16

The Nervous System: The Brain and Cranial Nerves
Introduction

• The brain is a complex three-dimensional structure that performs many functions
  • Think of the brain as an organic computer
  • However, the brain is far more versatile than a computer
  • The brain is far more complex than the spinal cord
  • The brain consists of roughly 20 billion neurons
Protection and Support of the Brain

• Protection involves:
  • **Bones of the skull**
    • Parietal, frontal, occipital, and temporal bones
  • **Cranial meninges**
    • Dura mater, arachnoid mater, and pia mater
  • **Cerebrospinal fluid**
    • Provides protection of the brain and spinal cord
    • Provides support
    • Transports nutrients to the CNS tissue
    • Transports waste away from the CNS
  • **Blood–brain barrier**
    • Maintains a constant environment, necessary for both control and proper functioning of CNS neurons
Figure 16.3a Relationships among the Brain, Cranium, and Meninges

Lateral view of the brain showing its position in the cranium and the organization of the meningeal coverings.
Figure 16.4 The Cranial Meninges, Part I

ANTERIOR

- Cranium
- Dura mater
- Subarachnoid space
- Arachnoid mater
- Cerebral cortex covered by pia mater

POSTERIOR

- Loose connective tissue and periosteum of cranium
- Epicranial aponeurosis
- Scalp

© 2012 Pearson Education, Inc.
Protection and Support of the Brain

• The Ventricles of the Brain
  • Ventricles are fluid-filled cavities
    • Filled with cerebrospinal fluid (CSF)
    • Fluid transports nutrients to the CNS and transports waste away from the CNS
  • CSF also provides protection
Protection and Support of the Brain

- **Circulation of CSF**
  - **Choroid plexus produces CSF**
  - **Lateral ventricles** communicate with the third ventricle through the **interventricular foramen**
  - Third ventricle communicates with the fourth ventricle through the **aqueduct of the midbrain**
  - Fourth ventricle communicates with the central canal of the spinal cord; Most of the CSF enters the subarachnoid space by passing through lateral apertures and a median aperture
Protection and Support of the Brain

• Blood–Brain Barrier
  • The lining of the blood vessels consists of endothelial cells that are highly interconnected by tight junctions
    • Due to this tight connection, only lipid-soluble material can pass from the blood to the cells of the brain and spinal cord
    • Water-soluble material can only pass via the action of transport mechanisms
    • The transport mechanisms are very specific
a. The location of the choroid plexus in each of the four ventricles of the brain.

b. The structure and function of the choroid plexus. The ependymal cells are a selective barrier, actively transporting nutrients, vitamins, and ions into the CSF. When necessary, these cells also actively remove ions or compounds from the CSF to stabilize its composition.
Hydrocephalus: This infant has severe hydrocephalus, a condition usually caused by impaired circulation and removal of cerebrospinal fluid. CSF buildup leads to distortion of the brain and enlargement of the cranium.
An Introduction to the Organization of the Brain

**CEREBRUM**
- Conscious thought processes, intellectual functions
- Memory storage and processing
- Conscious and subconscious regulation of skeletal muscle contractions

**CEREBELLMUM**
- Coordinates complex somatic motor patterns
- Adjusts output of other somatic motor centers in brain and spinal cord
The Cerebrum

- **Cerebrum** consists of:
  - Two hemispheres
  - Four lobes
  - Gyri and sulci
  - Conscious thought processes
  - Memory storage
  - Conscious regulation of skeletal muscle contractions
The Cerebral Lobes

- **Frontal lobe**: conscious control of skeletal muscles
- **Occipital lobe**: perception of visual stimuli
- **Parietal lobe**: conscious perception of touch, pressure, vibration, pain, temperature, and taste
- **Temporal lobe**: conscious perception of auditory and olfactory stimuli
The Cerebrum

- **Precentral gyrus = primary motor cortex**
  - Anterior to the central sulcus*
  - Neurons direct voluntary movements

