To run the animations you must be in Slideshow View. Use the buttons on the animation to play, pause, and turn audio/text on or off.

*Please Note:* Once you have used any of the animation functions (such as Play or Pause), you must first click on the slide’s background before you can advance to the next slide.

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes and animations.
Chapter 8 - Nervous System

- Brain
- Spinal cord
- Ganglia
- Nerves to face
- Nerves to upper limb
- Nerves to lower limb

CNS

PNS
Functions

1. Sensory input:
   sensory receptors respond to stimuli

2. Integration:
   brain and spinal cord process stimuli

3. Control of muscles and glands

4. Mental activity:
   brain

5. Homeostasis
Main Divisions of Nervous System

1. Central Nervous System (CNS):
   brain and spinal cord

2. Peripheral Nervous System (PNS):
   all neurons outside CNS
Neuron Characteristics

• Nerve cells

• Require oxygen and glucose

• Receive input, process input, produce a response
Neuron Structures

• Dendrite:
  receives stimulus from other neurons or sensory receptors

• Cell body:
  - processes stimulus
  - contains a nucleus

• Axon:
  transmits stimulus to a gland, muscle, organ, or other neuron
Figure 8.3 Typical Neuron

Structural features of a typical motor neuron in the PNS include a cell body and two types of cell processes: dendrites and an axon.
Myelin Sheath

• What is it?
  - fatty, protective wrapping around axons
  - excellent insulator

• Nodes of Ranvier:
  gaps in myelin sheath where action potentials develop

• Saltatory conduction:
  jumping of action potentials
• Myelinated axons conduct action potentials more quickly (3-15 meters/sec) than unmyelinated due to Nodes of Ranvier.

• **Multiple sclerosis:**
  disease of myelin sheath that causes loss of muscle function
An action potential, depicted as a red band, is propagated in one direction along the axon.
Figure 8.6 Comparison of Myelinated and Unmyelinated Axons
(a) Myelinated axon with two Schwann cells forming part of the myelin sheath around a single axon. Each Schwann cell surrounds part of one axon. (b) Unmyelinated axons with two Schwann cells surrounding several axons in parallel formation. Each Schwann cell surrounds part of several axons.
An action potential (orange part of the membrane) generates local currents that depolarize the membrane immediately adjacent to the action potential.

When depolarization caused by the local currents reaches threshold, a new action potential is produced adjacent to where the original action potential occurred.

The action potential is conducted along the axon cell membrane.
An action potential (orange) at a node of Ranvier generates local currents. The local currents flow to the next node of Ranvier because the myelin sheath of the Schwann cell insulates the axon between nodes.

When the depolarization caused by the local currents reaches threshold at the next node of Ranvier, a new action potential is produced (orange).

Action potential conduction is rapid in myelinated axons because the action potentials are produced at successive nodes of Ranvier (1–5) instead of at every part of the membrane along the axon.
Types of Neurons

• Multipolar:
  - many dendrites and a single axon
  - Ex. CNS and most motor neurons

• Bipolar:
  - one dendrite and one axon
  - Ex. Eye and nasal cavity

• Pseudo-unipolar:
  - one axon and no dendrites
  - Ex. Sensory neurons
(a) A multipolar neuron has many dendrites and an axon.

(b) A bipolar neuron has a dendrite and an axon.

(c) A pseudo-unipolar neuron appears to have an axon and no dendrites.

Figure 8.4 Types of Neurons
Neuroglia Characteristics

• Supporting cells for neurons

• More numerous than neurons

• Can divide to produce more cells

• 5 types
Types of Neuroglia

- **Astrocytes:**
  - star-shaped
  - most abundant
  - form blood-brain barrier
- **Ependymal Cells:**
  produce and circulate cerebrospinal fluid (CSF)
Types of Neuroglia

