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. **Diencephalon**
3. **Midbrain**
4. **Pons**
5. **Medulla**
6. **Cerebellum**

Ques:
What 3 brain regions make up the “brainstem”

*pons, medulla, midbrain*
Region 1: Cerebrum (Forebrain)

6 Cerebral Lobes and their major cortexes

1. Frontal Lobe: voluntary movement
   Motor cortex = primary motor cortex of frontal lobe which has motor control of body.
   
   ① Broca's Area: voluntary speech
   ② Prefrontal cortex: primordial area, sense of self

2. Parietal Lobe: sensory cortex - sensory perception (e.g., post-central gyrus)
   Sensory cortex - sensory perception (e.g., post-central gyrus)
   Part of Wernicke’s area

3. Temporal Lobe: olfactory cortex - smell
   Auditory cortex - sound
   Part of Wernicke’s area

4. Occipital Lobe: visual cortex
   Part of Wernicke’s area

5. Insula Lobe: gustatory cortex - taste

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

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

DO NOT need to memorize figure!
Cerebrum & Language

• Broca’s area:
  Motor speech area
  Frontal lobe

• Wernicke’s area:
  Language center
  Understanding the
  written & spoken
  word

Fig 5.9

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

**Broca’s aphasia** = (non-fluent aphasia)
  Understand language but difficulty speaking

**Wernike’s aphasia** = (fluent aphasia)
  Speak clearly but it’s gibberish. Speak “word salad”. Difficult language comprehension.

FMU’s Speech Pathology Master’s Program
Jobs market in SC is LARGE for speech pathologists.
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 w/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:*** autonomic regulation of movement w/ (visual) feedback
2. **Putamen:** autonomic regulation muscle movement
3. **Globus pallidus:** muscle tone
4. **Caudate nucleus:** swinging of arm & legs during movement

[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: **Center for Fear, Location of Female Orgasm**

Cingulate gyrus (above corpus callosum) = **Forms association between behavior & outcome (good or bad)**

Septal nuclei (below corpus callosum) = **Reinforcing behaviors have pleasurable outcome.**

Diencephalon structures:

Hypothalamus = has nuclei for the 4 F’s  1. **Feeding**  
2. **Fear** , 3. **Fighting** , 4. **Fornication**

Thalamus = **D** relay station for info descending or ascending CNS
Review

Brain Region 1: Cerebrum
- Cerebral lobe cortexes 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
- Cerebral nuclei & motor function
- Cerebral nuclei, diencephalon, & 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!
Brain Region 2: Diencephalon (forebrain)

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, produces **ADH** monitoring blood salt content.
- **Paraventricular** = produces **Oxytocin**

**Anterior nucleus:** regulates body temp (thermoregulation)

**Ventromedial nucleus:**
- Feeding, Fight/Flight/Reproduction
- the 4 F’s: **Feeding, Fear, Fighting, & Fornication**

**Lateral nucleus:** hunger regulation

**Preoptic nucleus:** thirst center

**Suprachiasmatic nucleus:** regulates circadian rhythm

---

**Brain Region 3: Midbrain**

1. Superior colliculus = **reflex response** (track to vision, having objects)

2. Inferior colliculus = **reflex response to sound**

   Turn your head towards an unexpected sound.

3. **Red nucleus** = motor coordination of postural muscles

4. **Substantia nigra:**
   - Nigrostantial dopamine system for **fine motor control**
   - Mesolimbic dopamine for **addictive behavior**

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:
  - Apneustic center
  - Respiratory 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 (HR)**
  2. **Vasomotor center (vasoconstrict)**
  3. Respiratory center
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 - acetylcholine
2. Monoamines (dopamine & norepinephrine)
3. Hypocretin-1 - low hypocretin → narcolepsy

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

Read Clinical App Pg 139 and **ONLINE:** The effect of drugs on RAS.
Announcements:

• Mistake on Practice Exam 1 (#7) – has been fixed and reposted.

• How many students don’t have their American Heart Association CPR certification, and would like to get it?

