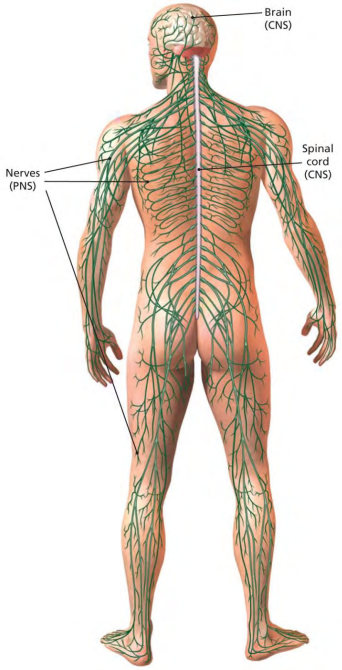
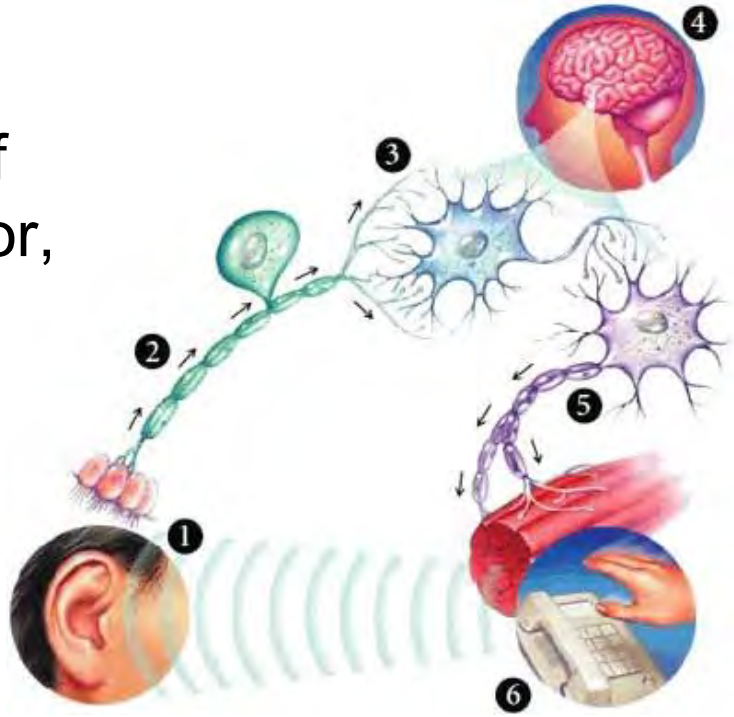
CHAPTER 2
the biological perspective

Overview of Nervous System

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

- ***Biological Psychology***
  - focuses on the biological bases of psychological processes, behavior, and learning





- ***Nervous system***
  - an extensive network of specialized cells that carry information to and from all parts of the body

Structure of the Neuron

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

Neuron

- is the basic cell that makes up the nervous system
- receives and sends messages within the nervous system

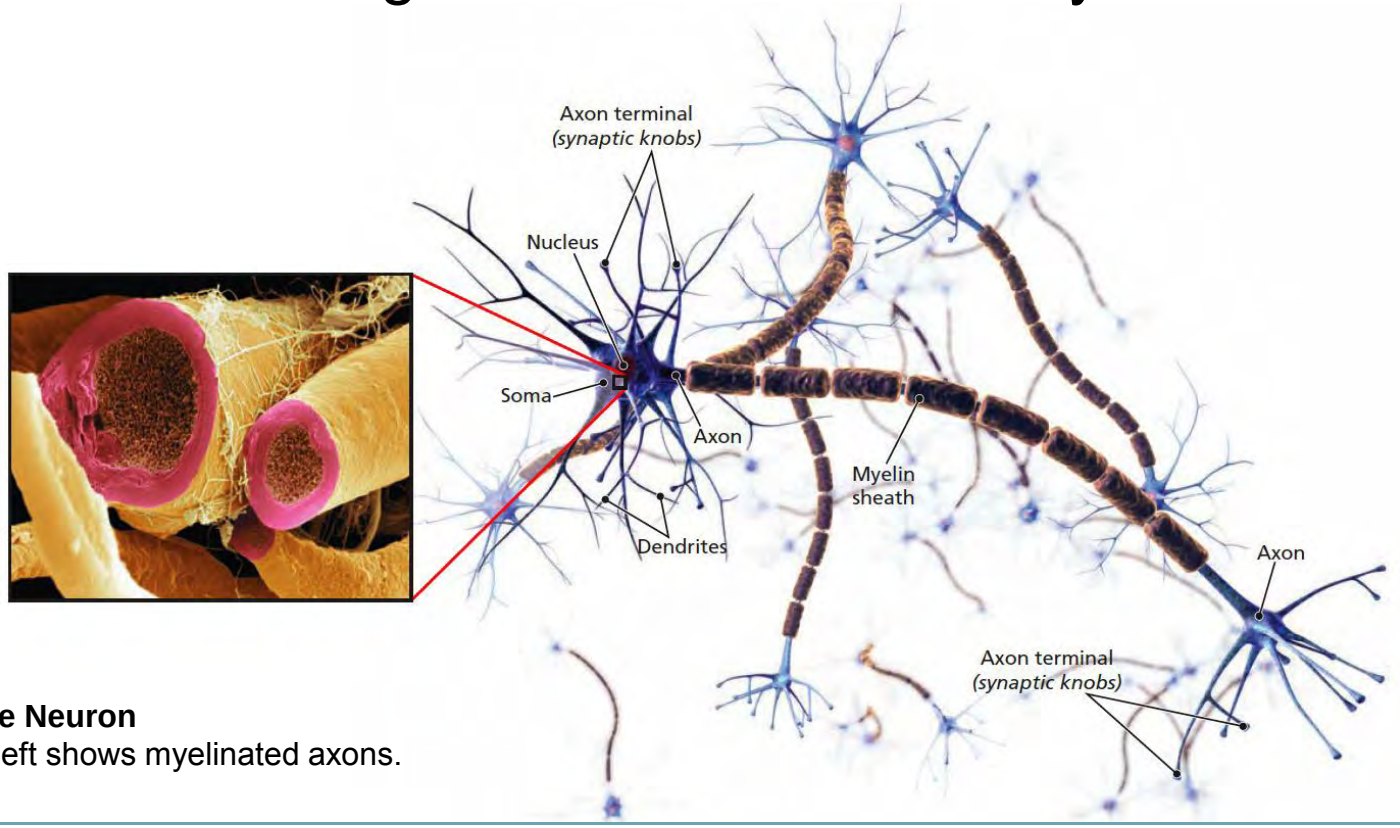


Figure 2.2 The Structure of the Neuron
The electronmicrograph on the left shows myelinated axons.

Structure of the Neuron

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

Parts of a neuron

1. ***Soma***:
   - the cell body of the neuron
   - responsible for maintaining the life of the cell

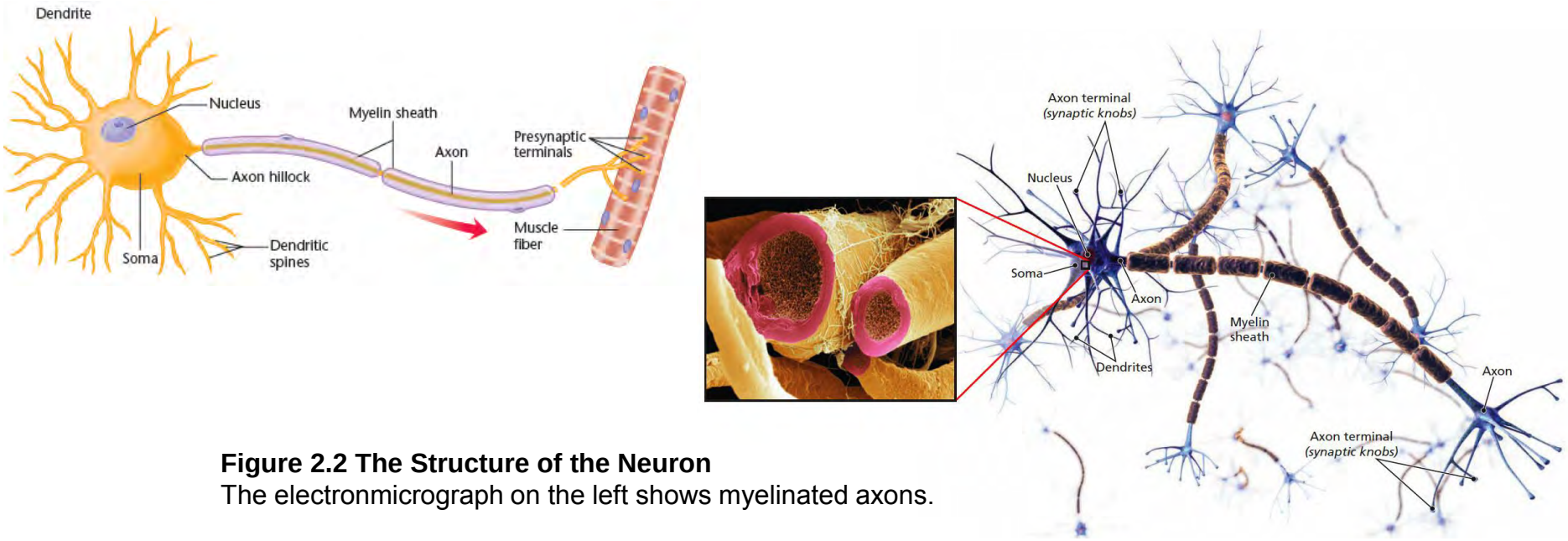


Figure 2.2 The Structure of the Neuron
The electronmicrograph on the left shows myelinated axons.

Structure of the Neuron

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

Parts of a neuron

2. ***Dendrites***: branch-like structures that receive messages from other neurons
3. ***Axon***: long, tube-like structure that sends messages to other cells

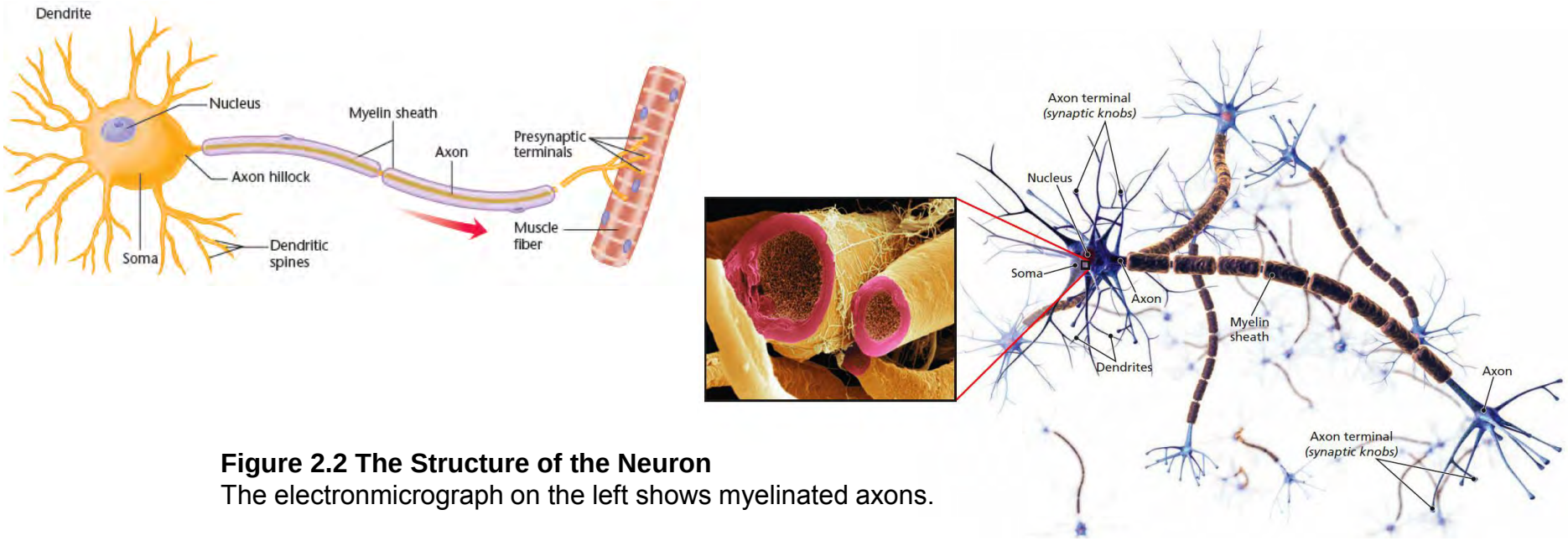
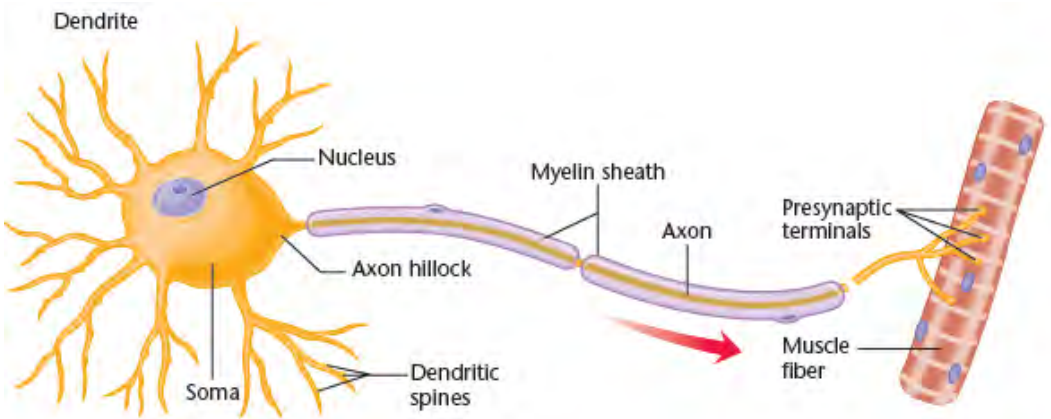


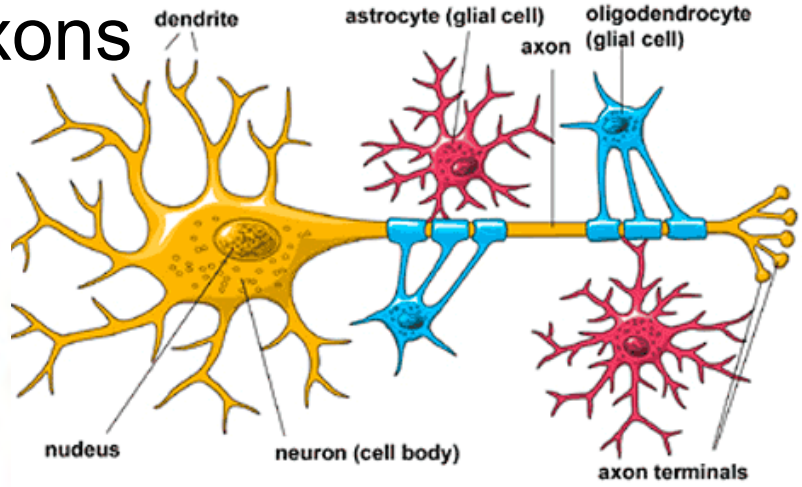
Figure 2.2 The Structure of the Neuron
The electronmicrograph on the left shows myelinated axons.

Other Types of Brain Cells

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

- ***Glial cells*** are fatty cells that:
  - provide support for the neurons to grow on
  - deliver nutrients to neurons
  - produce ***myelin*** to coat axons



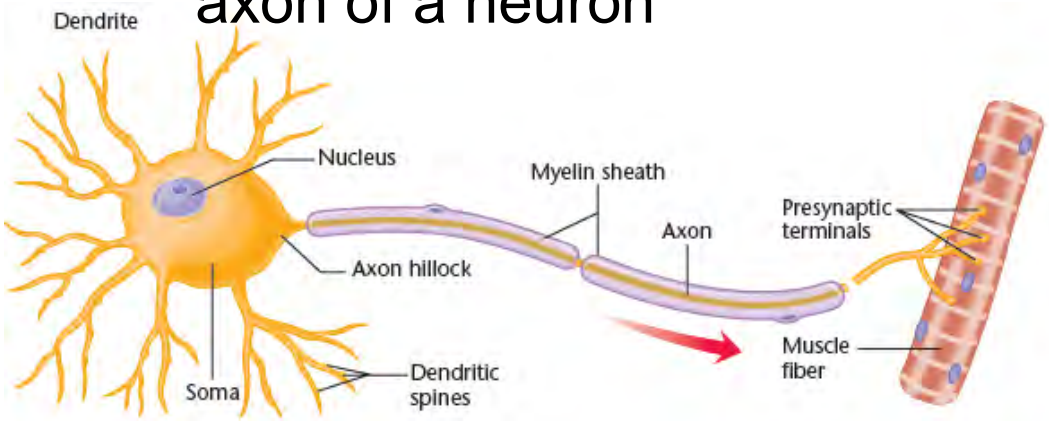


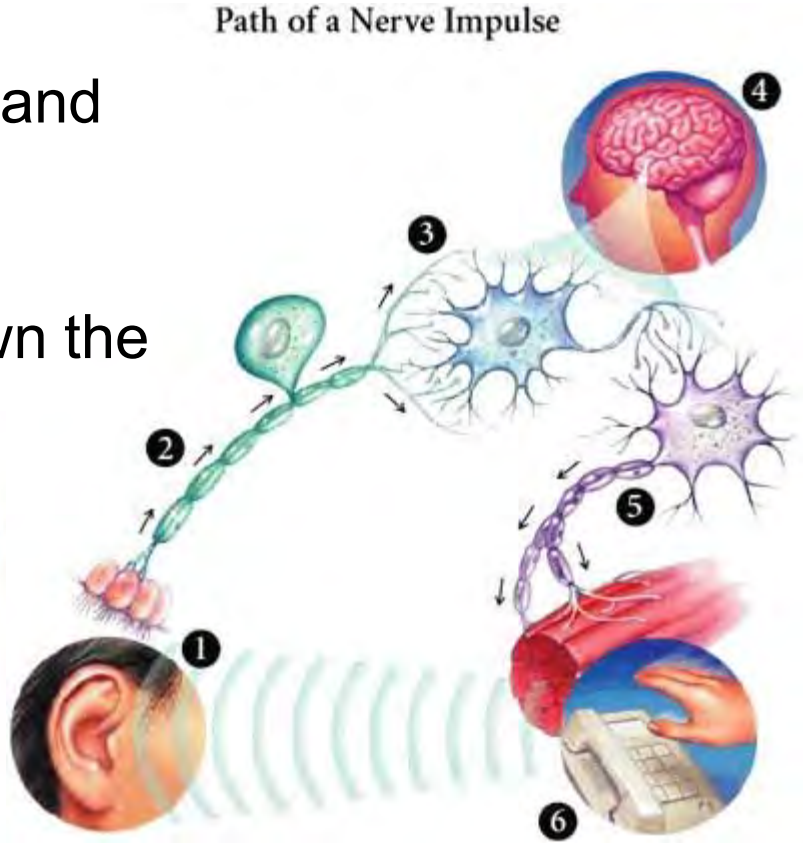
Other Types of Brain Cells

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

Myelin:

- fatty substances produced by certain glial cells
- coat the axons to insulate, protect, and speed up the neural impulse
  - ***Nerve impulse*** is the <u>electrical message</u> that is transmitted down the axon of a neuron

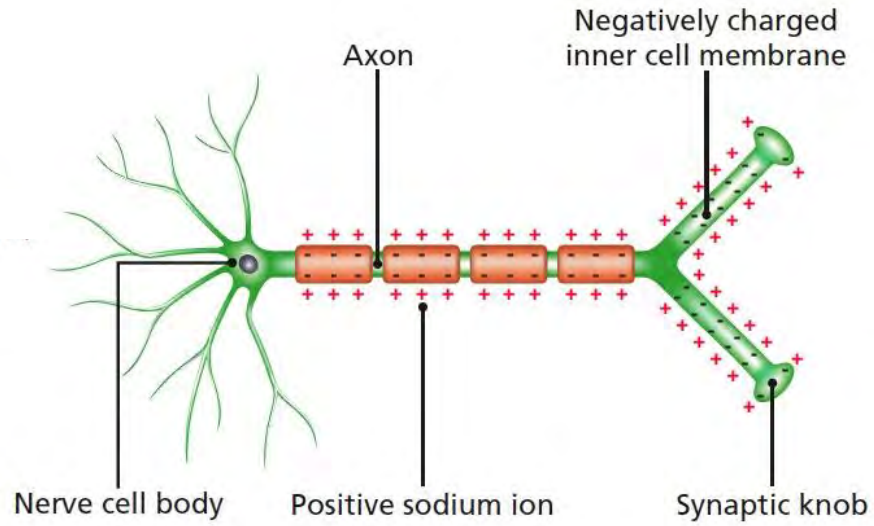


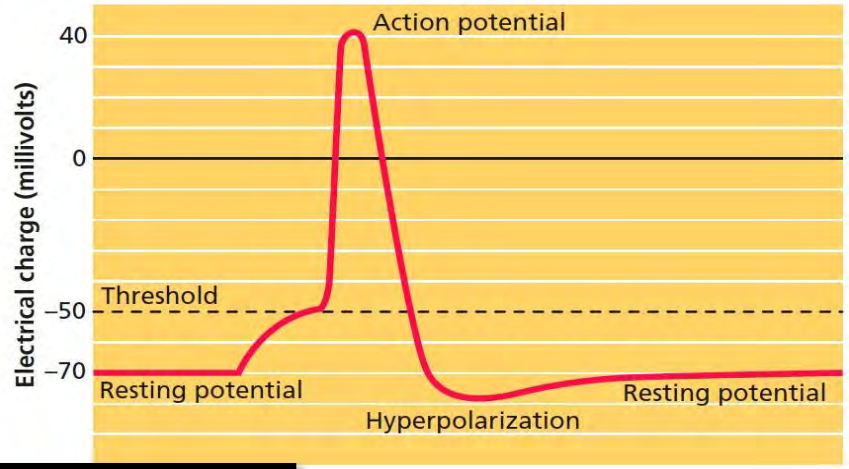


Generating the Message: Neural Impulse

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

- ***Ions***: charged particles located inside and outside of the cell
  - inside neuron: negatively charged
  - outside neuron: positively charged
  - Difference in charges creates an ***electrical potential***
- ***Resting potential***: the state of the neuron when not firing a neural impulse





The Neuron at Rest
During the resting potential, the neuron is negatively charged inside and positively charged outside.

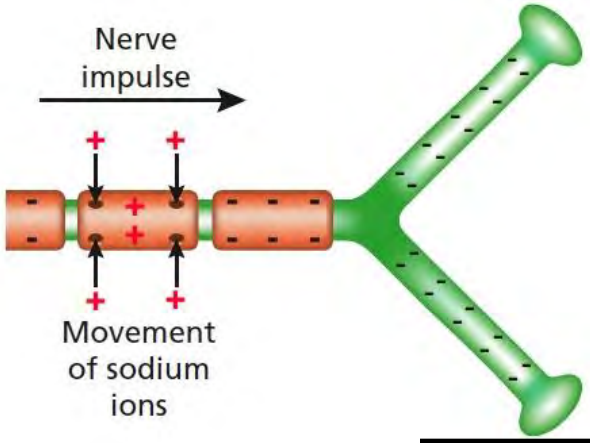
Generating the Message: Neural Impulse

LO 2.1 What Are the Nervous System, Neurons, and Nerves?

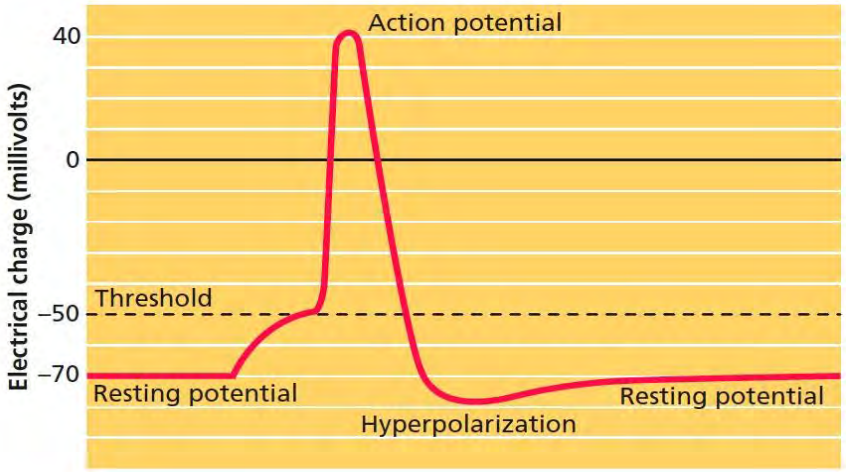
Action potential:

- occurs when there is a release of the neural impulse
- allows positive sodium ions to enter the cell
- consists of a reversal of the electrical charge within the axon

All-or-none law: a neuron either fires completely or does not fire at all



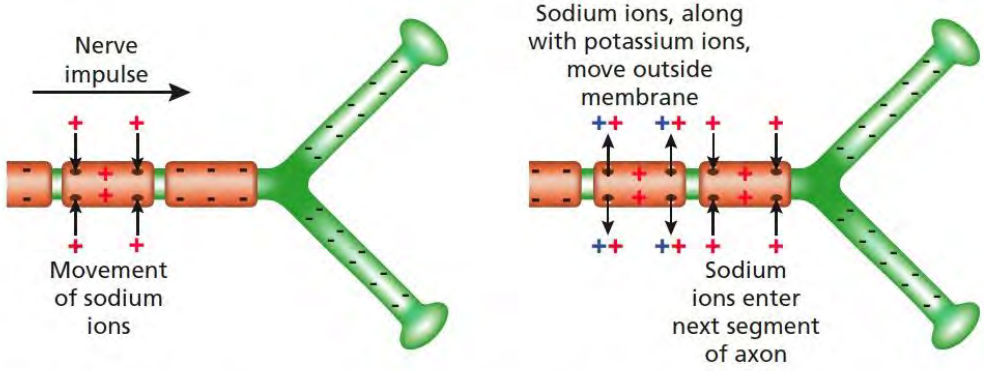
The Neural Impulse
The action potential occurs when positive sodium ions enter into the cell, causing a reversal of the electrical charge from negative to positive.



Generating the Message: Neural Impulse

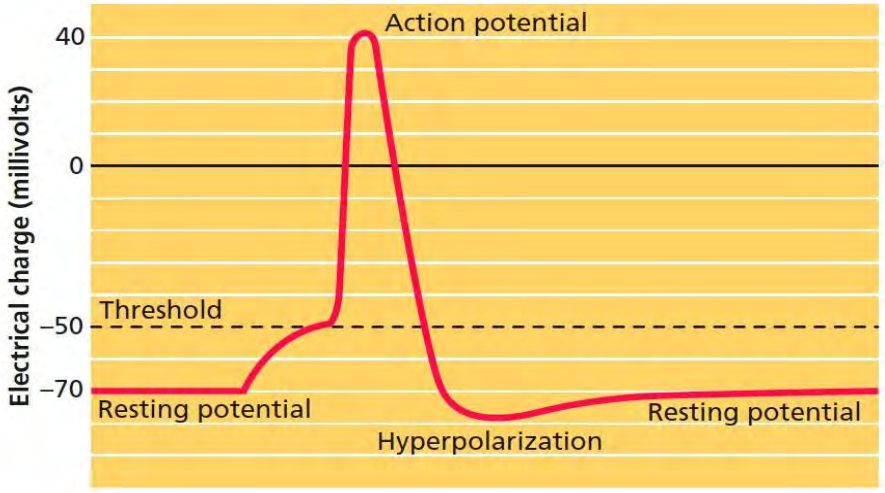
LO 2.1 What Are the Nervous System, Neurons, and Nerves?

- ***Hyperpolarization*** occurs when the negative charge inside the axon increases (e.g., -70 mV becomes -80 mV)
- Return to resting potential



The Neural Impulse
The action potential occurs when positive sodium ions enter into the cell, causing a reversal of the electrical charge from negative to positive.

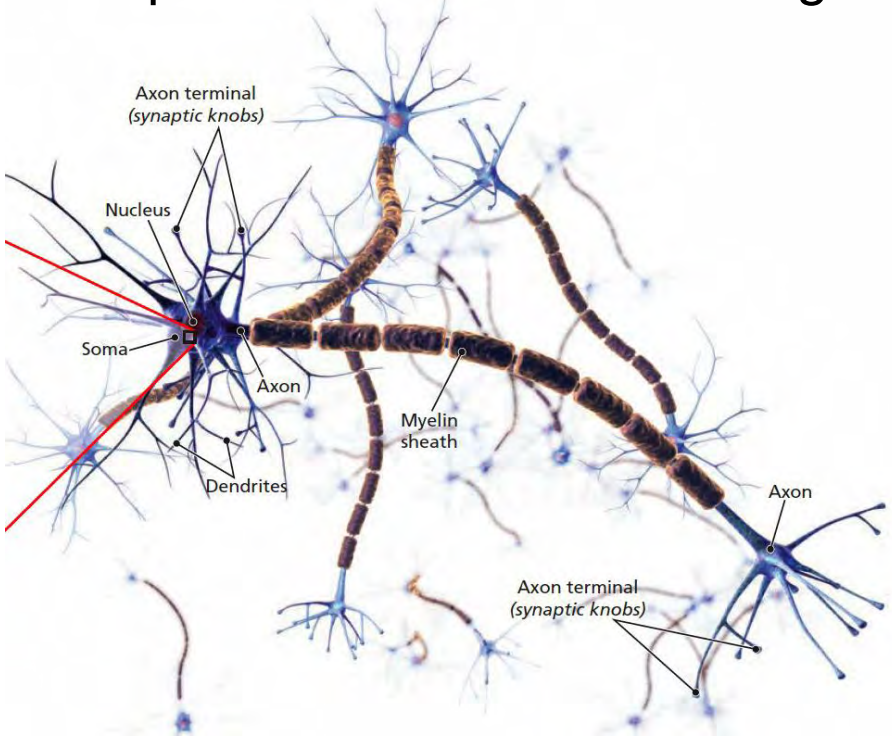
The Neural Impulse Continues
As the action potential moves down the axon toward the axon terminals, the cell areas behind the action potential return to their resting state of a negative charge as the positive sodium ions are pumped to the outside of the cell, and the positive potassium ions rapidly leave.

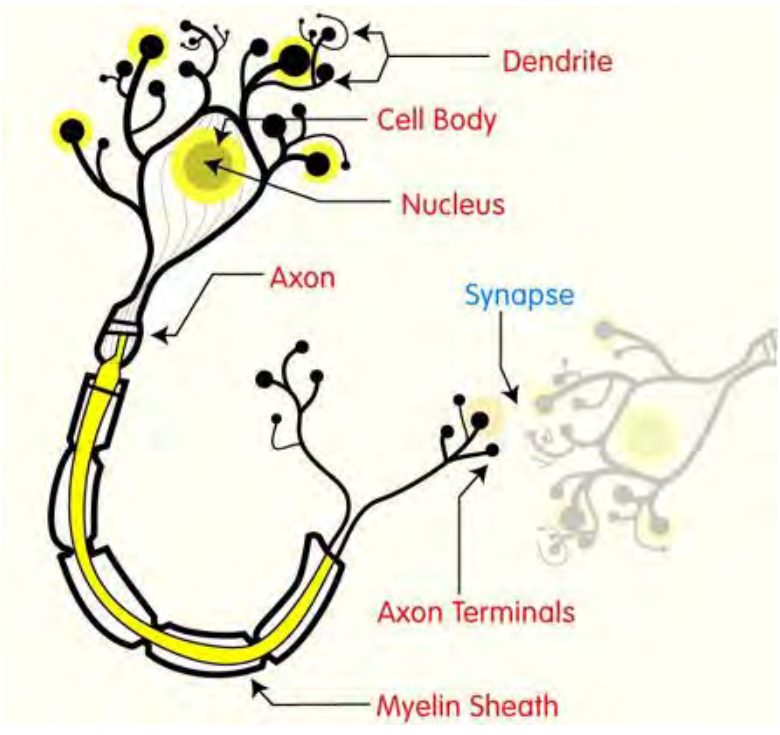


Communication Between Neurons

LO 2.2 How Neurons Use Neurotransmitters to Communicate

- Sending the message to other cells
- ***Axon terminals***:
  - rounded areas at the end of the branches at the end of the axon
  - responsible for communicating with other nerve cells

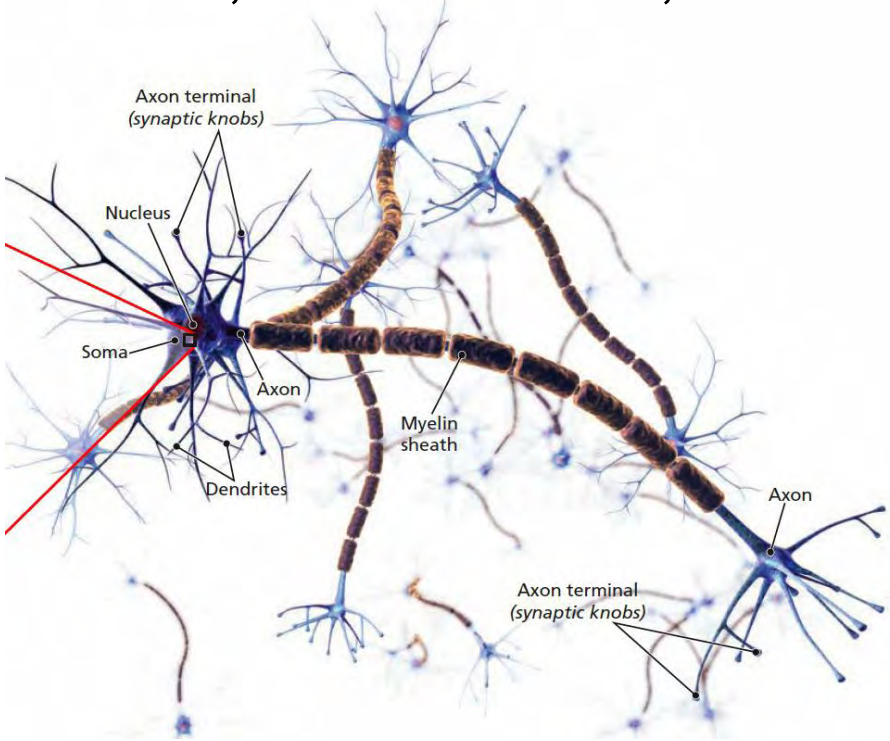


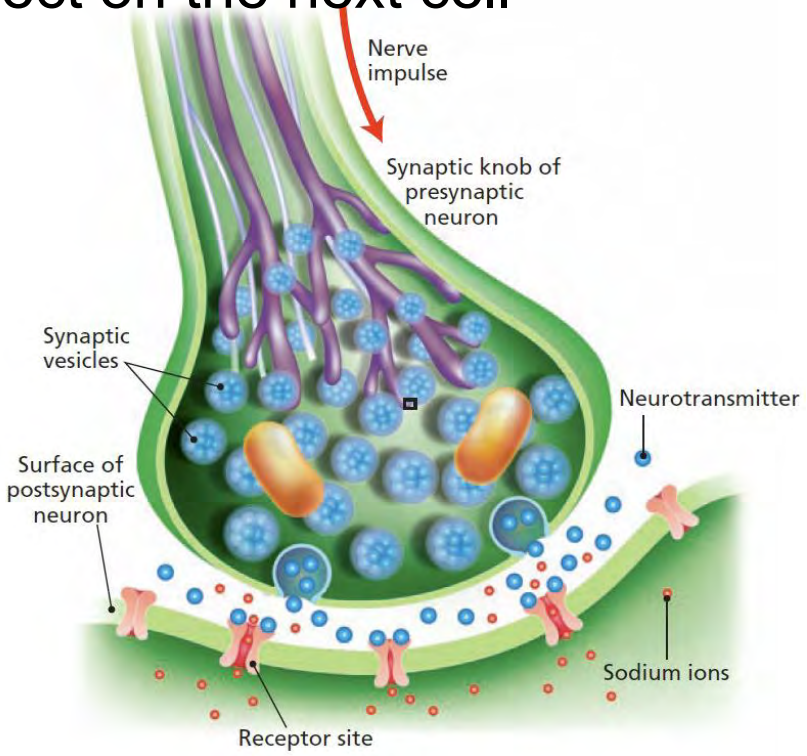


Communication Between Neurons

LO 2.2 How Neurons Use Neurotransmitters to Communicate

- ***Synaptic vesicles***: sack-like structures found inside the axon terminal containing chemicals
  - ***Neurotransmitter***: chemical found in the synaptic vesicles which, when released, has an effect on the next cell





