10-17 Effects of Alzheimer disease. (A) Normal brain. (B) Brain of a patient with Alzheimer disease shows atrophy of the cortex with narrow gyri and enlarged sulci. (Reprinted with permission from Rubin E, Farber JL. Pathology. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 1999.)

Degenerative Diseases

Alzheimer (ALZ-hi-mer) disease is a brain disorder resulting from an unexplained degeneration of the cerebral cortex and hippocampus (Fig. 10-17). The disorder develops gradually and eventually causes severe intellectual impairment with mood changes and confusion. Memory loss, especially for recent events, is a common early symptom. Dangers associated with Alzheimer disease are injury, infection, malnutrition, and inhalation of food or fluids into the lungs. Changes in the brain occur many years before noticeable signs of the disease appear. These changes include the development of amyloid, an abnormal protein, and a tangling of neuron fibers that prevents communication between cells.

At present, there is no cure, but several drugs have been developed that can delay the progression of early disease. In some tests, herbal extracts of *Ginkgo biloba*, the hormone estrogen, vitamin E, antiinflammatory drugs, and calcium channel blockers (drugs used primarily to regulate the heartbeat) have shown some signs of preventing or delaying the disease. Drugs also can control some of its physical and behavioral effects. Stress reduction is an important part of patient care.

Multi-infarct dementia (de-MEN-she-ah) represents the accumulation of brain damage resulting from chronic ischemia (is-KE-me-ah) (lack of blood supply), such as would be caused by a series of small strokes. There is a stepwise deterioration of function. People with multi-infarct dementia are troubled by progressive loss of memory, judgment, and cognitive function. Many people older than 80 years of age have some evidence of this disorder.

Parkinson disease is a progressive neurologic condition characterized by tremors, rigidity of limbs and joints, slow movement, and impaired balance. The disease usually arises from cell death in a part of the brain, the substantia nigra, that produces the neurotransmitter dopamine. The lack of dopamine results in overactivity of the basal nuclei, areas of the brain that control voluntary movement. The average age of onset is 55 years. Similar changes, together known as *parkinsonism*, may result from encephalitis or other brain diseases, exposure to certain toxins, or repeated head injury, as may occur in boxing.

The main therapy for Parkinson disease is administration of L-dopa, a substance that is capable of entering the brain and converting to dopamine (see Box 10-1). Drugs are now available that mimic the effects of dopamine, prevent its breakdown, or increase the effectiveness of L-dopa. Other approaches to treatment include implanting fetal cells that can do the missing cells' job and implanting a device that electrically stimulates the brain to control symptoms of Parkinson disease. (See also Box 10-3, Psychoactive Drugs: Adjusting Neurotransmitters to Alter Mood.)

► Cranial Nerves

There are 12 pairs of cranial nerves (in this discussion, when a cranial nerve is identified, a pair is meant). They are numbered, usually in Roman numerals, according to their connection with the brain, beginning anteriorly and proceeding posteriorly (Fig. 10-18). Except for the first two pairs, all the cranial nerves arise from the brain stem. The first 9 pairs and the 12th pair supply structures in the head.

Box 10-3 Hot Topics

Psychoactive Drugs: Adjusting Neurotransmitters to Alter Mood

Prozac (fluoxetine) and related compounds are among the newest chemicals used to alter mood. Many psychoactive drugs used today operate by affecting levels and activities of neurotransmitters such as serotonin, norepinephrine, and dopamine in the brain.

Prozac increases serotonin's activity by blocking presynaptic reuptake – that is, it blocks membrane transporters that carry serotonin back into the presynaptic cell at the synapse. Like other selective serotonin reuptake inhibitors (SSRIs), Prozac prolongs the neurotransmitter's activity at the synapse, producing a mood-elevating effect. Prozac is used to treat depression, anxiety, and symptoms of obsessive-compulsive disorder.

Other psychoactive drugs are less selective than Prozac. Effexor (venlafaxine) blocks presynaptic reuptake of serotonin and norepinephrine and is used to treat depression and gen-

eralized anxiety disorder. Zyban (bupropion) inhibits reuptake of norepinephrine and dopamine and is prescribed for depression and smoking cessation. Another class of antidepressants, the monoamine oxidase inhibitors (MAOIs), prevent the enzyme monoamine oxidase from breaking down serotonin in the synaptic cleft. Like SSRIs, MAOIs increase the amount of serotonin available in the synaptic cleft. Examples are Nardil (phenelzine) and Parnate (tranylcypromine).

