The Central Nervous System

Chapter 12

CNS Basic Design (Fig. 12.4)
- Central cavity surrounded by gray matter surrounded by white matter (myelinated fiber tracts)
  - Cerebrum and cerebellum also have external layer of gray matter cortex (neuron cell bodies)

Organization
- There are four principle parts of the brain
  - Cerebral hemispheres
  - Diencephalon
    - Thalamus
    - Hypothalamus
  - Brain stem
    - Midbrain
    - Pons
    - Medulla
  - Cerebellum

Ventricles (Fig. 12.5)

The Cerebrum: Highly Convoluted
- Divided into right and left hemispheres
- Highly convoluted
  - Gyri – elevated ridges (singular gyrus)
  - Sulci – shallow grooves (singular sulcus)
  - Fissures – deeper grooves separating large regions of brain

Cerebrum: Fissures
- Longitudinal fissure – separates cerebral hemispheres (Fig. 12.6b)
- Transverse cerebral fissure – separates the cerebral hemispheres from cerebellum below (Fig. 12.6a)
Cerebrum: Lobes
- Some sulci divide each hemisphere into five lobes (Fig. 12.6a)
  - Frontal
  - Parietal
  - Temporal
  - Occipital
  - Insula
- All except last are named for cranial bones overlying them

Cerebrum: Frontal Lobes
- Central sulcus – divides frontal & parietal lobes
- Involved in learning, reason, logic, concentration, social behavior, skeletal muscle contraction (Precentral gyrus)

Cerebrum: Parietal Lobes
- Involved in…
  - Speech
  - Expression of thoughts & feelings
  - Use of words
  - Reception and recognition of sensation impulses (Postcentral gyrus)

Cerebrum: Temporal Lobes
- Outlined by lateral sulcus
- Involved in…
  - Hearing
  - Interpretation of sound as speech, music, noise, etc.
  - Translation of words into thoughts

Cerebrum: Occipital Lobes
- Involved in sight and visual recognition of objects

Cerebrum: Insula
- Buried deep within the lateral sulcus
- Associated with visceral functions and integrating autonomic information
Cerebral Cortex (Gray Matter)
• Location of conscious mind, awareness
• Executive suite of nervous system
• Consists of gray matter composed of
  – Neuron cell bodies
  – Dendrites
  – Unmyelinated axons
  – Associated glial cells and blood vessels
  – No fiber tracts

Functional Areas of Cortex
• Three functional classifications
  – Motor Areas – control voluntary movement
  – Sensory Areas – concerned with conscious awareness of sensation
  – Association Areas – communicate (associate) with motor cortex and other sensory association areas to analyze and act on sensory inputs and experience; complex

Functional & Structural Areas of Cerebral Cortex Fig. 12.8:
Motor Areas
• Primary Motor Cortex
  – Each area of body represented spatially on PMC Fig. 12.9
  – Contralateral – left PMC controls muscles on right side and vice versa

Broca’s Area
• Directs muscles involved in speech production and involved in thinking about speaking
• Present in one hemisphere only (usually left)

Functional & Structural Areas of Cerebral Cortex Fig. 12.8:
Sensory Areas
• Primary Somatosensory Cortex
  – Receives sensory information from skin and skeletal muscles
  – Face and fingertip sensations have most space devoted to them in this region

Somatosensory Association Cortex
• Integrates sensory inputs
• Produces understanding of sensations size, texture, and relationships of parts
• Damage produces inability to feel an object and tell what it is
Functional & Structural Areas of Cerebral Cortex Fig. 12.8: Sensory Areas

- Wernicke’s Area – language interpretation
  - understanding written & spoken language; phonetics

Brain Lateralization

- Each hemisphere unique
- Left hemisphere – language, math, logic
- Right hemisphere - visual-spatial skills, intuition, emotion, artistic and musical abilities
- Most people who are left dominant are right handed and vice versa.
  - Most left handed people, right dominant, are males

Cerebral White Matter Fig. 12.10

- Responsible for communication between cerebral areas and between the cerebral cortex and lower CNS
- Consists of myelinated fibers bundled into large tracts.
- Tracts are either commissural, association, or projection

Cerebral White Matter

- Commissures
  - Conduct impulses between the two hemispheres
  - Corpus callosum – largest commissure
- Association
  - Conduct impulses to different parts of same hemisphere
- Projection
  - Form ascending and descending tracts with lower parts of nervous system and with receptors and effectors

