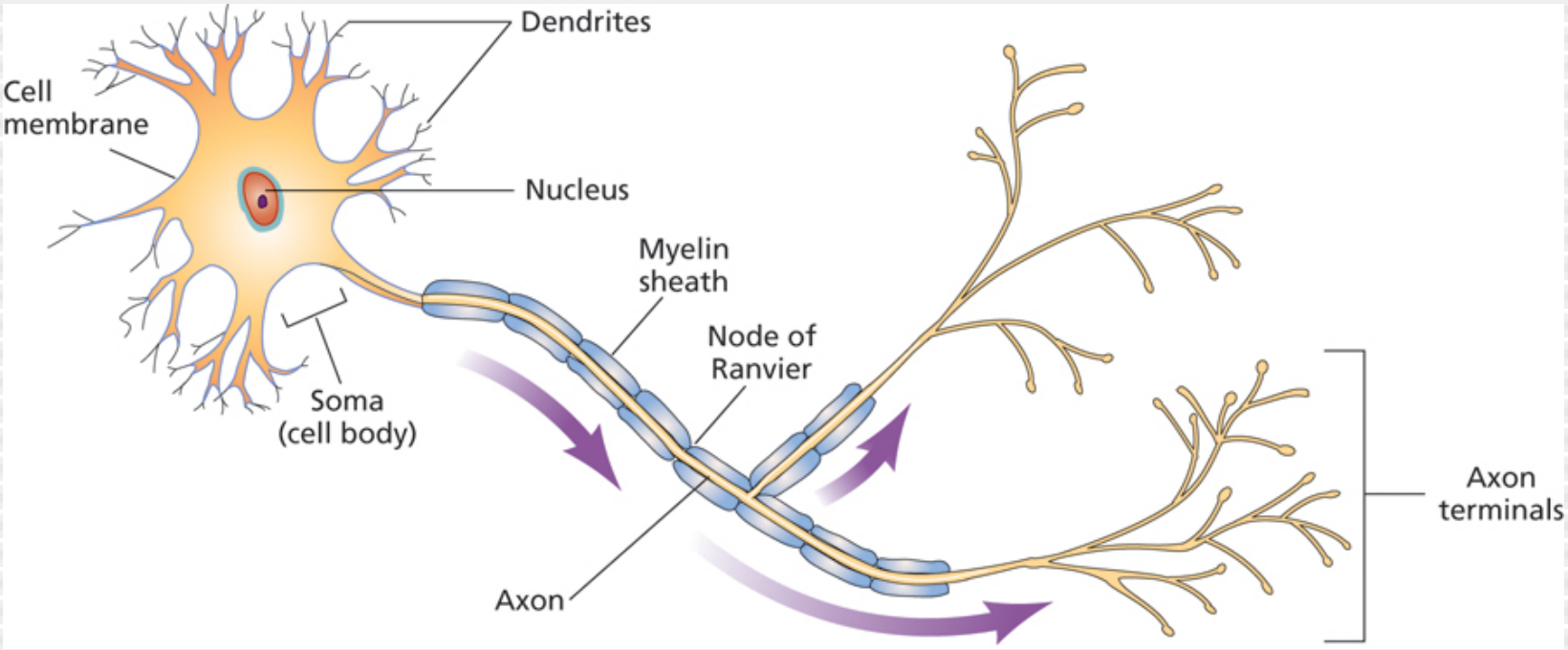
# The Brain and Behavior

# Neurons

- Neurons: the basic building blocks of the nervous system
- Three main parts:
  - Soma: the cell body
  - Dendrites: specialized receiving units that collect messages from neighboring neurons and send them on to the sell body
  - Axon: conducts electrical impulses away from the cell body to other neurons, muscles, or glands

