**Brain – Clinical Applications**

**Dr. Gary Mumaugh – Campbellsville University**

**Brain Functions**

* Sensory Information
* Motor System
* Behavioral State
* Sleep
* Motivation
* Moods
* Learning and Memory
* Language
* Personality

**Sensory Information**

* Integration of spinal reflexes
* Primary somatic sensory cortex
  + Termination point of pathways from skin, musculoskeletal system, and viscera
  + Somatosensory pathways
    - Touch
    - Temperature
    - Pain
    - Itch

**Sensory Information**

* Body position
* Special senses have devoted regions
  + Visual cortex
  + Auditory cortex
  + Olfactory cortex
  + Gustatory cortex
* Neural pathways extend from sensory areas to association areas, which integrate stimuli into perception

**Motor System**

* Three major types
  + Skeletal muscle movement
    - Somatic motor division
  + Neuroendocrine signals
    - Hypothalamus and adrenal medulla
  + Visceral responses
    - Autonomic division
* Voluntary movement
  + Primary motor cortex
  + Motor association areas
* Neuroendocrine and visceral responses are coordinated in the hypothalamus and medulla.

**Behavioral State**

* Modulator of sensory and cognitive processes
* Neurons collectively known as diffuse modulatory systems
  + Originate in reticular formation in brain stem
  + Project axons to large areas of the brain
* Reticular activating system controls consciousness

**Motivation**

* Defined as internal signals that shape voluntary behaviors
* Some states known as drives
* Work with autonomic and endocrine responses
* Motivated behaviors stop when a person has reached a certain level of satiety
* Pleasure and addictive behaviors: link to dopamine

**Moods**

* Similar to emotions but longer-lasting
* Mood disorders
  + Fourth leading cause of illness worldwide today
  + Depression
    - Sleep and appetite disturbances
    - Alterations of mood and libido
    - May affect function at school or work or in personal relationships
    - Antidepressant drugs alter synaptic transmission

**Learning and Memory**

* Learning has two broad types
* Associative learning
* Non-associative learning
  + Habituation and sensitization
  + Associative & Non-associative Learning
* Memory has several types
  + Short-term and long-term
    - Working memory and consolidation
  + Reflexive and declarative
    - Stored in memory traces
  + Anterograde amnesia is inability to remember new information
    - (Retrograde is past)
  + Memory loss in the elderly can be caused by dementia and Alzheimer’s disease

**Language**

* Integration of spoken language involves two regions
  + Damage to Wernicke’s area causes receptive aphasia
    - Difficulty understanding written or spoken language
  + Damage to Broca’s area causes expressive aphasia
    - Inability to produce language (written, manual, spoken)

**Personality**

* Combination of experience and inheritance
* Schizophrenia
  + Both genetic and environmental basis

**Brain Stem**

* Cerebellum
  + Movement coordination
  + Equilibrium and balance
* Diencephalon
  + Thalamus: relay station and integration of sensory input
  + Hypothalamus: control of homeostasis, hunger, thirst, endocrine function
  + Pituitary – Pineal gland

**The Medulla Oblongata**

* Location – superior continuation of the cord
* Major clinical note: The medulla is the region of the brain that is least affected by general anesthesia
* Functions
  + Relay station and conduction pathway between the spinal cord and higher levels of the brain for ascending and descending fiber tracts.

**Visceral Reflex Centers of Medulla**

* Cardiovascular Reflex Center
  + Regulates blood pressure
* Respiratory Reflex Center
  + Regulates O2, CO2, pH levels
* Associated centers that act to modulate breathing patterns
  + Coughing reflex center (forced exhalation)
  + Sneezing reflex center (forced exhalation)
  + Swallowing (deglutition) reflex center
  + Vomiting reflex center (Note: breathing stops in swallowing and vomiting)
* Vestibular reflex center (balance reflexes)
  + Reflexes maintain optimal orientation of the head and body and tracking of the eyes (when spinning or rotating)
  + Sensory inputs
    - Visual information of the eyes
    - Special information from proprioceptors and the vestibular apparatus
  + Principle Influences (outputs)
    - Body posture (via extrapyramidal tracts)
    - Movements of the eyes (via vestibuloocular tracts)
    - Vomiting reflex center
    - Higher brain centers (including cerebellum and cerebral cortex)

**Clinical Considerations of Medulla Oblongata**

* Vertigo
  + Loss of optimal orientation
  + Sensation of “spinning”
* Motion sickness
* Nystagmus
  + Rhythmic to-and–fro movements of the eyes
  + The eyes drift in the direction of spinning with rapid return in the opposite direction.