Neuron Communication

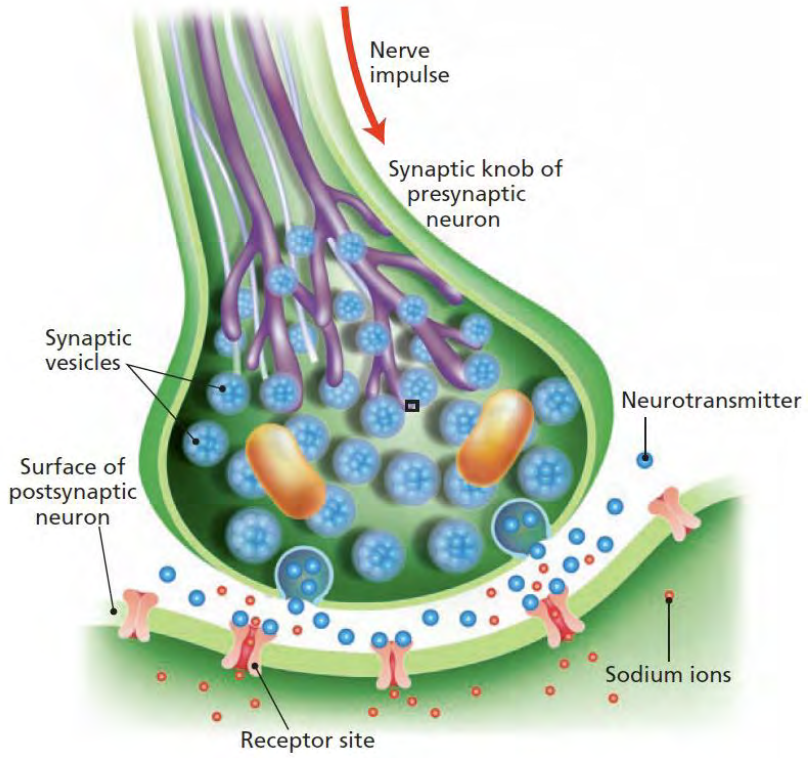
LO 2.2 How Neurons Use Neurotransmitters to Communicate

- ***Excitatory neurotransmitter***: neurotransmitter that causes the receiving cell to fire
- ***Inhibitory neurotransmitter***: neurotransmitter that causes the receiving cell to stop firing

Table 2.1

Some Neurotransmitters and Their Functions

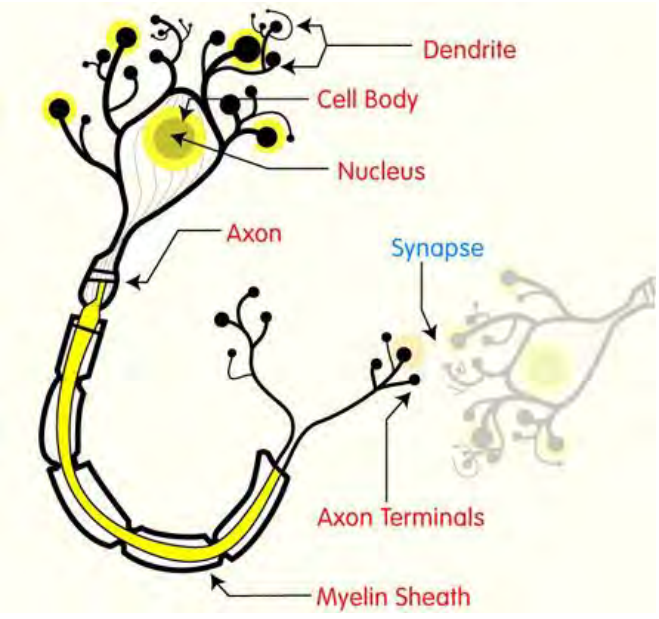
NEUROTRANSMITTERS	FUNCTIONS
Acetylcholine (ACh)	Excitatory or inhibitory; involved in arousal, attention, memory, and controls muscle contractions
Norepinephrine (NE)	Mainly excitatory; involved in arousal and mood
Dopamine (DA)	Excitatory or inhibitory; involved in control of movement and sensations of pleasure
Serotonin (5-HT)	Excitatory or inhibitory; involved in sleep, mood, anxiety, and appetite
Gaba-aminobutyric acid (GABA)	Major inhibitory neurotransmitter; involved in sleep and inhibits movement
Glutamate	Major excitatory neurotransmitter; involved in learning, memory formation, nervous system development, and synaptic plasticity
Endorphins	Inhibitory neural regulators; involved in pain relief

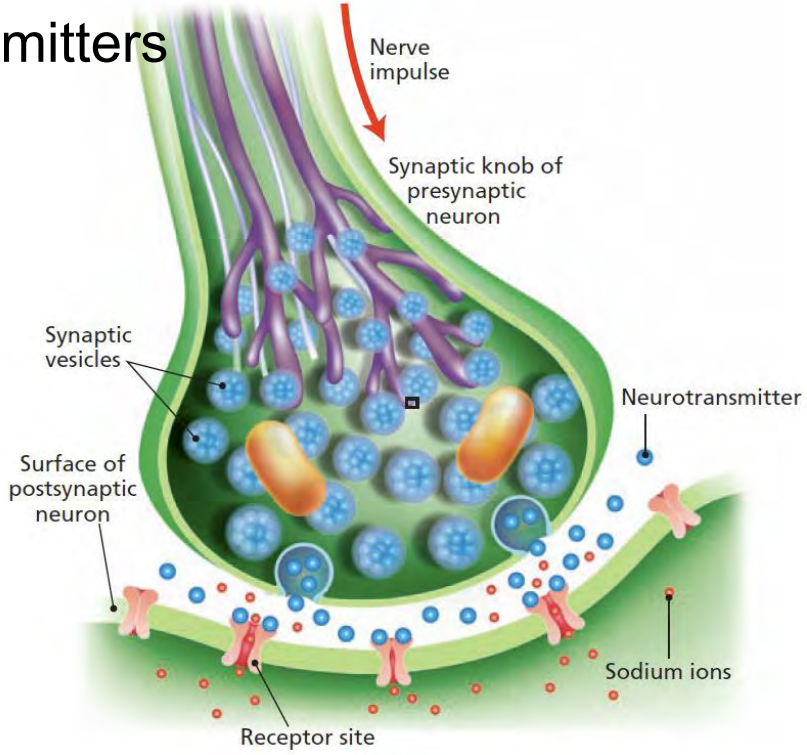


Communication Between Neurons

LO 2.2 How Neurons Use Neurotransmitters to Communicate

- ***Synapse/synaptic gap:*** fluid-filled space between "the rounded areas on the end of the axon terminals of one cell" and (2) "the dendrites or surface of the next cell"
- ***Receptor sites:*** holes in the surface of the dendrites or certain cells
  - shaped to fit only certain neurotransmitters

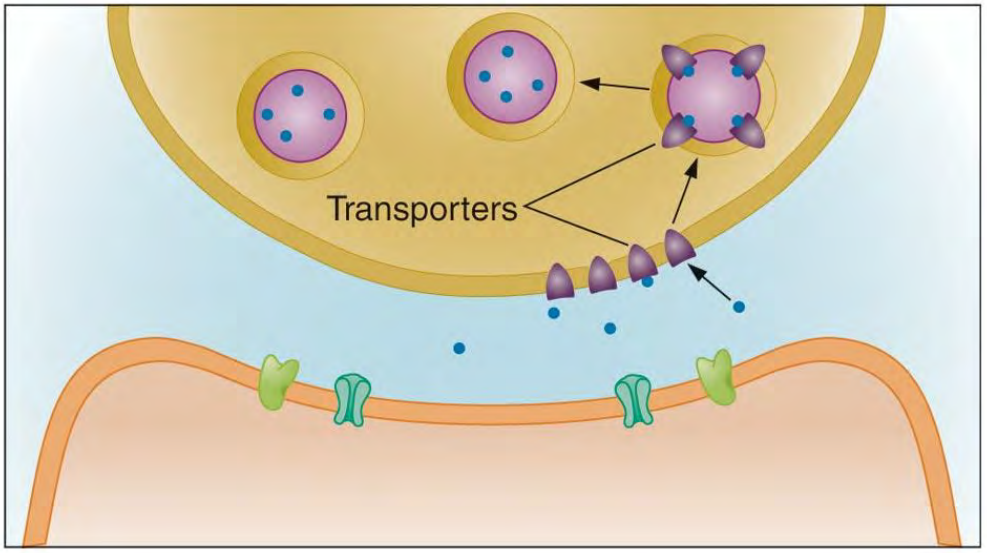




Cleaning up the Synapse

LO 2.2 How Neurons Use Neurotransmitters to Communicate

- ***Reuptake***: process by which neurotransmitters are taken back into the synaptic vesicles
  - ***Transporters*** are special membrane proteins that facilitate reuptake



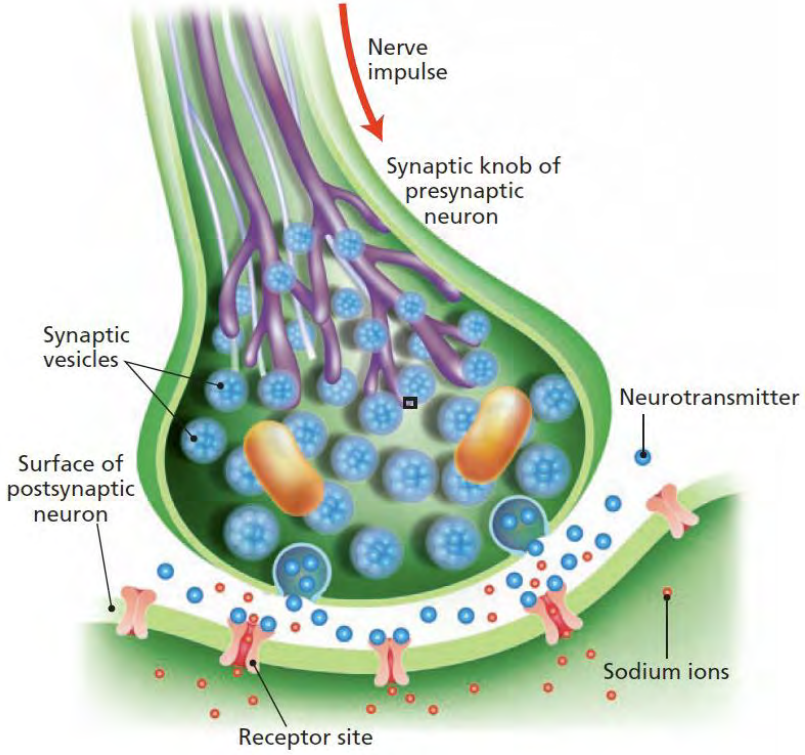
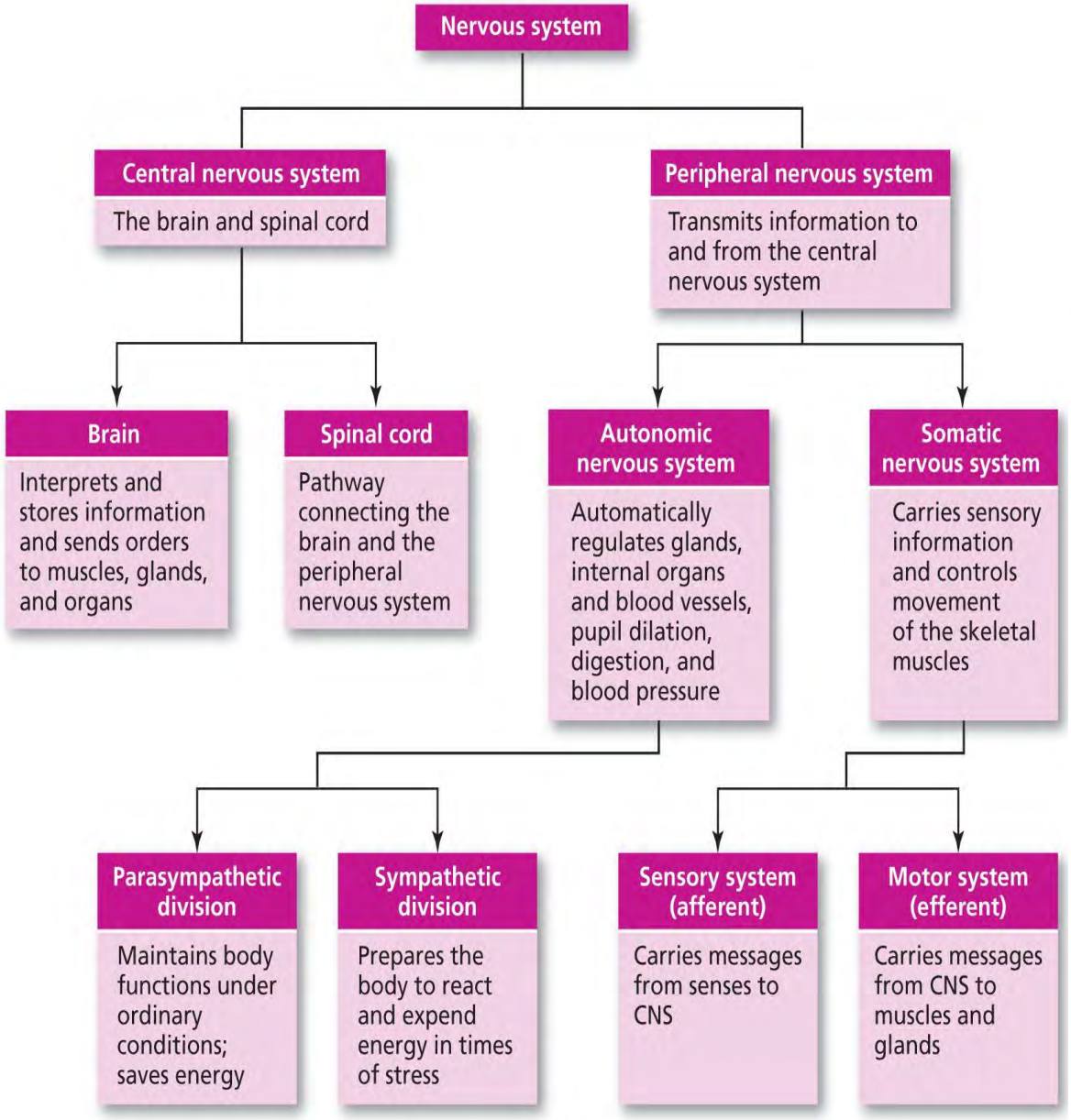
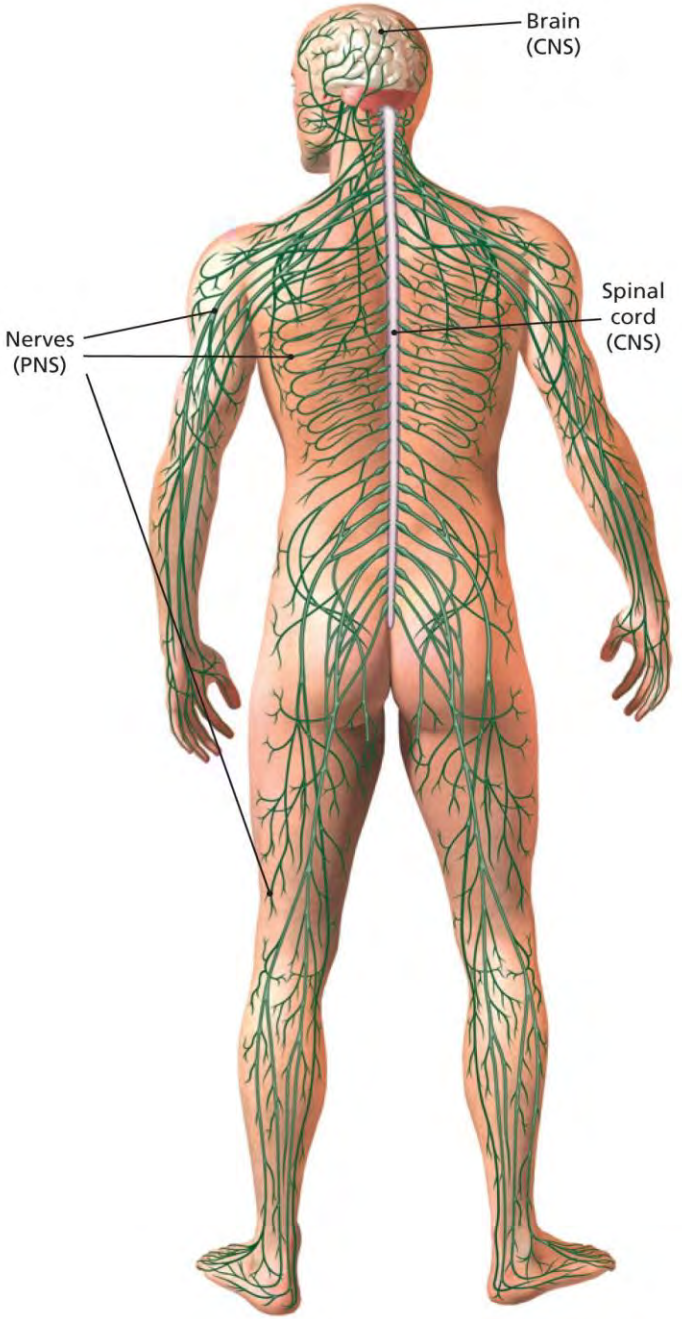