- **Microglia:**
  help remove bacteria and cell debris from CNS

- **Oligodendrocytes:**
  produce myelin sheath in CNS
Types of Neuroglia

- **Schwann cells:** produce myelin sheath in PNS
<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multipolar</td>
<td>Many dendrites and one axon</td>
<td>Most motor neurons and most CNS neurons</td>
</tr>
<tr>
<td>Bipolar</td>
<td>One dendrite and one axon</td>
<td>Found in special sense organs, such as eye and nose</td>
</tr>
<tr>
<td>Pseudo-unipolar</td>
<td>Appears to have a single axon</td>
<td>Most sensory neurons</td>
</tr>
<tr>
<td>Neuroglia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Astrocytes</td>
<td>Highly branched</td>
<td>Provide structural support; regulate neuronal signaling; contribute to blood-brain barrier; help with neural tissue repair</td>
</tr>
<tr>
<td>Ependymal cells</td>
<td>Epithelial-like</td>
<td>Line ventricles of brain and central canal of the spinal cord, circulate cerebrospinal fluid (CSF); some form choroid plexuses, which produce CSF</td>
</tr>
<tr>
<td>Microglia</td>
<td>Small, mobile cells</td>
<td>Protect CNS from infection; become phagocytic in response to inflammation</td>
</tr>
<tr>
<td>Oligodendrocytes</td>
<td>Cells with processes that can surround several axons</td>
<td>Cell processes form myelin sheaths around axons or enclose unmyelinated axons in the CNS</td>
</tr>
<tr>
<td>Schwann cells</td>
<td>Single cells surrounding axons</td>
<td>Form myelin sheaths around axons or enclose unmyelinated axons in the PNS</td>
</tr>
</tbody>
</table>
Organization of Nervous Tissue

• **Gray matter:**
  collection of dendrites and cell bodies

• **White matter:**
  collection of axons and their myelin sheath
<table>
<thead>
<tr>
<th>CNS</th>
<th>PNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligodendrocytes</td>
<td>Schwann cells</td>
</tr>
<tr>
<td>Produce myelin sheath</td>
<td></td>
</tr>
<tr>
<td>Nerve tracts</td>
<td>Nerves</td>
</tr>
<tr>
<td>Collection of axons</td>
<td></td>
</tr>
<tr>
<td>Nuclei</td>
<td>Ganglion</td>
</tr>
<tr>
<td>Collection of cell bodies</td>
<td></td>
</tr>
</tbody>
</table>
Electrical Signals and Neural Pathways

Resting Membrane Potential

• Outside of cell is more + (Na\(^+\))
• Inside of cell is more – (K\(^+\))

• Leak ion channels:
  - always open
  - K\(^+\) channels

• Gated ion channels:
  - closed until opened by specific signal
  - Na\(^+\) channels
In a resting cell, there is a higher concentration of K⁺ (purple circles) inside the cell membrane and a higher concentration of Na⁺ (pink circles) outside the cell membrane. Because the membrane is not permeable to negatively charged proteins (green) they are isolated to inside of the cell membrane.

There are more K⁺ leak channels than Na⁺ leak channels. In the resting cell, only the leak channels are opened; the gated channels (not shown) are closed. Because of the ion concentration differences across the membrane, K⁺ diffuses out of the cell down its concentration gradient and Na⁺ diffuses into the cell down its concentration gradient. The tendency for K⁺ to diffuse out of the cell is opposed by the tendency of the positively charged K⁺ to be attracted back into the cell by the negatively charged proteins.

The sodium-potassium pump helps maintain the differential levels of Na⁺ and K⁺ by pumping three Na⁺ out of the cell in exchange for two K⁺ into the cell. The pump is driven by ATP hydrolysis. The resting membrane potential is established when the movement of K⁺ out of the cell is equal to the movement of K⁺ into the cell.
Action Potentials

• “Electricity” that cause depolarization and repolarization

• Change resting membrane potential by activating gated ion channels

• **Local Current:**
  movement of Na\(^+\) which causes inside of cell to be more positive (depolarize)
- If enough Na\(^+\) enters then **threshold** is reached and more Na\(^+\) channels open

- Once threshold is reached all or none law applies

- Action potentials continue until Na\(^+\) channels close, K\(^+\) channels open, and **repolarization** occurs

- Sodium/potassium pump restores
Resting membrane potential. Na⁺ channels (pink) and most, but not all, K⁺ channels (purple) are closed. The outside of the plasma membrane is positively charged compared to the inside.