**The Midbrain**

* A relay center for the extrapyramidal tracts
  + Visceral Reflex Center
  + Salivation reflex center
  + Tearing reflex center
  + Oculomotor reflex center
    - Regulates pupil size
    - Controls reflex movement and accommodation of the eyeballs for focusing near and far

**The Thalamus**

* The waking center
* In the cerebral hemispheres, on each side of the 3rd ventricles
* Functions
  + All sensory information (except olfaction) is processed through the thalamus
  + The thalamus acts as a “sensory filter” that screens relevant information, then relays the information to higher brain centers
  + The amount of information relayed to the cerebral cortex affects one’s level of consciousness (alertness) – Called RAS reticular activating center

**Levels of Alertness**

* The person’s emotional state affects his level of alertness (via limbic system)
* Clinical considerations
* Action of CNS stimulants
  + Exerts neural activity
  + Epinephrine, caffeine, amphetamines –Actions of hallucinogens
  + Exerts extreme stimulation
  + LSD, psilocybin (mushrooms)
* Actions of CNS depressants
  + Inhibits neural activity
  + Alcohol, sedatives
* Lesions in the thalamus
  + Injury stops transmission of signals from thalamus to the cerebral cortex >>>>>>>>> COMA

**Cerebrum**

* Is the Site of Higher Brain Functions
* Corpus callosum connects the two hemispheres
* Gray matter
  + Cerebral cortex
  + Basal ganglia: control of movement
  + Limbic system: link between cognitive functions and emotions
    - Amygdala: emotion and memory
    - Hippocampus: learning and memory

**The Cerebral Cortex**

* Functionally divided into three specializations
  + Sensory areas
    - Sensory input translated into perception (awareness)
  + Motor areas
    - Direct skeletal muscle movement
  + Association areas
    - Integrate information from sensory and motor areas
    - Can direct voluntary behaviors
* Cerebral lateralization 34

**Diagram

Description automatically generated**

**The Cerebral Cortex**

* Consists of right and left hemispheres, joined together by 300 million myelinated commissural fibers (Corpus Callosum)
* Cerebral hemispheres show hemisphere specialization
  + The dominant hemisphere (left side of 90% of population) controls:
    - Voluntary movement using the dominant hand (right) and side of the body (primary motor area)
* Sensory discrimination on the dominant (right) side of the body (primary sensory area)

**Diagram

Description automatically generated**

**Dominant Hemisphere of Cerebral Cortex**

* Stereogenesis using the dominant (right) –Mental construct through touch –Recognizing an object by feeling
  + Understanding of written and oral language
  + Wernicke’s Area is located only in the dominant hemisphere
* Performance of Speech
  + Aphasia – inability to speak because of damage to Brocca’s Speech Center
  + Only in the dominant hemisphere
* Mathematical computations and analytic logic – only in dominant
* Learned reflexes and behaviors
  + Driving a car, doing a task, performing a procedure
  + Only in dominant hemisphere

**Subordinate Hemisphere of Cerebral Cortex**

* The subordinate hemisphere (right side of 90% of population) controls:
  + Voluntary movement using the weaker hand and weaker side of the body
  + Sensory discrimination on the weaker (left) side of the body
  + Stereogenesis using the weaker (left) hand
  + Spatial relations and tasks
  + Drawing figures, etc.
  + Musical abilities
  + Sense of body posture and balance
  + Example – dancer, surgeon, dentist
  + “Artistic” or intuitive thinking

**Other Cerebral Functions**

* Not localized
* Involves activity throughout cerebrum
* Consciousness
  + Awareness of the environment (wakefulness)
  + Sensations (perceptions)
  + Self awareness or self cognitions
  + Sensations (perceptions)
  + Self awareness or self cognitions
    - “aware that you are aware”
    - “cognition”
  + Social behaviors
  + Moral and ethical values

**Pathologies and Disorders of the Cerebral Cortex**

* Viral encephalitis
  + Clinical manifestations depend on which area of the brain has been damaged
* Cerebral palsy
  + Usually damage to a motor area due to cerebral ischemia
* Dyslexia
  + **Text

    Description automatically generated**Inability to properly read or write words
  + Mistakes “b” for “d” when reading
  + Writes “was when wanted to write “saw”
  + Occurs in up to 15% of schoolchildren
  + 6 times more common in males
  + Hypothesis is a lack of cerebral dominance for understanding language
* Cretinism
  + Retarded brain and body development
  + Caused by a deficiency of thyroxin from birth

**Cerebral Vascular Accident**

* CVA – Etiology
  + Cerebral thrombus
  + Cerebral hemorrhage
    - **![Diagram

      Description automatically generated]()**Decreased cerebral blood flow >>>>> cerebral ischemia (lack of O2) >>>>> cerebral infarction(death of brain cells)

**CVA**

* Clinical symptoms may include aphasia, limb paralysis or death
* Neuroplasticity of the cerebral cortex
  + Capacity of the brain to learn new tasks and compensate for the loss of damaged brain areas
* Two pairs of arteries carrying O2 to the brain
  + Right and left internal carotid arteries
  + Right and left vertebral arteries