Some herbal remedies are also used to treat depression. St. John's wort contains the active ingredient hypericin, which appears to both nonselectively inhibit serotonin reuptake and block norepinephrine and dopamine reuptake. As with any drug, care must be taken when using St. John's Wort, especially if combined with other antidepressant medications.

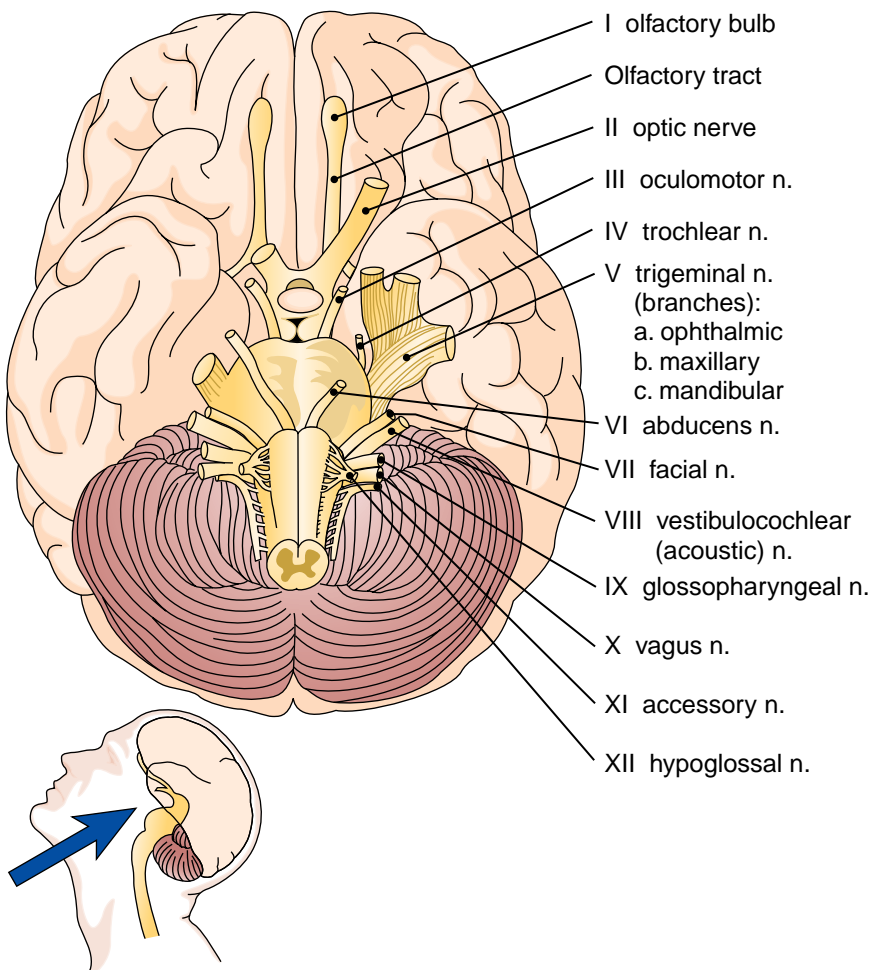


Figure 10-18 Cranial nerves. The 12 pairs of cranial nerves are seen from the base of the brain.

From a functional point of view, we may think of messages the cranial nerves handle as belonging to one of four categories:

- ▶ **Special sensory impulses**, such as those for smell, taste, vision, and hearing located in special sense organs in the head.
- ▶ **General sensory impulses**, such as those for pain, touch, temperature, deep muscle sense, pressure, and vibrations. These impulses come from receptors that are widely distributed throughout the body.
- ▶ **Somatic motor impulses** resulting in voluntary control of skeletal muscles.
- ▶ **Visceral motor impulses** producing involuntary control of glands and involuntary muscles (cardiac and smooth muscle). These motor pathways are part of the autonomic nervous system, parasympathetic division.

Names and Functions of the Cranial Nerves

A few of the cranial nerves (I, II, and VIII) contain only sensory fibers; some (III, IV, VI, XI, and XII) contain all or mostly motor fibers. The remainder (V, VII, IX, and X) contain both sensory