# Neurons



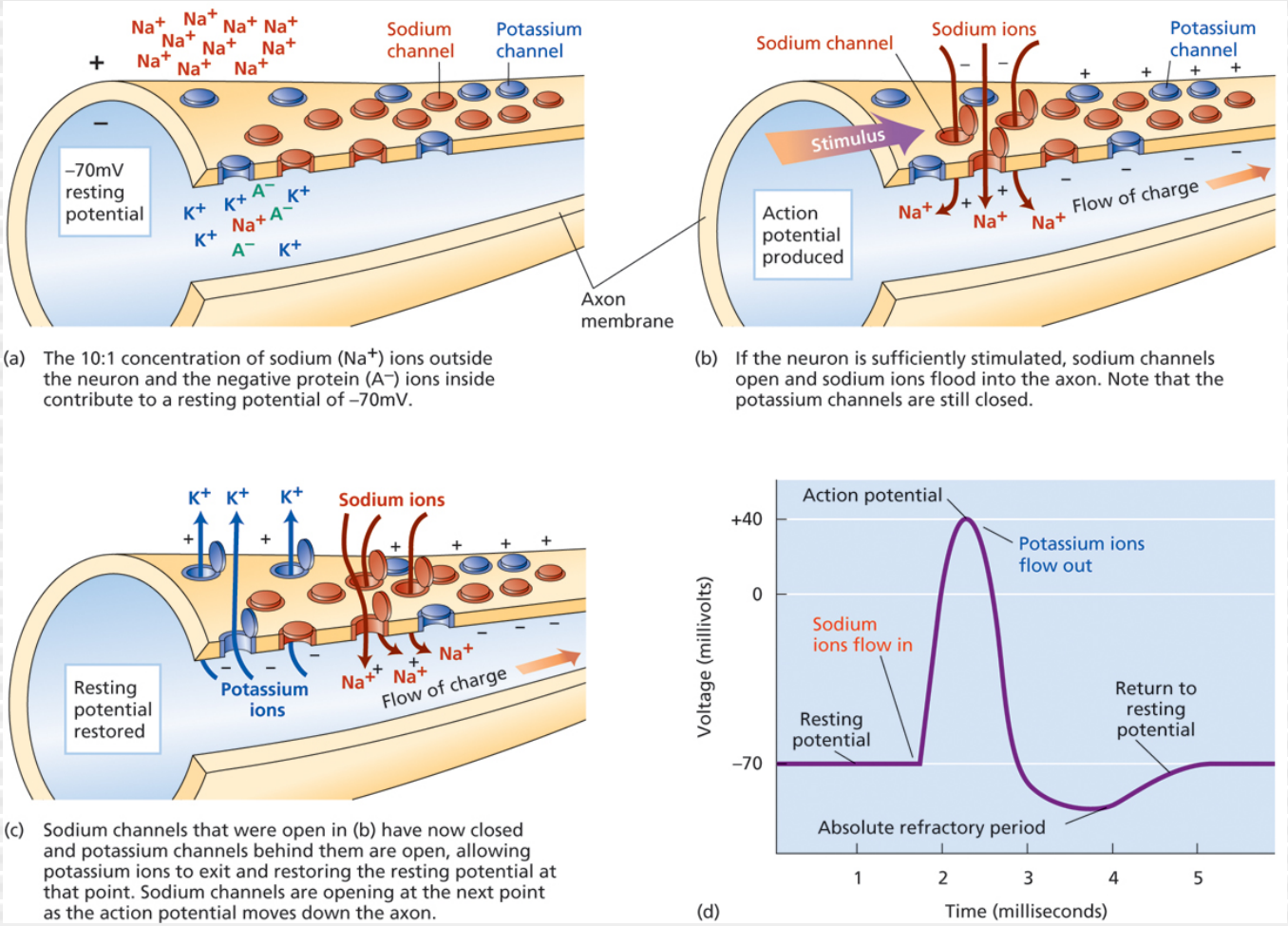
# Electrical Activity of Neurons

- Resting potential
  - Neuron is separated from surrounding fluid by a cell membrane; substances pass through *ion channels*
  - Inner ions are more negatively charged than outer ions, resulting in a net negative charge for the resting neuron

# Electrical Activity of Neurons

- Action potential: the electrical shift that occurs when a neuron is stimulated
  - Positive sodium ions enter the neuron, causing brief depolarization
- Absolute Refractory Period: the period immediately following the action potential in which the membrane is not excitable and cannot discharge another impulse

# Electrical Activity of Neurons




(a) The 10:1 concentration of sodium ($Na^+$) ions outside the neuron and the negative protein ($A^-$) ions inside contribute to a resting potential of –70mV.

(b) If the neuron is sufficiently stimulated, sodium channels open and sodium ions flood into the axon. Note that the potassium channels are still closed.

(c) Sodium channels that were open in (b) have now closed and potassium channels behind them are open, allowing potassium ions to exit and restoring the resting potential at that point. Sodium channels are opening at the next point as the action potential moves down the axon.