Diencephalon

- Core of forebrain
- Surrounded by cerebral hemispheres
- Consists of thalamus & hypothalamus
  - Gray matter areas enclosing the third ventricle (Fig. 12.12)

Diencephalon: Thalamus

- Contains two masses of gray matter (about 12 nuclei) held together by Intermediate Mass
- Central relay station for all sensory information (except smell)
  - Channels sensory information to appropriate area for interpretation
- Gives us awareness of pain, touch, temperature
- Plays key role in mediating sensation, motor activities, cortical arousal, learning, and memory
Diencephalon: Hypothalamus

- Inferior/anterior to thalamus
- Maintaining homeostasis by serving as...
  - Autonomic control center
    - Heart rate, blood pressure, breathing, etc.
  - 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

Brain Stem: Midbrain

- Located between diencephalon and pons Fig. 12.14 and 12.15
- Cerebral peduncles – two bulging “feet” on ventral surface
  - Contain the large pyramidal motor tracts descending toward spinal cord
- Corpora quadrigemina – four rounded bodies in dorsal portion of midbrain Fig. 12.12 and 12.15
  - Serve as visual reflex centers coordinating head and eye movements in visual tracking and in startle reflex

Brain Stem: Pons

- Bridge wedged between midbrain and medulla oblongata Fig. 12.12, 12.14, and 12.15
- Longitudinal fibers relay information between medulla and upper CNS
- Transverse fibers connect cerebrum to cerebellum
- Three cranial nerve emerge from pons nuclei
  - Trigeminal
  - Abducent
  - Facial

Brain Stem: Medulla Oblongata

- Blends into spinal cord at level of Foramen Magnum
  - Spinal central canal extends up into medulla where it broadens to form fourth ventricle
- Pyramids – two ridges formed by pyramidal tracts descending from motor cortex, Fig. 12.16c
  - Decussation of the pyramids – cross-over point of pyramidal tracts
  - Responsible for contralateralization
- Cranial Nerves Emerging from Medulla
  - Hypoglossal
  - Glossopharyngeal
  - Vagus
  - Portions of Accessory

Brain Stem: Medulla Oblongata

- Autonomic Reflex Center
  - Carries out functions of homeostasis directed to it by hypothalamus
- Visceral control centers found in medulla include...
  - Cardiac center
    - Force and rate of heart contractions
  - Vasomotor Center
    - Blood vessel diameter (blood pressure)
  - Respiratory Centers
    - Breathing rate and depth
  - Vomiting, hiccupping, swallowing, coughing, sneezing
Cerebellum

- Large, cauliflower-like structure located beneath occipital lobe of cerebrum
- Separated from cerebrum by transverse cerebral fissure Fig. 12.6a
- Subconscious timing and agility of skeletal muscle movement
- Cerebral peduncles connect cerebellum to brain stem Fig. 12.15
- Not contralateral (ipsilateral = same)
- No direct connections with cerebral cortex

Functional Brain Systems

- Limbic System
  - Area of gray matter in cerebral hemispheres and diencephalon
  - Functions in emotional behavior – fear, motivation, pleasure, rage, sorrow, docility
  - Recognizes changes in person’s physical or psychological condition that might threaten survival
  - Guides behavior to increase survival
- Reticular Formation
  - Central core of medulla, pons, and midbrain Fig. 12.19
  - Governs arousal of brain as a whole; consciousness

Protection of Brain

- Bone
- Membranes (meninges)
- Water cushion (cerebrospinal fluid)
- Blood-brain barrier (protects against harmful substances in the blood)

Protection of Brain: Meninges

- Three connective tissue membranes encircling brain and spinal cord
  - Dura mater
    - Outer covering
      - Forms sacs around spinal cord
  - Arachnoid
    - Middle, thin, web-like layer
      - Made up of collagen and elastin fibers
      - Separated from dura mater by subdural space
  - Pia mater
    - Transparent, innermost layer; adheres tightly to brain
      - Contains many small blood vessels (vascular membrane)
      - Separated from arachnoid by subarachnoid space
- All contain cerebrospinal fluid (CSF)

Meningitis

- Inflammation of meninges
- Bacterial or viral
- Dangerous because can spread to CNS leading to encephalitis
- Diagnosis: withdraw CSF from subarachnoid space and examine for microbes

