CHAPTER 13&14: The Central Nervous System

Anatomy of the CNS

- in human consists of brain and spinal cord
- as stated earlier neurons have little support from their extracellular matrix and depend on glial cells etc. for support
- there are other larger anatomical features that also assist in supporting the CNS
- bony casing, connective tissue (3 layers), fluid between these layered membranes

- skull and vertebral column provide bony support
- between bone and nervous tissue are three connective tissue layers called the meninges
- these stabilize and protect
- from outer layer inward have: dura matter, arachnoid membrane, pia matter

Cerebrospinal fluid and the ventricular system

- CSF is a salty solution continuously secreted into hollow cavities in the brain called ventricles
- there are 4 ventricles: 2 lateral and two descending
- together with blood the CSF makes up 0.4 L of the 1.4 L total volume of the human brain
- CSF is secreted by the choroid plexus which is a secretory membrane lining the ventricles
- similar to the kidney in structure
- CSF flows from ventricles to the space between the pia matter and arachnoid membrane
- this provides a protective fluid layer (explain) (brain floats)
- entire volume of CSF replenished 3 to 4 times per day so secretion is rapid
- serves two functions: chemical and physical protection
- not only is a pad for brain against blows but also provided buoyancy to allow free flow of blood
- provides closely regulated chemical environment for brain
- few proteins in CSF so if find high protein content then indicates infection
- sample via spinal tap or lumbar puncture

Blood-Brain Barrier

- protection from harmful substances
- accomplished via the continuous capillaries present in CNS
- much needed nutrients that cannot easily diffuse across the membrane such as glucose etc. must be transported across and the capillaries are adapted to do this
- lipid soluble substances can still get across
- many poisons are dangerous because of this
• DDT
• PCB

Neurons of the CNS

• neurons of the CNS are called interneurons that do not extend outside the CNS
• sensory and efferent neurons connect to these interneurons to transfer signals
• classify as gray matter (unmyelinated)
• or white matter (myelinated)
• cell bodies of gray matter cluster into groups in brain and spinal cord called nuclei
• white matter has fewer cell bodies but bundles of axons connecting different regions of the CNS
• these bundles are called tracts
• descending carry away from brain
• ascending carry toward brain
• propriospinal tracts found only in spinal cord

Spinal Cord

• conduction pathway from peripheral NS and brain
• also has internal function of coordination of locomotion as well as coordination of simple reflex activities without the info having to go to the brain
• if severed then paralysis below that point
• divided into 4 regions that correspond to adjacent verts.
• use to describe the cross sectional view and the function of each area

The Brain

• ~1400 g
• contains ~ $10^{12}$ neurons each having as many as 200000 synapses
• very complex yet well organized
• different regions have different functions so compartmentalized
• also has backup mechanisms where if one region has problems another can pick up or adapt to handle its load
• single function carried out in more than just one region
• contains both neuron cell bodies and nerve fibers in bundles
• divided into brain stem, cerebellum and cerebrum
• cerebrum is largest and most obvious in human

Brain Stem

• extension of spinal cord
• 3 sections: medulla oblongata, the pons, and midbrain (mesencephalon)
• 4\textsuperscript{th} ventricle also here
• most cranial nerve emerge from here
- these carry sensory and motor into for head and neck
- the vagus nerve also originating here, carries both sensory and motor into for internal organs
- medulla oblongata: transition from spinal cord into brain
- contains fibers connecting cerebral cortex and spinal cord
- pons: relay station for information transfer between cerebellum and cerebrum
- also coordinates control of breathing along with medullary centers
- midbrain: control of eye movement and relay of auditory and visual reflexes and signals

**Cerebellum**

- most nerve cells in the brain found here
- processes and coordinates the execution of movement
- receives input from peripheral nervous system and cerebral cortex

**Diencephalon**

- between brain stem and cerebrum
- composed of thalamus and hypothalamus as well as pineal gland (melatonin synthesis)
- thalamus makes up most
- relay station for incoming info to the cerebral cortex
- can shape this info
- so also integrating center
- optic, auditory, spinal cord, etc.
- hypothalamus beneath the thalamus
- stalk of pituitary gland is downgrowth of this region
- various centers for behavior drive such as hunger, thirst, etc.
- therefore has major role in homeostasis

**Cerebrum**

- fills most of cranial cavity
- two hemispheres
- connected by corpus callosum that insures proper communication between hemispheres
- 4 regions in each hemisphere: frontal, parietal, temporal, occipital
- surface is very furrowed due to rapid growth in cranium and folding during development
- interior contains three clusters of nuclei
- basal ganglia: control of movement
- amygdale: emotion and memory
- hippocampus: learning and memory
• together these last two make up part of the limbic system surrounding the brain stem which is the link between cognitive functions such as reasoning and primitive emotional response

