Chapter 19  Adapted from Tortora 10th ed.

LECTURE OUTLINE

A. Overview of Brain Organization (p. 584)
   I. Principal Parts of the Brain:
      1. The adult brain consists of about 100 billion neurons and 10-50 trillion neuroglia; it can be divided into four major regions (see Table 19.1):
         i. brain stem (continuous with the spinal cord), which consists of:
            a. medulla oblongata
            b. pons
            c. midbrain
         ii. cerebellum (posterior to the brain stem)
         iii. diencephalon (superior to the brain stem), which consists of:
            a. thalamus
            b. hypothalamus
            c. epithalamus
            d. subthalamus
         iv. cerebrum (spreads over the diencephalon like a mushroom cap)

   II. Protective Coverings of the Brain:
      1. The brain is protected by:
         i. cranial bones
         ii. cranial meninges (that are continuous with the spinal meninges):
            a. outer dura mater
               - three extensions of the dura mater separate parts of the brain:
               1. falx cerebri separates the two cerebral hemispheres
               2. falx cerebelli separates the two cerebellar hemispheres
               3. tentorium cerebelli separates the cerebrum from the cerebellum
            b. middle arachnoid mater
            c. inner pia mater
         iii. cerebrospinal fluid

III. Brain Blood Flow and the Blood-Brain Barrier:
   1. Blood supply to the brain is provided primarily by the internal carotid and vertebral arteries.
   2. The blood-brain barrier (BBB) regulates the passage of substances from the blood into brain tissue and thereby protects brain cells from harmful substances and pathogens; it is formed by:
      i. tight junctions that seal together the endothelial cells of brain capillaries
      ii. basement membrane that surrounds the brain capillaries
      iii. processes of astrocytes that press up against the capillaries

IV. Cerebrospinal Fluid Production and Circulation in Ventricles: (p. 587)
1. The cerebrospinal fluid (CSF):
   i. is a clear, colorless liquid that protects the brain and spinal cord against chemical and physical injuries; it carries oxygen, glucose, and other needed substances from the blood to neurons and neuroglia
   ii. circulates through the subarachnoid space and four ventricles which include:
      a. right and left lateral ventricles (separated anteriorly by the septum pellucidum) located in the two cerebral hemispheres
      b. third ventricle located between the right and left halves of the thalamus
      c. fourth ventricle located between the brain stem and the cerebellum
   iii. contributes to homeostasis by performing three major functions:
      a. mechanical protection by serving as a shock-absorbing liquid
      b. chemical protection by providing an optimal chemical environment
      c. circulation, i.e., by exchanging nutrients and wastes between the blood and nervous tissue
   iv. is formed as blood flows through choroid plexuses located in the walls of ventricles; these networks of capillaries are covered by ependymal cells which produce the CSF from blood plasma by filtration and secretion
   v. does not contain harmful blood-borne substances due to the presence of the blood-cerebrospinal fluid barrier formed by tight junctions located between the ependymal cells
   vi. flows along the following route:
      a. CSF produced in the choroid plexuses of the lateral ventricles flows into the third ventricle via the interventricular foramina
      b. more CSF is added by the choroid plexus of the third ventricle
      c. the fluid then flows into the fourth ventricle via the aqueduct of the midbrain (cerebral aqueduct)
      d. more CSF is added by the choroid plexus of the fourth ventricle
      e. CSF then flows into the subarachnoid space via:
         -one median aperture
         -two lateral apertures
      f. after flowing through the subarachnoid space and the spinal cord’s central canal, CSF is gradually reabsorbed into the blood through fingerlike extensions of the arachnoid called arachnoid villi that project into the dural venous sinuses, especially the superior sagittal sinus

V. Brain Stem consists of: (p. 590)
   1. medulla oblongata (or more simply the medulla):
      i. It is a continuation of the upper part of the spinal cord and forms the inferior part of the brain stem; it lies just superior to the foramen magnum and extends upward about 3 cm to the inferior portion of the pons.
ii. It contains all ascending and descending tracts that connect the spinal cord to the brain, plus many nuclei that regulate various vital body functions.