Table 10-2 The Cranial Nerves and Their Functions

NERVE (ROMAN NUMERAL DESIGNATION)	NAME	FUNCTION
I	Olfactory	Carries impulses for the sense of smell toward the brain
II	Optic	Carries visual impulses from the eye to the brain
III	Oculomotor	Controls contraction of eye muscles
IV	Trochlear	Supplies one eyeball muscle
V	Trigeminal	Carries sensory impulses from eye, upper jaw and lower jaw toward the brain
VI	Abducens	Controls an eyeball muscles
VII	Facial	Controls muscles of facial expression; carries sensation of taste; stimulates small salivary glands and lacrimal (tear) gland
VIII	Vestibulocochlear	Carries sensory impulses for hearing and equilibrium from the inner ear toward the brain
IX	Glossopharyngeal	Carries sensory impulses from tongue and pharynx (throat); controls swallowing muscles and stimulates the parotid salivary gland
X	Vagus	Supplies most of the organs in the thoracic and abdominal cavities; carries motor impulses to the larynx (voice box) and pharynx
XI	Accessory	Controls muscles in the neck and larynx
XII	Hypoglossal	Controls muscles of the tongue

and motor fibers; they are known as *mixed nerves*. All 12 nerves are listed below and summarized in **Table 10-2**:

- I. The **olfactory nerve** carries smell impulses from receptors in the nasal mucosa to the brain.
- II. The **optic nerve** carries visual impulses from the eye to the brain.
- III. The **oculomotor nerve** is concerned with the contraction of most of the eye muscles.
- IV. The **trochlear** (TROK-le-ar) **nerve** supplies one eyeball muscle.
- V. The **trigeminal** (tri-JEM-in-al) **nerve** is the great sensory nerve of the face and head. It has three branches that transport general sense impulses (e.g., pain, touch, temperature) from the eye, the upper jaw, and the lower jaw. Motor fibers to the muscles of mastication (chewing) join the third branch. It is branches of the trigeminal nerve that a dentist anesthetizes to work on the teeth without causing pain.
- VI. The **abducens** (ab-DU-senz) **nerve** is another nerve sending controlling impulses to an eyeball muscle.
- VII. The **facial nerve** is largely motor. The muscles of facial expression are all supplied by branches from the facial nerve. This nerve also includes special sensory fibers for taste (anterior two-thirds of the tongue), and it contains secretory fibers to the smaller salivary glands (the submandibular and sublingual) and to the lacrimal (tear) gland.
- VIII. The **vestibulocochlear** (ves-tib-u-lo-KOK-le-ar) **nerve** carries sensory impulses for hearing and equilibrium from the inner ear. This nerve was formerly called the auditory or acoustic nerve.
- IX. The **glossopharyngeal** (glos-o-fah-RIN-je-al) **nerve** contains general sensory fibers from the back of the tongue and the pharynx (throat). This nerve also contains sensory fibers for taste from the posterior third of the tongue, secretory fibers that supply the largest salivary gland (parotid), and motor nerve fibers to control the swallowing muscles in the pharynx.

- X. The **vagus** (VA-gus) **nerve** is the longest cranial nerve. (Its name means “wanderer.”) It supplies most of the organs in the thoracic and abdominal cavities. This nerve also contains motor fibers to the larynx (voice box) and pharynx and to glands that produce digestive juices and other secretions.
- XI. The **accessory nerve** (formerly called the *spinal accessory nerve*) is a motor nerve with two branches. One branch controls two muscles of the neck, the trapezius and sternocleidomastoid; the other supplies muscles of the larynx.
- XII. The **hypoglossal nerve**, the last of the 12 cranial nerves, carries impulses controlling the muscles of the tongue.

It has been traditional in medical schools for students to use mnemonics (ne-MON-iks), or memory devices, to remember anatomical lists. As an aside, part of the tradition was that these devices be bawdy. The original mnemonic for the names of the cranial nerves no longer applies, as a few of the names have been changed. Can you and your classmates make up a mnemonic phrase using the first letter of each cranial nerve? You can also check the Internet for sites where medical mnemonics are shared.

Checkpoint 10-11 How many pairs of cranial nerves are there?

Checkpoint 10-12 The cranial nerves are classified as being sensory, motor, or mixed. What is a mixed nerve?

Disorders Involving the Cranial Nerves

Destruction of optic nerve (II) fibers may result from increased pressure of the eye fluid on the nerves, as occurs

in glaucoma, from the effect of poisons, and from some infections. Certain medications, when used in high doses over long periods, can damage the branch of the vestibulo-cochlear nerve responsible for hearing.

Injury to a nerve that contains motor fibers causes paralysis of the muscles supplied by these fibers. The oculomotor nerve (III) may be damaged by certain infections or various poisonous substances. Because this nerve supplies so many muscles connected with the eye, including the levator, which raises the eyelid, injury to it causes a paralysis that usually interferes with eye function.

