

- I. Central Nervous System: The brain
 - A. The **forebrain** is composed of the 2 cerebral hemispheres (**cerebrum**) and the **diencephalon** (thalamus, hypothalamus and the pineal gland).
 - 1. **Cerebrum**
 - a. The largest part of the brain consisting of right and left hemispheres separated by the **longitudinal fissure**.
 - b. The outermost layer of the cerebral hemispheres (2mm thick) is known as the **cortex**.
 - i. Composed of gray matter, cell bodies of neurons (75% of all cell bodies in the nervous system are found in the cortex).
 - c. **Fissures** are deep grooves in the cerebrum (**longitudinal fissure** and **transverse fissure**).
 - d. **Sulci** are shallow grooves (**lateral sulcus, central sulcus, parietal-occipital sulcus**).
 - e. **Gyri** are the folds on either side of a sulcus or a fissure (**precentral gyrus** and **postcentral gyrus**).
 - f. **Lobes** are the major sections of the hemispheres delineated by the sulci and fissures (frontal, parietal, occipital, temporal).
 - g. Functional areas of the cortex
 - i. **The prefrontal area** (frontal lobe)
 - (a) The site of higher intellectual processes (reasoning, deliberation, worry, concentration, planning, problem solving, knowledge of consequences of behavior).
 - (b) Damage to this area (lobotomy) results in personality reversals and a lack of caring.
 - ii. **Primary motor area** (located on the precentral gyrus of frontal lobe)
 - (a) Controls voluntary contractions of specific muscles on the opposite side of the body.
 - (b) Muscles spatially represented on the gyrus.
 - (c) Damage can result in muscle weakness or paralysis.
 - iii. **Premotor area** (frontal lobe)
 - (a) Controls learned motor skills of a repetitious nature (walking, riding a bike, and playing the piano).
 - (b) Primarily coordinates the movements by sending activating impulses to the primary motor area.
 - iv. **Frontal eye field** (frontal lobe)
 - (a) Controls voluntary movement of the eyes.
 - v. **Broca's area** (frontal lobe)
 - (a) Usually most highly developed on the left hemisphere of the brain.
 - (b) Programs muscles involved in communication such as those used for speech, writing and signing.
 - (c) Coordinates the movements by sending activating impulses to the primary motor area.
 - (d) Damage to this area results in **nonfluent aphasia**, an inability to properly form words.
 - vi. **Primary auditory cortex** (temporal lobe)

- (a) Where impulses generated in the ear for hearing terminate.
- vii. **Auditory association area** (temporal lobe)
 - (a) Interprets the sound to determine if it is speech, music or a noise.
- viii. **Wernicke's area** (temporal lobe)
 - (a) Surrounds and encompasses part of the auditory association area.
 - (b) Responsible for comprehension of the written and spoken word.
 - (c) Involved in sounding out unfamiliar words.
 - (d) Damage to this area results in **fluent aphasia**, when words are easily spoken but not in any meaningful order. There is also faulty understanding of the written or spoken word.
- ix. **Olfactory cortex** (temporal lobe)
 - (a) Where impulses originating in the nose representing smell terminate.
- x. **Primary somatosensory cortex** (postcentral gyrus of parietal lobe)
 - (a) Receives impulses representing the general senses (hot, cold, touch, pressure) from the skin, joints and internal organs.
 - (b) The body is spatially represented on the gyrus in order to determine specifically where the sensation originated.
- xi. **Primary gustatory cortex** (parietal lobe)
 - (a) On the base of the postcentral gyrus.
 - (b) Receives impulses for taste.
- xii. **Primary visual cortex** (occipital lobe)
 - (a) Impulses from the retina of the eye terminate here and a visual image is created.
 - (b) Damage to this area results in blindness.
- xiii. **Visual association area** (occipital lobe)
 - (a) Interprets the visual stimuli relating it to past visual experiences in order to recognize what we are seeing.
 - (b) Damage to this area results in an inability to comprehend what is being looked at.
- xiv. **Common integrative area (Gnostic area)**
 - (a) Receives input from each of the sensory association areas.
 - (b) Integrates the sensory data from all the regions to generate a single "sensory thought".
 - (c) Sends the "thought" to the prefrontal area where decisions are made.
- h. The **medulla** is the inner portion of the cerebral hemispheres that is composed of white matter, myelinated and unmyelinated axons.
 - i. **Commissural fibers**
 - (a) Axons that carry information between the two hemispheres.
 - (b) Form the **Corpus Callosum**.
 - ii. **Association fibers**
 - (a) Axons that connect areas within a hemisphere.
 - iii. **Projection fibers**
 - (a) Axons that carry motor information away from the brain down the spinal cord, and sensory information up the spinal cord towards the brain.
- i. The **basal ganglia** are 3 masses of gray matter (cell bodies) imbedded within the cerebral medulla.