iii. On the anterior side of the medulla are two **pyramids** which contain the largest motor tracts that pass from the cerebrum to the spinal cord
   a. just superior to the medulla-spinal cord junction, 90% of the axons in each pyramid cross over to the opposite side
   b. this crossing over is called the **decussation of pyramids**, an anatomical feature which results in motor fibers originating in the left cerebral cortex activating muscles on the right side of the body, and motor fibers originating in the right cerebral cortex activating muscles on the left side of the body

iv. Just lateral to each pyramid is an oval projection called an **olive**; it is caused primarily by the **inferior olivary nucleus** within the medulla.

v. On the posterior side of the medulla are the right and left **gracile nucleus** and **cuneate nucleus**
   - these nuclei receive sensory fibers from ascending tracts and relay the sensory information to the thalamus on the opposite side, an anatomical feature which results in nearly all sensory information from one side of the body being eventually delivered to the cerebral cortex on the opposite side;

vi. The medulla contains the **cardiovascular center**, the **medullary rhythmicity area** of the **respiratory center**, and centers that control reflexes for vomiting, coughing, and sneezing.

vii. The medulla also contains the nuclei of origin for cranial nerves VIII (i.e., the cochlear branches of VIII) through XII.

2. **pons**:
   i. The pons is superior to the medulla and is about 2.5 cm long.
   ii. It consists of nuclei, called **pontine nuclei**, and tracts.
   iii. It bridges parts of the brain with each other; these connections are provided by axons that are organized into tracts:
      a. some tracts connect the right and left sides of the cerebellum
      b. others are part of ascending and descending tracts
   iv. It contains the **pneumotaxic area** and the **apneustic area** which help control respiration.
   v. It also contains the nuclei of origin for cranial nerves V through VII and the vestibular branches of VIII.

3. **midbrain** (or **mesencephalon**):
   i. The midbrain is about 2.5 cm long, extends upward from the pons to the diencephalon, and contains both tracts and nuclei; the cerebral aqueduct passes through the midbrain and connects the third ventricle to the fourth ventricle.
   ii. The anterior portion contains a pair of **cerebral peduncles** which contain:
      a. motor fibers that convey information from the cerebral cortex to the pons, medulla, and spinal cord
b. sensory fibers that pass from the medulla to the thalamus

iii. The posterior portion of the midbrain is called the tectum and contains four rounded elevations:
   a. two superior colliculi that serve as reflex centers for movements of the eyes, head, and neck in response to visual and other stimuli
   b. two inferior colliculi that help relay auditory information from the ears to the thalamus and also serve as reflex centers for movements of the head and trunk in response to auditory stimuli

iv. The midbrain also contains:
   a. the right and left substantia nigra which control subconscious muscle activities
   b. the right and left red nuclei which function with the cerebellum to coordinate muscle movements
   c. the medial lemniscus that extends through the medulla, pons, and midbrain; it conveys impulses for discriminative touch, proprioception, pressure, and vibrations from the medulla to the thalamus

v. The midbrain also contains the nuclei of origin for cranial nerves III and IV.

4. reticular formation:
   i. A large portion of the brain stem (medulla, pons, and midbrain) is a region called the reticular formation (which also extends into the spinal cord and the diencephalon); it consists of small areas of gray matter interspersed among small bundles of white matter.
   ii. It has both motor and sensory functions.
   iii. Its main motor function is to help regulate muscle tone.
   iv. Its main sensory function is to alert the cerebral cortex to incoming sensory signals.
   v. It contains the reticular activating system (RAS) which is responsible for maintaining consciousness and awakening from sleep; it does so by arousing the cerebral cortex in response to incoming sensory signals.

VI. Cerebellum: (p. 595)
   1. The cerebellum is located in the inferior and posterior aspects of the cranial cavity; it is posterior to the medulla and pons and inferior to the posterior portion of the cerebrum.
   2. It is separated from the cerebrum by the transverse fissure and by an extension of the cranial dura mater called the tentorium cerebelli.
   3. The cerebellum resembles a butterfly; it consists of a central constricted area called the vermis located between two cerebellar hemispheres.
   4. Each hemisphere consists of lobes that are separated by fissures; the lobes are:
      i. anterior lobe is concerned with subconscious movements of skeletal muscles
      ii. posterior lobe is also concerned with subconscious movements of skeletal muscles
      iii. flocculonodular lobe is concerned with the sense of equilibrium
Between the hemispheres is an extension of the cranial dura mater called the **falx cerebelli**.

5. The **cerebellar cortex** consists of gray matter organized in a series of slender, parallel ridges called **folia**.

6. Beneath the gray matter are tracts called **arbor vitae** that resemble branches of a tree.

7. Within the underlying white matter are masses of gray matter called **cerebellar nuclei** which give rise to nerve fibers that transmit information from the cerebellum to other brain centers and to the spinal cord.