Depolarization. Na⁺ channels open. K⁺ channels begin to open. Depolarization results because the inward movement of Na⁺ makes the inside of the membrane positive.

Repolarization. Na⁺ channels close and additional K⁺ channels open. Na⁺ movement into the cell stops, and K⁺ movement out of the cell increases, causing repolarization.
The diagram illustrates the components of an action potential:

- **Threshold**: The point at which the membrane potential crosses from -70 mV to +20 mV, initiating the action potential.
- **Depolarization**: The rapid increase in membrane potential from -70 mV to +30 mV.
- **Repolarization**: The return of the membrane potential to -70 mV.
- **Hyperpolarization**: The membrane potential remains below -70 mV for a brief period after repolarization.
- **Resting membrane potential**: The membrane potential at equilibrium, typically -70 mV.

These processes occur over time, as indicated on the x-axis labeled "Time (ms)."
The sodium-potassium exchange pump is an example of an active transport process.
Synapse

• What is it?
  - where an axon attaches to a muscle, gland, organ, or other neuron
  - involved with release of neurotransmitters
  - Ex. Neuromuscular junction
Chemical Synapse

Action potentials arriving at the presynaptic terminal cause voltage-gated calcium ion channels to open.
Neurotransmitter bound to receptor site opens a chemically-gated Na\(^+\) channel.

1. Action potentials arriving at the presynaptic terminal cause voltage-gated Ca\(^{2+}\) channels to open.
2. Ca\(^{2+}\) diffuses into the cell and cause synaptic vesicles to release neurotransmitter molecules.
3. Neurotransmitter molecules diffuse from the presynaptic terminal across the synaptic cleft.
4. Neurotransmitter molecules combine with their receptor sites and cause chemically-gated Na\(^+\) channels to open. Na\(^+\) diffuses into the cell (shown in illustration) or out of the cell (not shown) and cause a change in membrane potential.
<table>
<thead>
<tr>
<th>Substance</th>
<th>Site of Release</th>
<th>Effect</th>
<th>Clinical Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetylcholine (ACh)</td>
<td>CNS synapses, ANS synapses, and neuromuscular junctions</td>
<td>Excitatory or inhibitory</td>
<td>Alzheimer disease (a type of senile dementia) is associated with a decrease in acetylcholine-secreting neurons. Myasthenia gravis (weakness of skeletal muscles) results from a reduction in acetylcholine receptors.</td>
</tr>
<tr>
<td>Norepinephrine (NE)</td>
<td>Selected CNS synapses and some ANS synapses</td>
<td>Excitatory</td>
<td>Cocaine and amphetamines increase the release and block the reuptake of norepinephrine, resulting in overstimulation of postsynaptic neurons.</td>
</tr>
<tr>
<td>Serotonin</td>
<td>CNS synapses</td>
<td>Generally inhibitory</td>
<td>It is involved with mood, anxiety, and sleep induction. Levels of serotonin are elevated in schizophrenia (delusions, hallucinations, and withdrawal). Drugs that block serotonin transporters, such as prozac, are used to treat depression and anxiety disorders.</td>
</tr>
<tr>
<td>Dopamine</td>
<td>Selected CNS synapses and some ANS synapses</td>
<td>Excitatory or inhibitory</td>
<td>Parkinson disease (depression of voluntary motor control) results from destruction of dopamine-secreting neurons.</td>
</tr>
<tr>
<td>Gamma-aminobutyric acid (GABA)</td>
<td>CNS synapses</td>
<td>Inhibitory</td>
<td>Drugs that increase GABA function have been used to treat epilepsy (excessive discharge of neurons).</td>
</tr>
<tr>
<td>Glycine</td>
<td>CNS synapses</td>
<td>Inhibitory</td>
<td>Glycine receptors are inhibited by the poison strychnine. Strychnine increases the excitability of certain neurons by blocking their inhibition. Strychnine poisoning results in powerful muscle contractions and convulsions. Tetanus of respiratory muscles can cause death.</td>
</tr>
<tr>
<td>Endorphins</td>
<td>Descending pain pathways</td>
<td>Inhibitory</td>
<td>The opiates morphine and heroin bind to endorphin receptors on presynaptic neurons and reduce pain by blocking the release of a neurotransmitter.</td>
</tr>
</tbody>
</table>
Reflexes

