

TOPIC 12: CENTRAL NERVOUS SYSTEM / LEARNING AND MEMORY (Dr. Magnusson)

A) Spinal cord

1) Gray matter

- Sensory neurons - dorsal horn

- Autonomic motor neurons - intermediate gray

- Somatic motor neurons - ventral horn

2) White matter - axons

- Tracts for sensory and motor information

B) Brain

1) Brain Stem

- Cranial nerves III-XII

- Cardiovascular and Respiratory control

- Digestive control

- Analgesia

- Visual and auditory reflexes

- Reticular formation - arousal and sleep,

2) Cerebellum - "little brain"

- Modulates voluntary muscle activity - rate, range and force of movement

- Motor learning

3) Diencephalon

a) Thalamus

- Relay processing center for all sensory info but smell

b) Hypothalamus

i) Regulates

-body temperature

-thirst

-hunger

-reproduction

ii) Controls

-endocrine system

-autonomic nervous system

-behavior

4) Telencephalon

a) Cerebral cortex

-Sensory areas - direct perception

-Motor areas - direct movement

-Association cortex

Thinking and planning

Personality

Memory storage

b) Limbic system

-a collection of CNS structures the link higher cognitive function with primitive emotional responses

-Mediate emotions, motivation, drives

-Hippocampus - also important in learning / memory

-Amygdala - fear

-Basal forebrain nuclei - reward systems

c) Basal ganglia

-Involved in modulating movement

-Defects lead to movement disorders: Parkinson's, Huntington's

C) Support of the neurons in CNS: glial cells

1) Support CNS neurons physically and metabolically

2) Astrocytes

-Act as glue and scaffold for neurons

-Repair of injury (glial scars)

-Remove transmitters and ions to maintain environment

3) Oligodendrocytes

-Provide myelin sheath for axons

4) Ependymal cells

-Line internal cavities of CNS

-Produce cerebrospinal fluid (CSF)

5) Microglia

-Immune defense of CNS

D) Protection / Nourishment of the CNS

- 1) CNS covered by bone
- 2) CNS “floats” in cerebrospinal fluid (CSF)
- 3) Blood Brain Barrier

- Capillaries have tight junctions

- Shield brain from fluctuations in hormones, ions, neurotransmitters

- Lipid soluble molecules can pass through (O₂, CO₂, alcohol, steroid hormones)

- Other molecules have to have carrier proteins

- Brain requires glucose as fuel (can't use fatty acids)

E) CNS function: Learning and Memory

- 1) Terminology
 - a) Learning
 - b) Memory
 - c) Declarative memory – memory for facts and events
 - d) Reflexive memory – tend to be unconscious

- Procedural – skills and habits memory

- Learned fear – amygdala

- Classical conditioning

- 2) Long-term potentiation - potential cellular mechanism of memory
 - a) Presynaptic neuron releases glutamate (excitatory neurotransmitter)
 - b) Postsynaptic neuron has 2 kinds of receptors for glutamate
 - First is a Na^+ channel-associated receptor (AMPA receptor) and binding of glutamate to receptor causes an EPSP
 - Second receptor (NMDA receptor) is a Ca^{++} channel and opens only when glutamate binds AND the membrane is depolarized
 - c) Some synaptic activity only opens the AMPA receptor
 - d) Prolonged synaptic activity or strong inputs from two sources at the same time depolarizes membrane enough to open NMDA receptor
 - e) Influx of Ca^{++} triggers several second messenger systems: enzymes become active and characteristics of the AMPA receptors change (more likely to open)
 - f) A retrograde messenger (nitric oxide; NO) is made and can diffuse back to the presynaptic terminal to cause changes there (more transmitter released with each action potential)
 - g) Outcome of all this is that signals from presynaptic to post-synaptic neuron become stronger with repeated use
 - h) Long long-term potentiation
 - i) Changes in gene expression / protein synthesis are involved
 - ii) Lead to changes in neuron
 - Increase or decrease in neurotransmitter synthesis
 - Permanent changes in number or type of neurotransmitter receptors
 - New synapses