An Introduction to the Brain and Cranial Nerves

• Learning Objectives
  • List the main components of the cerebellum and specify the functions of each.
  • List the main components of the midbrain and specify the functions of each.
  • List the main components of the diencephalon and specify the functions of each.
  • Identify the major anatomical subdivisions and functions of the cerebrum, and discuss the origin and significance of the major types of brain waves seen in an electroencephalogram
  • Name the 12 cranial nerves and describe the functions of each
An Introduction to the Brain and Cranial Nerves

- The Adult Human Brain
  - Ranges from 750 cc to 2100 cc
  - Contains almost 97% of the body’s neural tissue
  - Average weight about 1.4 kg (3 lb)

- Six Regions of the Brain
  1. Cerebrum
  2. Cerebellum
  3. Diencephalon
  4. Mesencephalon
  5. Pons
  6. Medulla oblongata
14-1 The Brain

- **Cerebrum**
  - Largest part of brain
  - Controls higher mental functions
  - Divided into left and right cerebral hemispheres
  - Surface layer of gray matter (neural cortex)

- **Neural cortex**
  - Also called cerebral cortex
  - Folded surface increases surface area
  - Elevated ridges (gyri)
  - Shallow depressions (sulci)
  - Deep grooves (fissures)
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- **Cerebellum**
  - Second largest part of brain
  - Coordinates repetitive body movements
  - Two hemispheres
  - Covered with *cerebellar cortex*
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- **Diencephalon**
  - Located under cerebrum and cerebellum
  - Links cerebrum with **brain stem**
  - Divisions of the diencephalon
    - **Thalamus (left & right)**
      - major relay center for sensory information
    - **Hypothalamus**
      - part of emotion center
      - hormone production (endocrine system)
      - control center for autonomic function
  - **Pituitary gland**
    - Major endocrine gland
    - Connected to hypothalamus
    - Via **infundibulum** (stalk)
    - Interfaces nervous and endocrine systems
14-1 The Brain

- **Midbrain**
  - Also called *mesencephalon*
  - Processes sight, sound, and associated reflexes
  - Maintains consciousness

- **Pons**
  - Connects cerebellum to brain stem
  - Is involved in somatic and visceral motor control

- **Medulla Oblongata**
  - Connects brain to spinal cord
  - Relays information
  - Regulates autonomic functions
    - Heart rate, blood pressure, and digestion
14-1 The Brain: Ventricles

- Ventricles of the Brain
  - Each cerebral hemisphere contains one large lateral ventricle
  - Separated by a thin medial partition (septum pellucidum)

- Third ventricle
  - Ventricle of the diencephalon
  - Lateral ventricles communicate with third ventricle
  - Via interventricular foramen (foramen of Monro)

- Fourth ventricle
  - Extends into medulla oblongata
  - Becomes continuous with central canal of the spinal cord
  - Connects with third ventricle
    - Via narrow canal in midbrain called the cerebral aqueduct
14-5 The Cerebellum

- Functions of the Cerebellum
  1. Adjusts postural muscles
  2. Fine-tunes conscious and subconscious movements

CEREBELLUM
- Coordinates complex somatic motor patterns
- Adjusts output of other somatic motor centers in brain and spinal cord
14-5 The Cerebellum

- Structures of the Cerebellum
  - Folia
    - Surface of cerebellum
    - Highly folded neural cortex
  - Anterior and posterior lobes
    - Separated by primary fissure
  - Cerebellar hemispheres
    - Separated at midline by vermis
14-5 The Cerebellum

- Structures of the Cerebellum
  - Vermis
    - Narrow band of cortex
  - Flocculonodular lobe
    - Below fourth ventricle
14-5 The Cerebellum

- Structures of the Cerebellum
  - **Purkinje cells**
    - Large, branched cells
    - Found in cerebellar cortex
    - Receive input from up to 200,000 synapses
  - **Arbor vitae** ("tree of life")
    - Highly branched, internal white matter of cerebellum
    - Cerebellar nuclei embedded in arbor vitae
      - Relay information to **Purkinje cells**

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- Structures of the Cerebellum
  - The peduncles
    - Tracts link cerebellum with brain stem, cerebrum, and spinal cord
      - Superior cerebellar peduncles
      - Middle cerebellar peduncles
      - Inferior cerebellar peduncles
14-5 The Cerebellum

- Disorders of the Cerebellum
  - Ataxias (cerebellar degeneration)
    - Causes include:
      - hereditary factors or from
      - damage (due to trauma or stroke)
      - viral infection (chicken pox)
      - tumors
      - Intoxication (temporary impairment)
    - Disturbs muscle coordination
      - impairs speech/makes swallowing difficult
      - affects gait (walking)
      - affects fine-motor tasks
      - caused involuntary back and forth eye movements (nystagmus)
14-7 The Diencephalon

- The Thalamus
  - Filters ascending sensory information for primary sensory cortex
  - Relays information between basal nuclei and cerebral cortex
  - Structurally there are two: **left thalamus** and **right thalamus**

