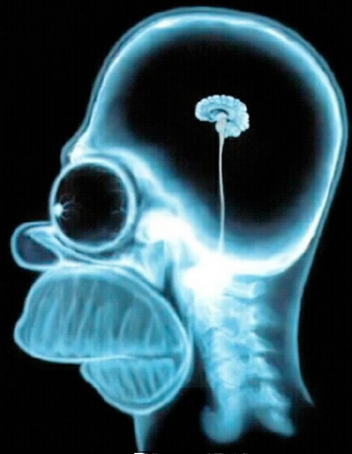
Chapter 12: The CNS (Brain & Spinal Cord)



72 slides

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Development of the Neural Tube from Embryonic Ectoderm

Figure 12.34
Development of the neural tube from embryonic ectoderm.

Human Embryo **Day 19**

2

Development of the Neural Tube from Embryonic Ectoderm

Figure 12.34
Development of the neural tube from embryonic ectoderm.

Human Embryo **Day 20**

3

Development of the Neural Tube from Embryonic Ectoderm

Figure 12.34
Development of the neural tube from embryonic ectoderm.

Human Embryo **Day 22**

Development of the Neural Tube from Embryonic Ectoderm

Figure 12.34
Development of the neural tube from embryonic ectoderm.

Human Embryo **Day 26**

Embryonic Brain Development

Figure 12.1
Embryonic development of the human brain.

Effect of Space Restriction on Brain Development

Figure 12.2a
Brain Development.

Because the ***brain grows more rapidly than the membranous skull that contains it***, two flexures develop: the **midbrain flexure** and the **cervical flexure**, both of which move the forebrain toward the brain stem.

Effect of Space Restriction on Brain Development

Figure 12.2b
Brain Development.

A second consequence of restricted space is that ***the cerebral hemispheres are forced to take a horseshoe-shaped course and grow posteriorly and laterally***. As a result, they grow back over and almost completely envelop the diencephalon and midbrain.

Effect of Space Restriction on Brain Development

Figure 12.2c
Brain Development.

By week 26, the continued growth of the cerebral hemispheres causes their **surfaces to** "**crease & fold**", **producing** ***convolutions*** and **increasing their surface area**, which **allows more neurons to occupy the limited space**.

4 Ventricles in the Brain

Figure 12.4
Ventricles of the brain.

Ventricles are lined with **ependymal cells.**
The two **lateral apertures** and the single **median aperture** in the fourth ventricle are the openings that connect the four ventricles to the **subarachnoid space**. The fluid that surrounds the brain and spinal cord is the same that is in these ventricles... **CSF.**

The Cerebral Hemispheres

- 85% of total brain mass
- ridges are called **gyri**.
- "shallow grooves" are called **sulci.**
  - the sulci divide each hemisphere into five lobes.
    - **Frontal, Parietal, Temporal, Occipital** and **Insula.**
- "deep grooves" are called **fissures.**
  - these separate large regions of the brain
  - **median longitudinal fissure** separates the brain into right and left hemispheres.
  - the **transverse cerebral fissure**, separates the cerebral hemisphere from the cerebellum below.

Lobes & Fissures of the Cerebral Hemispheres

Figure 12.5c
Lobes, sulci, and fissures of the cerebral hemispheres.

Lobes & Fissures of the Cerebral Hemispheres

Figure 12.5d
Lobes, sulci, and fissures of the cerebral hemispheres.

Lobes & Fissures of the Cerebral Hemispheres

Figure 12.5a
Lobes, sulci, and fissures of the cerebral hemispheres.

Lobes & Fissures of the Cerebral Hemispheres

Figure 12.5b
Lobes, sulci, and fissures of the cerebral hemispheres.

Cerebral Cortex

- is the outer layer of gray matter of the brain which is composed of:
  – neuron cell bodies
  – dendrites
  – neuroglia cells
  – blood vessels
  – NO axon / fiber tracts!!!
- billions of neurons arranged in 6 layers
  – only 2 to 4 mm thick
  – is about 40% of brain mass
    - the many gyri & sulci allow it to effectively triple its surface area.

Functional & Structural Areas of the Cerebral Cortex

Figure 12.7a
Functional and structural areas of the cerebral cortex.

Functional & Structural Areas of the Cerebral Cortex

Figure 12.7b
Functional and structural areas of the cerebral cortex.

Brain Cortex Function Basics

- the cerebral cortex contains 3 kinds of functional areas:
  - motor areas, sensory areas, association areas
- all neurons in the cortex are interneurons
- each hemisphere controls the sensory and motor functions of the opposite side of the body.
- some functions of the brain are primarily found in one of the two hemispheres.
- no functional area of the cortex acts alone, and conscious behavior involves the entire cortex in one way or another.