8. The cerebellum is attached to the brain stem by three pairs of **cerebellar peduncles**:
   i. **inferior cerebellar peduncles** connect the cerebellum to the medulla; these peduncles contain axons extending from the inferior olivary nucleus of the medulla and from spinocerebellar tracts of the spinal cord to the cerebellum
   ii. **middle cerebellar peduncles** contain axons that extend from the pons to the cerebellum
   iii. **superior cerebellar peduncles** contain axons that extend from the cerebellum into the midbrain and to the thalamus

9. The main functions of the cerebellum is to **smooth and coordinate sequences of skeletal muscle contractions required for skilled movements and to regulate posture and balance**.

**VII. Diencephalon** consists of (see Table 19.2): (p. 596)

1. **Thalamus**:
   i. The thalamus is superior to the midbrain, is about 3 cm long, and constitutes about 80% of the diencephalon.
   ii. It consists of paired oval masses of mostly gray matter organized into nuclei with interspersed tracts of white matter.
   iii. In about 70% of human brains, the right and left portions of the thalamus are connected by a bridge of gray matter called the **intermediate mass (interthalamic adhesion)** that crosses the third ventricle.
   iv. The thalamus is the **major relay station for sensory impulses** transmitted to the cerebral cortex from the spinal cord, brain stem, cerebellum, and other parts of the cerebrum.
   v. The thalamus:
      a. provides crude perception of pain, temperature and pressure
      b. mediates motor functions by transmitting information from the cerebellum and basal ganglia to the primary motor area in the cerebral cortex
      c. helps regulate autonomic activities and the maintenance of consciousness
      d. is connected to the cerebral cortex by the **internal capsule** (which also connects the cerebral cortex to the brain stem and spinal cord)
   vi. The gray matter of the thalamus is divided by the **internal medullary lamina** which separates the thalamic nuclei into six major groups:
      a. **anterior nuclei**
      b. **medial nuclei**
c. lateral nuclei including lateral dorsal nuclei, lateral posterior nuclei, and pulvinar nuclei
d. ventral group including ventral anterior nuclei, ventral lateral nuclei, ventral posterior nuclei, medial geniculate nuclei, lateral geniculate nuclei
e. intralaminar nuclei
f. midline nuclei
g. reticular nuclei

2. Hypothalamus:
   i. The hypothalamus is located inferior to the thalamus.
   ii. It lacks a blood-brain barrier and forms the floor and part of the lateral walls of the third ventricle.
   iii. It is divided into about a dozen nuclei in four major regions:
      a. mammillary region, which includes the two mammillary bodies and the posterior hypothalamic nucleus
      b. tuberal region, which includes several nuclei, infundibulum, and medial eminence
      c. supraoptic region, which includes several nuclei
      d. preoptic region, which includes several nuclei
   iv. The hypothalamus is one of the major regulators of homeostasis; its chief functions are:
      a. control of the autonomic nervous system, which regulates contraction of smooth muscle and cardiac muscle and the secretions of many glands
      b. control of the pituitary gland
      c. regulation of emotional and behavioral patterns
      d. regulation of eating and drinking via its feeding center, satiety center, and thirst center
      e. regulation of body temperature
      f. regulation of circadian rhythms and states of consciousness

3. Epithalamus:
   i. The epithalamus is a small region superior and posterior to the thalamus.
   ii. It consists of:
      a. pineal gland that protrudes from the posterior midline of the third ventricle; it secretes melatonin which is believed to promote sleepiness and appears to contribute to the setting of the biological clock
      b. habenular nuclei which are involved in olfaction, especially emotional responses to odors

4. Subthalamus:
   i. The subthalamus is located inferior to the thalamus, includes tracts and the paired subthalamic nuclei which connect to motor areas of the cerebrum.
   ii. Parts of the substantia nigra and the red nucleus extend from the midbrain into the subthalamus.
   iii. The subthalamus participates in the control of body movements.
5. Circumventricular organs
   i. The **circumventricular organs (CVOs)** are located in the walls of the third and fourth ventricles.
   ii. They lack the blood-brain barrier and therefore can monitor chemical changes in the blood.
   iii. CVOs include part of the hypothalamus, the pineal gland, pituitary gland, and several other nearby structures.