Figure 2.5 An Overview of the Nervous System



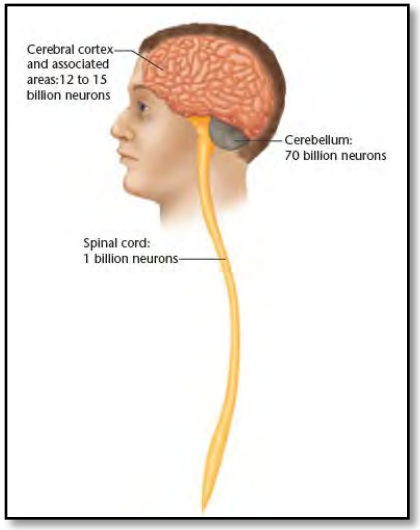


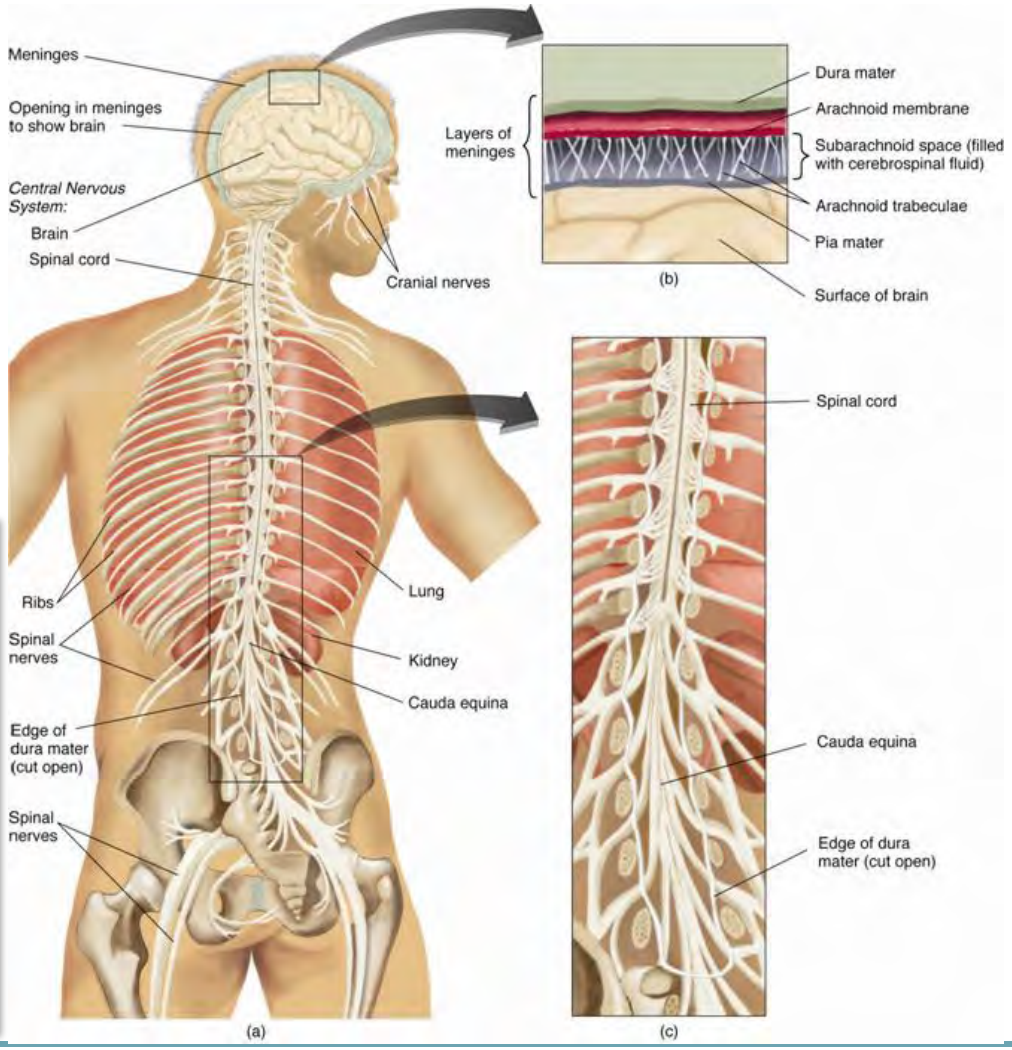
Central Nervous System (CNS)

LO 2.3 How the Brain and Spinal Cord Interact

CNS: part of the nervous system consisting of the brain and spinal cord

Spinal cord: a long bundle of neurons that carries messages to and from the body to the brain that is responsible for very fast, lifesaving reflexes

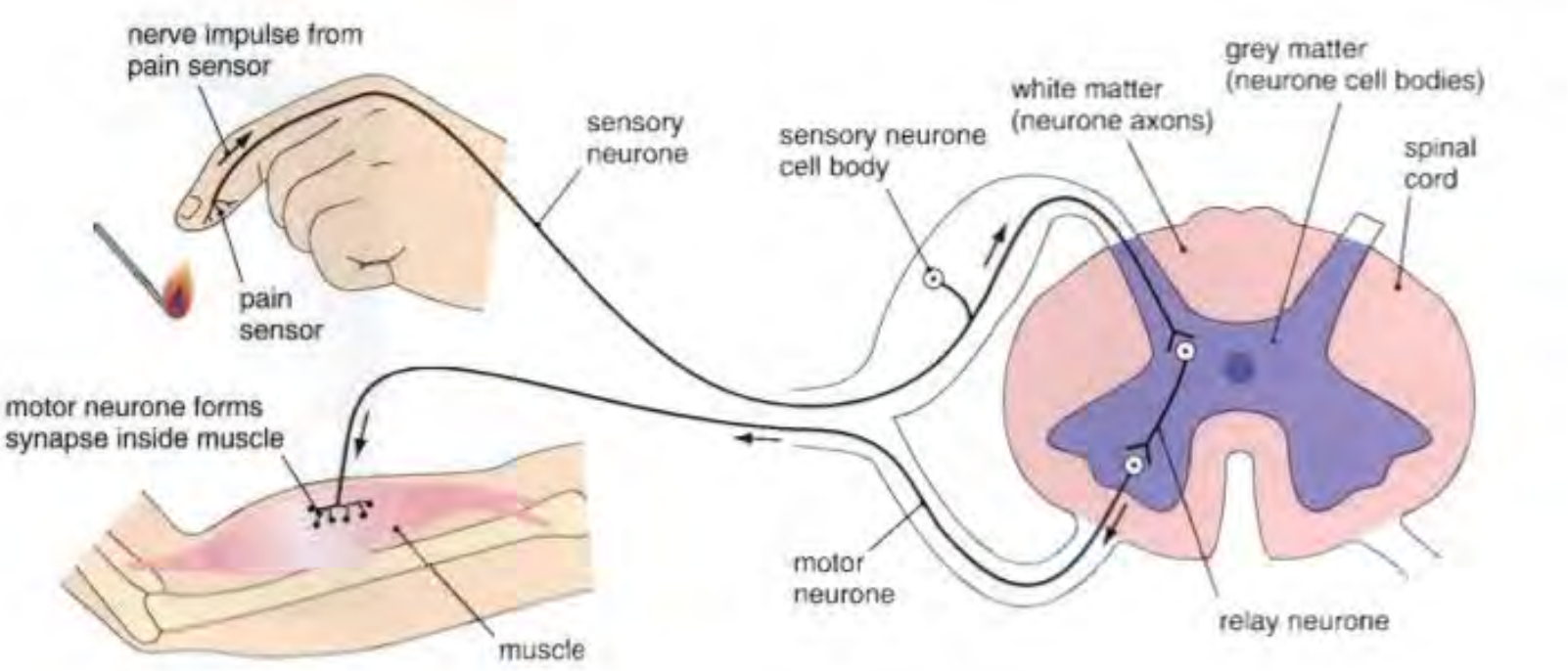




The Reflex Arc: Three Types of Neurons

LO 2.3 How the Brain and Spinal Cord Interact

1. ***Sensory neuron***: carries information from the senses to the CNS
   - also called an afferent neuron
2. ***Motor neuron***: carries messages from CNS to the muscles of the body
   - also called an efferent neuron



The Reflex Arc: Three Types of Neurons

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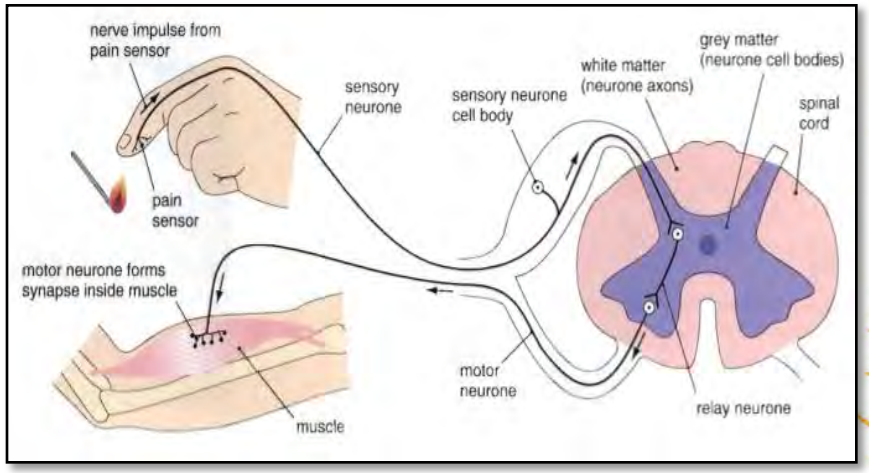
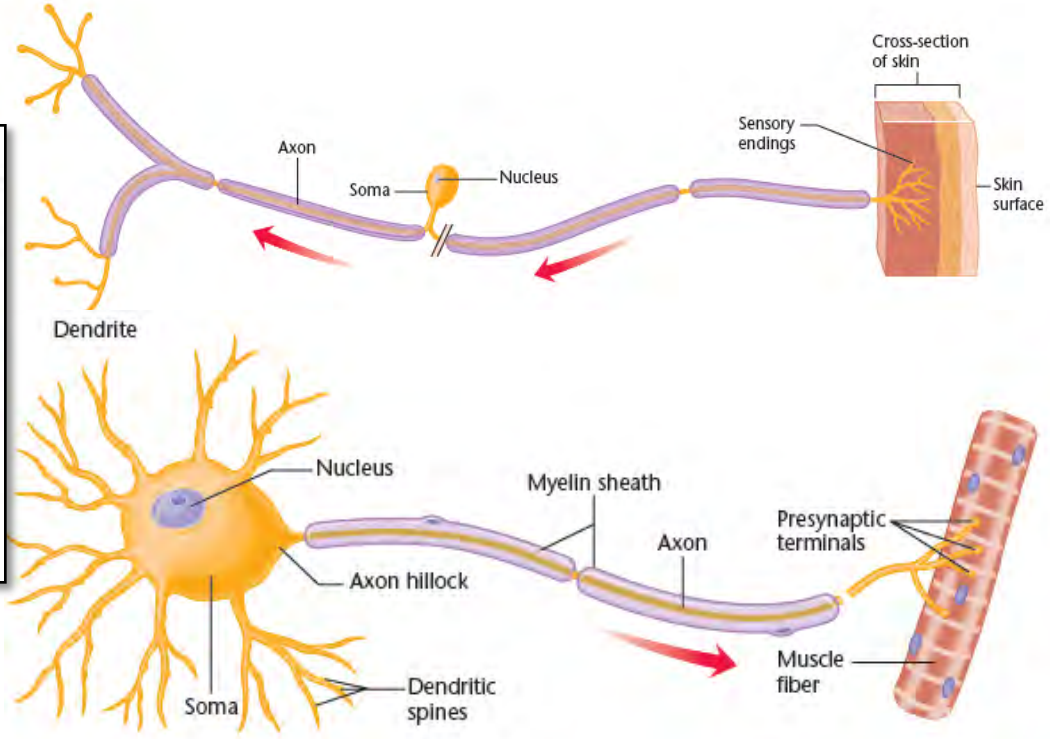
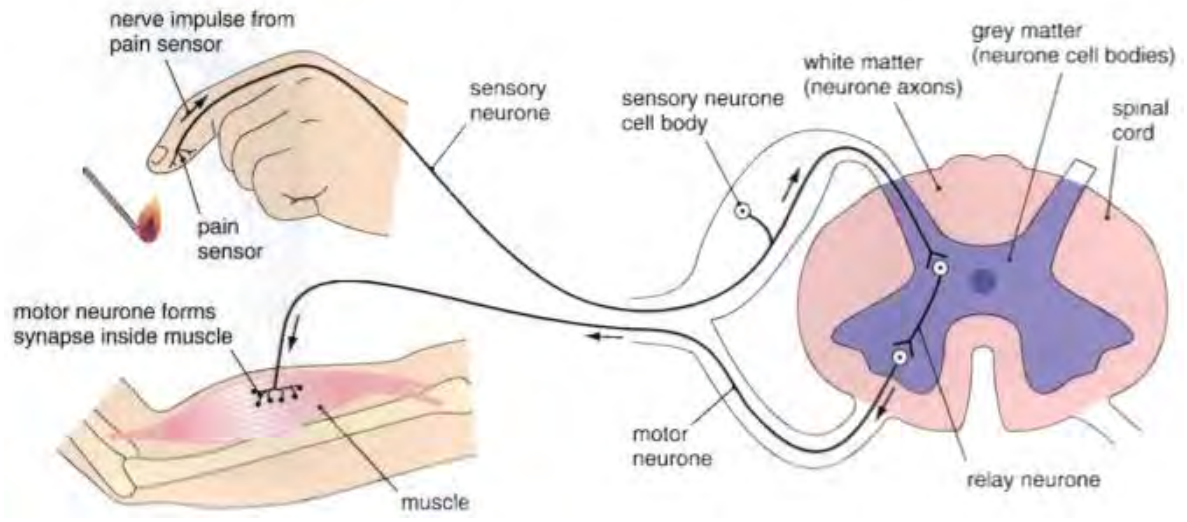


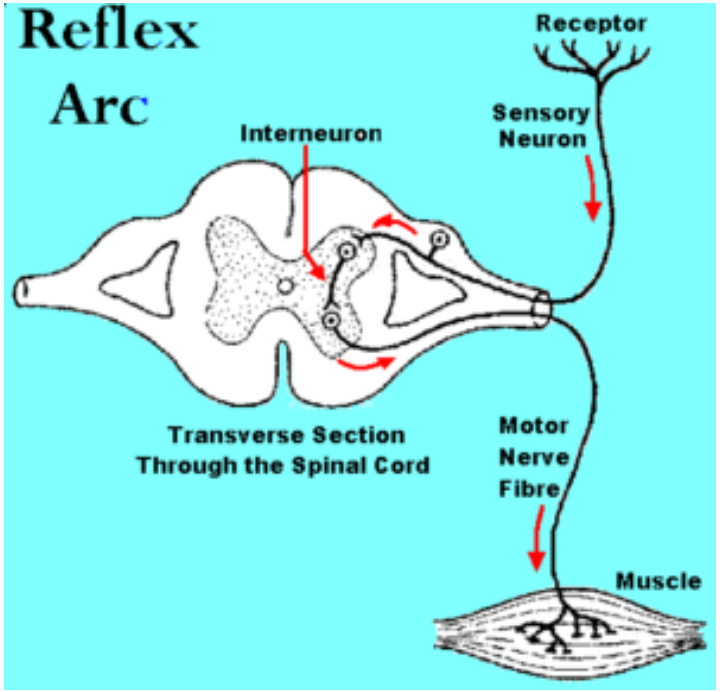


The Reflex Arc: Three Types of Neurons

LO 2.3 How the Brain and Spinal Cord Interact

3. ***Interneuron***: a neuron found in the center of the spinal cord that receives information from the sensory neurons and sends commands to the muscles through the motor neurons





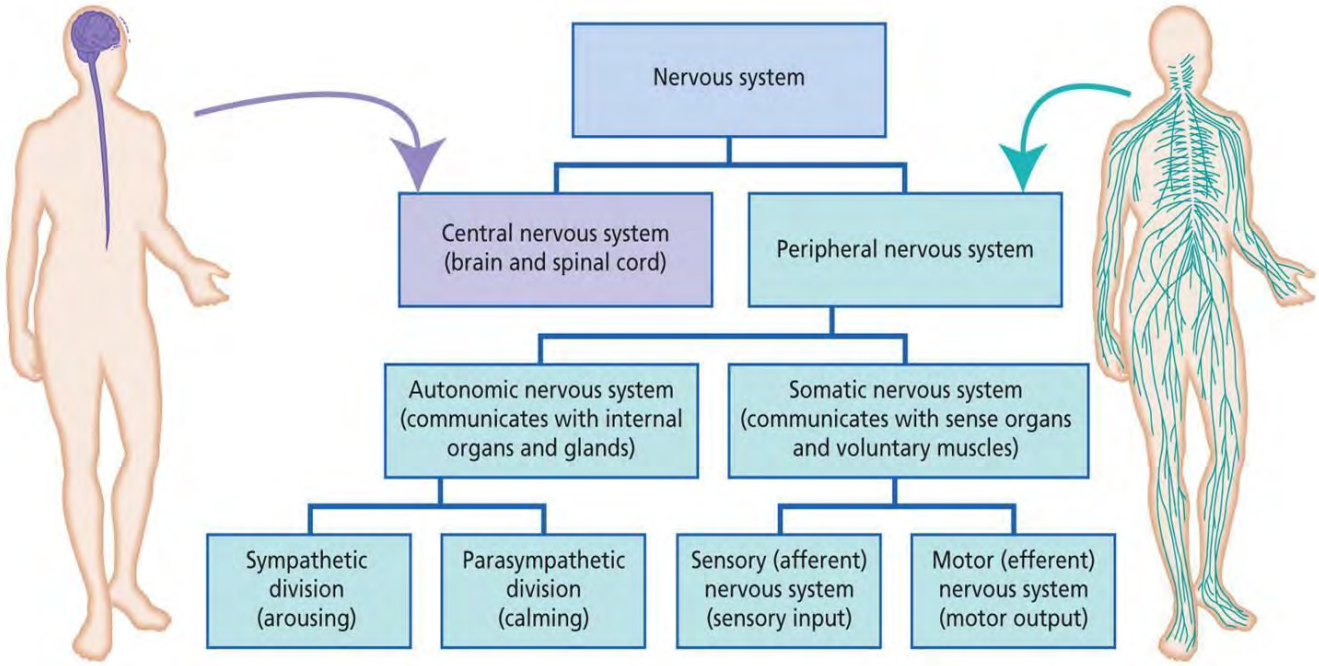
Peripheral Nervous System (PNS)

