### Ch. 5: Central Nervous System

**Objectives:**

1. Recognize the 6 brain regions & their primary functions.
2. Brain Blood Supply, Blood-Brain Barrier, and Brain Injuries
3. Brain Imaging Techniques Used in Medicine

---

**Anatomy Review!**

* CNS = brain & spinal cord *(where majority of neurons located).*

* PNS = other nervous tissue outside CNS*
Part 1. Six Brain Regions & Their Functions

Anatomy Review!

1. Cerebrum
2. _______________________
3. _______________________
4. _______________________
5. _______________________
6. _______________________

Ques:
What 3 brain regions make up the “brainstem”
__________________, ________________, ___________________
Region 1: Cerebrum (Forebrain)

6 Cerebral Lobes and their major cortexes

1. Frontal Lobe:
   Motor cortex for voluntary muscle movement.
   Broca’s area – motor control of speech
   
2. Parietal Lobe:
   Sensory cortex – for interpreting senses
   Part of Wernike’s area – for understanding language (written & spoken word)

3. Temporal Lobe:
   Auditory cortex – for sounds
   Olfactory cortex – for smell
   Part of Wernike’s area

4. Occipital Lobe:
   Visual cortex – for vision

5. Insula Lobe:
   Gustatory cortex – for taste

Precentral gyrus = primary motor cortex of frontal lobe which has motor control of body.

Postcentral gyrus = primary somatosensory cortex of parietal lobe that receives sensory info from body (dermatome)

Fig 8.7

DO NOT need to memorize figure!
Cerebrum & Language

• Broca’s area:

• Wernicke’s area:

Aphasias = communication disorder that results from damage or injury to language parts of the brain.

**Broca’s aphasia** = (non-fluent aphasia) difficulty speaking but have understanding of words and language.

**Wernike’s aphasia** = (fluent aphasia) fluid speech but it is nonsense because do not understand words and language (word salad)

FMU’s Speech Pathology Program
Cerebrum & Sleep

2 Sleep Categories:
1. non-REM = stages 1 – 4 (80% of sleep)
2. REM = stage 5 (20% of sleep)
   > Limbic (emotional) system remains active
   > GABA inhibition of:
     a. awareness of unimportant stimuli
     b. skeletal muscle (voluntary) movement

_During sleep the reticular activating system (RAS) can arouse you with excitatory neurotransmitters if important stimuli sensed. (see RAS later)_

---

Cerebral Basal Nuclei (Ganglia) & Motor function:
- Nuclei located deep within the cerebrum
- Frontal motor cortex neurons communicate with basal nuclei
- Basal nuclei send inhibitory signals to thalamus which send signals back to frontal motor cortex.

_Fig 5.11_
Cerebral Basal Nuclei (Ganglia) & Motor function:

- Nuclei located **deep within the cerebrum**
- Frontal motor cortex neurons communicate with basal nuclei
- Basal nuclei send inhibitory signals to thalamus which send signals back to frontal motor cortex.

**MOTOR Effects of cerebral basal nuclei:**
- Maintaining purposeful motor activity but inhibit unwanted activity
- Monitor & coordinate slow sustained muscle contractions

1. **Claustrum** — help regulate autonomic motor responses to vision.
2. **Putamen** — involuntary control of muscle movement.
3. **Globus pallidus** — involuntary control of muscle tone.
4. **Caudate nucleus** — autonomic control of rhythmic swinging of arms & legs while moving.

[Degeneration of neurons here associated w/**Huntington’s Chorea**]

---

**CLINICAL APPLICATIONS**

Degeneration of the neurons in the *caudate nucleus*, one the basal nuclei and part of the corpus striatum, occurs in **Huntington’s disease**. This produces *chorea*—a disorder characterized by uncontrolled, jerky movements. Degeneration of dopamine-releasing neurons that go from the substantia nigra to the caudate nucleus produces the symptoms of **Parkinson’s disease**. The symptoms of Parkinson’s disease include muscular rigidity, resting tremor, and difficulty initiating voluntary movements.
Cerebral basal nuclei & Emotions: The limbic system

Cerebral nuclei work with hypothalamic and thalamus nuclei to process primal emotions & behavioral drives.