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14-7 The Diencephalon

• The Thalamus
  • Five Groups of Thalamic nuclei
    • Are rounded masses that form thalamus
    • Relay sensory information to basal nuclei and cerebral cortex
  1. Anterior group (part of limbic system: emotions)
  2. Medial group (awareness and emotional states)
  3. Ventral group (relay sensory info)
  4. Posterior group (sensory: visual/auditory info)
  5. Lateral group (affects emotional states/integrates sensory info)

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- The Hypothalamus
  - Mamillary bodies
    - Process olfactory and other sensory information
    - Control reflex eating movements
  - Infundibulum
    - A narrow stalk
    - Connects hypothalamus to pituitary gland
14-7 The Diencephalon

**Eight Functions of the Hypothalamus**

1. **Provides subconscious control of skeletal muscle**
2. **Controls autonomic function**
3. **Coordinates activities of nervous and endocrine systems**
4. **Secretes hormones**
   - Antidiuretic hormone (ADH) by **supraoptic nucleus**
   - Oxytocin (OT; OXT) by **paraventricular nucleus**
5. **Produces emotions and behavioral **drives**
   - The **feeding center** (hunger)
   - The **thirst center** (thirst)
6. **Coordinates voluntary and autonomic functions**
7. **Regulates body temperature**
   - **Preoptic area** of hypothalamus
8. **Controls circadian rhythms (day–night cycles)**
   - **Suprachiasmatic nucleus**
14-8 The Limbic System

- **The Limbic “System”**
  - Is a functional “grouping” that:
    - Establishes emotional states
    - Links conscious functions of cerebral cortex with autonomic functions of brain stem
    - Facilitates memory storage and retrieval

- **Components of the Limbic System includes**
  - Amygdaloid body “amygdala”
  - Limbic lobe of cerebral hemisphere
    - Cingulate gyrus
    - Dentate gyrus
    - Parahippocampal gyrus
    - Hippocampus
    - Parts of the anterior thalamus
    - Reticular formation

![A three-dimensional reconstruction of the limbic system, showing the relationships among the major components.](image-url)
14-9 The Cerebrum

• The Cerebrum
  • Is the largest part of the brain
  • Controls all conscious thoughts and intellectual functions
  • Processes somatic sensory and motor information

• Structurally it is comprised of
  • Gray Matter - *cerebral cortex, basal nuclei*
  • White Matter – *deep to cortex, surrounds basal nuclei*
14-9 The Cerebrum

- **Structures of the Cerebrum**
  - **Gyri** of neural cortex (increase surface area)
  - **Longitudinal fissure** – *separate left and right cerebral hemispheres*
  - **Lobes** – *divisions of cerebral hemispheres (frontal, parietal, temporal, occipital)*
  - **Sulci (sulcus singular)** – *deep fissures which separate lobes*
    - **Central sulcus** divides: *frontal from parietal lobe*
    - **Lateral sulcus** divides: *frontal from temporal lobe*
    - **Parieto-occipital sulcus** divides: *parietal from occipital lobe*
14-9 The Cerebrum: Inter and Intra-hemispheric communication

- White Matter of the Cerebrum – communication within and between cerebral hemispheres is mediated by a variety of fibers including:
  - **Association fibers** - Connections within one hemisphere
    - Arcuate fibers, longitudinal fasciculi
  - **Commissural fibers** - Bands of fibers connecting the two hemispheres
    - Corpus callosum, anterior commissure
  - **Projection fibers** - Connect cerebrum with lower areas
    - Internal capsule
14-9 The Cerebrum

- Functionally the Cerebrum (cerebral cortex) can be divided into areas devoted to motor control, sensory processing and association areas.

- Motor and Sensory Areas of the Cortex
  - Central sulcus divides motor from sensory areas
14-9 The Cerebrum

- **Motor areas**
  - **Precentral gyrus** (frontal lobe) - *Directs voluntary movements, contains the primary motor cortex*

- **Sensory areas**
  - **Postcentral gyrus** (parietal lobe) - *Receives somatic sensory information (touch, pressure, pain, vibration, taste, and temperature)*
  - Contains Primary sensory (somatosensory) cortex
Within different lobes of the cerebrum, there are discreet areas specialized for different sensory “modalities”. They include:

- **Visual cortex** (occipital lobe) – *processing visual information*
- **Auditory cortex** (temporal lobe) – *processing sound*
- **Olfactory cortex** (temporal lobe) – *processing smell*
- **Gustatory cortex** (frontal lobe) – *processing taste*
14-9 The Cerebrum

- In addition to the sensory and motor areas, there are a series of association “integrative” areas devoted to

- **Association Areas**
  - **Sensory association areas**
    - Monitor and interpret arriving information at sensory areas of cortex

  - Somatic sensory association area
    - Somatic sensory association area - interprets input to primary sensory cortex (e.g., recognizes and responds to touch)

  - Somatic motor association area (premotor cortex)
    - Somatic motor association area (premotor cortex) - coordinates motor responses (learned movements)

  - Visual association area
    - Visual association area - interprets activity in visual cortex