Bell palsy is a facial paralysis caused by damage to the facial nerve (VII), usually on one side of the face. This injury results in distortion of the face because of one-sided paralysis of the muscles of facial expression.

Neuralgia (nu-RAL-je-ah) in general means “nerve pain.” A severe spasmodic pain affecting the fifth cranial nerve is known as **trigeminal neuralgia** or **tic douloureux** (tik du-lu-RU). At first, the pain comes at relatively long intervals, but as time goes on, intervals usually shorten while durations lengthen. Treatments include microsurgery and high-frequency current.

► Aging of the Nervous System

The nervous system is one of the first systems to develop in the embryo. By the beginning of the third week of development, the rudiments of the central nervous system have appeared. Beginning with maturity, the nervous system begins to undergo changes. The brain begins to decrease in size and weight due to a loss of cells, especially in the cerebral cortex, accompanied by decreases in synapses and neurotransmitters. The speed of processing information decreases, and movements are slowed. Memory diminishes, especially for recent events. Changes in the vascular system throughout the body with a narrowing of the arteries (atherosclerosis) reduce blood flow to the brain. Degeneration of vessels increases the likelihood of stroke.

Much individual variation is possible, however, with regard to location and severity of changes. Although age might make it harder to acquire new skills, tests have shown that practice enhances skill retention. As with other body systems, the nervous system has vast reserves, and most elderly people are able to cope with life’s demands.

Word Anatomy

Medical terms are built from standardized word parts (prefixes, roots, and suffixes). Learning the meanings of these parts can help you remember words and interpret unfamiliar terms.

WORD PART

MEANING

EXAMPLE

The Brain and its Protective Structures

cerebr/o
chori/o

brain
membrane

Cerebrospinal fluid circulates around the brain and spinal cord. The *choroid* plexus is the vascular membrane in the ventricle that produces CSF.

gyr/o
encephal/o

circle
brain

A *gyrus* is a circular raised area on the surface of the brain. The *diencephalon* is the part of the brain located between the cerebral hemispheres and the brain stem.

contra-
later/o

opposed, against
lateral, side

The cerebral cortex has *contralateral* control of motor function. See preceding example.

Imaging the Brain

tom/o

cut

Tomography is a method for viewing sections as if cut through the body.

Disorders of the Brain and Associated Structures

cephal/o
-rhage

head
bursting forth

Hydrocephalus is the accumulation of fluid within the brain. A cerebral *hemorrhage* is a sudden bursting forth of blood in the brain.

phasia

speech, ability to talk

Aphasia is a loss or defect in language communication.

Cranial Nerves

gloss/o

tongue

The *hypoglossal* nerve controls muscles of the tongue.

Summary

I. The brain

- A. Main parts—cerebrum, diencephalon, brain stem, cerebellum

II. Protective structures of the brain and spinal cord

- A. Meninges
1. Dura mater—tough outermost layer
 2. Arachnoid—weblike middle layer
 3. Pia mater—vascular innermost layer
- B. Cerebrospinal fluid (CSF)
1. Circulates around and within brain and spinal cord
 2. Cushions and protects
 3. Ventricles—four spaces within brain where CSF is produced
 - a. Choroid plexus—vascular network in ventricle that produces CSF

III. Cerebral hemispheres

- A. Lobes—frontal, parietal, temporal, occipital, insula
- B. Cortex—outer layer of gray matter
1. In gyri (folds) and sulci (grooves)
 2. Specialized functions—interpretation, memory, conscious thought, judgment, voluntary actions
- C. Basal nuclei (ganglia)—regulate movement and facial expression
- D. Corpus callosum—band of white matter connecting cerebral hemispheres
- E. Internal capsule—connects each cerebral hemisphere to lower parts of brain

IV. Diencephalon—area between cerebral hemispheres and brain stem

- A. Thalamus—directs sensory impulses to cortex
- B. Hypothalamus—maintains homeostasis, controls pituitary
- C. Limbic system
1. Contains parts of cerebrum and diencephalon
 2. Controls emotion and behavior

V. Brain stem

- A. Midbrain—involved in eye and ear reflexes
- B. Pons—connecting link for other divisions
- C. Medulla oblongata
1. Connects with spinal cord
 2. Contains vital centers for respiration, heart rate, vaso-motor activity

VI. The cerebellum—regulates coordination, balance, muscle tone

VII. Brain studies

- A. Imaging—computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET)
1. Electroencephalograph (EEG)—measures electrical waves produced as brain functions