Motor Cortex & Sensory Cortex

Figure 12.8
Functional and structural areas of the cerebral cortex.

Primary (Somatic) Motor Cortex

- located in the precentral gyrus of frontal lobe.
- known as Brodmann area 4.
- has large neurons called **pyramidal cells**
  - these allow *conscious control* of muscles.
  - their long axons go down the spinal cord
    - form the motor tracts called **pyramidal tracts** or **corticospinal tracts. Innervation is Contralateral !!!**
  - as seen in slide 15, the pyramidal cells that control "specific" body parts are grouped together.
    - this kind of neuron mapping is called **somatotopy.**
    - the size distorted figure (**motor homunculi**) represents how much gyrus is devoted to a body part.

Premotor Cortex

- just anterior to the precentral gyrus in the frontal lobe.
- known as Brodmann Area 6.
- controls *learned motor skills of a repetitious or patterned nature.*
  - ex: typing, playing instrument, driving stick.

Broca's Area

- lies anterior to the inferior region of the premotor area.
- overlaps Brodmann Areas 44 & 45.
- is present "only" in the left hemisphere.
- is a special **motor speech area.**

Frontal Eye Field

- located partially in and anterior to the premotor cortex and superior to Broca's area.
- Brodmann Area 8
- controls **voluntary movement of eyes.**

Stroke Symptoms by Stroke Location

- **stroke to primary motor cortex**
  - loss of voluntary control (paralysis) of muscle
  - reflexes intact.
- **stroke to premotor cortex**
  - loss of muscle motor memory.
  - retain voluntary muscle control, but have to learn how to do activity all over again.
  - reflexes intact.

Primary Somatosensory Cortex

- in the **postcentral gyrus of parietal lobe.**
- is **Brodmann areas 1, 2, 3.**
- two groups of neurons supply this area:
  - **sensory skin receptors (Touch).**
  - **proprioceptors (Position Sense Receptors)**
    - in skeletal muscles, joints and tendons.
  - together, information from these two groups of neurons give you a sense of **spatial discrimination.**
  - this is represented graphically by the **somatosensory homunculus.**

Somatosensory Association Cortex

- lies just posterior to the primary somatosensory cortex.
- Brodmann area 5 and 7.
- major function is to **integrate sensory inputs**
  - temperature, pressure, texture, size, memory, etc...
  - this is being used when you feel in a pocket and pick out a quarter without looking at it.
  - someone with damage to this area will have difficulty recognizing objects without seeing them.

Visual Areas of the Cortex

- is on the extreme posterior tip of the **occipital lobe.**
  - most of it is buried deep in the **calcarine sulcus.**
  - receives visual information from the retinas.
  - the **visual association area** surrounds the primary visual cortex and covers much of the occipital lobe.
    - this area **uses past visual experiences to interpret** visual stimuli
    - it enables us to **recognize & appreciate what we see**

Auditory Cortex

- The **Primary Auditory Cortex:**
  - each one is located in the **superior margin of the temporal lobe** abutting the lateral sulcus.
- interpretations done here are for:
  - **pitch, loudness, location.**
- The **Auditory Association Area:**
  - **permits the perception of the sound stimulus**
    - understanding what we hear
    - memories of past sounds understood stored here.
    - **Wernicke's Area** includes parts of the Auditory Cortex.

Olfactory (Smell) Cortex

- The **Primary Olfactory Cortex**:
  - lies on the medial aspect of the **temporal lobe.**
    - in a small region called the **piriform lobe which is dominated by the hooklike uncus.**
    - **awareness of different odors.**

Other Sense Location in the Cortex

- **The Gustatory (taste) cortex:**
  - located in the **insula,** deep in the **Temporal Lobe**
  - involved in the perception of taste.
- **Visceral Sensory Area:**
  - cortex of the **insula**, posterior to gustatory cortex.
  - perception of visceral sensations:
    - upset stomach, full bladder, constipation, etc...
- **Vestibular (Equilibrium) Cortex:**
  - posterior **insula**, deep in the **Temporal Lobe**.
  - conscious awareness of balance, head position.

Multimodal Association Areas

- sensory information flow in the brain goes:
  - **First,** to the **primary sensory cortex.**
    - you can see the words on the test.
  - **Second,** to the **sensory association cortex.**
    - you recognize the words as something you read.
  - **Third,** to the **multimodal association cortex.**
    - the words you read, have meaning (based on memory).

3 Parts of the Multimodal Association Cortex

- **Anterior Association Area (prefrontal cortex):**
  - located in frontal lobe
  - involved with intellect, complex learning, recall, personality, working memory, abstract ideas, judgment, reasoning, persistence, planning.
  - heavily dependent on positive and negative feedback from one's social environment.
- **Posterior Association Area:**
  - located in temporal, parietal and occipital lobes!
  - role in recognizing patterns, faces, localization, binding sensory inputs, understanding written & spoken language.
- **Limbic Association Area:**
  - located in cingulate gyrus, hippocampus areas.
  - provides the **emotional impact of a scene**.