- i. Functions in initiating and terminating movements.
 - ii. Monitors and inhibits unwanted motor activities.
 - iii. A loss of dopamine to this area results in the development of **Parkinson's Disease**.
 - (a) Characterized by tremors at rest, shuffling gait, lack of facial expression and difficulty initiating and executing movements.
 - j. The ventricles of the brain (introduced here to act as landmarks for structures of the diencephalon).
 - i. Cavities within the brain filled with **cerebrospinal fluid**.
 - ii. There are 4 total ventricles
 - (a) There are 2 **lateral ventricles** within the cerebral hemispheres.
 - (b) The fluid drains from the 2 lateral ventricles through the **interventricular foramen** to the **3rd ventricle**, in the center of the diencephalon.
 - (c) The fluid drains from the 3rd ventricle through the **cerebral aqueduct** to the **4th ventricle** in the brain stem.
 - (d) The 4th ventricle is continuous with the **central canal** of the spinal cord and with the **subarachnoid space** (to be covered later with meninges).
2. Diencephalon (thalamus, hypothalamus and pineal gland)
- a. **Thalamus**
 - i. Consists of 2 oval masses of gray matter joined by a bridge that crosses the 3rd ventricle (looks like a yo-yo).
 - ii. A relay station to the cortex for sensory impulses and motor commands.
 - iii. Also plays a role in awareness.
 - b. **Hypothalamus**
 - i. Lies below the thalamus and forms the floor of the 3rd ventricle.
 - ii. Is a major regulator of **homeostasis**.
 - iii. Controls and integrates the activity of the Autonomic Nervous System (controls smooth and cardiac muscle and the activity of glands).
 - iv. Controls the release of hormones from the pituitary gland.
 - v. Contains **neurosecretory cells**.
 - (a) Neurons that synthesize 2 neurohormones which are transported to the axon terminals where they are released into the blood.
 - vi. Associated with feelings of rage and aggression and triggers sexual responses to the opposite sex.
 - vii. Regulates food and water intake by monitoring blood sugar and hydration levels.
 - viii. Controls body temperature.
 - viii. Regulates circadian rhythms (sleep-wake cycles).
 - c. **Pineal gland**
 - i. Posterior to the thalamus.
 - ii. Secretes the hormone **melatonin**, targeting the sleep center of the hypothalamus inducing sleepiness.
 - iii. The amount of melatonin rises at night and falls during the day.
 - iv. **Seasonal Affective Disorder (SAD)** occurs when there is a delayed drop in melatonin levels during the day resulting in depression.

