Ch. 4 part 2: The Central Nervous System

Objectives:

1. Recognize the 6 brain regions & their functions.
2. Review brain blood supply, meninges, and significance of some brain injuries.
3. Go over brain imaging techniques used in diagnostics.

Six Brain Regions:

1. Cerebrum
2. Diencephalon
3. Midbrain
4. Pons
5. Medulla oblongata
6. Cerebellum

Midbrain, pons, & medulla oblongata collectively called the "**brain stem**"
- have nuclei that control body's life-support system.

Brain Region 1: Cerebrum

5 Cerebral Lobes (Table 8.1)

Frontal Lobe = higher cognitive functioning, recognition of self, personality, verbal communication, control of voluntary movement (skeletal muscles).

- Has **primary motor cortex & premotor cortex** or "precentral gyrus" - (controls voluntary movement of skeletal muscle)

- Has **prefrontal cortex** –higher order thinking, primal emotions, personality, multi-tasking.

- Has **Broca's speech area** – controls muscles involved in speaking.

Parietal Lobe ("post-central gyrus") = sensory for skin, muscle, tendon, joins.

- Has **primary somatosensory cortex** & **association area** ("postcentral gyrus")

- (receives sensory info. from. sensory nerves on touch, hot, cold, pressure).
- part of Wernike's and Gnostic areas

Wernike's area = area for understanding the written & spoken word (language!)

SKIP ~~Gnostic Area~~ ~~= common integrative area for sight, sound, smell.~~

~~- Ex. wake up in morning, hear someone cooking bacon & eggs, smell bacon, get up & see food, start to salivate.~~

Occipital Lobe = perception of vision, focus

- Has **primary visual cortex**

> receives info on vision from optic nerve, & integrates memories associated w/vision

Temporal Lobe = interprets sounds and smells, stores memory of sounds & smells

- Has **auditory cortex** (receives audiory info. for "hearing").

> receive info on sounds from auditory nerve, interprets sounds, and integrates memories associated w/sounds

- Has **olfactory cortex** (receives & interprets info on smell)
- Has part of Wernike's and Gnostic areas

Insula Lobe

- **primary gustatory cortex** (interprets sensory info. on tastes: sweet, sour, bitter, and salty).

Cerebrum & Language

Broca's speech area – controls muscles involved in speaking. L frontal hemisphere.
Wernike's Area = part of temporal & parietal lobes involved w/understanding the written & spoken word. L hemisphere.

Aphasia = disorder of speech & language
Broca's aphasia (non-fluent aphasia) = difficulty speaking but understand words & language.
Wernike's aphasia (fluent aphasia) = fluid speech that is nonsens (word salad). Can speak but not understand words.

Cerebrum and Sleep Pg 211

2 Sleep Categories:
1. Resting Sleep (non-REM) = stages 1-4. Spend 80% of sleep here. EEG – Theta waves
2. Rapid Eye Movement (REM) = stage 5. Spend 20% of sleep here. EEG – Delta waves
    > Limbic system active during REM (experience emotions)
    > Body shuts down through **GABA** inhibition
        a) "awareness of unimportant external stimuli" (see reticular system later w/)
        b) skeletal muscle movement

~~Cerebrum & Memory (Table 8.3)~~ SKIP for time

~~- involve many brain regions (cerebral temporal lobe & thalamus)~~
~~**2Types Memory:**~~
~~> Short-term memory (working memory) = seconds - minutes~~
- ~~words/numbers short term – prefrontal cortex, Broca's & Wernike's areas~~
- ~~spatial short term – prefrontal cortex, visual ass. area.~~

~~> Long-term memory = more complex.~~
- ~~involves making new neural connections (new RNA & proteins)~~
- ~~involves hippocampus & amygdala (of medial temporal lobe) to transform short-term into long-term.~~
- ~~Amygdala – involved in memory & emotional experience (can stregthen or block memory)~~

~~**Post-traumatic Stress Disorder (PTSD) –** see hippocampal atrophy, ↑ cortisol (stress hormone) from adrenal cortex.~~
~~**2 types long term:**~~
~~**a) nondeclarative (Procedural or explicit) memory –** simple skills and training (like tie shoes)~~
~~You can't explain it but have the muscle/motor memory to do it~~
~~**b) declarative** = can be verbally explained.~~
~~> semantic – word & fact memory (like remembering the names of bones on lab practical in anatomy)~~
~~> Episodic – remembering Events - Experiences (memory of taking that lab practical, what u ate @lunch)~~

~~**Amnesia** = loss of declarative long-term memory.~~

Cerebral Basal Ganglia (Nuclei) in Motor Function

- Masses of gray matter located within the cerebrum – important in motor control of movement.

Corpus striatum
> **Caudate nucleus** – control rhythm of swinging of arms & legs while moving. Degeneration of neurons here associated w/**Huntington's Chorea**
> **Putamen** (plays role in motor movement planning, learning, and excecution) & **globus pallidus** – plays role in voluntary movement.
> **Claustrum** – subconscious processing of vision for motor control of balance.