- **Postcentral gyrus = primary sensory cortex**
  - Posterior to the central sulcus*
  - Neurons receive somatic sensory information for touch, pressure, pain, taste, and temperature
The Cerebrum

• Association areas
  • **Ex. Somatic motor/sensory association area**
  • Control our ability to understand sensory information and help coordinate motor output
  • “Higher-order” integrative centers receive information from many different association areas and direct complex motor activities and analytical functions.
The Cerebrum

• Each hemisphere receives sensory information from and generates motor commands to the opposite side of the body

• Hemispheric Specialization
  • **Left hemisphere = logical**
    • Speech center, writing, language, mathematics
  • **Right hemisphere = artistic**
    • Analysis by touch, spatial visualization
Figure 16.13a Sectional Views of the Brain

- Precentral gyrus
- Central sulcus
- Postcentral gyrus
- Corpus callosum
- Septum pellucidum
- Interventricular foramen
- Frontal lobe
- Anterior commissure
- Optic chiasm
- Mamillary body
- Temporal lobe
- Mesencephalon
- Pons
- Cingulate gyrus
- Fornix
- Thalamus
- Membranous portion of epithalamus
- Hypothalamus
- Pineal gland
- Parieto-occipital sulcus
- Superior colliculus
- Inferior colliculus
- Corpora quadrigemina
- Aqueduct of midbrain
- Fourth ventricle
- Cerebellum
- Medulla oblongata

A sagittal section through the brain
The Diencephalon

- The diencephalon consists of:
  - Epithalamus
  - Thalamus
  - Hypothalamus
The Diencephalon

• The **epithalamus**
  - Contains the **pineal gland**
    - Produces the hormone melatonin
    - Regulates our day/night cycles

• The **thalamus**
  - Relays information to the cerebrum
  - Processes sensory information
  - Coordinates voluntary and involuntary somatic motor activities
The Diencephalon

• The **hypothalamus**
  • Involved in emotions, thirst, some habitual activity
  • Consists of numerous nuclei
  • Consists of an **infundibulum**, which connects to the pituitary gland
  • Consists of the **mamillary body** on the posterior wall of the hypothalamus
The Diencephalon

• The hypothalamus (continued)
  • Subconscious control of skeletal muscles
  • Heart rate, blood pressure, respiration, and digestive functions
  • Secretion of antidiuretic hormone and oxytocin
  • Emotional and behavioral drives and thirst drives
  • Coordination between voluntary and autonomic functions
  • Body temperature
  • Circadian rhythm
Midsagittal section through the brain. This view shows the major features of the diencephalon and adjacent portions of the brain stem.
The Mesencephalon

- Mesencephalon (also called the midbrain)
  - Consists of two pairs of nuclei collectively called **corpora quadrigemina**
  - Responsible for processing auditory **(inferior colliculus)** and visual stimuli **(superior colliculus)**
  - Maintains consciousness and alertness
The Pons

- **Pons** consists of
  - Sensory and motor nuclei for cranial nerves:
  - Nuclei involved with involuntary control of breathing
  - Nuclei that relay cerebellar commands:
    - Consist of **cerebellar peduncles**
  - Ascending, descending, and transverse tracts
  - Relays information to the thalamus and cerebellum
  - Regulates subconscious somatic and visceral motor centers
An Introduction to the Organization of the Brain

- **Medulla oblongata**
  - Contains sensory and motor nuclei of cranial nerves
  - Continuous with the spinal cord to the brain stem
  - Relays information to the thalamus and brain stem
  - Regulates visceral function (Cardiovascular centers and respiratory rhythmicity centers)
An Introduction to the Organization of the Brain

- Cerebellum
  - Coordinates somatic motor function
  - Adjusts output of somatic motor centers resulting in smooth operation

Sagittal view of the cerebellum showing the arrangement of gray matter and white matter. Purkinje cells are seen in the photomicrograph; these large neurons are found in the cerebellar cortex.
The Cerebellum