- B. The midbrain is a portion of the brain stem consisting of the cerebral peduncles and the corpora quadrigemina.
1. **Cerebral peduncles**
 - a. On the ventral surface of the midbrain.
 - b. The main motor and sensory connection between the forebrain and the hindbrain (cerebellum, pons and medulla oblongata).
 2. **Corpora quadrigemina**
 - a. On the dorsal surface of the midbrain.
 - b. Includes 2 **superior colliculi** for visual reflexes.
 - i. Help to move the eyes when tracking a moving object.
 - ii. Change the pupil and lens to changing conditions.
 - c. Includes 2 **inferior colliculi** for hearing reflexes.
 - i. Important for the startle reflex. Causes you to move your head and neck when you hear a loud noise in order to hear clearly.
- C. The hindbrain is also a portion of the brain stem consisting of the pons, cerebellum and medulla onblongata.
1. **Pons**
 - a. Anterior to the 4th ventricle.
 - b. Contains axons to connect the 2 portions of the cerebellum.
 - c. Also contains axons to carry ascending sensory information and descending motor information.
 - d. Contains nuclei that assist in controlling breathing.
 2. **Cerebellum**
 - a. Located below the occipital lobe.
 - b. Consists of 2 cerebral hemispheres.
 - c. Constantly receives sensory information from the eyes, the **vestibular apparatus** in the ears (regarding balance), and the **proprioceptors** in muscles and joints to indicate joint movement.
 - d. Uses this information to smooth out and coordinate sequences of skeletal muscle contractions. Ensures that the right muscles contract the right amount at the right time.
 3. **Medulla Oblongata**
 - a. Forms the inferior portion of the brain stem.
 - b. Contains nuclei to control reflex activity for cardiac and smooth muscle.
 - i. The **cardiac center** controls the heart rate.
 - ii. The **vasomotor center** controls the diameter of blood vessels.
 - iii. The **medullary rhythmicity center** controls the rate of breathing.
 - iv. Also contains reflex centers for swallowing, vomiting, coughing and sneezing.
 - c. Contains axons for ascending sensory and descending motor pathways connecting the brain with the spinal cord.
- D. Brain Systems
1. The reticular formation
 - a. Distributed throughout the pons, midbrain and medulla oblongata.
 - b. Consists of 3 columns of loosely organized neurons that have both an ascending (sensory) function and a descending (motor) function.

- c. The ascending portion forms the **Reticular Activating System (RAS)** which functions in maintaining the brain in an alert state.
 - d. Impulses from all sensory pathways synapse in the RAS stimulating it to send a continuous stream of impulses to the cortex, maintaining the cortex in an alert and conscious state.
 - e. The RAS also acts as a filter for weak, common and repetitive stimuli (**Note:** about 99% of all sensations are considered to be unimportant and are ignored by the brain).
 - f. RAS is inhibited by the sleep center in the hypothalamus to allow the person to achieve a state of partial unconsciousness.
2. Limbic System
- a. Consists of regions of the cerebrum and diencephalon.
 - b. Plays a role in forming emotions such as pain, pleasure, affection, anger and rage.
 - c. Plays an important role in establishing memory.
 - d. **Alzheimer's disease** impacts areas of the cortex and the limbic system (hippocampus [involved in short-term memory]; nucleus basalis).
 - i. Characterized by a loss of language skills, memory loss of recent events and personality changes.
 - ii. There is an accelerated loss of neurons.
 - iii. Causes?
 - (a) Accumulation of toxic chemicals, or trauma.
 - (b) Formation of **beta-amyloid plaques** (incorrectly cut protein) around neurons.
 - (c) **Neurofibrillary tangles** within the nerve cells.

II. The cranial meninges

- A. 3 connective tissue wrappings that surround the brain (these same layers continue to wrap the spinal cord).
1. **Dura mater** (tough mother)
 - a. Outermost layer of the meninges.
 - b. Composed of dense irregular connective tissue.
 2. **Arachnoid mater**
 - a. The middle layer of the meninges.
 - b. Secretes fluid into the **subdural space** (the space between the dura mater and the arachnoid mater).
 - c. The **subarachnoid space** is the space below the arachnoid mater that is filled with cerebrospinal fluid.
 - d. Produces extensions known as **arachnoid granulations (villi)** to drain the cerebrospinal fluid from the subarachnoid space into dural sinuses to return to the venous blood supply.
 3. **Pia mater**
 - a. The innermost layer of the meninges that adheres to the surface of the brain.
 - b. Contains numerous blood vessels.
 - c. Forms the **choroid plexuses**.
 4. **Meningitis**
 - a. Inflammation of the meninges usually caused by a microbial infection.
- B. Cerebrospinal fluid

1. Produced by the **choroid plexuses** (networks of capillaries covered with ependymal cells) within the ventricles at a rate of 150 mL every 3-4 hours.
2. The ependymal cells form the cerebrospinal fluid by filtration and secretion of the blood.
3. Functions
 - a. Protection
 - b. Produces a chemically stable environment for the brain.
 - c. Supplies nutrients
4. **Hydrocephalus**
 - a. Occurs when there is blocked flow of cerebrospinal fluid out of the ventricles and the fluid builds up causing an increase in pressure.
 - b. If fluid is not drained the buildup can compress the brain against the inner surface of the skull.