Cerebral Basal Ganglia (Nuclei) in Emotion & Behavior

> Amygdala – fear center

> **cingulate gyrus** (above corpus callosum) – forms associations between behaviors and positive or negative outomes.

> **septal nuclei** – reinforces pleasurable behaviors

Brain region 2. Diencephalon

Thalamus – most of diencephalon. Relay station to sort ascending and descending signals.

Epithalamus – secretes melatonin, at night, to regulate circadian rhythm.

Hypothalamus – regulates pituitary gland secretions

- is link between nervous & endocrine systems (see CH. 11) Via arcuate nucleus & releasing hormones.

- has specialized neurons

1) Supraoptic – secretes ADH to cause water retention at kidneys
2) paraventricular – secretes oxytocin (during breast feeding, childbirth, - also "cuddle" hormone for bonding
3) anterior – for regulation of body temperature
4) ventromedial - for the 4 F's (feeding, fight/flight (sympathetic), and reprodutive functions control
5) lateral – for regulating hunger (has letters "ate" in it)
6) preoptic – thirst center, when dehydrated or blood salt content rises
7) suprachiasmatic – for circadian rhythm (day/night cycle)

Brain Region 3: Midbrain

- **Superior colliculus** - regulates reflex responses to visual information. (you track moving objects subconsciously)
- **Inferior colliculus** - regulates reflex responses to sound (reflexively turn your head towards sudden sounds)
- **Red nucleus** - motor coordination of postural muscles for balance (like erector spinae group).
- **Substantia nigra** – fine control of voluntary movement & thought to play role in ***Parkinson's Disease*** = loss of these dopaminergic (dopamine-secreting) neurons. Leads to brain atrophy.
- **part of Reticular Activating System (RAS)**

RAS

> in midbrain, pons, & medulla

> filters "white noise" or "habituation to background stimuli" that are not important to current situation. (*E.g. blocking barking dog, music, lawn mower*)

> Help regulate "wakefulness" or alertness during sleeping cycle if sense important stimuli. (E.g. *hear baby cry, cat running @ sound of can opener!*)

- RAS found in midbrain & pons also
- Involves 4 types neurotransmitters:

Excitatory neurotransmitters

1. ACh from cholinergic neurons in thalamus
2. Norepinephrine
3. Hypocretin-1 secreting neurons = polypeptide neurotransmitter

Loss of these neurons associated w/narcolepsy (fall asleep at inappropriate times)

Inihibitory neurotransmitter

4. GABA secreting neurons in hypothalamus

Brain Regions 4 & 5: Pons & Medulla

Pons - connected to cranial nerves (trigeminal, abducens, facial, vestibulocochlear nerves) *"the anatomy final very"*

- has nuclei for autonomic control of rate & depth of breathing (**pneumotaxic center, apneustic center**).

- some of **Reticular Activating System (RAS)**

Medulla Lowest part of brain, connected to and continuous with spinal cord.

- Has decussation of pyramids – regulates cross-over of L hemisphere on R side of body and of R hemisphere on L side for involuntary body movement.
- Autonomic center for heart rate (cardiac center), blood pressure (vasomotor center), respiration (respiratory center)
- controls sneezing, salivating, swallowing, gagging, vomiting.
- connected to cranial nerves (vestibulocochlear, glossopharyngeal, vagus, accessory, hypoglossal) *"very good vacations are heavenly"*

Brain Region 6: Cerebellum

- Center for "balance" and "body posture"
- Integrates feedback from joints, muscles, eyes, vestibular apparatus of inner ear WITH fine motor control of muscles
- Stores **learned motor patterns** - why you always remember how to ride a bike or drive a car, why some motor patterns seem automatic after doing them repeatedly).
- **Fine control of voluntary and involuntary movements**

Cerebellar ataxia = disorder in movement from congenital (born with) problem, or brain injury.

Cerebellar hypoplasia = born with decreased development of cerebellum, leads to ataxic movement. Can improve somewhat with physical therapy.

CNS Meninges & Blood-Brain Barrier

Meninges = 3 membranes surrounding brain & spinal chord

- **dura mater** = outermost meninge. Very strong connective tissue.
- **arachnoid mater** has "subarachnoid space" for blood vessels.
- **pia mater** - has **astrocytes** & endothelial cells held w/ tight junctions. Act as **blood brain barrier**, allowing some things to pass while blood & cells restricted. Some drugs pass (nicotine, alcohol, anesthetics, pharmaceuticals, and THC & drugs (LSD, cocaine, heroin, etc...)

Brain needs a lot of O2!

- 15% of blood supply directed to brain
- Brain uses 50% blood glucose for glycolysis
- Hi metabolic demand
- Few minutes starvation $\rightarrow$ tissue death from stroke

Ischemia = Loss of blood flow.

Stroke: = ischemic (loss of blood flow) event of brain. Loss of O2 & glucose. Brain tissue dies.