Papez Circuit = flow of info between cerebral nuclei & diencephalon (thalamus, & hypothalamus)

Limbic effects of cerebral nuclei:

Amygdala – aggression.

Cingulate gyrus (above corpus callosum) = for forming associations between behavioral outcomes & motivation.

Septal nuclei (below corpus callosum) = reinforces pleasurable behaviors.

Diencephalon structures:

Hypothalamus = has nuclei for the 4 F’s 1. feeding, 2. fighting, 3. fear, 4. fornicating

Thalamus = relay station (helps info move between cerebral and hypothalamic nuclei)

Review

Brain Region 1: Cerebrum

- Cerebral lobe cortices and their functions (frontal, parietal, temporal, occipital, and insula)
- Cerebral division of motor and sensory perception in body (precentral an postcentral gyrus).
- Cerebrum & language (broca’s and wernike’s areas, and aphasias
- Cerebrum & sleep
- Cerebrum & memory
- Cerebral nuclei & motor function
- Cerebral nuclei & emotions (limbic system)
Brain Region 2: Diencephalon (forebrain)

- **Thalamus** = relay station that receives and sorts sensory (ascending) info & relays to appropriate cerebral cortex.

- **Hypothalamus** = has many neurons with many functions!
Hypothalamus nuclei & functions:

- Link between nervous & endocrine systems
- Controls pituitary gland
- Controls autonomic sympathetic response of body - adrenal medulla’s production of epinephrine during fight/flight.

Hypothalamus nuclei & functions:

Has nuclei that functions in homeostasis:

Supraoptic = osmolarity (water balance) center, produce ADH

Paraventricular = produce oxytocin

Anterior = regulates body temp (thermoregulation)

Ventromedial
>fullness (satiety) center,
>fear, aggression, & reproductive (GnRH)
the 4 F’s: __________, __________, __________, & __________

Lateral = hunger regulation

Preoptic = thirst center

Suprachiasmatic = regulates circadian rhythm (sleep/wake cycle).
Brain Region 3: Midbrain

1. Superior colliculus = reflex visual tracking of moving objects.

2. Inferior colliculus = reflex response to sound (turn head in direction of unexpected or scary sound).


4. Substantia nigra:
   > Nigrostantial dopamine system - fine motor control.
   > Mesolimbic dopamine system – pleasure /reward center.

5. Part of RAS

Drug Abuse & Dopamine Stimulation:

Nicotine - dopamine agonist
Heroin & morphine - dopamine agonist by stopping GABA inhibition of dopamine
Benzodiazepine (Valium) - dopamine agonist
Cocaine & amphetamines – dopamine agonist
Alcohol – dopamine agonist
Brain Regions 4 & 5: Pons & Medulla (hindbrain)

Pons
- Some of RAS
- 2 autonomic respiratory centers:
  - Pneumotaxic center
  - Apneustic center

Medulla oblongata
- Some of RAS
- Regulates involuntary sneezing, swallowing, gagging, and vomiting
- Primary site for crossover of motor control (decussation of pyramids)
- Has 3 autonomic life-support centers:
  1. Cardiac center (control heart rate)
  2. Vasomotor center (arteriole dilation)
  3. Respiratory center for resp. rate.

The reticular activating system (RAS)
The reticular activating system (RAS) = system that distinguishes between unimportant and important (ex. life-threatening or saving) stimuli.

> In Midbrain, Pons, and Medulla (brainstem), thalamus & hypothalamus.

> Involves 4 neurotransmitters to arouse or inhibit cerebrum:

**Excitatory (wakefulness or awareness)**
1. ACh
2. Monoamines (dopamine & norepinephrine)
3. Hypocretin-1

**Inhibitory (promotes sleep or decreased awareness)**
4. GABA

Read Clinical App Pg 139 and ONLINE: The effect of drugs on RAS.
Brain Region 6: Cerebellum (also hindbrain)

- Receives sensory info from proprioceptors (in joints & muscles) to coordinate muscle movement for balance & posture.