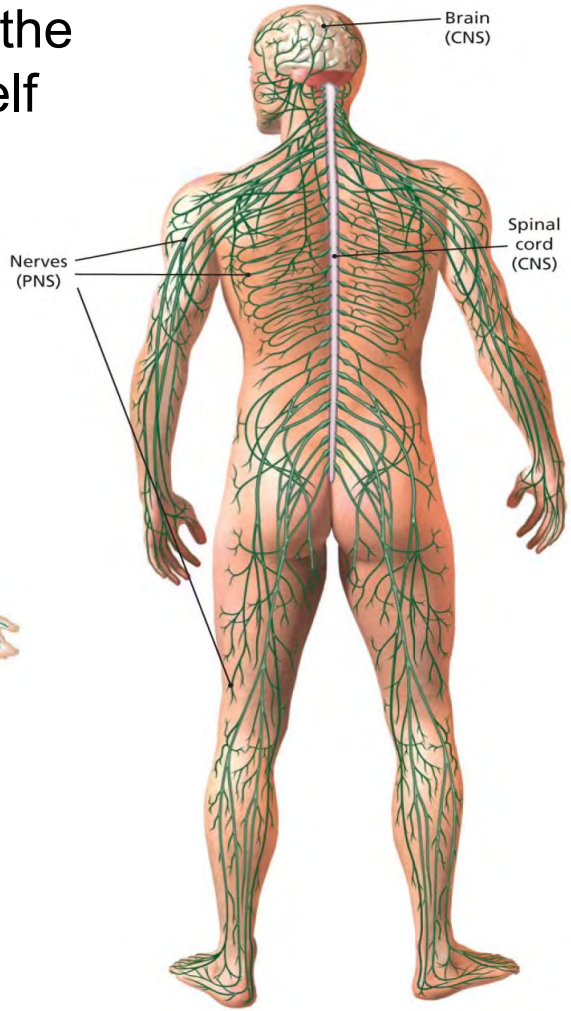
LO 2.4 Somatic and Autonomic Nervous Systems

PNS: all nerves and neurons that are not contained in the brain and spinal cord but that run through the body itself

- divided into the:

1. ***Somatic nervous system***
2. ***Autonomic nervous system***

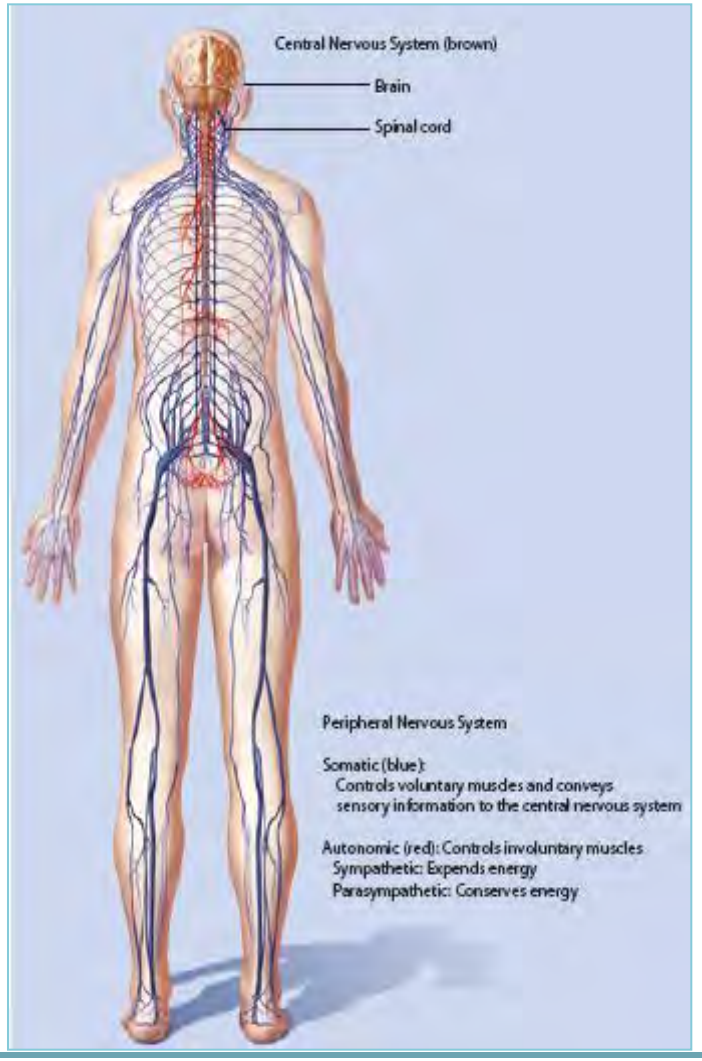




Somatic Nervous System

LO 2.4 Somatic and Autonomic Nervous Systems

- ***Somatic nervous system***:
  - consists of nerves that carry information from the senses to the CNS and from the CNS to the voluntary muscles of the body
- ***Autonomic nervous system***:
  - consists of nerves that control all of the involuntary muscles, organs, and glands

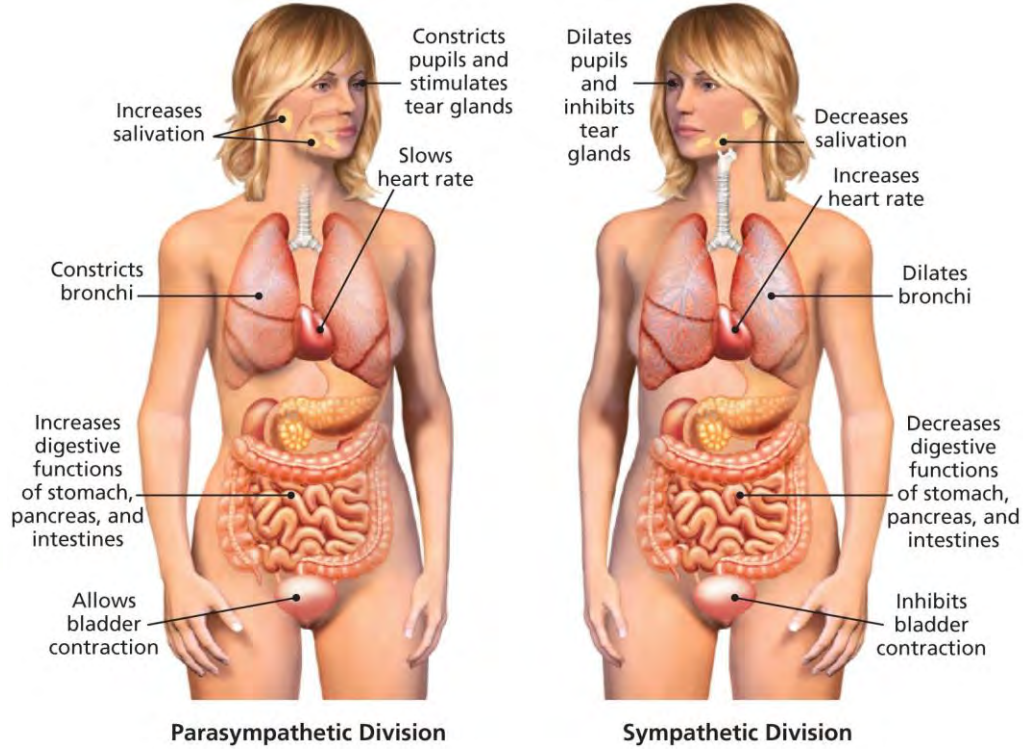


Autonomic Nervous System

LO 2.4 Somatic and Autonomic Nervous Systems

Sympathetic division (fight-or-flight system): responsible for reacting to stressful events and bodily arousal

Parasympathetic division: restores the body to normal functioning after arousal and is responsible for the day-to-day functioning of the organs and glands



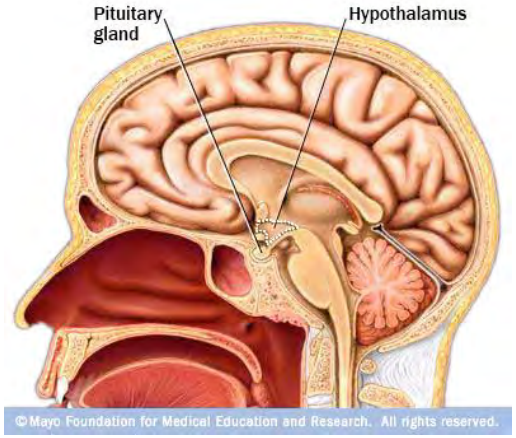
How Hormones Interact with the Nervous System and Affect Behavior

LO 2.5 Endocrine Glands

- ***Endocrine glands***: glands that secrete chemicals called hormones directly into the bloodstream

1. ***Pituitary gland (腦下垂體)***:

- located in the brain
- secretes human growth hormone
- influences all other hormone-secreting glands
- also known as the ***master gland***



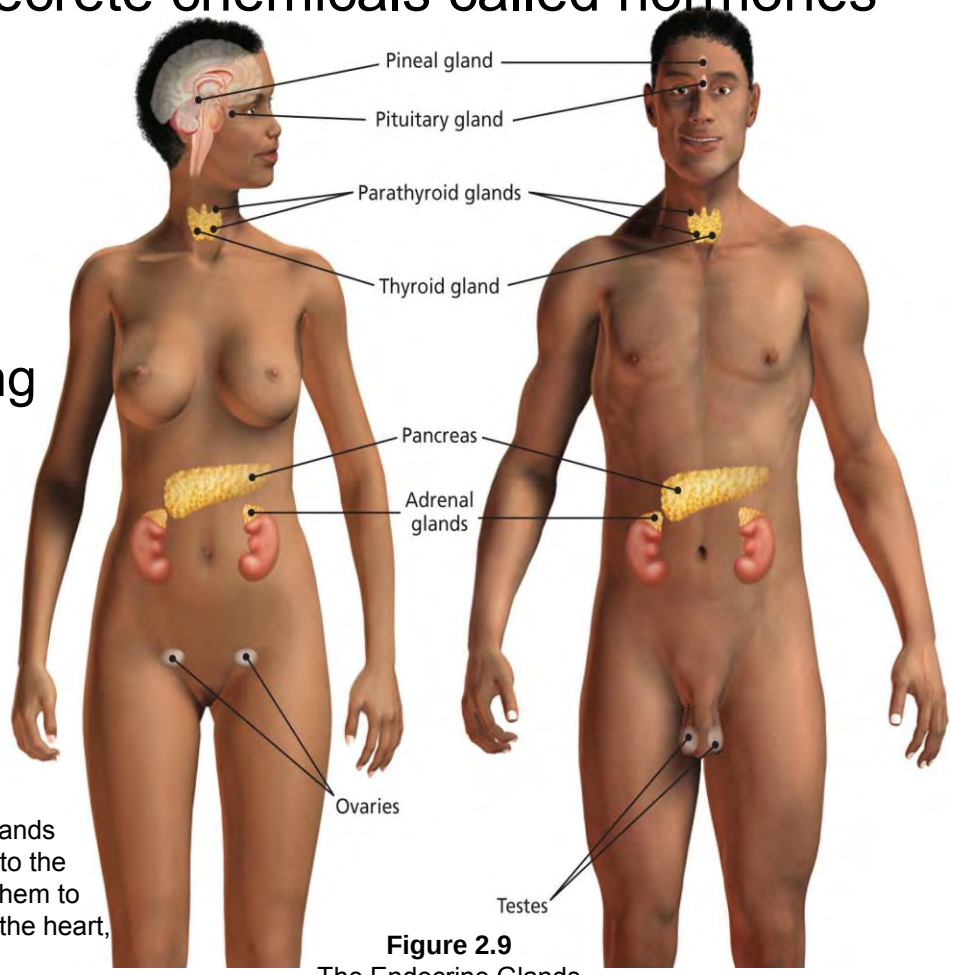


Figure 2.9 The endocrine glands secrete hormones directly into the bloodstream, which carries them to organs in the body, such as the heart, pancreas, and sex organs.

Figure 2.9
The Endocrine Glands

How Hormones Interact with the Nervous System and Affect Behavior

LO 2.5 Endocrine Glands

2. ***Pineal gland (松果體)***: secretes melatonin
3. ***Thyroid gland (甲狀腺)***: regulates metabolism
4. ***Pancreas (胰臟)***: controls the levels of sugar in the blood
5. ***Gonads (生殖腺)***: the sex glands; secrete hormones that regulate sexual development and behavior as well as reproduction
   - ovaries and testes
6. ***Adrenal gland (腎上腺)***: secrete hormones to deal with stress; regulate salt intake; provide a secondary source of sex hormones affecting the sexual changes that occur during adolescence

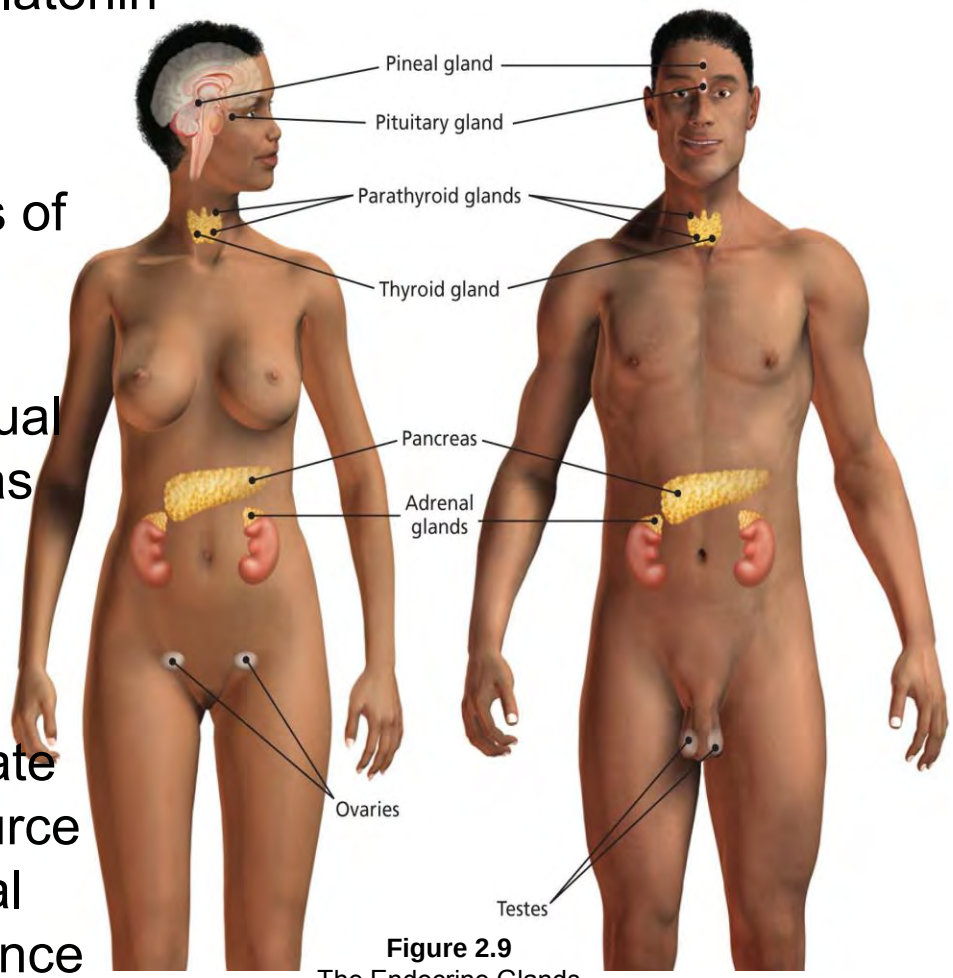
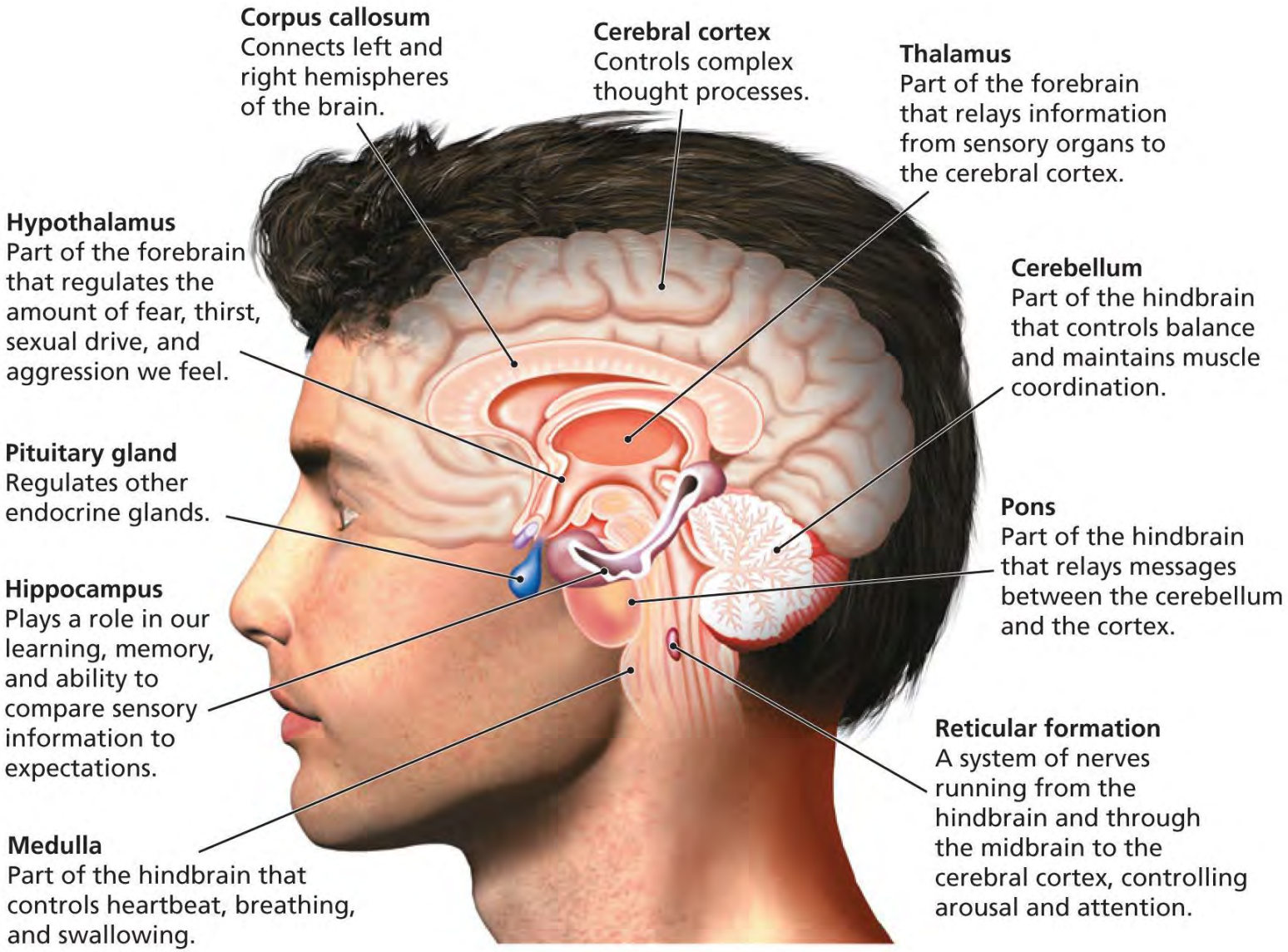