**The Cerebellum (“little brain”**

* Located on the dorsal surface of the brainstem
* Functions
  + Unconsciously maintains body posture and balance
  + Unconsciously coordinates voluntary motor activity
  + Unconsciously modulates “set point” of muscle spindles to maintain some degree of muscle tonus (partial contraction)
* Inputs and Outputs
  + The cerebellum receives kinesthetic and proprioceptive information.
  + It evaluates it and subconsciously activates skeletal muscles to maintain posture and balance and coordinate skeletal muscular movements.
* Clinical symptoms associated with cerebellar lesions (injuries)
  + Cerebellar ataxia – loss of coordination
  + Dysarthria – hesitating and slurred speech
  + Hypotonia – (muscle flaccidity) decreased muscle resistance to stretch “limp”
  + Decomposition of voluntary movements

**Basal Nuclei**

* Located very deep within the white matter of each cerebral hemisphere
* Exerts primarily an inhibitory influence on the somatic motor neurons (via extrapyramidal tracts)
* Functions
  + Generation of mannerisms
  + Stretching, tics and twitches
* Clinical symptoms associated with basal ganglia lesion (injuries)
* Resting muscle tremors
* Hypertonia (muscle rigidity)
* Increased muscle resistance to stretch
* Delay in initiating movement
  + - Example – Parkinson’s Disease (“paralysis agitans”)
    - 1st discovered in 1817 by Dr. James Parkinson
    - Associated with decreased dopamine in the basal ganglia
    - Treatment: L-Dopa >>>> increases dopamine level in brain

**The Limbic System**

* Consists of a complex network of neurons in many associated areas of the brain including:
* Olfactory bulbs
  + Parts of the cerebral cortex
  + Parts of the thalamus
  + Parts of the hypothalamus
  + Amygdeloid nucleus or amygdala
* Functions
  + Generations of emotions
    - Happiness, joy, and euphoria
    - Anger and rage
    - Anxiety, fear, and terror
    - Sadness and depression
  + Emotional state can affect the general level of alertness (via thalamus RAS)

**Anxiety, Fear, Excitement, Anger**

* Anxiety, Fear, Excitement, Anger >>>>>>>> increased level of alertness
* Depression, sadness >>>>>>>>>>> decreased level of alertness (sedation)
* Motivation (Motivation causes passion)
* Short term memory and learning
  + Motivation and passion are needed for learning
* Sense of smell
  + Odors (like perfumes and aftershave) affect
* Sensitivity to pain (pain is an emotion)
* Sexual behavior

**Limbic System – Clinical Considerations**

* Rabies – viral infection that damages the limbic system
* Schizophrenia
  + Antisocial
  + Increased dopamine
  + Familial (genetic)

**The Medulla Oblongata**

* Bipolar Mania and Depression
* Mania (“Hyper”; Impulsive)
  + A form of aggression
  + Increased levels of norepinephrine and serotonin
  + Rx – lithium
* Depression (“sad”; reclusive)
  + Increased catecholamine levels in the brain
  + Decreased norepinephrine and increased serotonin
  + Rx – use anti-depressants and ECS

**The Hypothalamus**

* Located just below the thalamus and the third ventricle
* Linked to the pituitary gland by
  + Nerve fiber tracts
  + Profuse network of capillaries – (hypothalamic-pituitary portal system)
* Functions
  + Visceral reflex centers
    - Thermoregulatory reflex center
    - Appetite / satiety reflex center
    - Osmoregulatory reflex center
  + Modulates activities of lower visceral reflex centers
    - Cardiovascular reflex center (blood pressure) - in medulla
    - Swelling and vomiting reflex center
    - Micturation reflex center - in spinal cord
    - Defecation reflex center - in spinal cord
* Adjusts the activity of the various visceral organs to match the physical activity and energy requirements of the person
  + –Via descending autonomic fiber tract and the autonomic motor neurons
* Secretes two hormones
  + ADH – vasopressin
  + Oxytocin
* Secretes releasing hormones that affect the anterior lobe of the pituitary
  + These releasing hormones are carried by the anterior pituitary gland via the hypothalamic-pituitary portal veins
  + Different releasing hormones stimulate the release of the anterior pituitary hormones.
    - CRH – Corticotropin Releasing Hormone
    - TRH – Thyrotropin Releasing Hormone
    - GnRH – Gonadotropin Releasing Hormone
    - Growth Hormone Releasing Hormone
    - Growth Hormone Inhibitory Hormone
    - Prolactin Releasing Hormone
    - Prolactin Inhibitory Hormone

**CNS Tumors – Pituitary Gland**

* Pituitary adenoma – 2 types
  + “Secreting type” (less common) - secretes excess hormones
  + “Null cell”- goes undetected until there is damage
    - Symptoms: “tunnel vision,” cranial nerve compression, hypopituitarism (if blood supply compressed)
    - Treatment - surgery or radiation