- Stores learned motor patterns (“muscle memory”)

Read Clinical App Pg 138: Damage to cerebellum and ataxia.

Review

- 6 Brain Regions
- Know cortexes of cerebrum, wernike’s and broca’s areas.
  > aphasias
- Diencephalon (Thalamus & hypothalamus functions)
- Midbrain & nuclei
  - superior/inferior colliculus
  - Red nucleus
  - Substantia nigra
  - RAS
- Pons (pneumotaxic and apneustic centers, RAS)
- Medulla oblongata (cardiac, vasomotor, respiratory centers & RAS)
- Cerebellum
Cerebella ataxia

Clinical applications

Damage to the cerebellum produces ataxia—a lack of coordination resulting from errors in the speed, force, and direction of movement. The movements and speech of a person with ataxia may resemble those of someone who is intoxicated. A person with damage to the cerebellum may reach and miss an object, and then attempt to compensate by moving the hand in the opposite direction. This can produce back-and-forth oscillations of the arm. = “intention tremors”

https://youtu.be/ZkM-1MLn0_A?t=1

CNS Meninges = membranes that cover the brain & spinal cord.

3 Meninges:

1. Dura mater = outermost meninge

2. Arachnoid mater = middle meninge with a blood supply.

3. Pia mater = innermost meninge, with a blood brain barrier (BBB) of astrocytes.

Common drugs that are lipid-soluble & cross BBB...

- Ethanol
- Nicotine
- caffeine
- Tetrahydro-cannabinol (THC)
- anesthetics
Brain blood supply:
> Uses 15% of arterial blood supply
> Uses 50% of blood glucose!
> Few minutes of “ischemia” = brain tissue death!

**Ischemia** = interruption in blood flow to an organ or tissue.

**Stroke** = loss of blood flow to brain

Necrosis typical of Ischemic stroke

---

Acute Cerebral Hemorrhage (Hematoma)

Blunt force blow to head can rupture small blood vessels (hemorrhage) causing formation of hematoma (blood pocket).

Fluid buildup causes damaging pressure necrosis.

Blunt force injury to brain and hemorrhage and/or brain swelling

Ex. Coup-Contrecoup brain injury:

Blunt force blow to one part of head causes brain to bounce within cranial cavity, hitting opposing side of skull.

Hard cranial bone damages soft brain tissue and can also cause hemorrhaging and hematomas.

Coup-Contrecoup brain injury: https://youtu.be/BCDBs8RvlRg
1) X-Ray = single x-ray beams sent through body part, which produces image showing high density tissue (bone or contrast media) as white and lower density tissues (soft tissue) as variations of gray, and air spaces as black.
- Relatively cheap (national average for chest x-ray = $100, but depending on city and insurance can be more or less)
- Best for viewing bone
- Poor for viewing soft tissue

2) CT Scan = multiple x-ray beams sent through body, and tissue of different densities are analyzed by a computer to produce high quality images of tissues. Can show “slices” through a tissue. (computed tomography)
- Expensive (national average cost = $1,200, but depending on city and insurance can be more or less)
- Good for viewing soft tissue
3) MRI Scan = uses a powerful magnetic field and pulses of radio wave energy to make pictures of tissues. (magnetic resonance imaging)

- VERY expensive (national average cost = $2,600, but depending on city and insurance more or less)
- BEST for viewing high detail in soft tissue
- Not safe for use in patients with cochlear or pacemaker implants (etc...)

4) PET scan = uses radioactive glucose tracer to determine how tissues are working. (positron emission tomography)

- VERY expensive (national average cost = $1,600 – 4,000, but depending on city and insurance more or less)
- Can tell you if tissues or organs are functioning normally
5) EEG = Brain neuron activity measured with electrodes placed on scalp. (electroencephalogram)
Review

CNS meninges

Blood flow to brain

Hematomas and coup-contracoup brain injuries

Brain imaging techniques
  - X-Ray
  - CT scan
  - MRI scan
  - PET scan
  - EEG