Chapter 14 - Outline

I. INTRODUCTION

A. The brain is the center for registering sensations, correlating them with one another and with stored information, making decisions, and taking action.

   1. It is also the center for intellect, emotions, behavior, and memory.

   2. It also directs our behavior towards others.

B. In this chapter we will consider the principal parts of the brain, how the brain is protected and nourished, and how it is related to the spinal cord and to the 12 pairs of cranial nerves.

II. OVERVIEW OF BRAIN ORGANIZATION AND BLOOD SUPPLY

A. The major parts of the brain are the brain stem, diencephalon, cerebrum, and cerebellum.

B. Blood Flow and the Blood-Brain Barrier

   1. Blood flows to the brain mainly via blood vessels that branch from the cerebral arterial circle (circle of Willis) at the base of the brain (Ch. 21); the veins that return blood from the head to the heart are also seen in Ch. 21.

   2. Although the brain comprises only about 2% of the total body weight, it utilizes about 20% of the oxygen used by the entire body. The brain is one of the most metabolically active organs of the body, and the amount of oxygen it uses varies with the degree of mental activity.

   3. Any interruption of the oxygen supply to the brain can result in weakening, permanent damage, or death of brain cells. Interruption of the mother’s blood supply to a child during childbirth before it can breathe may result in paralysis, mental retardation, epilepsy, or death.

   4. Because carbohydrate storage in the brain is limited, the supply of glucose to the brain must be continuous. Glucose deficiency may produce mental confusion, dizziness, convulsions, and unconsciousness.
5. A blood-brain barrier (BBB) protects brain cells from harmful substances and pathogens by serving as a selective barrier to prevent passage of many substances from the blood to the brain.

6. An injury to the brain due to trauma, inflammation, or toxins causes a breakdown of the BBB, permitting the passage of normally restricted substances into brain tissue. The BBB may also prevent entry of drugs that could be used as therapy for brain cancer or other CNS disorders, so research is exploring ways to transport drugs past the BBB.

C. Protective Covering of the Brain

1. The brain is protected by the cranial bones and the cranial meninges.

2. The cranial meninges are continuous with the spinal meninges and are named dura mater, arachnoid, and pia mater.

3. Three extensions of the dura mater separate parts of the brain: the falx cerebri, falx cerebelli, and the tentorium cerebelli.

III. CEREBROSPINAL FLUID

A. Cerebrospinal fluid (CSF) is a clear, colorless liquid that protects the brain and spinal cord against chemical and physical injuries and carries oxygen, glucose, and other needed chemicals from the blood to neurons and neuroglia.

B. There are four CSF filled cavities within the brain called ventricles.

C. CSF contributes to hemostasis by providing mechanical protection, chemical protection, and circulation.

D. CSF is formed by filtration from networks of capillaries called choroid plexuses (found in the ventricles) and circulates through the subarachnoid space, ventricles, and central canal.

E. Materials entering CSF from the choroid capillaries cannot leak between the surrounding ependymal cells; these constitute the blood-cerebrospinal fluid barrier, which permits certain
substances to enter the fluid but excludes others and protects the brain and spinal cord from harmful elements.

F. Most of the fluid is absorbed by the *arachnoid villi* of the *superior sagittal blood sinus*; this absorption normally occurs at the same rate at which CSF is produced in the choroid plexuses, thereby maintaining a relatively constant CSF volume and pressure.

G. If CSF cannot circulate or drain properly due to some obstruction in the ventricles or subarachnoid space, a condition called *hydrocephalus* develops. The fluid buildup that occurs causes increased pressure on the brain, either internally or externally, depending on where the blockage is present. Surgically draining the ventricles and diverting the flow of CSF by an implanted shunt can positively and dramatically affect the individual’s prognosis.

IV. THE BRAIN STEM

A. Medulla Oblongata

1. The *medulla oblongata*, or just *medulla*, is continuous with the upper part of the spinal cord and contains portions of both motor and sensory tracts.

2. It also contains the nuclei of origin for cranial nerves VIII (cochlear and vestibular branches) through XII.

3. Structural regions of the medulla include the *pyramids* and the *inferior olivary nucleus*.
   a. Decussation of pyramids results in neurons in the left cerebral cortex controlling skeletal muscles on the right side of the body and neurons in the right cerebral cortex controlling skeletal muscles on the left side.
   b. Inferior olivary neurons relay impulses from proprioceptors to the cerebellum.