• What are they?
  involuntary response to a stimulus

• Reflex arc:
  path reflex travels
Components of Reflex Arc

1. Sensory receptors:
   - pick up stimulus
   - in skin

2. Sensory (afferent) neurons:
   send stimulus to interneurons in spinal cord

3. Interneurons (Association) neuron:
   - located in CNS and connect to motor neurons
   - process stimulus
4. **Efferent (motor) neurons:**
   send response to effector

5. **Effector:**
   muscle, gland, or organ
Neuronal Pathways

- **Converging:**
  - two or more neurons synapse same neuron
  - allows info. to be transmitted in more than one neuronal pathway to converge into a single pathway

- **Diverging:**
  - axon from one neuron divides and synapses with more than one neuron
  - allows info. to be transmitted in one neuronal pathway to diverge into 2 or more pathways
Central Nervous System

Consists of brain and spinal cord

Brain in brain case:

Spinal cord in vertebral column:

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Spinal Cord

- Extends from foramen magnum to 2nd lumbar vertebra
- Protected by vertebral column
- Spinal nerves allow movement
- If damaged paralysis can occur
Gray and White Matter in Spinal Cord

• **Gray Matter:**
  - center of spinal cord
  - looks like letter H or a butterfly

• **White Matter:**
  - outside of spinal cord
  - contains myelinated fibers
White Matter in Spinal Cord

• Contains 3 columns dorsal, ventral, lateral columns

• **Ascending tracts:**
  axons that conduct action potentials toward brain

• **Descending tracts:**
  axons that conduct action potentials away from brain
Gray Matter in Spinal Cord

• Posterior horns:
  contain axons which synapse with interneurons

• Anterior horns:
  contain somatic neurons

• Lateral horns:
  contain autonomic neurons

• Central canal:
  fluid filled space in center of cord
Gray matter

Posterior horn
Lateral horn
Anterior horn

White matter

Dorsal (posterior) column
Ventral (anterior) column
Lateral column

Dorsal root
Dorsal root ganglion
Spinal nerve

Ventral root
Rootlets

Central canal

Dorsal root
Dorsal root ganglion
Spinal nerve

Interneuron

Posterior horn
Dorsal root
Dorsal root ganglion

Sensory neuron
Spinal nerve

Autonomic neuron
Somatic motor neuron

(b) Lateral horn

Anterior horn
Ventral root

(a)
Spinal Nerves

• Arise along spinal cord from union of dorsal roots and ventral roots
• Contain axons sensory and somatic neurons
• Located between vertebra
• Categorized by region of vertebral column from which it emerges (C for cervical)
• 31 pairs
• Organized in 3 plexuses
Cervical Plexus