3 Parts of the Multimodal Association Cortex

Lateralization of Cortical Functioning

- Each hemisphere has some unique abilities. This is known as **lateralization**.
- in 90%, the **left hemisphere** is **dominant for:**
  - **language, math, logic**
- in 90%, the **right hemisphere** is **dominant for**:
  - **visual-spacial, intuition, emotion, artistic, music**
- the 90% with left hemisphere dominance tend to be right-handed.
- in the remaining 10% of people, the roles of the hemispheres are reversed or share functions equally.

Cerebral White Matter

- consists largely of myelinated fibers bundled into large **tracts.**
- we name these tracts according to the direction in which they run:
  - **Commissural Tracts**
    - one of these is the **corpus callosum** that connects the right and left hemispheres.
  - **Association Fibers**
    - connect different parts of the *same hemisphere*.
  - **Projection Fibers**
    - connect the cerebral hemispheres to the lower brain and spinal cord.

Types of Fiber Tracts in White Matter

Figure 12.9b
White fiber tracts of the cerebral hemispheres.

Types of Fiber Tracts in White Matter

Figure 12.9a
White fiber tracts of the cerebral hemispheres.

Basal Nuclei

- The **Basal Nuclei** are spots deep in the brain where large groups of neuron cell bodies are located. There are 3 groups:
  - **Caudate Nucleus**
  - **Putamen**
  - **Globus Pallidus**
- basal nuclei are particularly important in **starting**, **stopping** and **monitoring** the **intensity of movements** executed by the cortex, especially if they are **slow** or **stereotyped**.
  - ex: swinging arms when walking
- basal nuclei also **inhibit unwanted movements**
  - ex: absent in Huntington's Chorea and Parkinson's Dz.

Basal Nuclei

Figure 12.10
Basal nuclei.

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Thalamus

- one of the Diencephalon brain structures
- is two egg-shaped collections of nuclei in the center of the brain with a small space between them called the **third ventricle.**
  - small connection between them called the **interthalamic adhesion (intermediate mass).**
- some of the thalamus functions are:
  - sorting and editing information.
  - process touch, pressure, and pain
  - directing information to appropriate location
- is composed of multiple separate nuclei.

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Midsagittal Section of Brain

Figure 12.11
Midsagittal section of the brain.

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Hypothalamic Nuclei

Figure 12.12
Selected structures of the diencephalon.

Hypothalamus

- lies below the thalamus
- parts include:
  - the **mammillary bodies**
    - are relay stations in the olfactory (smell) pathway.
  - the **infundibulum** (connecting stalk of **pituitary**).
- has the following roles:
    - **Autonomic Control Center**
    - **Center for Emotional Response**
    - **Body Temperature Regulation**
    - **Regulation of Food Intake**
    - **Regulation of Water Balance and Thirst**
    - **Regulation of Sleep-Wake Cycles**
    - **Control of Endocrine System Functioning**

Epithalamus

- most dorsal part of the diencephalon
- forms the roof of the third ventricle
- **pineal gland (body)** is located here.
  - secretes the hormone **melatonin**.
  - this helps regulate the **sleep-wake cycle.**

Brain Stem

- composed of:
  - **Midbrain**
  - **Pons**
  - **Medulla Oblongata**
- 10 of the 12 cranial nerves come out of it.

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Inferior View of the Brain & Brain Stem

Figure 12.14
Inferior view of the brain, showing the three parts of the brain stem: midbrain, pons, and medulla oblongata.

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Brain Stem (Left Lateral View)

Figure 12.15
Cross sections through different regions of the brain stem.

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Midbrain

- located between the diencephalon and the pons.
- has a part that looks like two pillars holding up the brain called the **cerebral peduncles.**
- has the **cerebral aqueduct** channel in the middle of it joining the 3rd and 4th ventricles.
  - surrounding the aqueduct is the **periaqueductal gray matter**, that is involved in **pain suppression** and serves as the link for the **fight-flight** response.
- nuclei for the 3rd and 4th cranial nerves are located here.