  - Auditory association area
    - Auditory association area - monitors auditory cortex

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14-9 The Cerebrum

- **Integrative Centers**
  - Are located in lobes and cortical areas of both cerebral hemispheres
  - Receive information from association areas
  - Direct complex motor or analytical activities

- **Speech center**
  - Is associated with general interpretive area
  - Coordinates all vocalization functions

- **Prefrontal cortex of frontal lobe**
  - Integrates information from sensory association areas
  - Performs abstract intellectual activities (e.g., predicting consequences of actions)

- **General Interpretive Area (Wernicke’s area)**
  - Present in only one hemisphere (usually left)
  - Receives information from all sensory association areas
  - Coordinates access to complex visual and auditory memories

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14-9 The Cerebrum

- *Hemispheric Lateralization*
  - Functional differences between left and right hemispheres
  - Each cerebral hemisphere performs certain functions that are not ordinarily performed by the opposite hemisphere
14-9 The Cerebrum

The Left Hemisphere

- In most people, left brain (*dominant hemisphere*) controls:
  - Reading, writing, and math
  - Decision making
  - Speech and language

The Right Hemisphere

- Right cerebral hemisphere relates to:
  - Senses (touch, smell, sight, taste, feel)
  - Recognition (faces, voice inflections)
14-9 The Cerebrum

- Monitoring Brain Activity
  - Brain activity is assessed by an electroencephalogram (EEG)
    - Electrodes are placed on the skull
    - Patterns of electrical activity (brain waves) are printed out

- Four Categories of Brain Waves
  1. **Alpha waves** - Found in healthy, awake adults at rest with eyes closed
  2. **Beta waves** - Higher frequency waves; found in adults concentrating or mentally stressed
  3. **Theta waves** - Found in children; also in intensely frustrated adults; can be indicator for brain disorders
  4. **Delta waves** - Present during certain phases of sleep
14-10 Cranial Nerves

- Cranial Nerves

- 12 pairs connected to brain

- Four Classifications of Cranial Nerves

1. Sensory nerves - carry somatic sensory information, including touch, pressure, vibration, temperature, and pain
2. Special sensory nerves - carry sensations such as smell, sight, hearing, balance
3. Motor nerves: - axons of somatic motor neurons
4. Mixed nerves: - mixture of motor and sensory fibers
14-10 Cranial Nerves

- **Olfactory Nerves (I)**
  - Primary function:
    - Special sensory (smell)
14-10 Cranial Nerves

- **Optic Nerves (II)**
  - *Primary function*: Special sensory (vision)
  - *Origin*: Retina of eye
14-10 Cranial Nerves

- **Oculomotor Nerves (III)**
  - *Primary function:* Motor (eye movements – extrinsic and intrinsic muscles)

- **Trochlear Nerves (IV)**
  - *Primary function:* Motor (eye movements – superior oblique muscle)
14-10 Cranial Nerves

- **Trigeminal Nerves (V)**
  - *Primary function* - Mixed (sensory and motor) to face
  - 2 sensory branches *maxillary branch & mandibular* – receive information from eyelids, mouth (upper lip, gums, teeth, palate), cheeks
  - 1 motor branch *mandibular* – muscles of mastication

- **Abducens Nerves (VI)**
  - *Primary function* - Motor (eye movements – lateral rectus muscles)
14-10 Cranial Nerves

• **Facial Nerves (VII)**
  - *Primary function* - Mixed (sensory and motor) to face
    - *Sensory* - Taste receptors on anterior 2/3 of tongue
    - *Motor (somatic and visceral)* – *Somatic* - muscles of facial expression; visceral – tear & salivary gland secretions

• **The Vestibulocochlear Nerves (VIII)**
  - *Primary function* - special senses (hearing, balance and equilibrium)
    - Vestibular branch - Balance and equilibrium
    - Cochlear branch - Hearing
14-10 Cranial Nerves

- Glossopharyngeal Nerves (IX)
  
  **Primary function:**
  
  - **Mixed** (sensory and motor) to head and neck
  - **Sensory** – anterior 1/3 of tongue, pharynx, palate, carotid arteries
  - **Motor** – nerves involved swallowing; parotid salivary glands

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14-10 Cranial Nerves

The **Vagus Nerves (X)**

- **Primary function** - Mixed (sensory and motor)
  - Widely distributed in thorax and abdomen
- **Sensory**
  - Sensory nuclei and autonomic centers of medulla oblongata *(major output of parasympathetic branch of ANS)*
- **Visceral motor**
  - Muscles of the palate and pharynx
  - Muscles of the digestive, respiratory, and cardiovascular systems in thoracic and abdominal cavities
14-10 Cranial Nerves

- **The Accessory Nerves (XI)**
  - *Primary function* - Motor to muscles of neck and upper back
    - *Internal branch* - voluntary muscles of palate, pharynx, and larynx
    - *External branch* - sternocleidomastoid and trapezius muscles
- **The Hypoglossal Nerves (XII)**
  - *Primary function* - Motor (tongue movements)
    - Controls muscles of the tongue