• Spinal nerves C1-4

• Innervates muscles attached to hyoid bone and neck

• Contains phrenic nerve which innervates diaphragm
Brachial Plexus

- Originates from spinal nerves C5-T1

- Supply nerves to upper limb, shoulder, hand
Lumbosacral Plexus

• Originates from spinal nerves L1 to S4

• Supply nerves lower limbs
<table>
<thead>
<tr>
<th>Plexus</th>
<th>Origin</th>
<th>Major Nerves</th>
<th>Muscles Innervated</th>
<th>Skin Innervated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>C1–C4</td>
<td>Phrenic</td>
<td>Several neck muscles, Diaphragm</td>
<td>Neck and posterior head</td>
</tr>
<tr>
<td>Brachial</td>
<td>C5–T1</td>
<td>Axillary</td>
<td>Two shoulder muscles</td>
<td>Part of shoulder</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radial</td>
<td>Posterior arm and forearm muscles (extensors)</td>
<td>Posterior arm, forearm, and hand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Musculocutaneous</td>
<td>Anterior arm muscles (flexors)</td>
<td>Radial surface of forearm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ulnar</td>
<td>Two anterior forearm muscles (flexors), most intrinsic hand muscles</td>
<td>Ulnar side of hand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>Most anterior forearm muscles (flexors), some intrinsic hand muscles</td>
<td>Radial side of hand</td>
</tr>
<tr>
<td>Lumbosacral</td>
<td>L1–S4</td>
<td>Obturator</td>
<td>Medial thigh muscles (adductors)</td>
<td>Medial thigh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Femoral</td>
<td>Anterior thigh muscles (extensors)</td>
<td>Anterior thigh, medial leg and foot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tibial</td>
<td>Posterior thigh muscles (flexors), anterior and posterior leg muscles, most foot muscles</td>
<td>Posterior leg and sole of foot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Common fibular</td>
<td>Lateral thigh and leg, some foot muscles</td>
<td>Anterior and lateral leg, dorsal (top) part of foot</td>
</tr>
</tbody>
</table>
Cerebrospinal Fluid

- Fluid that bathes the brain and spinal cord
- Provides a protective cushion around the CNS
- Produced in choroid plexus of brain
Brainstem

- Components:
  - Medulla oblongata
  - Pons
  - Midbrain
Brainstem Components

- Medulla oblongata
  - Location: continuous with spinal cord
  - Function: regulates heart rate, blood vessel diameter, breathing, swallowing, vomiting, hiccupping, coughing, sneezing, balance
  - Other: pyramids: involved in conscious control of skeletal muscle
• **Pons**
  – **Location:**
    above medulla, bridge between cerebrum and cerebellum
  – **Function:**
    breathing, chewing, salivation, swallowing

• **Midbrain**
  – **Location:**
    above pons
  – **Function:**
    coordinated eye movement, pupil diameter, turning head toward noise
- **Reticular Formation**
  - **Location:** scattered throughout brainstem
  - **Function:** regulates cyclical motor function, respiration, walking, chewing, arousing and maintaining consciousness, regulates sleep-wake cycle
- Located between the brainstem and cerebrum
- Components:
  - Thalamus
  - Hypothalamus
Diencephalon Components

• **Thalamus**
  - **Characteristics:**
    - largest portion of diencephalon
  - **Function:**
    - influences moods and detects pain

• **Epithalamus:**
  - **Location:**
    - above thalamus
  - **Function:**
    - emotional and visceral response to odors
• **Hypothalamus**
  - **Location:**
    below thalamus
  - **Characteristics:**
    controls pituitary gland and is connected to it by infundibulum
  - **Function:**
    controls homeostasis, body temp, thirst, hunger, fear, rage, sexual emotions
Cerebrum Characteristics

- Largest portion of brain
- Divisions:
  - Right Hemisphere
  - Left Hemisphere separated by longitudinal fissure
- Lobes: frontal, parietal, occipital, temporal
Cerebrum Components

- **Cerebral Cortex**
  - **Location:**
    surface of cerebrum, composed of gray matter
  - **Function:**
    controls thinking, communicating, remembering, understanding, and initiates involuntary movements
• **Gyri:**
  
  folds on cerebral cortex that increase surface area

• **Sulci:**
  
  shallow indentations

• **Fissure:**
  
  deep indentations
• **Left hemisphere:**
  - controls right side of body
  - responsible for math, analytic, and speech

• **Right hemisphere:**
  - controls left side of body
  - responsible for music, art, abstract ideas

• **Corpus callosum:**
  connection between 2 hemispheres
Lobes of Brain

• **Frontal lobe**  
  - **Location:** front  
  - **Function:** controls voluntary motor functions, aggression, moods, smell

• **Parietal lobe**  
  - **Location:** top  
  - **Function:** evaluates sensory input such as touch, pain, pressure, temp., taste
• **Occipital lobe**
  - **Location:** back
  - **Function:** vision

• **Temporal lobe**
  - **Location:** sides
  - **Function:** hearing, smell, memory
Cerebellum

• **Location:**
  below cerebrum

• **Characteristics:**
  - means little brain
  - cortex is composed of gyri, sulci, gray matter

• **Functions:** controls balance, muscle tone, coordination of fine motor movement
Sensory Functions