# Electrical Activity of Neurons

- All-Or-None-Law: action potentials occur either at a uniform and maximum intensity, or they do not occur at all
  - Graded Potentials: changes in the negative resting potential that do not reach the action potential threshold
    - May combine to trigger an action potential in certain circumstances

# Electrical Activity of Neurons

- Myelin Sheath: a layer of fatty insulation that surrounds the axon
  - Improves the efficiency of neural transmissions
  - Damage to myelin sheath can be tragic and severe

# How Neurons Communicate

- Synaptic Space: a tiny gap between the axon terminal and the next neuron
- Neurotransmitters: chemical substances that carry messages across the synaptic space to other neurons, muscles, or glands
  - Step 1: *synthesis:* the transmitter molecules are formed
  - Step 2: *storage:* transmitter molecules are stored in synaptic vesicles (in axon terminal)

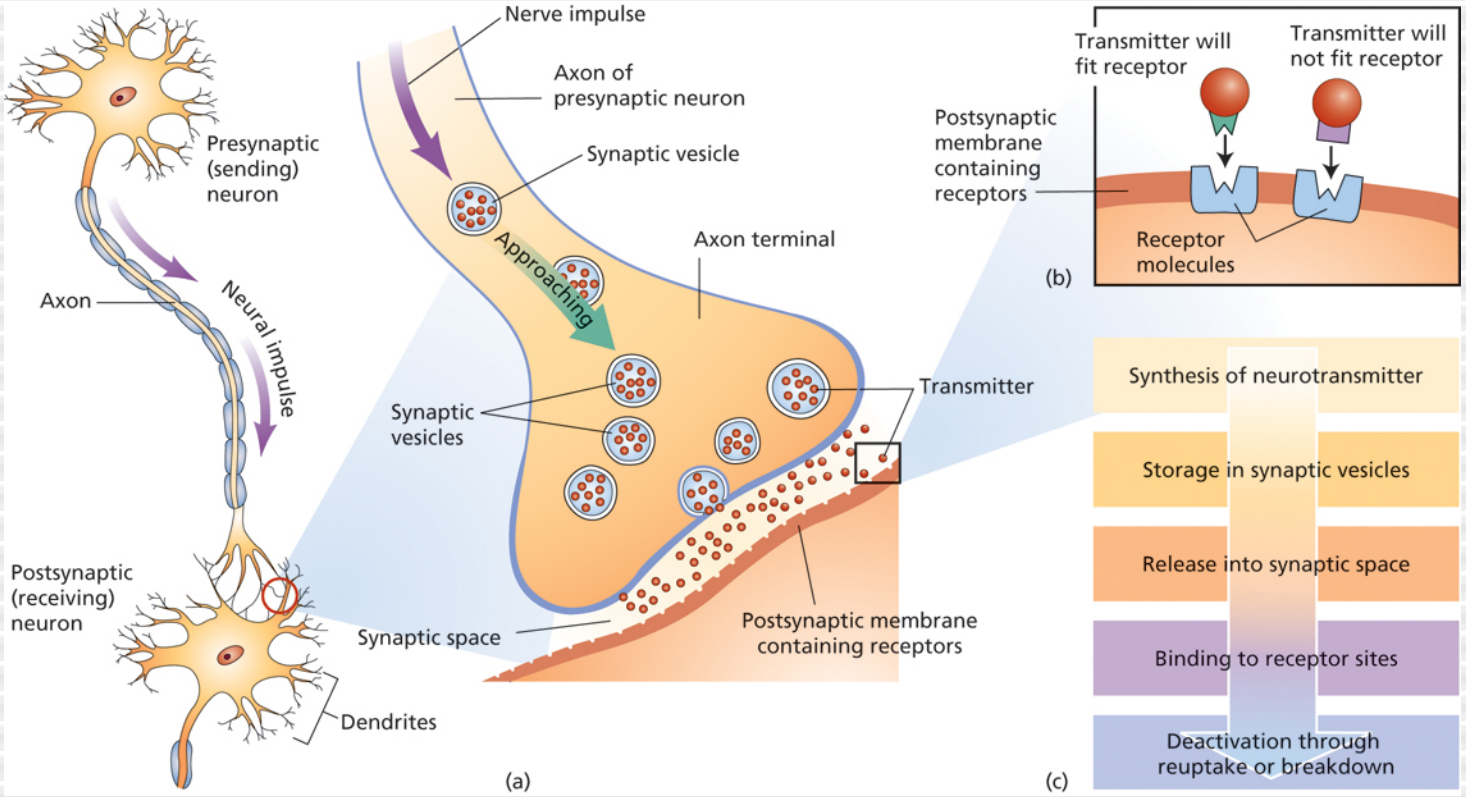
# How Neurons Communicate

- Neurotransmitters (continued)
  - Step 3: *release:* action potential causes transmitter molecules to move from synaptic vesicles across the gap
  - Step 4: *binding:* transmitter molecules bind themselves to receptor sites embedded in the receiving neuron's cell membrane
    - Each neurotransmitter fits like a lock and key

# How Neurons Communicate

- Neurotransmitters (continued)
  - Two types of chemical reactions can occur:
    - *Excitatory:* causes the action potential to fire
    - *Inhibitory:* prevents the neuron from firing
  - Step 5: *deactivation*: occurs in two ways:
    - Transmitter can be broken down by other chemicals
    - Reuptake: transmitter molecules are taken back into the presynaptic axon terminals