- The cerebellum
  - Cerebellar cortex: subconscious coordination of movements
  - Arbor vitae: connects cerebellar cortex with cerebellar peduncles
  - Cerebellar peduncles
    - Superior
    - Middle
    - Inferior

© 2012 Pearson Education, Inc.
Figure 16.15b The Cerebellum

Sagittal view of the cerebellum showing the arrangement of gray matter and white matter. Purkinje cells are seen in the photomicrograph; these large neurons are found in the cerebellar cortex.
Figure 16.1  Major Divisions of the Brain

CEREBRUM
- Conscious thought processes, intellectual functions
- Memory storage and processing
- Conscious and subconscious regulation of skeletal muscle contractions

DIENCEPHALON
THALAMUS
- Relay and processing centers for sensory information

HYPOTHALAMUS
- Centers controlling emotions, autonomic functions, and hormone production

MESENCEPHALON
- Processing of visual and auditory data
- Generation of reflexive somatic motor responses
- Maintenance of consciousness

PONS
- Relays sensory information to cerebellum and thalamus
- Subconscious somatic and visceral motor centers

MEDULLA OBLONGATA
- Relays sensory information to thalamus and to other portions of the brain stem
- Autonomic centers for regulation of visceral function (cardiovascular, respiratory, and digestive system activities)

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

Spinal cord
Brain stem
Gyri
Sulci
Fissures
Figure 16.17a The Cerebral Hemispheres, Part II

Lateral view of intact brain after removal of the dura mater and arachnoid mater showing superficial surface anatomy of the left hemisphere.

- Precentral gyrus
- Central sulcus
- Lateral sulcus
- Frontoal lobe of left cerebral hemisphere
- Branches of middle cerebral artery emerging from lateral sulcus
- Temporal lobe
- Postcentral gyrus
- Parietal lobe
- Occipital lobe
- Medulla oblongata
- Pons
- Cerebellum
The Cranial Nerves

- There are 12 pairs of cranial nerves
  - These nerves innervate the periphery emerging from the brain (not the spinal cord)
  - These nerves are on the ventral* surface of the brain
  - They are numbered beginning at the anterior aspect of the brain
  - They are numbered CN I to CN XII
Mnemonic: Oh, Once One Takes The Anatomy Final, Very Good Vacations Are Heavenly
The Cranial Nerves
• CN I: The Olfactory Nerve
  • sensory (smell)
The Cranial Nerves

- **CN II: The Optic Nerve**
  - sensory (vision)
The Cranial Nerves

- CN III: The Oculomotor Nerve
  - controls extra-ocular eye muscles
The Cranial Nerves

- CN IV: The Trochlear Nerve
  - controls extra-ocular eye muscles
The Cranial Nerves

- CN V: The Trigeminal Nerve
  - Mixed (sensory and motor) function
    - Sensory function: teeth and gum sensation
    - Motor function: controls mastication muscles
The Cranial Nerves

• CN VI: The Abducens Nerve
  • controls eye movements
The Cranial Nerves

- **CN VII: The Facial Nerve**
  - Mixed (sensory and motor)
    - Sensory: sensations from the face / taste
    - Motor: controls muscles of the face
The Cranial Nerves

• CN VIII: The Vestibulocochlear Nerve
  • Sensory: balance and hearing
The Cranial Nerves

• CN IX: The Glossopharyngeal Nerve
  • Mixed (sensory and motor)
    • Sensory function: tongue pain
    • Motor function: swallowing
The Cranial Nerves

- CN X: The Vagus Nerve
  - Sensory: information from organs
  - Motor: sends information to the organs
The Cranial Nerves

• **CN XI: The Accessory Nerve**
  • Motor: controls the sternocleidomastoid, trapezius, palate, pharynx, and larynx muscles
The Cranial Nerves

- **CN XII: The Hypoglossal Nerve**
  - Motor: controls tongue movement