- 3rd leading cause of death in US

Cerebral Hemorrhage (hematoma) & Pressure Necrosis

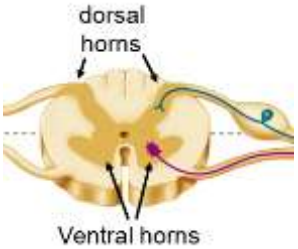
- Hemorrhage beneath dura
- Caused by fast force trauma $\rightarrow$ tear veins in arachnoid space
- $\uparrow$ intracranial pressure - Pressure necrosis (tissue death)
- Coma, death
- Craniotomy (drill), evacuate clot

Techniques for evaluating the brain:

1. X-ray = single xray beams pass through a tissue. Dense tissue (bone) looks white, while air spaces look black. Not good for soft tissue analysis.
2. CT scan (computerized tomography) = multiple xray beams sent through tissue of different densities. Can take "slices" through a tissue or organ. Images computerized. Good for viewing soft tissue.
3. MRI scan (magnetic resonance imaging) = uses powerful magnetic field and pulses of radio waves to take images of soft tissues. Best for viewing soft tissues.
4. PET scan (positron emission tomography) = injection of radio-labeled glucose to examine metabolically active tissue in real time.
5. EEG scan (electroencephalogram) = brain neuronal electrica
    - alpha waves = parietal & occipital lobe activity (sensory & vision) 10-12 cycles/sec
    - beta waves = frontal lobes (congnition, frontal eye fields) 13-25 c/sec
    - theta waves = temporal & occipital lobes (emotional stress!) 5-8 c/sec
    - delta waves = cerebral cortex, see when asleep BUT activity in awake person indicates brain damage! 1-5 c/secl
        activity measured using electrodes placed over scalp.

Coup - Contrecoup brain injury = blunt force trauma to brain, brain "bounces" back and forth against cranial bones causing bruising (contusion). Coup = frontal damage. Contrecoup = occipital damage

Organization of Spinal Cord



> Spinal chord part of CNS
> Has 4 regions: cervical, thoracic, lumbar, sacral, (& some include coccygeal)
> Divided into white & gray matter:
- **White matter**- outer surrounding tracts of descending/ascending fibers
- **Gray matter**- inner dorsal & ventral horns, they lead to "roots" where sensory or motor nerves enter/exit

Spinal Chord Gray Matter:

> Dorsal horn - are (afferent) "sensory"
> Ventral horn - are (efferent) "motor" – deliver command from brain to muscle/gland

Dermatome. = Map body sensory regions. Loss of sensation in particular area may indicate damage to specific nerve. Chicken Pox virus can lay dormant in dermatome and give rise to "**shingles**" later in life. There is now a vaccine for this.

Dermatory sensory divided into:

1. Cervical (C1-C8) - back of head, neck & shoulders, & arms
2. Thoracic (T1 – T12) - chest, back, & abdomen
3. Lumbar (L1- L5) - lower back & anterior legs
4. Sacral (S1 – S5) - groin & anus & posterior legs

Difference between ascending & descending tracts of spinal cord:

Ascending carries sensory info up spinal cord, sorted at thalamus, and ends in parietal lobe (sensory cortex)
Descending tract carries motor commands from brain down spinal cord.

Testing the descending tract example : the **Babinski reflex**. Toes in baby flare out (dorsiflexion) when sole or side of foot stroked. In adults with same stimulation, toes curl (planter flexion) as normal response.

SKIP

Organization of Spinal Nerves

Ventral Nerve Plexuses:

Cervical Plexus (C1-C4) - head, neck, shoulder movement

> End of Spinal Chord are Spinal Roots (part of PNS)

>spinal roots merge to form **spinal nerves** (have both sensory & motor component)

> spinal nerves have dorsal & ventral **"rami" (branches)**

> Dorsal rami become part of "**Dermatome**"

> Ventral rami become **"nerve plexuses"**

Nerve Plexuses divided into

Cervical (C1-C7)

Thoracic (T1 – T 12) **Sacral (S1 – S5)**

Lumbar (L1 – L5) **coccygeal nerves (Co1)**

- Diaphragm (phrenic n.)

Brachial Plexus (C5 – T1) - Arm & forearm, hand, & fingers movement

- Ex. Axillary, musculocutaneous, median, radial, ulnar nerves.

Anterior arm – musculocutaneous n. – flexors of elbow (biceps brachii, brachialis, coracobrachialis)

Posterior arm - Radial n. - extensors of elbow (triceps brachii, anconeus)

Anterior forearm – median n. (flexors of wrist & fingers)

Posterior forearm – radial n. (extensors of fingers)

Lumbar Plexus (L1-L4) - Hip, anterior & medial thigh movement

- Ex. Obturator, femoral, tibial nerves.

Femoral nerve (quadriceps femoris, part of pectineus)

Obturator nerve (gracilis, adductors, part of pectineus etc..)

Sacral Plexus (L4 – S5) - Posterior thigh, leg, & toes movement

- Ex. Sciatic (tibial & common fibular) nerve.

posterior leg (tibial n. - gast. soleus)

anterior leg (deep fibular n.) tibialis anterior, flexor digit. longus, brevis,

lateral leg (superficial fibular n. – fibularis longus/brevis)