VIII. Cerebrum: (p. 600)
1. The cerebrum is the “seat of intelligence”, performing many mental tasks such as reading, writing, speaking, calculating, composing, imagining, etc.
2. The surface of the cerebrum is composed of **gray matter** (2 to 4 mm thick) and is called the **cerebral cortex**; beneath the cortex is the cerebral **white matter** which contains gray matter nuclei.
3. The cortex contains folds called **gyri** or **convolutions**; deep grooves between folds are called **fissures** and shallow grooves between folds are called **sulci**.
4. The **longitudinal fissure** separates the cerebrum into right and left **cerebral hemispheres**; the hemispheres are connected internally by the **corpus callosum**.
5. Between the hemispheres is an extension of the cranial dura mater called the **falx cerebri**.
6. Lobes of the cerebrum:
   i. Each cerebral hemisphere is subdivided into four lobes that are named after the overlying bones:
      a. **frontal lobe**
      b. **parietal lobe**
      c. **temporal lobe**
      d. **occipital lobe**
   ii. The **central sulcus** separates the frontal lobe from the parietal lobe;
      a. anterior to the central sulcus is the **precentral gyrus** which contains the primary motor area of the cerebral cortex
      b. posterior to the central sulcus is the **postcentral gyrus** which contains the primary somatosensory area of the cerebral cortex
   iii. The **lateral cerebral sulcus** separates the frontal lobe from the temporal lobe.
   iv. The **parieto-occipital sulcus** separates the parietal lobe from the occipital lobe.
   v. The **transverse fissure** separates the cerebrum from the cerebellum.
   vi. A fifth part of the cerebrum, the **insula**, is located deep within the lateral cerebral sulcus, under the parietal, frontal, and temporal lobes.
7. Cerebral White Matter:
i. The white matter underlying the cortex consists of myelinated and unmyelinated axons in three types of tracts:
   a. association tracts
   b. commissural tracts including the corpus callosum, anterior commissure, and posterior commissure
   c. projection tracts

8. Basal Ganglia:
   i. The basal ganglia are several pairs of nuclei located in the cerebral hemispheres.
   ii. The largest nucleus is the corpus striatum, which consists of:
       a. caudate nucleus
       b. lenticular nucleus, which consists of:
          - lateral putamen
          - medial globus pallidus
   iii. Other structures that are functionally linked to the basal ganglia are the substantia nigra and the subthalamic nuclei.
   iv. The basal ganglia control subconscious movements of skeletal muscles, such as swinging the arms while walking.
   v. The globus pallidus helps regulate the muscle tone required for specific body movements.
   vi. The basal ganglia also help initiate and terminate some cognitive processes and may help regulate emotional behaviors.

9. Limbic System:
   i. The limbic system is a ring of structures on the inner border of the cerebrum and floor of the diencephalon that encircle the upper part of the brain stem and the corpus callosum.
   ii. Among its components are the following structures:
       a. limbic lobe, which includes the parahippocampal and cingulate gyri and the hippocampus
       b. dentate gyrus
       c. amygdala
       d. septal nuclei
       e. mammillary bodies of the hypothalamus
       f. anterior nucleus and medial nucleus of the thalamus
       g. olfactory bulbs
       h. fornix, stria terminalis, stria medullaris, medial forebrain bundle, and mammillothalamic tract are linked by bundles of interconnecting myelinated axons
   iii. The limbic system functions in emotional aspects of behavior related to survival; it also functions in olfaction and memory.

10. Functional Organization of the Cerebral Cortex: (p. 607)
   i. Specific types of sensory, motor, and integrative signals are processed in certain cerebral regions.
   ii. Sensory areas receive and interpret sensory information; they include:
       a. primary somatosensory area (areas 1, 2, and 3)
       b. primary visual area (area 17)
       c. primary auditory area (areas 41 and 42)
d. primary gustatory area (area 43)
e. primary olfactory area (area 28)
f. secondary sensory areas and sensory association areas integrate sensory experiences to generate meaningful patterns of recognition and awareness

iii. **Motor areas** initiate movements; they include:
   a. primary motor area (area 4)
   b. Broca’s speech area (areas 44 and 45) that is usually located in the left frontal lobe

iv. **Association areas** deal with more complex integrative functions such as memory, emotions, reasoning, will, judgment, personality traits, and intelligence; they include:
   a. somatosensory association area (areas 5 and 7)
   b. visual association area (areas 18 and 19)
   c. auditory association area (area 22)
   d. Wernicke’s (posterior language) area (area 22 and perhaps areas 39&40)
   e. common integrative area (areas 5, 7, 39, & 40)
   f. premotor area (area 6)
   g. frontal eye field area (area 8)
   h. other language areas