**Cerebral Cortex Organization**

• cerebral cortex is outer layer of neurons in cerebrum that is only a few mm thick
• higher brain functions such as reasoning originate here
• highly developed in humans compared to other verts.
• three specializations here: sensory areas directing perception, motor areas directing movement, and association areas integrating information and directing voluntary behaviors
• the association areas are responsible for integrating information for perception or our understanding of stimuli
• cerebral lateralization: each lobe has developed specialized function not shared by other lobes
• right vs. left brain dominance etc.
• language and verbal skills are concentrated in left hemisphere (dominant hemisphere for right handed people)
• spatial skills concentrated on right hemisphere
• certain degree of plasticity of nervous system and brain
• ability to adapt or change neuronal connections if needed

**Brain Function**

• the brain is capable of not only taking external info, integrating it and responding but also able to generate info and produce output without external info
• this is unique
• mental imaging helping immune response in cancer patients
• explain how we know about brain function traditionally and in modern terms (PET and MRI)

**Neurotransmitters and Neuromodulators and communication in CNS**

• remember that the CNS acts as an integrating center for all kinds of signals coming in from external environment and then responds to these
• the meaning of these signals or how they are interpreted depends on neurotransmitters and neuromodulators that are released by presynaptic cells and the receptors for these on the target cells
• different combinations of receptor and chemicals result in a multitude of possible signals reaching the brain
• therefore not all signals are alike
• some chemicals act as both neurotransmitter (fast) and neuromodulator (slow and use second messenger system often) depending on where located and the neuron being influenced (receptors present)
CHAPTER 15: Autonomic Nervous System

- the efferent peripheral nervous system carries out the response to stimuli from the CNS
- this can be divided into two divisions
- somatic motor neurons: carry out mostly voluntary control of skeletal muscles
- autonomic neurons: control smooth muscle, cardiac muscle, many glands, some adipose tissue (mostly involuntary actions thus auto designation)

Autonomic division

- can be divided into sympathetic and parasympathetic branches
- sympathetic: dominant in stressful situations and responsible for fight or flight response
- parasympathetic: often associated with rest and digestion so works somewhat counter to sympathetic
- these are not always involved with this great of contrast however do function in normal daily physiological activity

Homeostasis and autonomic division

- maintenance of homeostasis involves balancing sympathetic and parasympathetic control
- these two branches exhibit antagonistic control with the sympathetic branch being excitatory while the parasympathetic is inhibitory
- most organs etc. are innervated by both branches
- sympathetic stimulation of the heart causes HR to increase
- parasympathetic has opposite influence
- sweat glands and smooth muscle are different in that only innervated by sympathetic so get all or none response

Autonomic regulation

- autonomic response is controlled by the brain homeostatic control centers in the hypothalamus, pons, and medulla
- influence many responses in all systems
- also have autonomic reflexes or spinal reflexes where brain is not needed
- urination, defecation etc.

Autonomic pathways

- target tissues of autonomic control are smooth muscle, cardiac muscle, many exocrine glands, some endocrine glands, and some adipose tissue
- once released the autonomic neurotransmitters are not necessarily picked up directly by receptors on the target tissue but rather released into the extracellular fluid
- this allows the neurotransmitters to flow over the tissues to the proper receptors
• this allows the autonomic response to influence a large area of tissue at one time

Adrenal Medulla

• the innermost part of the adrenal gland
• basically is a modified sympathetic ganglion (cluster of neurons)
• function to secrete the neurotransmitters known as catecholamines (epinephrine and norepinephrine)
• because secreted by medulla and diffuse directly into bloodstream where carried throughout the body these are neurohormones rather than transmitters
• release is stimulated by alarm signals from CNS

Neurotransmitter Activity at target tissues

• formation and release much like that described earlier when discussing neuron communication
• removed from junction by enzymatic breakdown or in the case of catecholamines they must be pumped back into the neuron

Autonomic neurotransmitters

• the control exerted by the autonomic nervous system is through a combination of neurotransmitters and receptors
• will be covered in individual chapters as needed

Somatic Motor Division

• single neuron that has axon extending from CNS to target tissue
• target always skeletal muscle
• always excitatory
• cell body located within the gray matter of spinal cord or brain
• myelinated axons 1 m or more in length
• students should review motor neuron function from chapter 12.