• CNS constantly receives sensory input

• We are unaware of most sensory input

• Sensory input is vital for our survival and normal functions
Ascending Tracts

• What are they?
  - pathways in brain and spinal cord
  - transmit info. via action potentials from periphery to brain
  - each tract has limited type of sensory input (temp, touch, pain, etc.)
  - tracts are named that indicated origin and termination
  - made of 2-3 neurons in sequence
Anterior spinocerebellar tract
Posterior spinocerebellar tract
Dorsal columns
Anterior spinothalamic tract
Sensory Areas of Cerebral Cortex

• Primary sensory areas:
  - where ascending tracts project
  - where sensations are perceived

• Primary somatic sensory cortex:
  - general sensory area
  - in parietal lobe
  - sensory input such as pain, pressure, temp.
Motor Areas of Cerebral Cortex

- **Primary motor cortex:**
  - frontal lobe
  - control voluntary motor movement

- **Premotor area:**
  - frontal lobe
  - where motor functions are organized before initiation

- **Prefrontal area:**
  motivation and foresight to plan and initiate movement
Primary motor cortex
Premotor area
Prefrontal area
Motor speech area (Broca area)
Primary auditory cortex
Auditory association area
Visual association area
Sensory speech area (Wernicke area)
Visual cortex
Taste area (beneath surface in insula)
Central sulcus
Primary somatic sensory cortex
Somatic sensory association area
Head
Upper limb
Trunk
Lower limb
Lateral view
Descending Tracts

- Project from upper motor neurons in cerebral cortex to lower motor neurons in spinal cord and brainstem

- Control different types of movements
Lateral corticospinal
Rubrospinal
Anterior corticospinal
Reticulospinal
Vestibulospinal
Tectospinal

Posterior (dorsal)
Anterior (ventral)
Basal Nuclei

• Group of functionally related nuclei
• Plan, organize, coordinate motor movements and posture

• Corpus striatum:
  deep in cerebrum

• Substantia nigra:
  in midbrain
Thalamus

Corpus striatum

Basal nuclei

Substantia nigra (in midbrain)
Speech

• Mainly in left hemisphere

• Sensory speech (Wernicke’s area):
  - parietal lobe
  - where words are heard and comprehended

• Motor speech (Bronca’s area):
  - frontal lobe
  - where words are formulated
Brain Waves and Consciousness

• Used to diagnose and determine treatment of brain disorders

• Electroencephalogram (EEG):
  electrodes plated on scalp to record brain’s electrical activity

• Alpha waves:
  person is awake in quiet state
• Beta waves:
  intense mental activity

• Delta waves:
  deep sleep

• Theta waves:
  in children
Alpha waves

Beta waves

Theta waves

Delta waves
Memory

- **Encoding:**
  - brief retention of sensory input received by brain while something is scanned, evaluated, and acted up
  - also called sensory memory
  - in temporal lobe
  - lasts less than a second
• Consolidated:
  - data that has been encoded
  - temporal lobe
  - short term memory

• Storage:
  - long term memory
  - few minutes or permanently (depends on retrieval)

• Retrieval:
  how often info. is used
Types of Memory

• **Short-term memory:**
  - info. is retained for a few seconds or min.
  - bits of info. (usually 7)

• **Long-term memory:**
  can last for a few minutes or permanently

• **Episodic memory:**
  places or events

• **Learning:**
  utilizing past memories
Meninges

• What are they?
  protective wrapping around brain and spinal cord

• Meningitis:
  infection of meninges (bacterial or viral)
Types of Meninges

- **Dura Mater:**
  - superficial
  - thickest layer

- **Arachnoid mater:**
  2^{nd} layer

- **Pia mater:**
  - 3^{rd} layer
  - surface of brain

- **Subarachnoid space:**
  where cerebrospinal fluid sits
• **Epidural space:**
  - in vertebral column between dura and vertebra
  - injection site for epidural anesthesia

• **Spinal block and spinal tap:**
  - in subarachnoid space where cerebrospinal fluid can be removed or anesthetic inject
  - numbs spinal nerves
Ventricles