> Put check ✓ next to your name on sign-in sheet.
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. Cerebella ataxia = "intention tremors"

Click “intention tremors” to go to YouTube video
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

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

3 Meninges:

1. Dura mater = outer
2. Arachnoid mater = middle
   * has blood supply
3. Pia mater = inner w/blood brain barrier

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

---

**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/BCDBs8RvIRg
**READING ASSIGNMENT**

**Part 3. Brain Imaging Techniques**

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...)

![MRI Scan Cutaway](image)

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

![PET Scan Images](image)
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
Part 4. Spinal chord structure, spinal roots, and spinal nerves.

The Spinal Chord
• is part of CNS
• Has 4 paired regions:
  1. Cervical (C1-C8)
  2. Thoracic (T1-T12)
  3. Lumbar (L1 – L5)
  4. Sacral (S1 – S5)
  5. Coccygeal (1 pair)

Solid spinal cord ends ~L2 and branches into bundle of separate Lumbar & Sacral nerves called cauda equina (horse’s tail).

CNS Division of White Matter Vs Gray Matter:

White matter = myelinated neurons in brain and spinal cord. Functions to transmit info from one place to another.

> In brain – white matter found interior

> In spinal chord – white matter exterior

Gray matter = pigmented neurons found in brain & spinal cord. Function as integration centers where info is interpreted and motor commands made.

> In brain – gray matter in outer cortexes and cerebral nuclei center.

> In spinal chord – gray matter in center marks end of CNS, has butterfly shape.
Dorsal horn of spinal cord = receives sensory (afferent) info from body. **Ventral horn of spinal cord** = delivers motor (efferent) commands to muscles/glands.

> horns lead to dorsal & ventral roots (outside cord), which is start of PNS.  
- dorsal root has enlarged ganglion – where cell bodies of sensory neuron cell located.  
> Roots merged into mixed spinal nerves (contain both sensory & motor info.)

Dorsal spinal roots receive sensory info. **Dermatome** = Skin’s sensory body map.

1. **Cervical (C1-C8)**  
   - back of head  
   - neck & shoulders  
   - dorsal & lateral arms

2. **Thoracic (T1 – T12)**  
   - torso

3. **Lumbar (L1- L5)**  
   - lower back  
   - anterior legs

4. **Sacral (S1 – S5)**  
   - groin & anus  
   - posterior legs
**Dermatome & Shingles**

“Shingles” = painful skin blisters & rashes that develop, usually on one side of body due to childhood exposure to chickenpox virus (varicella zoster), which lies dormant in dermatome.

**Virus** lies dormant in dermatome for years, reactivated later in life or w/immunosuppression.

There is now a Shingles vaccine.

---

**Ascending & Descending Tracts of Spinal Cord**

- Tracts of axons carry information between spinal nerves and brain

1. **Ascending tracts**
   - Carry sensory information up to the brain
   - Originate in spinal cord
   - Sorted at thalamus
   - End in somatosensory cortex (postcentral gyrus)
   - **Ex. spinothalamic tracts**
     - Carry signals to thalamus

---

Fig 5.17
• Tracts of axons carry information between spinal nerves and brain

1. Ascending tracts
2. Descending tracts
   – carry motor commands from brain to motor neurons
   – Corticospinal (pyramidal) tracts
     • Originate in primary motor cortex (precentral gyrus)
     • Sorted at thalamus
     • End in spinal cord
     • Important for complex voluntary movements.
   – Extrapyramidal tracts
     • Originate from various locations

Clinical App: Babinski reflex – in normal infants or adults with corticospinal tract damage.
Review

- **Spinal cord structure, spinal roots, and spinal nerves.**
  > diff division of white and gray matter between brain & spinal cord.
  > spinal cord has dorsal & ventral horn (sensory Vs motor info)
  > spinal horns give rise to spinal roots
  > dorsal root of spinal cord provides “dermatome”

- **Ascending & Descending tracts of spinal cord.**