4. Functional regions include nuclei that are vital reflex centers for regulation of heart rate and vasoconstriction (cardiovascular center), respiratory rate (medullary rhythmicity center), and non-vital reflex centers for swallowing, coughing, vomiting, sneezing, and hiccapping.
5. Injury to the medulla can be fatal or lead to serious problems.

B. Pons

1. The pons is located superior to the medulla. It connects the spinal cord with the brain and links parts of the brain with one another by way of tracts.
2. It relays nerve impulses related to voluntary skeletal movements from the cerebral cortex to the cerebellum.
3. The pons also contains the pneumotaxic and apneustic areas, which help control respiration along with the medullary rhythmicity center in the medulla.
4. It contains nuclei for cranial nerves V through VII and the vestibular branch of VIII.

C. Midbrain

1. The midbrain connects the pons and diencephalon. It conveys motor impulses from the cerebrum to the cerebellum and spinal cord, sends sensory impulses from the spinal cord to the thalamus, and regulates auditory and visual reflexes.
2. Structures within the midbrain include the cerebral peduncles, the tectum (containing the superior and inferior colliculi, the left and right substantia nigra, and the left and right red nuclei. You should know the locations and functions of these structures as discussed in lecture.
3. It also contains nuclei of origin for cranial nerves III and IV.

D. Reticular Formation and Medial Lemniscus run through all 3 parts of the brainstem.

1. Reticular Formation
   a. It consists of small areas of gray matter interspersed among fibers of white matter and has both sensory and motor functions.
   b. It helps regulate muscle tone, alerts the cortex to incoming sensory signals (reticular activating system, or RAS) and is responsible for maintaining consciousness and awakening from sleep.
2. Medial Lemniscus
   a. The axons of the cuneate and gracile fasciculi ascend through the brain stem to the thalamus as a band of white matter called the medial lemniscus.

V. THE CEREBELLUM
   A. The cerebellum occupies the inferior and posterior aspects of the cranial cavity and consists of two hemispheres and a central, constricted vermis.
   B. It is attached to the brain stem by three pairs of cerebellar peduncles - inferior attach to medulla, middle to the pons, and superior to the midbrain.
   C. The cerebellum functions in the coordination of skeletal muscle contractions and in the maintenance of normal muscle tone, posture, and balance. Refer to our discussion of cerebellar functions in your lecture notes.

VI. THE DIENCEPHALON
   A. Thalamus
      1. The thalamus is located superior to the midbrain and contains nuclei that serve as relay stations for all sensory impulses, except smell, to the cerebral cortex. There are seven major groups of thalamic nuclei on each side.
      2. It also registers conscious recognition of pain and temperature and some awareness of light touch and pressure.
      3. It plays an essential role in awareness and the acquisition of knowledge, which is termed cognition.
   B. Hypothalamus
      1. The hypothalamus is found inferior to the thalamus, controls many body activities, and is one of the major regulators of homeostasis.
      2. The hypothalamus has a great number of functions.
         a. Controls the autonomic nervous system.
         b. Produces hormones.
c. It functions in regulation of emotional and behavioral patterns.
d. It regulates eating and drinking through the feeding center, satiety center, and thirst center.
e. It aids in controlling body temperature.
f. It regulates circadian rhythms and states of consciousness.

C. Epithalamus

1. The epithalamus lies superior and posterior to the thalamus and contains the pineal gland and the habenular nuclei.
2. The pineal gland secretes melatonin to influence diurnal cycles in conjunction with the hypothalamus.
3. The habenular nuclei are involved in olfaction, especially emotional responses to odors.

D. Circumventricular Organs

1. These parts of the diencephalon lie in the wall of the third ventricle and monitor chemical changes in the blood because they lack a blood-brain barrier.
2. They coordinate homeostatic activities of the endocrine and nervous systems and include part of the hypothalamus, pineal gland, pituitary and other nearby structures.

VII. THE CEREBRUM

A. The cerebrum is the largest part of the brain.

1. The surface layer, the cerebral cortex, is 2-4 mm thick and is composed of gray matter. The cortex contains billions of neurons.
2. The cortex contains gyri (convolutions), deep grooves called fissures, and shallower sulci.
3. Deep to the cortex lies the cerebral white matter, tracts that connect parts of the brain with itself and other parts of the nervous system.
B. The cerebrum is nearly separated into right and left halves, called hemispheres, by the longitudinal fissure. Internally it remains connected by the corpus callosum, a bundle of transverse white fibers.