VIII. Disorders of the brain and associated structures

- A. Inflammation
1. Meningitis—inflammation of the meninges
 2. Encephalitis—inflammation of the brain
- B. Hydrocephalus—abnormal accumulation of CSF
- C. Stroke and other brain disorders
1. Cerebrovascular accident (CVA); stroke
 - a. Causes—cerebral hemorrhage, blood clot
 - b. Effects—paralysis, aphasia
 2. Cerebral palsy—cause is brain damage before or during birth
 3. Epilepsy—characterized by seizures
 4. Tumors—usually involve neuroglia (gliomas)
- D. Injury
1. Often results in hematoma—accumulation of blood
 2. Concussion—caused by sudden blow
- E. Degenerative diseases
1. Alzheimer disease—degeneration of cerebral cortex and hippocampus
 2. Multi-infarct dementia—caused by many small strokes
 3. Parkinson disease—deficiency of neurotransmitter dopamine

IV. Cranial nerves

- A. 12 pairs attached to brain
1. Names and functions of the cranial nerves
- B. Functions
1. Carry special and general sensory impulses
 2. Carry somatic and visceral motor impulses
 3. Sensory (I, II, VIII)
 4. Motor (III, IV, VI, XI, XII)
 5. Mixed (V, VII, IX, X)
- C. Disorders involving the cranial nerves
1. Bell palsy—facial paralysis (cranial nerve VII)
 2. Trigeminal neuralgia—pain in Vth cranial nerve

VI. Aging of the nervous system

Questions for Study and Review

Building Understanding

Fill in the blanks

1. The thickest and toughest layer of the meninges is the _____.
2. The third and fourth ventricles are connected by a small canal called the _____.
3. The muscles of speech are controlled by a region named _____.
4. Inflammation of the brain is termed _____.
5. The cells responsible for most brain tumors are _____.

Matching

Match each numbered item with the most closely related lettered item.

- | | |
|--|----------------------------|
| ___ 6. The sensory nerve of the face | a. trigeminal nerve |
| ___ 7. The motor nerve of the muscles of facial expression | b. facial nerve |
| ___ 8. The sensory nerve for hearing and equilibrium | c. vestibulocochlear nerve |
| ___ 9. The motor nerve for swallowing | d. glossopharyngeal nerve |
| ___ 10. The motor nerve for digestion | e. vagus nerve |

Multiple choice

- ___ 11. The cerebrum is divided into left and right hemispheres by the
- central sulcus
 - lateral sulcus
 - longitudinal fissure
 - insula
- ___ 12. The primary sensory area interprets all of the following sensations except
- vision
 - pain
 - touch
 - temperature
- ___ 13. An abnormal accumulation of CSF within the brain is called
- cerebral hemorrhage
 - subdural hematoma
 - hemiplegia
 - hydrocephalus
- ___ 14. Tremors, limb rigidity, slow movement, and impaired balance are signs of
- meningitis
 - Bell palsy
 - Alzheimer disease
 - Parkinson disease
- ___ 15. Pain messages are classified as
- special sensory impulses
 - general sensory impulses
 - somatic motor impulses
 - visceral motor impulses
17. A neurosurgeon has drilled a hole through her patient's skull and is preparing to remove a cerebral glioma. List, in order, the membranes she must cut through to reach the cerebral cortex.
18. Compare and contrast the functions of the following structures:
- frontal lobe and parietal lobe
 - temporal lobe and occipital lobe
 - thalamus and hypothalamus
19. What is the function of the limbic system? Describe the effect of damage to the hippocampus.
20. Compare and contrast the following nervous system disorders:
- meningitis and encephalitis
 - epidural hematoma and subdural hematoma
 - Alzheimer disease and multi-infarct dementia
 - Bell palsy and trigeminal neuralgia
21. Describe Parkinson disease and therapies used to treat it.
22. The term cerebellum means "little cerebrum." Why is this an appropriate term?
23. Make a table of the 12 cranial nerves and their functions. According to your table, which ones are sensory, motor, or mixed?

Conceptual Thinking

24. The parents of Molly R (2-month-old Caucasian female) are informed that their daughter requires a shunt to drain excess CSF from her brain. What disorder does Molly have? How would you explain this disorder to her parents? What would happen to Molly if the shunt was not put in place?
25. Mr. Wong has suffered a brain stem stroke and his healthcare team does not expect him to survive. How would you explain the term "stroke" to his family? Why is damage to the brain stem life-threatening?

Understanding Concepts

16. Briefly describe the effects of injury to the following brain areas:
- cerebrum
 - diencephalon
 - brain stem
 - cerebellum