11. **Hemispheric Lateralization** (see Table 19.3):
   i. The cerebral hemispheres are not anatomically or functionally symmetrical.
   ii. The left hemisphere receives sensory signals from and controls the right side of
       the body, and in most people is more important for:
       a. spoken and written language
       b. numerical and scientific skills
       c. ability to use and understand sign language
       d. reasoning
   iii. The right hemisphere receives sensory signals from and controls the left side of
       the body, and in most people is more important for:
       a. musical and artistic awareness
       b. spatial and pattern perception
       c. recognition of faces
       d. emotional content of language
       e. generating mental images of sight, sound, touch, taste, and smell to compare relationships among them
   iv. Lateralization seems less pronounced in females than in males, both for language (left hemisphere) and for visual and spatial skills (right hemispheres).

12. **Brain Waves:**
   i. Brain waves may be detected due to the generation of electrical potentials by neurons.
   ii. A record of brain waves generated by neurons in the cerebral cortex is called an **electroencephalogram** or **EEG**.
B. Cranial Nerves (p. 610)

1. The 12 pairs of cranial nerves are part of the peripheral nervous system.
2. All cranial nerves travel through foramina of the skull; 10 pairs originate from the brain stem.
3. The cranial nerves are designated by:
   i. roman numerals which indicate the order in which the nerves arise from the brain from anterior to posterior
   ii. names which indicate the distribution or function
4. Two cranial nerves (I and II) contain only sensory fibers and are therefore called sensory nerves.
5. The other cranial nerves contain both sensory and motor fibers and are therefore called mixed nerves; some of the mixed nerves are primarily motor in function.
6. The cell bodies of sensory fibers are located in ganglia outside the brain.
7. The cell bodies of motor fibers are located in nuclei within the brain; some cranial nerves include both somatic motor and parasympathetic fibers of the autonomic nervous system.
8. The individual names (and roman numeral designations) of the 12 pairs of cranial nerves and their major characteristics are:
   i. olfactory (I) nerve:
      a. entirely sensory
      b. transmits nerve impulses related to smell
      c. arises as bipolar neurons from the olfactory epithelium of the nasal cavity
      d. axons from these neurons pass through the cribriform plate of the ethmoid bone and synapse with other neurons in the olfactory bulb (an extension of the brain)
      e. the axons of the latter neurons form the olfactory tract and travel to the primary olfactory area in the cerebral cortex
   ii. optic (II) nerve:
      a. entirely sensory
      b. transmits nerve impulses related to vision
      c. signals initiated by the rods and cones of the retina are relayed by bipolar neurons to ganglion cells
      d. axons of the ganglion cells converge to form the optic nerve which exits the orbit via the optic foramen
      e. the two optic nerves unite to form the optic chiasm where fibers from the medial half of each retina cross to the opposite side and fibers from the lateral side remain on the same side
      f. posterior to the chiasm, the regrouped fibers form the optic tracts
      g. from the optic tracts most fibers travel to the lateral geniculate nuclei in the thalamus where they synapse with neurons that pass to the primary visual areas of the cerebral cortex
      h. some fibers from the optic chiasm travel to the superior colliculi of the midbrain; here they synapse with motor neurons that control the extrinsic and intrinsic eye muscles
iii. oculomotor (III) nerve:
   a. mixed nerve; but principally motor, serving to stimulate (primarily skeletal) muscle contractions
   b. originates from nucleus in the ventral portion of the midbrain
   c. travels forward and divides into superior and inferior branches, both of which enter the orbit via the superior orbital fissure
   d. the superior branch innervates the superior rectus and levator palpebrae superioris muscles
   e. the inferior branch innervates the medial rectus, inferior rectus, and inferior oblique muscles
   f. the inferior branch also provides parasympathetic innervation to the ciliary ganglion, a relay center of the autonomic nervous system that connects a nucleus in the midbrain with the intrinsic eye muscles
   g. therefore, major functions are regulating movements of upper eyelid and eyeball, adjustment of lens for near vision, and constriction of pupil
   h. the sensory portion of the oculomotor nerve consists of afferent fibers from proprioceptors in the eyeball muscles supplied by the nerve to the midbrain