• What are they?
  cavities in CNS that contain fluid

• Fourth ventricle:
  - base of cerebellum
  - continuous with central canal of spinal cord
Lateral ventricle (anterior horn)

Third ventricle

Lateral ventricle (inferior horn)

Lateral ventricle (posterior horn)

Cerebral aqueduct

Fourth ventricle

Central canal of spinal cord

Lateral view
Cranial Nerves

• 12 pair of cranial nerves

• Named by roman numerals

• 2 categories of functions: sensory and motor
# Cranial Nerves and Their Functions (see figure 8.37)

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>General Function*</th>
<th>Specific Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Olfactory</td>
<td>S</td>
<td>Smell</td>
</tr>
<tr>
<td>II</td>
<td>Optic</td>
<td>S</td>
<td>Vision</td>
</tr>
<tr>
<td>III</td>
<td>Oculomotor</td>
<td>M, P</td>
<td>Motor to four of six extrinsic eye muscles and upper eyelid; parasympathetic:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>constricts pupil, thickens lens</td>
</tr>
<tr>
<td>IV</td>
<td>Trochlear</td>
<td>M</td>
<td>Motor to one extrinsic eye muscle</td>
</tr>
<tr>
<td>V</td>
<td>Trigeminal</td>
<td>S, M</td>
<td>Sensory to face and teeth; motor to muscles of mastication (chewing)</td>
</tr>
<tr>
<td>VI</td>
<td>Abducens</td>
<td>M</td>
<td>Motor to one extrinsic eye muscle</td>
</tr>
<tr>
<td>VII</td>
<td>Facial</td>
<td>S, M, P</td>
<td>Sensory: taste; motor to muscles of facial expression; parasympathetic to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>salivary and tear glands</td>
</tr>
<tr>
<td>VIII</td>
<td>Vestibulocochlear</td>
<td>S</td>
<td>Hearing and balance</td>
</tr>
<tr>
<td>IX</td>
<td>Glossopharyngeal</td>
<td>S, M, P</td>
<td>Sensory: taste and touch to back of tongue; motor to pharyngeal muscles;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>parasympathetic to salivary glands</td>
</tr>
<tr>
<td>X</td>
<td>Vagus</td>
<td>S, M, P</td>
<td>Sensory to pharynx, larynx, and viscera; motor to palate, pharynx, and larynx;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>parasympathetic to viscera of thorax and abdomen</td>
</tr>
<tr>
<td>XI</td>
<td>Accessory</td>
<td>M</td>
<td>Motor to two neck and upper back muscles</td>
</tr>
<tr>
<td>XII</td>
<td>Hypoglossal</td>
<td>M</td>
<td>Motor to tongue muscles</td>
</tr>
</tbody>
</table>

*S, sensory; M, somatic motor; P, parasympathetic
Peripheral Nervous System

- Consists of all neurons outside brain and spinal cord
- Collects input from different sources, relays input to CNS, and performs action
Divisions of Peripheral Nervous System

1. Afferent (Sensory):
   collects input from periphery and sends it to CNS

2. Efferent (Motor):
   carries processed input from CNS to effector
Divisions of Efferent (Motor)

1. Autonomic:
   - response is automatic (involuntary)
   - controls smooth and cardiac muscles and glands

2. Somatic:
   - response is voluntary
   - controls skeletal muscles
**Skeletal muscle**

Autonomic ganglion

Effector organ (e.g., smooth muscle of colon)

Postganglionic neuron

Spinal nerve

Spinal cord

Somatic motor neuron

Skeletal muscle

Spinal nerve

Spinal cord

Preganglionic neuron

Autonomic ganglion

Postganglionic neuron

Effector organ (e.g., smooth muscle of colon)
Divisions of Autonomic

1. Sympathetic:
   – activated during times of stress
   – part of fight or flight response
   – prepares you for physical activity by:
     - $\uparrow$ HR
     - $\uparrow$ BP
     - $\uparrow$ BR
     - sending more blood to skeletal muscles
     - inhibiting digestive tract
2. Parasympathetic:
   – “housekeeper”
   – activated under normal conditions
   – involved in digestion, urine production, and dilation/constriction of pupils, etc.