Figure 2.9
The Endocrine Glands

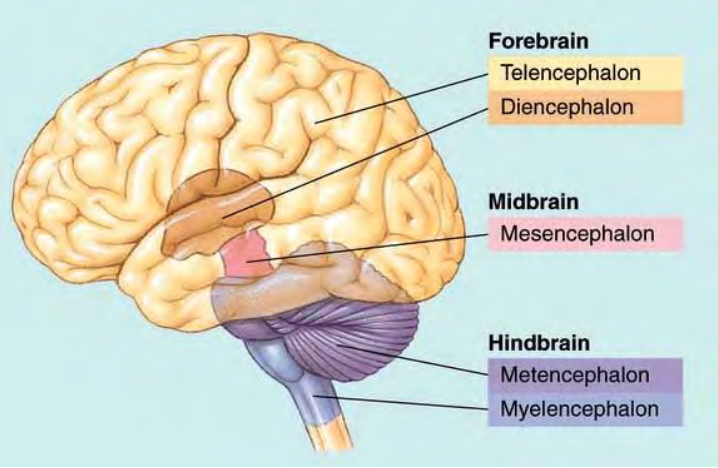
Figure 2.12 Major Structures of the Human Brain

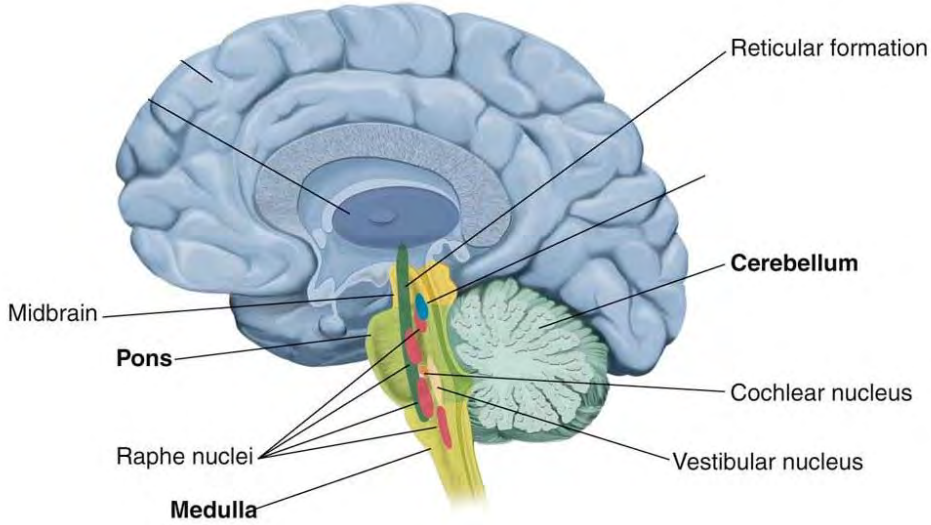


The Hindbrain

LO 2.7 Structures and Functions of the Bottom Part of Brain

1. ***Medulla***: first large swelling at the top of the spinal cord, forming the lowest part of the brain
   - responsible for life-sustaining functions such as breathing, swallowing, and heart rate
2. ***Pons***: larger swelling above the medulla that connects the top of the brain to the bottom
   - plays a part in sleep, dreaming, left–right body coordination, and arousal

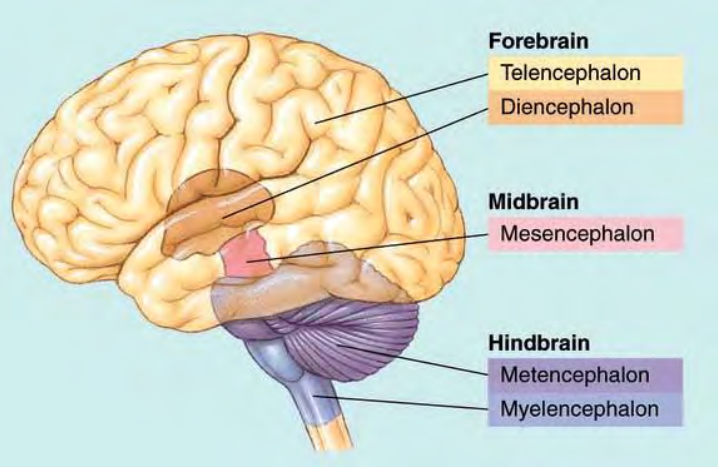


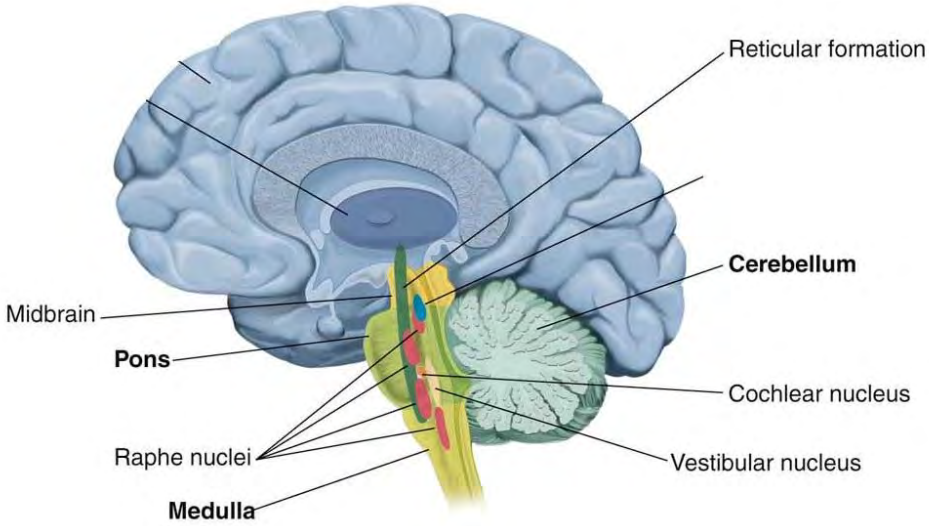


The Hindbrain

LO 2.7 Structures and Functions of the Bottom Part of Brain

3. ***Reticular formation***: area of neurons running through the middle of the medulla and the pons and slightly beyond
   - responsible for selective attention
4. ***Cerebellum***: part of the lower brain located behind the pons
   - controls and coordinates involuntary, rapid, fine motor movement

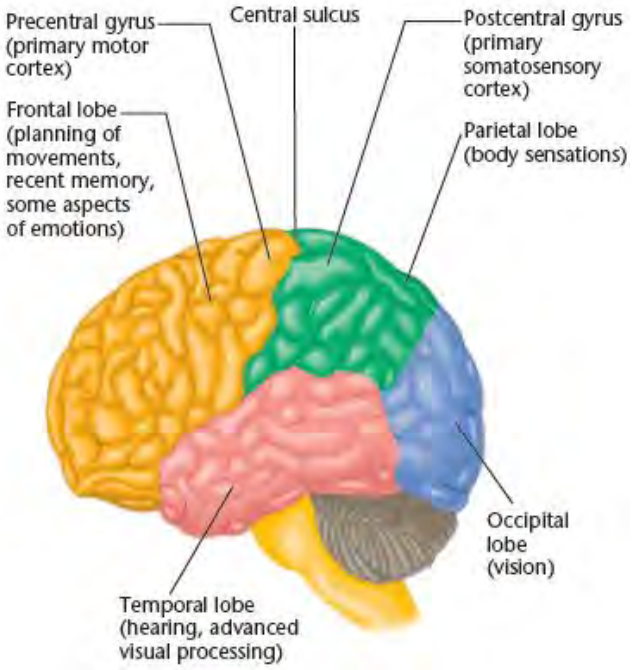


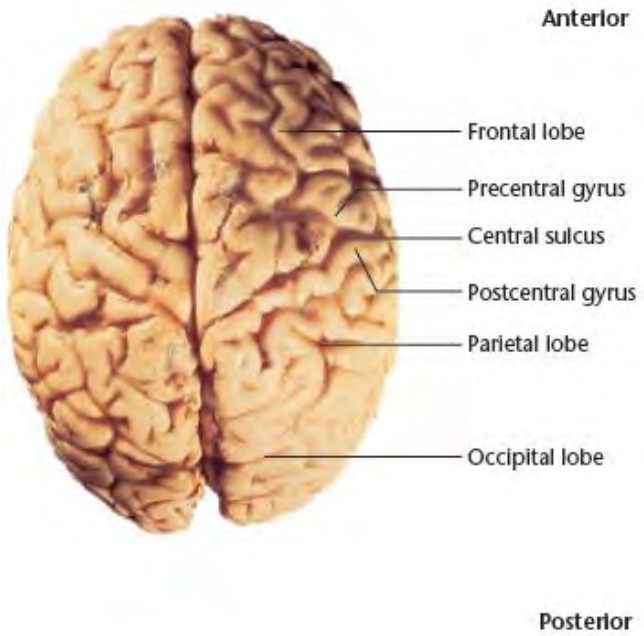


Cortex

LO 2.9 Parts of Cortex Controlling Senses and Movement

- ***Cortex* 腦皮層**: outermost covering of the brain; consists of densely packed neurons on the outer surface of the cerebral hemispheres
  - responsible for higher thought processes and interpretation of sensory input
  - divided into four lobes: occipital, parietal, temporal, and frontal

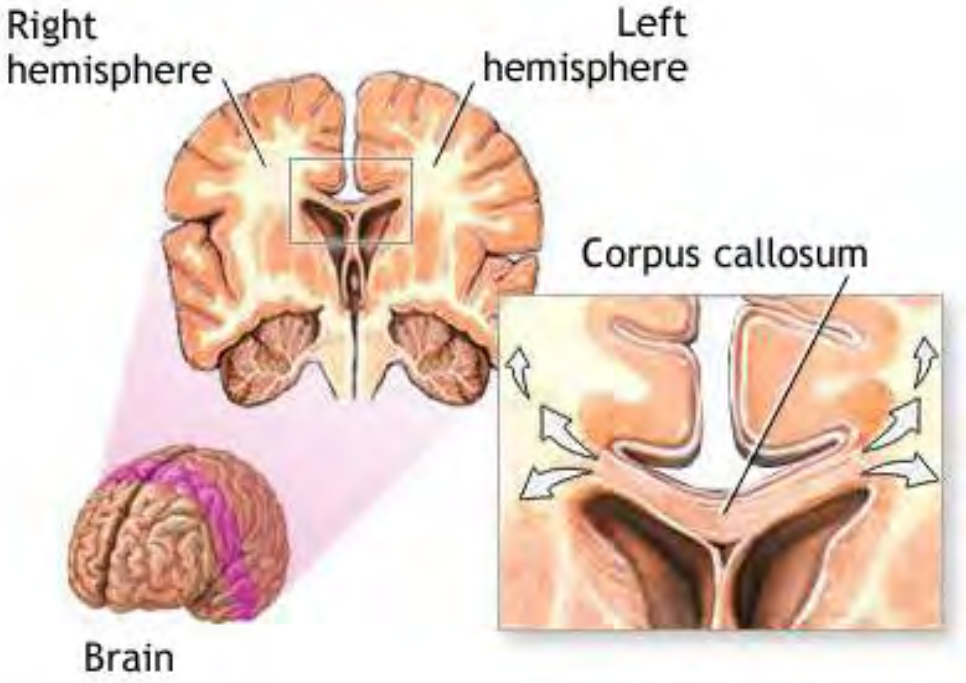


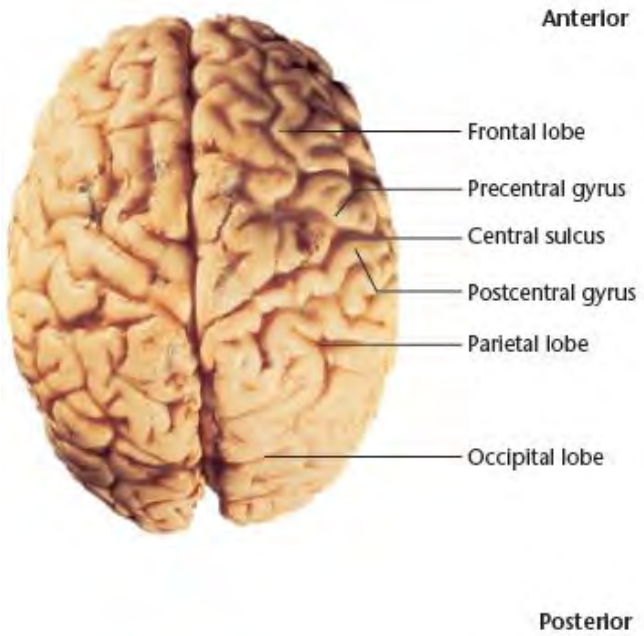


Cerebral Hemispheres

LO 2.9 Parts of Cortex Controlling Senses and Movement

- ***Cerebral hemispheres***: the two sections of the cortex on the left and right sides of the brain
- ***Corpus callosum***: thick band of neurons that connects the right and left cerebral hemispheres





Four Lobes of the Brain

LO 2.9 Parts of Cortex Controlling Senses and Movement

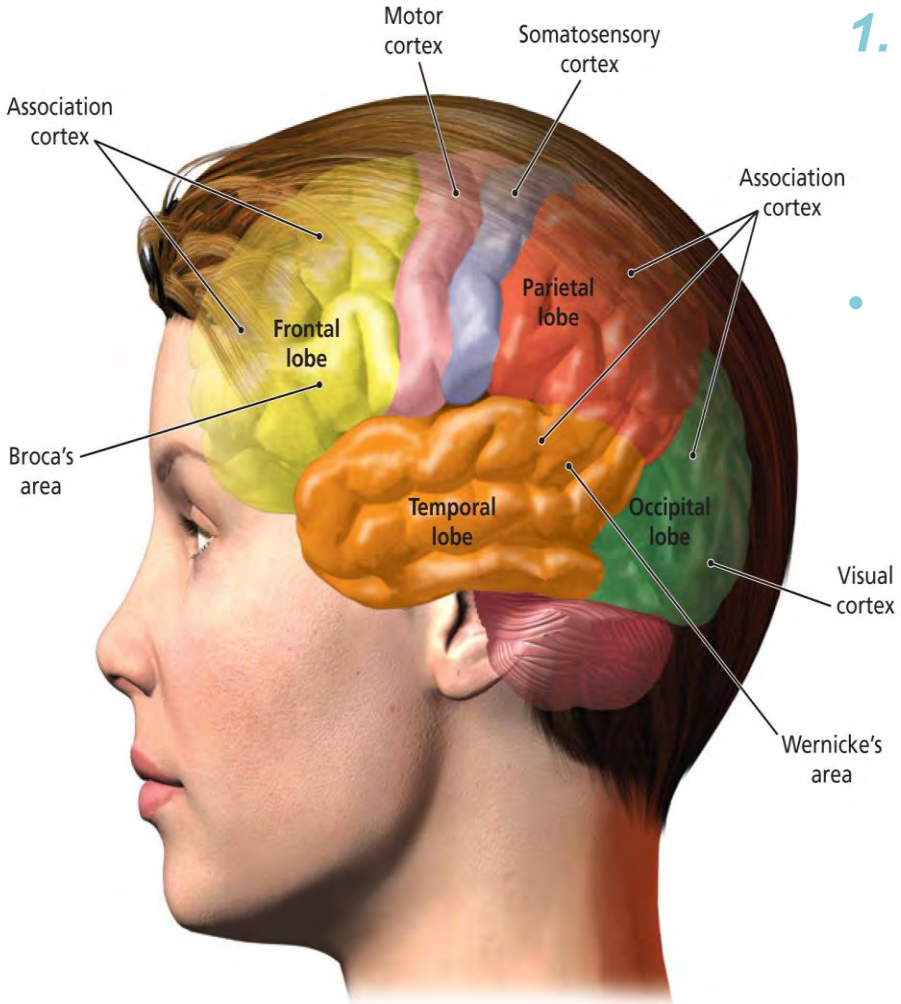
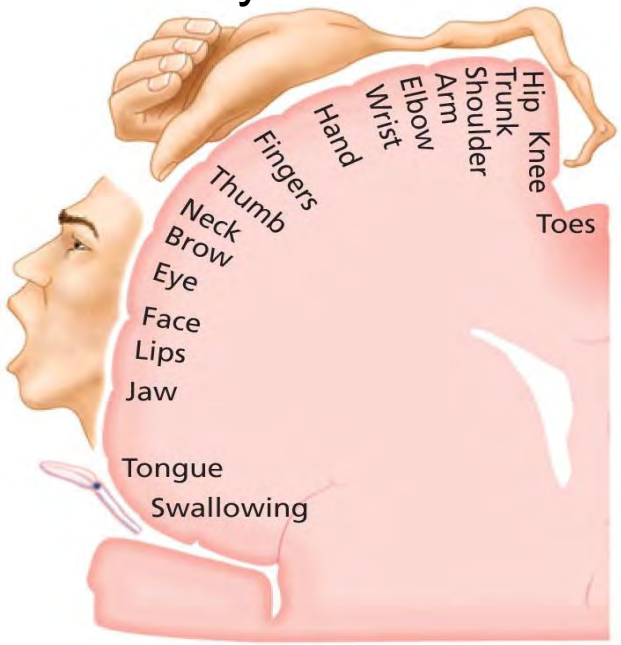