iv. trochlear (IV) nerve:
   a. mixed nerve; but primarily motor, serving to stimulate skeletal muscle contractions
   b. smallest of the cranial nerves and only one to arise from the posterior aspect of the brain stem
   c. the motor portion originates in nucleus in midbrain, and axons from the nucleus enter the orbit via the superior orbital fissure
   d. the motor fibers innervate the superior oblique muscle
   e. therefore, major function is regulating movement of eyeball
   f. the sensory portion of the trochlear nerve consists of afferent fibers that travel from proprioceptors in the superior oblique muscle to a nucleus of the nerve in the midbrain

v. trigeminal (V) nerve:
   a. mixed nerve
   b. largest of the cranial nerves
   c. has three branches:
      1. ophthalmic nerve
      2. maxillary nerve
      3. mandibular nerve
   d. emerges from two roots on the ventrolateral surface of the pons
   e. the large sensory root has a swelling called the trigeminal ganglion which contains the cell bodies of most of the primary sensory neurons
   f. from this ganglion:
      1. the ophthalmic nerve enters the orbit via the superior orbital fissure
      2. the maxillary nerve enters the foramen rotundum
      3. the mandibular nerve exits through the foramen ovale
g. the small motor root originates in a nucleus in the pons; the motor fibers join the mandibular branch and supply the muscles of mastication

h. the sensory portion of the trigeminal nerve delivers nerve impulses related to touch, pain, and temperature from numerous structures in the head and from proprioceptors in the muscles of mastication

vi. abducens (VI) nerve:
   a. mixed nerve; but primarily motor
   b. originates from nucleus in the pons
   c. motor fibers travel from nucleus to the lateral rectus muscle via the superior orbital fissure of the orbit
   d. nerve called abducens because motor fibers deliver nerve impulses that cause abduction of the eyeball (lateral rotation)
   e. sensory fibers travel from proprioceptors in the lateral rectus muscle to the pons

vii. facial (VII) nerve:
   a. mixed cranial nerve
   b. motor fibers originate from nucleus in the pons and innervate facial, scalp, and neck muscles; some motor fibers provide parasympathetic innervation (via the pterygopalatine and submandibular ganglia) to various glands in the head
   c. therefore, major motor functions are regulating muscles of facial expression and secretion of saliva and tears
   d. sensory fibers travel from the taste buds of the anterior two-thirds of the tongue to the geniculate ganglion; from here, the fibers pass to a nucleus in the pons (which sends fibers to the thalamus for relay to the gustatory area of the cerebral cortex)
   e. the sensory portion also transmits proprioceptive information from muscles of the face and scalp

viii. vestibulocochlear (VIII) nerve:
   a. formerly called the acoustic or auditory nerve
   b. mainly a sensory nerve
   c. consists of two branches:
      1. cochlear branch
      2. vestibular branch
   d. the cochlear branch transmits nerve impulses associated with hearing from the spiral organ in the cochlea of the inner ear; the cell bodies of the cochlear branch are located in the spiral ganglion of the cochlea from which axons travel to nuclei in the medulla; the nerve impulses are ultimately relayed to the auditory areas of the cerebral cortex
   e. the vestibular branch transmits nerve impulses associated with equilibrium from the semicircular canals, saccule, and utricle of the inner ear to the vestibular ganglion, where the cell bodies are located; from here, the fibers travel to nuclei in the thalamus; some fibers also travel to the cerebellum
ix. glossopharyngeal (IX) nerve:
   a. mixed nerve
   b. nerve exits the skull via the jugular foramen
   c. motor fibers originate from nuclei in the medulla and innervate the stylopharyngeus muscle and parotid gland (some of the cell bodies of parasympathetic motor neurons are located in the otic ganglion)
   d. therefore, major motor function is regulation of secretion of saliva
   e. sensory fibers originate from the pharynx, taste buds of the posterior third of the tongue, carotid sinus baroreceptors, proprioceptors in swallowing muscles, and carotid body chemoreceptors; these sensory fibers travel to the medulla
   f. therefore, major sensory function is taste, monitoring of blood pressure, proprioception, and monitoring blood gas levels