Pons

- between the midbrain and medulla oblongata.
- behind it is the **4th ventricle**.
- nuclei for many cranial nerves are here:
  - **Trigeminal (CN V)**
  - **Abducens (CN VI)**
  - **Facial (CN VII)**

Medulla Oblongata

- between the pons and the spinal cord
- has at its lowest part a collection of longitudinal fibers called **Pyramids**.
  - the fibers cross from left to right and vice versa, and this crossover point is called the **decussation of the pyramids.**
  - cranial nerve nuclei located here are:
    - **Vestibulocochlear (CN VIII)**
    - **Glossopharyngeal (CN IX)**
    - **Vagus (CN X)**
    - **Accessory (CN XI)**
    - **Hypoglossal (CN XII)**

Medulla Oblongata

- Functions of the Medulla Oblongata are:
  - **Cardiovascular Center**
    - heart rate up and down
  - **Respiratory Center**
    - rate of breathing up and down
  - **Vomiting**
  - **Hiccuping**
  - **Swallowing**
  - **Sneezing**
  - **Coughing**

Cerebellum

- means “small brain”
- is behind the pons and medulla
- is below the **transverse cerebral fissure**
- provides:
  - precise timing and appropriate patterns of skeletal muscle contraction for **smooth, coordinated movements**.
    - ex: driving, typing, sports, etc...
- all of its functions are **subconscious.**

Cerebellum

Figure 12.16
Cerebellum.

Limbic System

- It is our system for **emotional** or **affective feelings**.
  - helps you **recognize facial emotions**.
  - helps you **assess danger.**
  - elicits the **fear response.**
- some people can unfortunately connect with an emotion and induce and illness:
  - **psychosomatic illnesses.**

Limbic System

Figure 12.17
The Limbic System.

The Reticular Formation

- extends through the core of the medulla oblongata, pons, and midbrain.
  - certain reticular neurons, unless inhibited by other brain areas, send a continuous stream of impulses to the cerebral cortex, which keeps the cortex alert and conscious and enhances its excitability.
    - this is the **Reticular Activating System**
    - this can filter out familiar or weak signals so you can focus on new things.
    - this is why you can study with the TV on or in the Cafeteria and **ignore the background noise**.

The Reticular Formation

Figure 12.18
The Reticular Formation.

Meninges

- from external to internal the layers are:
  - **Dura Mater**
    - has partitions that subdivide the cranial cavity
      - **Falx Cerebri** (between the right and left hemispheres)
      - **Falx Cerebelli** (between the right and left cerebellum)
      - **Tentorium Cerebelli** (separates the cerebrum and cerebellum)
  - **Arachnoid Mater**
    - between the dura and the arachnoid mater is a small space filled with serous fluid called the **subdural space**.
    - between the arachnoid mater and pia mater is the **subarachnoid space.** It is filled with **CSF.**
  - **Pia Mater**
    - is directly attached to the brain.

Meninges

Figure 12.22
Meninges: dura mater, arachnoid mater, and pia mater.

Dural Septa & Dural Venous Sinuses

Figure 12.23
Dural septa and dural venous sinuses.

Cerebrospinal fluid

- CSF is found in and around the spinal cord and brain.
  - cushions and protects the brain & spinal cord.
  - the **choroid plexus** (found in the roof of each ventricle) is a bunch of capillaries where the CSF is released (as an ultrafiltrate of plasma)
  - total volume is about 150 ml
  - it is constantly being formed and reabsorbed
  - it is replaced every 8 hours
  - about 500 ml is formed every day.

CSF Circulation

Figure 12.24a
Formation, location, and circulation of CSF.

CSF Formation by Choroid Plexus

Figure 12.24b
Formation, location, and circulation of CSF.

Hydrocephalus (CSF Accumulation)

Figure 12.25
Hydrocephalus in a newborn.

Spinal Cord

- protected by the **spinal dura mater** and the CSF.
  - a potential **epidural space** is exterior to the spinal dura mater.
- a spinal cord tip ends at about L_1 or L_2.
  - this cone shaped end is the **conus medullaris**
  - a bunch of sacral nerve fibers come out of it like a horse's tail called the **cauda equina.**
    - this is the best area to do a **lumbar spinal tap** to collect a sample of CSF.

Lumbar Tap

Figure 12.28
Diagram of a lumbar puncture.

Spinal Cord Cross-Sectional Anatomy

- the gray matter of the spinal cord looks like the letter *"H"* or like a *"butterfly"*.
- in the center of the cord is the **central canal**.
- gray mater of the spinal cord:
  - two posterior projections are the **dorsal horns.**
    - **afferent fibers bring info into the spinal cord here.**
    - **a dorsal root ganglion is part of the entering nerve.**
    - example: nerve fiber stretched by reflex hammer.
  - two anterior projections are the **ventral horns.**
    - **efferent fibers project info out of the spinal cord.**
    - example: muscle is stimulated by nerve to contract.

Spinal Cord Cross-Sectional Anatomy

Figure 12.29a
Anatomy of the spinal cord.

Spinal Cord Cross-Sectional Anatomy

Figure 12.29b
Anatomy of the spinal cord.

Organization of the Gray Matter of the Spinal Cord

Figure 12.30
Organization of the gray matter of the spinal cord.

Lumbar Myelomeningocele

Figure 12.36
Newborn with a lumbar myelomeningocele.