Figure 2.14 The Lobes of the Brain

1. ***Frontal lobes:*** located in the front and top of the brain; responsible for higher mental processes, decision making, and the production of fluent speech

- ***Motor cortex*:** located at the back; sends motor commands to the muscles of the somatic nervous system



Motor Cortex

Four Lobes of the Brain

LO 2.9 Parts of Cortex Controlling Senses and Movement

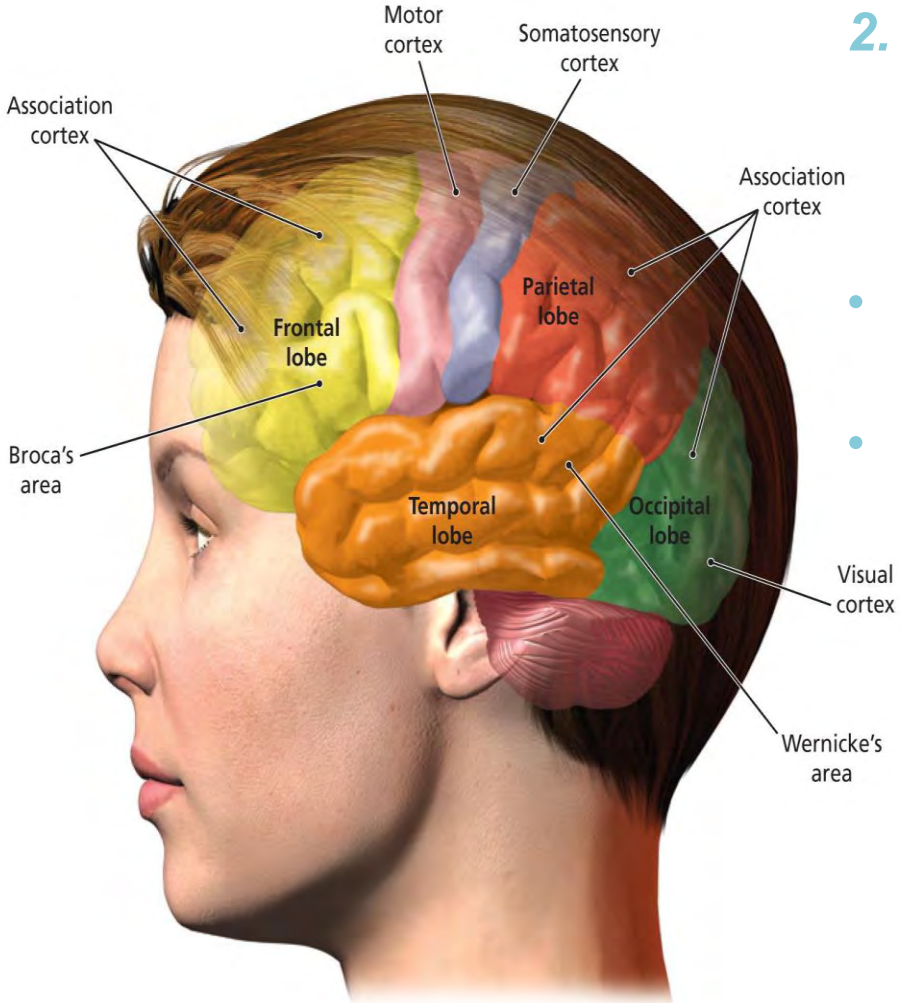
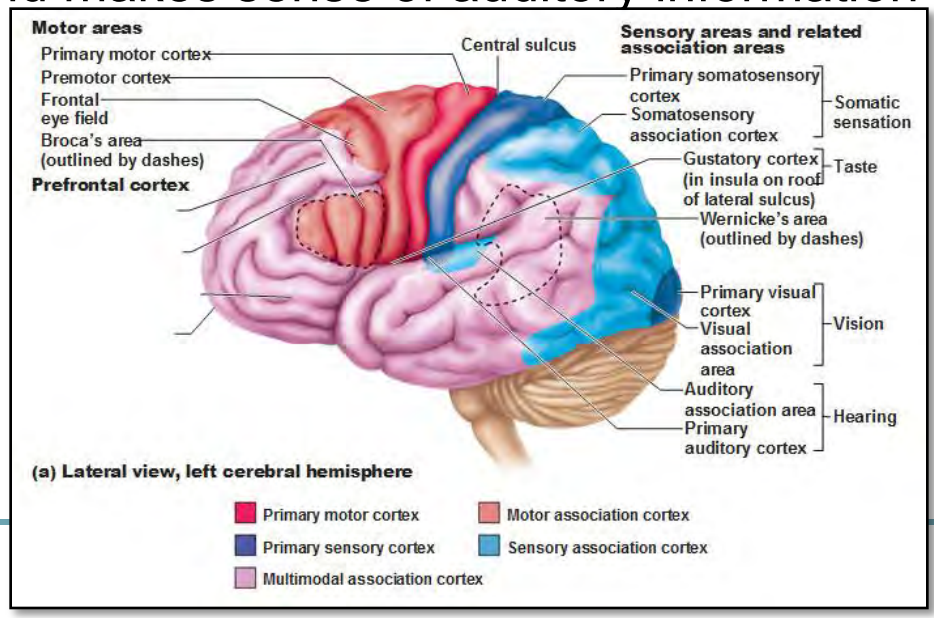


Figure 2.14 The Lobes of the Brain

2. ***Temporal lobes***: located just behind the temples containing the neurons responsible for the sense of <u>hearing</u> <u>and meaningful speech</u>

- ***Primary auditory cortex***: processes auditory information from the ears
- ***Auditory association cortex***: identifies and makes sense of auditory information



Four Lobes of the Brain

LO 2.9 Parts of Cortex Controlling Senses and Movement

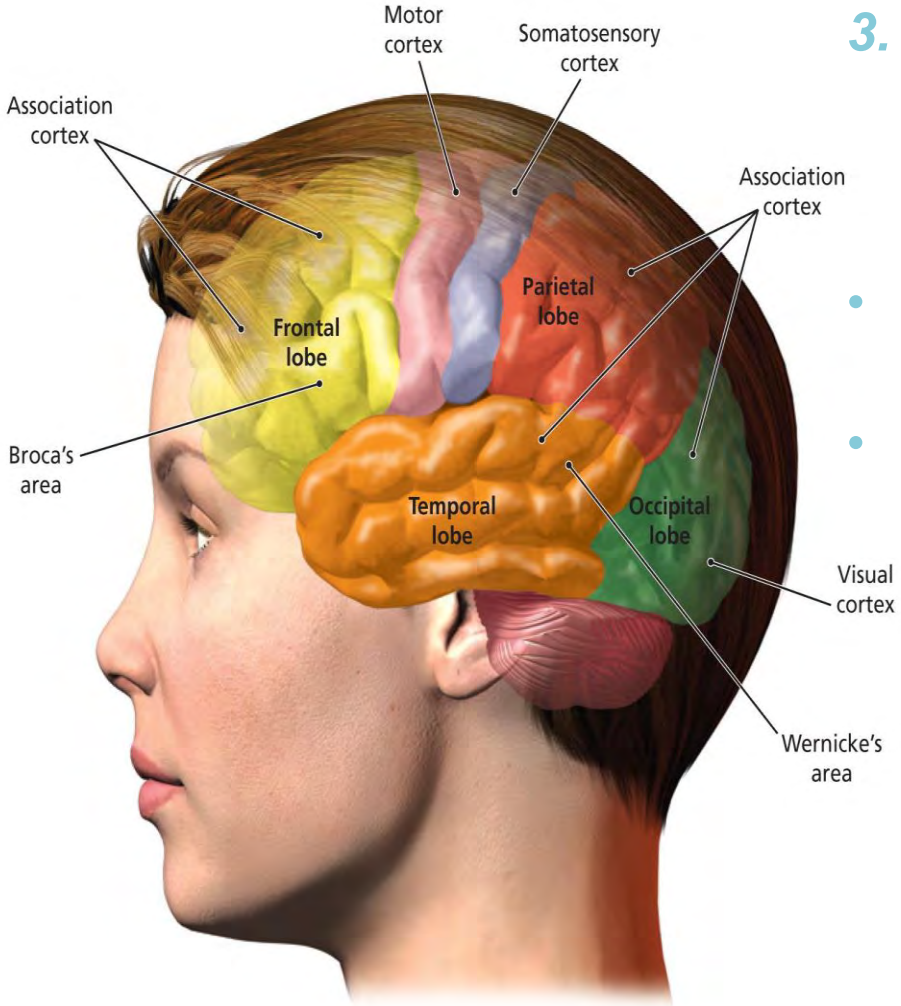
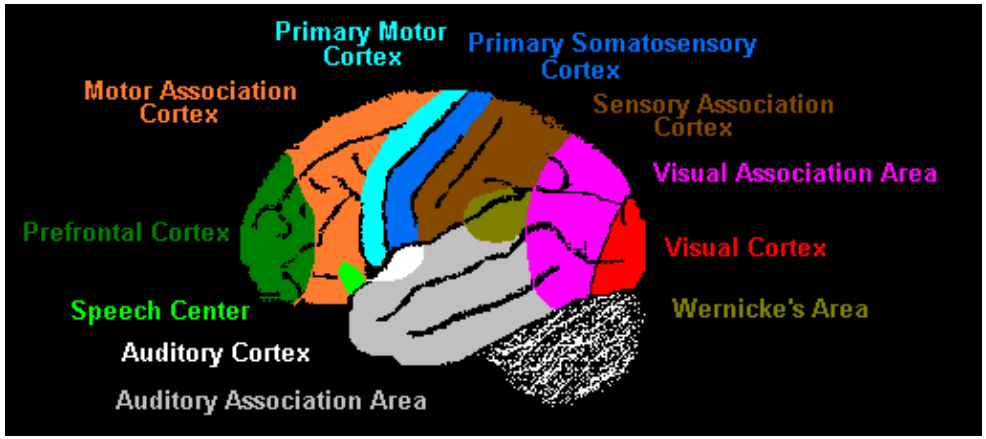


Figure 2.14 The Lobes of the Brain

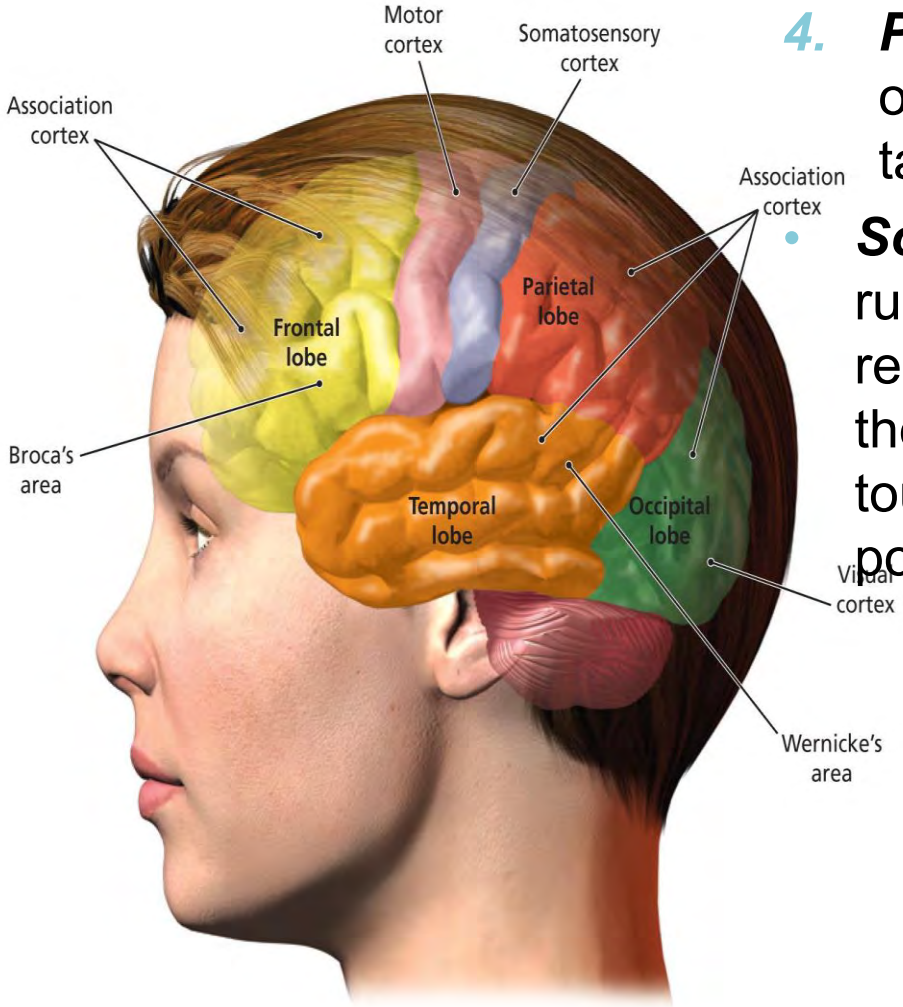
3. ***Occipital lobe***: located at the rear and bottom of each cerebral hemisphere containing the visual centers of the brain

- ***Primary visual cortex***: processes visual information from the eyes
- ***Visual association cortex***: identifies and makes sense of visual information



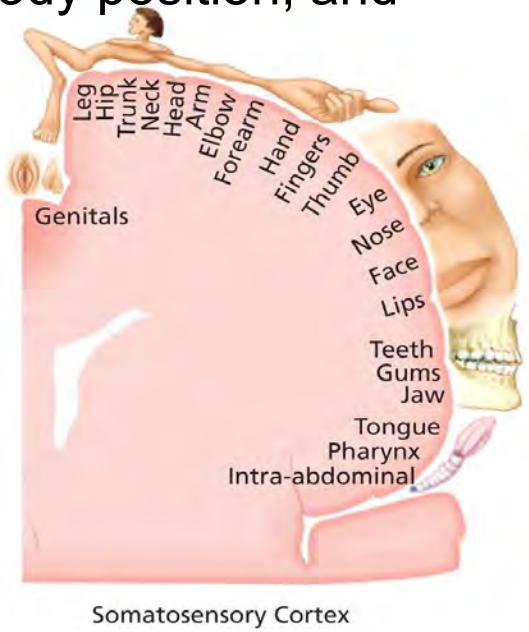
Four Lobes of the Brain

LO 2.9 Parts of Cortex Controlling Senses and Movement



4. ***Parietal lobe***: located at the top and back of each hemisphere; responsible for touch, taste, and temperature sensations

Somatosensory cortex: area of neurons running down the front of the parietal lobes; responsible for processing information from the skin and internal body receptors for touch, temperature, body position, and possibly taste



Somatosensory Cortex

Structures under the Cortex

LO 2.8 Structures that Control Emotion, Learning, Memory, and Motivation

- ***Limbic system***: a group of several brain structures located under the cortex and involved in learning, emotion, memory, and motivation

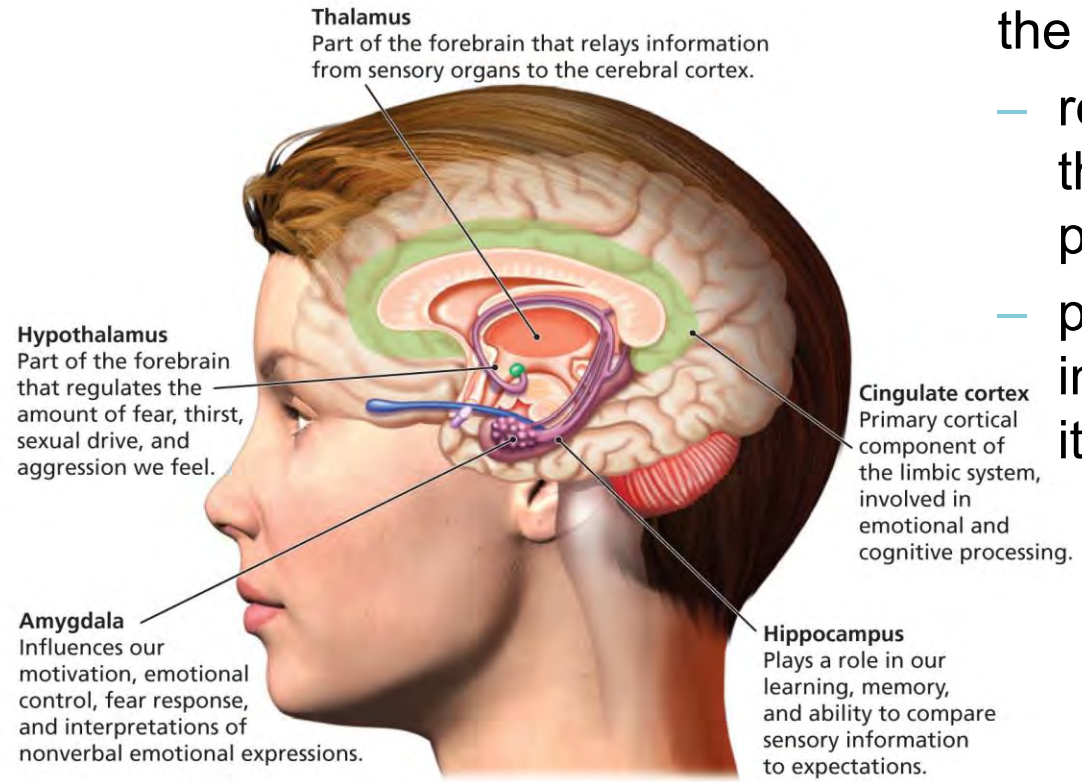


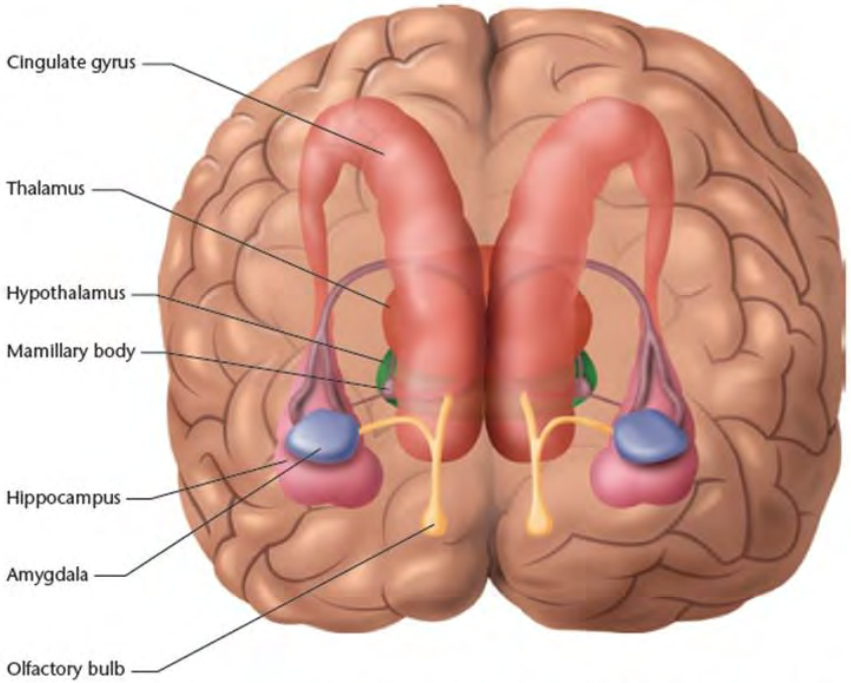
Figure 2.13 The Limbic System

1. ***Thalamus***: located in the center of the brain
   - relays sensory information from the lower part of the brain to the proper areas of the cortex
   - processes some sensory information before sending it to its proper area