x. vagus (X) nerve:
   a. mixed cranial nerve that is widely distributed from the head and neck into the thorax and abdomen
   b. motor fibers originate in nuclei of the medulla and travel to muscles in the respiratory passageways, lungs, heart, esophagus, stomach, small intestine, most of the large intestine and the gallbladder; nerve impulses are delivered to smooth, cardiac, and skeletal muscle tissues as well as to glands of the gastrointestinal tract
   c. sensory fibers travel from visceral sensory receptors of thoracic and abdominal organs, the ear, some taste buds, proprioceptors in neck and throat muscles, carotid sinus baroreceptors, and carotid body chemoreceptors to the medulla and pons

xi. accessory (XI) nerve:
   a. formerly called the spinal accessory nerve
   b. mixed nerve; but primarily motor, serving to stimulate skeletal muscle contractions
   c. originates from both the brain stem and the spinal cord
   d. cranial root originates from nuclei in the medulla and innervates the skeletal muscles of the pharynx, larynx, and soft palate that are used in swallowing
   e. spinal root originates in the anterior gray horn of the first five segments of the cervical spinal cord; the fibers from the segments converge, enter the foramen magnum, and exit via the jugular foramen along with the cranial root
   f. the spinal portion transmits motor impulses to the sternocleidomastoid and trapezius muscles to coordinate head movements; its sensory fibers transmit nerve impulses from proprioceptors in these muscles

xii. hypoglossal (XII) nerve:
   a. mixed nerve; but primarily motor, serving to stimulate skeletal muscle contractions
   b. motor fibers originate in a nucleus in the medulla, travel through the hypoglossal canal, and innervate muscles of the
tongue; these fibers transmit nerve impulses related to speech and swallowing
c. sensory fibers travel from proprioceptors in the tongue muscles to the medulla
9. An excellent summary of cranial nerves (their types, locations, functions, and clinical applications related to dysfunctions) is presented in Table 19.4.

C. Development of the Nervous System (p. 624)
1. The development of the nervous system begins with a thickening of the ectoderm called the neural plate which folds inward and forms the neural groove; the raised edges of the neural plate are called neural folds and the latter increase in height and meet to form the neural tube.
2. The cells of the wall that encloses the neural tube differentiate to form three layers:
   i. outer or marginal layer, which develops into the white matter
   ii. middle or mantle layer, which develops into the gray matter
   iii. inner or ependymal layer, which develops into the lining of the ventricles and lining of the spinal cord’s central canal
3. The neural crest is a mass of tissue between the neural tube and the skin ectoderm; it differentiates into the:
   i. posterior (dorsal) root ganglia of spinal nerves
   ii. spinal nerves
   iii. ganglia of cranial nerves
   iv. cranial nerves
   v. ganglia of the autonomic nervous system
   vi. adrenal medulla
   vii. meninges
4. The anterior portion of the neural tube develops into three enlarged fluid-filled areas called primary brain vesicles:
   i. prosencephalon (forebrain)
   ii. mesencephalon (midbrain)
   iii. rhombencephalon (hindbrain)
5. As development proceeds, the three primary vesicles develop into four secondary brain vesicles:
   i. the prosencephalon develops into:
      a. an anterior telencephalon, which develops into the cerebral hemispheres, basal ganglia, and lateral ventricles
      b. a posterior diencephalon, which develops into the epithalamus, thalamus, subthalamus, hypothalamus, and pineal gland, and houses the third ventricle
   ii. the rhombencephalon develops into:
      a. an anterior metencephalon, which develops into the pons, cerebellum, and houses upper part of the fourth ventricle
      b. a posterior myelencephalon, which develops into the medulla oblongata, and houses the rest of the fourth ventricle
   iii. the mesencephalon remains unchanged and develops into the midbrain
6. The area of the neural tube inferior to the myelencephalon develops into the spinal cord.

D. Aging and the Nervous System (p. 626)
1. The effects of aging on the nervous system include:
i. during the early years of life, rapid brain growth occurs primarily due to an increase in the size of neurons and proliferation and growth of neuroglia
ii. after early adulthood, brain weight gradually decreases slightly and the number of synaptic contacts declines
iii. with aging, there is also a decreased capacity for sending nerve impulses to and from the brain, resulting in diminished processing of information
iii. other aging effects include decreased conduction velocity, slowing of voluntary motor movements, and increased reflex times

E. Key Medical Terms Associated with the Brain and the Cranial Nerves (p. 627)
1. Students should familiarize themselves with the glossary of key medical terms.