C. Lobes

1. Each cerebral hemisphere is further subdivided into four lobes by sulci or fissures.
2. The cerebral lobes are named the frontal, parietal, temporal, and occipital.
3. A fifth part of the cerebrum, the insula, lies deep to the parietal, frontal, and temporal lobes and cannot be seen in an external view of the brain.

D. White Matter

1. The white matter is deep to the cortex and consists of myelinated axons running in three principal directions.
2. Association fibers connect and transmit nerve impulses between gyri in the same hemisphere.
3. Commissural fibers connect gyri in one cerebral hemisphere to the corresponding gyri in the opposite hemisphere.
4. Projection fibers form ascending and descending tracts that transmit impulses from the cerebrum to other parts of the brain and spinal cord.

E. Basal Ganglia

1. The basal ganglia are paired masses of gray matter in each cerebral hemisphere.
2. They are responsible for helping to control subconscious muscular movements, regulating muscle tone, and helping regulate the initiation and termination of movements.

F. Limbic System

1. The limbic system is found in the cerebral hemispheres and diencephalon.
2. It functions in emotional aspects of behavior and memory, and is associated with pleasure and pain. It is also involved in olfaction which explains why memories are easily triggered by smells associated with the original stimulus.

VIII. CEREBRAL CORTEX AREAS AND FUNCTIONS

A. Specific types of sensory, motor, and integrative signals are processed in certain cerebral regions.

1. Sensory Areas
   a. The sensory areas of the cerebral cortex are concerned with the reception and interpretation of sensory impulses. The size of the cortical area receiving impulses from a particular part of the body corresponds to the number of receptors present there.
   b. Some important sensory areas include the primary somatosensory area, primary visual area, primary auditory area, and primary gustatory area and primary olfactory area. You should refer to your lecture notes for our discussion of the functions of these areas.

2. Motor Areas
   a. The motor areas are the regions that govern muscular movement.
   b. Important motor areas are the primary motor area and Broca’s speech area. You should refer to your lecture notes for our discussions of the functions of these areas.

3. Association Areas
   a. The association areas are concerned with complex integrative functions such as memory, emotions, reasoning, will, judgment, personality traits, and intelligence.
   b. Association areas include the somatosensory association area, visceral association area, auditory association area, Wernicke’s (posterior language)
area, common integrative area, premotor area, frontal eye field area, and language areas. You should refer to your lecture notes for our discussion of the functions of these areas.

B. Hemispheric Lateralization

1. The two hemispheres of the cerebrum are not bilaterally symmetrical, either anatomically or functionally, with the functional asymmetry called **hemispheric lateralization**.

2. The left hemisphere is more important for right-handed control, spoken and written language, and numerical and scientific skills.

3. The right hemisphere is more important for left-handed control, musical and artistic awareness, space and pattern perception, insight, imagination, and generating mental images of sight, sound, touch, taste, and smell.

C. Brain Waves

1. Electrical potentials generated by brain cells are called **brain waves**.

2. Brain waves generated by the cerebral cortex are recorded as an **electroencephalogram (EEG)**.

3. An EEG may be used to diagnose epilepsy and other seizure disorders, infectious diseases, tumors, trauma, hematomas, metabolic abnormalities, degenerative diseases, and periods of unconsciousness and confusion; it may also provide useful information regarding sleep and wakefulness.

4. An EEG may also be one criterion in confirming brain death (complete absence of brain waves in two EEGs taken 24 hours apart).

IX. CRANIAL NERVES

A. Twelve pairs of **cranial nerves** originate from the brain.

B. The pairs are named primarily on the basis of distribution and numbered by order of attachment to the brain.
C. Some cranial nerves (I, II, VIII) contain only sensory fibers and are called *sensory nerves.* Others contain only motor fibers (III, IV, VI, XI, and XII) and are called *motor nerves.* All the rest contain both sensory and motor fibers and are called *mixed nerves.*

**You should know the name, number, and function of all cranial nerves and whether the nerve is a sensory, motor or mixed nerve.**