Structures under the Cortex

LO 2.8 Structures that Control Emotion, Learning, Memory, and Motivation

2. ***Amygdala***: brain structure located near the hippocampus
   - responsible for fear responses and the memory of fear
3. ***Cingulate cortex***: found in the cortex
   - plays important roles in cognitive and emotional processing

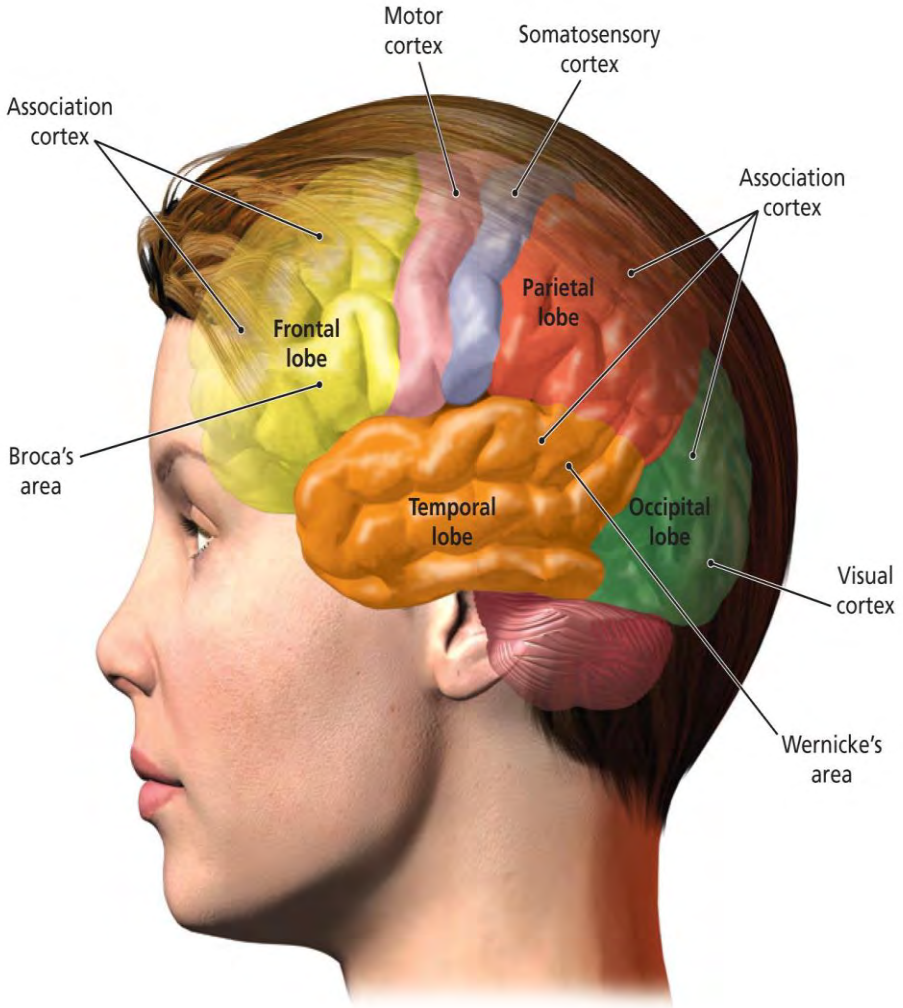


The limbic system is a set of subcortical structures that form a border (or limbus) around the brainstem

4. ***Hippocampus***: curved structure located within each temporal lobe
   - responsible for the formation of long-term memories and the storage of memory for location of objects
5. ***Hypothalamus***: small structure located below the thalamus and directly above the pituitary gland
   - responsible for motivational behavior such as sleep, hunger, thirst, and sex

Association Areas of Cortex

LO 2.10 Parts of Cortex Responsible for Higher Thought



- ***Broca's aphasia 達性失語症***: resulting from damage to Broca's area (usually in left frontal lobe)
  - causes the affected person to be unable to speak fluently, to mispronounce words, and to speak haltingly
- ***Wernicke's aphasia接受性失語症***: resulting from damage to Wernicke's area (usually in left temporal lobe)
  - causes the affected person to be unable to understand or produce meaningful language

Association Areas of Cortex

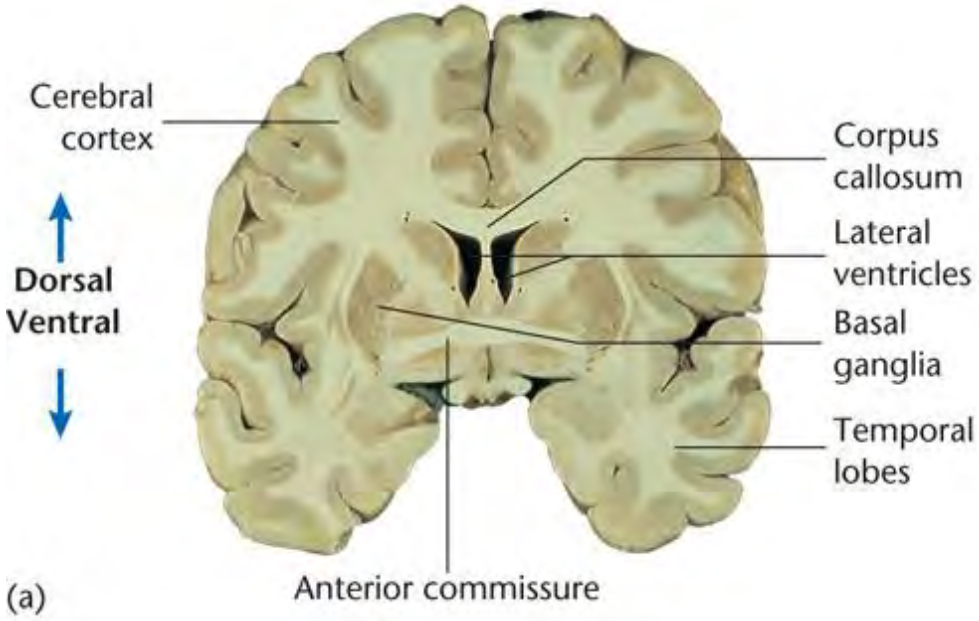
LO 2.10 Parts of Cortex Responsible for Higher Thought

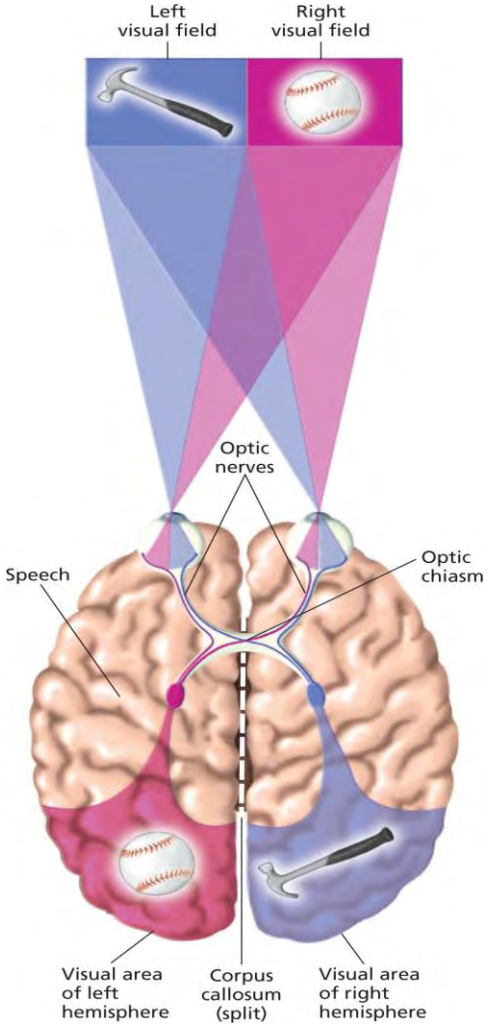
- ***Spatial neglect* 單側空間忽略**: caused by damage to the *parietal* lobe association areas of the right hemisphere
  - an inability to recognize objects or body parts in the left visual field

Split-Brain Research

LO 2.11 Differences between the Left and Right Sides of the Brain

- Split-Brain Research
  - study of patients with severed corpus callosum
  - involves sending messages to only one side of the brain
  - demonstrates right and left brain specialization





Results of Split-Brain Research

LO 2.11 Differences between the Left and Right Sides of the Brain

Left side of the brain

- controls language, writing, logical thought, analysis, mathematical abilities
- processes information sequentially, and enables one to speak

Right side of the brain

- controls emotional expression, spatial perception, recognition of faces, patterns, melodies, and emotions
- processes information globally and cannot influence speech

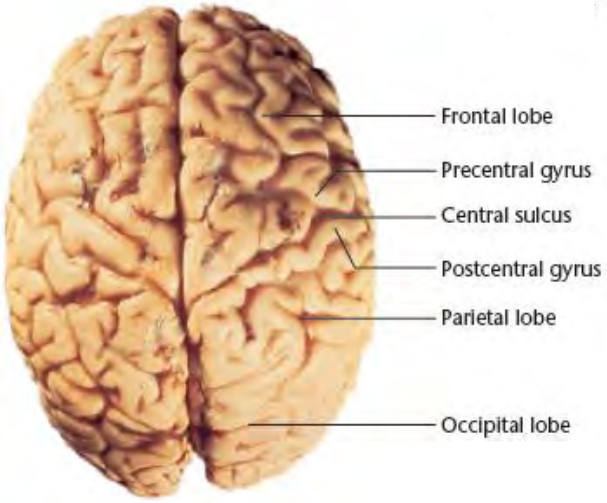


Table 2.2

Specialization of the Two Hemispheres

LEFT HEMISPHERE	RIGHT HEMISPHERE
Controls the right hand	Controls the left hand
Spoken language	Nonverbal
Written language	Visual–spatial perception
Mathematical calculations	Music and artistic processing
Logical thought processes	Emotional thought and recognition
Analysis of detail	Processes the whole
Reading	Pattern recognition
	Facial recognition

Looking Inside the Living Brain: Mapping Structure

LO 2.6 Study of the Brain and How It Works

Computed Tomography (CT) 電腦掃描:

- brain-imaging method using computer-controlled X-rays of the brain

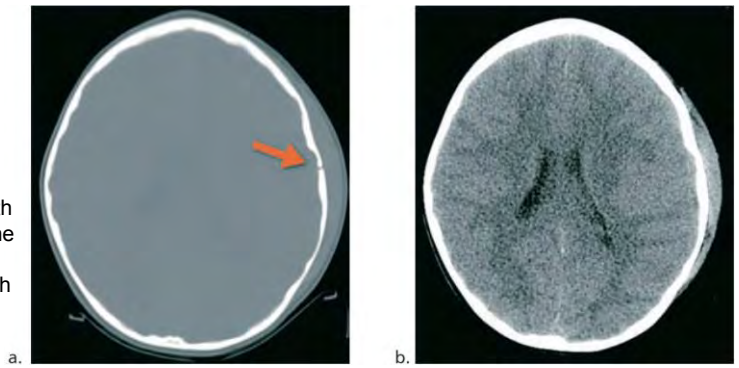
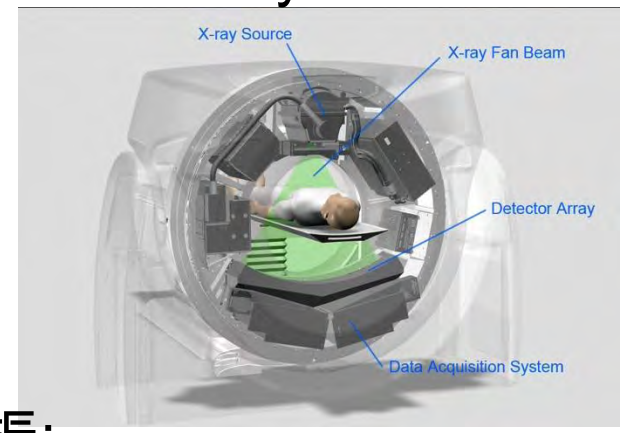
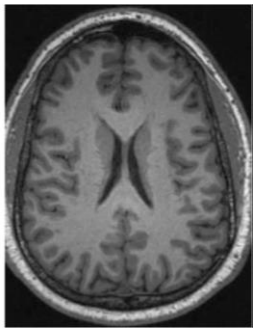


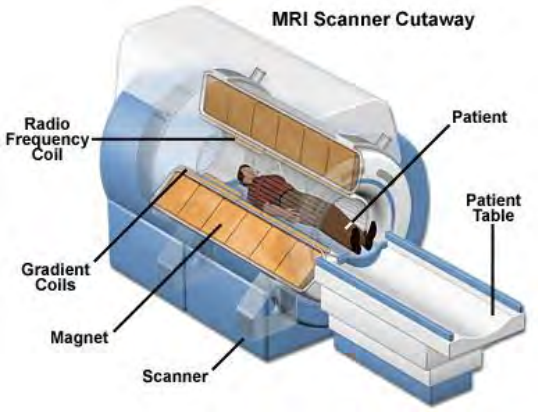
Fig. a shows CT scan from a 5-year-old girl with a head injury and skull fracture (indicated by the red arrow); Fig. b shows the same CT scan depicting the brain and swelling associated with the injury.



Magnetic Resonance Imaging (MRI) 磁力共振:

- brain-imaging method using radio waves and magnetic fields of the body to produce detailed images of the brain

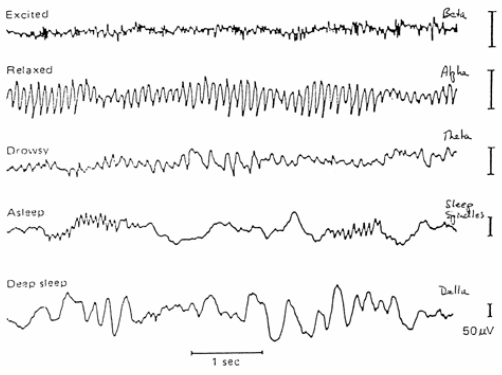


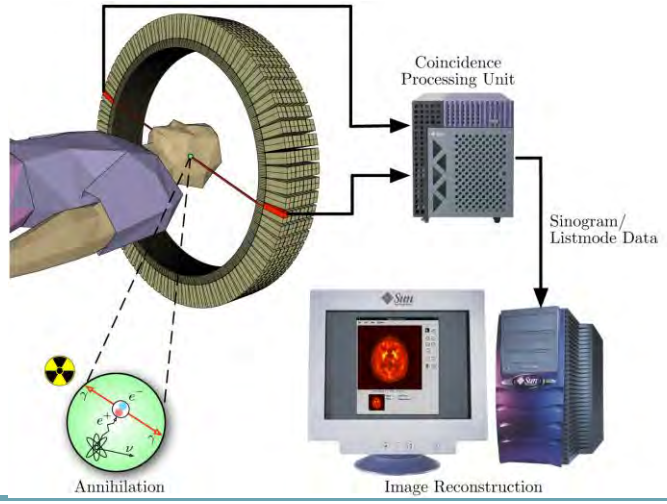


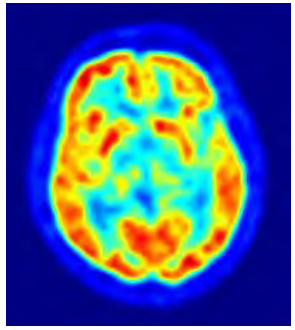
Looking Inside the Living Brain: Mapping Function

LO 2.6 Study of the Brain and How It Works

- ***Electroencephalogram*** (EEG) 腦電圖: records electric activity of the brain below specific areas of the skull
  - output is displayed in the form of waves via computer
- ***Positron Emission Tomography*** (PET)正子電腦斷層掃: radioactive sugar is injected into the subject and a computer compiles a color-coded image of brain activity of the brain; lighter colors indicate more activity
- ***Single Photon Emission Computed Tomography*** (SPECT)單光子衍射: similar to PET, but uses different radioactive tracers to examine brain blood flow







Looking Inside the Living Brain: Mapping Function

LO 2.6 Study of the Brain and How It Works

- ***functional Magnetic Resonance Imaging*** (fMRI): a computer makes a sort of "movie" of changes in the oxygen levels of blood using images from different time periods