Protection of Brain: CSF

- Water broth similar to plasma
- Synthesized by choroid plexuses Fig. 12.25a
  - Thin walled capillaries enclosed by pia mater (1st layer) and then ependymal cells (2nd)
  - Filter CSF of waste products
- Once produced, CSF moves freely through ventricles
  - Cilia of ependymal cells lining ventricles helps drive flow of CSF
Protection of Brain: Blood Brain Barrier

- Maintains stable brain environment
- Created by...
  - Reduced leakiness of brain capillaries
  - Selective action of astrocytes (glial cells)
- Selective rather than absolute
  - Glucose, amino acids, some electrolytes enter through facilitated diffusion
  - Blood-borne metabolic wastes, toxins, most drugs are denied entry
  - Ineffective against most fats, fatty acids, oxygen, carbon dioxide, blood-borne alcohol, nicotine, anesthetics

Spinal Cord

- Located in dorsal body cavity
- Surrounded by vertebral column
- Extends from foramen magnum to first or second lumbar vertebra (about 17” x ¾”)

Spinal Cord: Functions

- Two way conduction pathway to and from brain
- Major reflex center

Spinal Cord: Neural Tissue

- Two categories
  - Gray matter
    - Contains cell bodies of neurons and non-myelinated fibers (dendrites and proximal ends of axons)
  - White matter
    - Composed of myelinated nerve fibers (axons) and contains NO cell bodies

Spinal Cord: Coverings

- Spinal Column
  - Hard, protective covering for spinal cord
  - Vertebral foramina stack on top of each other creating spinal canal for cord
- Meninges
  - Three connective tissue membranes encircling brain and spinal cord; contain CSF

Spinal Cord Anatomy

- Cylindrical
- At 1st or 2nd lumbar vertebra, tapers into a cone called the Conus Medullaris
- Extending inferiorly from the conus medullaris to the coccyx are the
  - Cauda equina — collection of spinal nerves shaped like a horse’s tail
  - Filum Terminale — fibrous, threadlike extension of pia mater
Spinal Cord Anatomy

- Two obvious, enlarged regions in spinal cord
  - Cervical enlargement
    - Houses nerves of the arms
  - Lumbar enlargement
    - Houses nerves of the legs

Internal Spinal Cord Anatomy

- Cross Section p. 472
- Inner gray matter is "H" or butterfly shaped
  - Arms of H or wings of butterfly are called horns
- White matter surrounds
- Central canal is at center of gray matter
  - Extends full length of cord
  - Continuous with fourth ventricle of brain

Spinal Cord Anatomy: Horns

- **Anterior horns** – located in front portion of cord
- **Posterior horns** – located closer to back
- Horns divide white matter into distinct areas
- Each of these areas contains distinct bundles of fibers called **Tracts**
  - **Ascending tracts**
    - Sensory axons
    - Extend up to brain
  - **Descending tracts**
    - Motor axons
    - Descend down through spinal cord to muscles and glands

Spinal Cord Trauma: Paralysis

- Paralysis – loss of motor function
- Flaccid paralysis – severe damage to the ventral root or anterior horn cells
  - Lower motor neurons are damaged and impulses do not reach muscles
  - There is no voluntary or involuntary control of muscles
- Spastic paralysis – only upper motor neurons of the primary motor cortex are damaged
  - Spinal neurons remain intact and muscles are stimulated irregularly
  - There is no voluntary control of muscles
Spinal Cord Trauma: Transection
- Cross sectioning of the spinal cord at any level results in total motor and sensory loss in regions inferior to the cut
- Paraplegia – transection between T1 and L1
- Quadriplegia – transection in the cervical region

Poliomyelitis
- Destruction of the anterior horn motor neurons by the poliovirus
- Early symptoms – fever, headache, muscle pain and weakness, and loss of somatic reflexes
- Vaccines are available and can prevent infection

Amyotrophic Lateral Sclerosis (ALS)
- Lou Gehrig’s disease – neuromuscular condition involving destruction of anterior horn motor neurons and fibers of the pyramidal tract
- Symptoms – loss of the ability to speak, swallow, and breathe
- Death occurs within five years

Spina bifida
- Spina bifida (SB) is a neural tube defect (a disorder involving incomplete development of the brain, spinal cord, and/or their protective coverings) caused by the failure of the fetus's spine to close properly during the first month of pregnancy.