# How Neurons Communicate



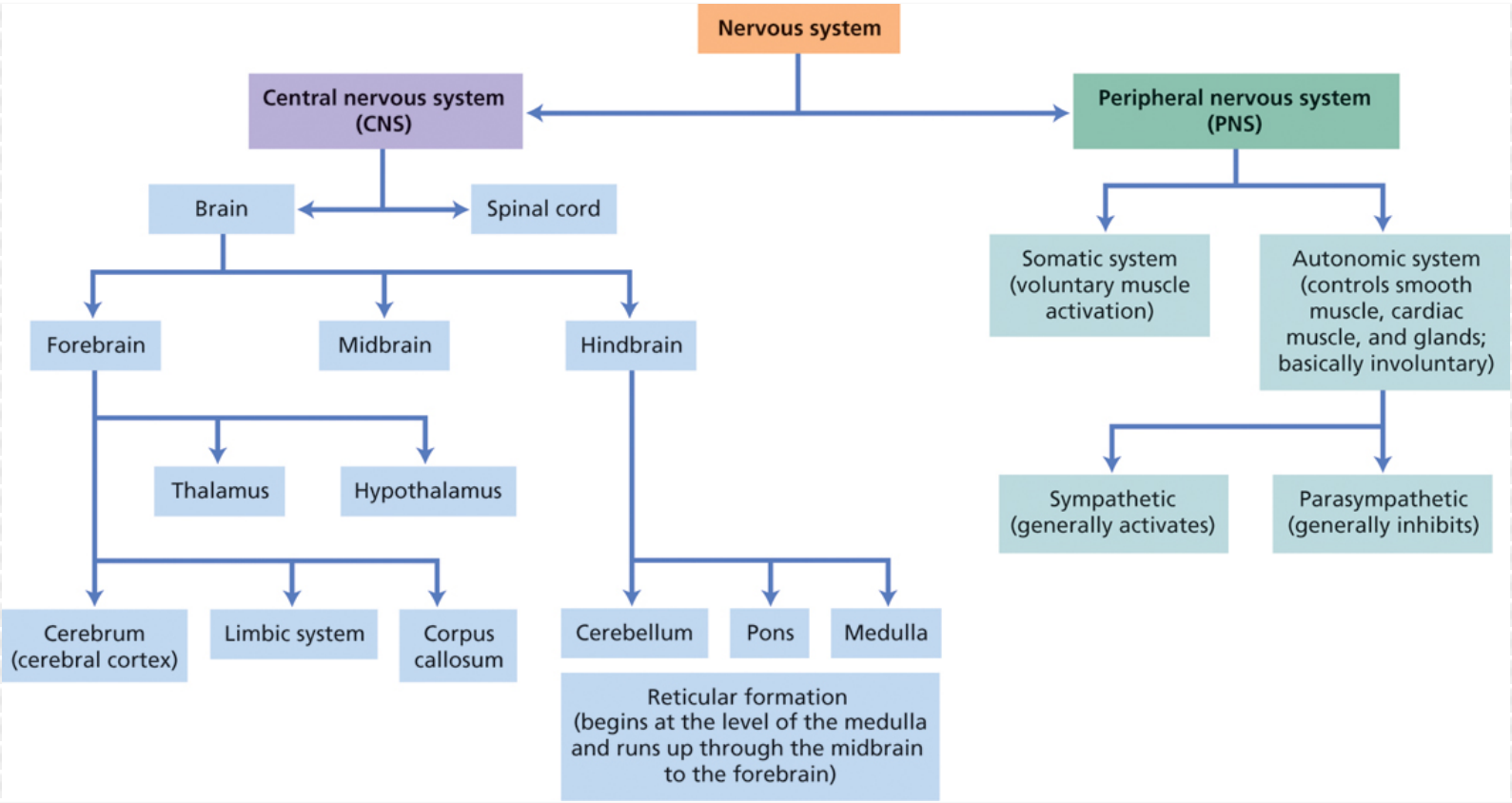
# Major Neurotransmitters

- Acetylcholine (ACh): a neurotransmitter involved in muscle activity and memory
  - Underproduction involved in Alzheimer's
  - Drugs that block ACh production:
    - Botulism
    - Botox
  - Overproduction occurs with Black Widow spider bites

# The Nervous System

- Sensory Neurons: carry input messages from the sense organs to the spinal cord and brain
- Motor Neurons: transmit output impulses from the brain and spinal cord to the body's muscles and organs
- Interneurons: perform connective or associative functions

# The Nervous System



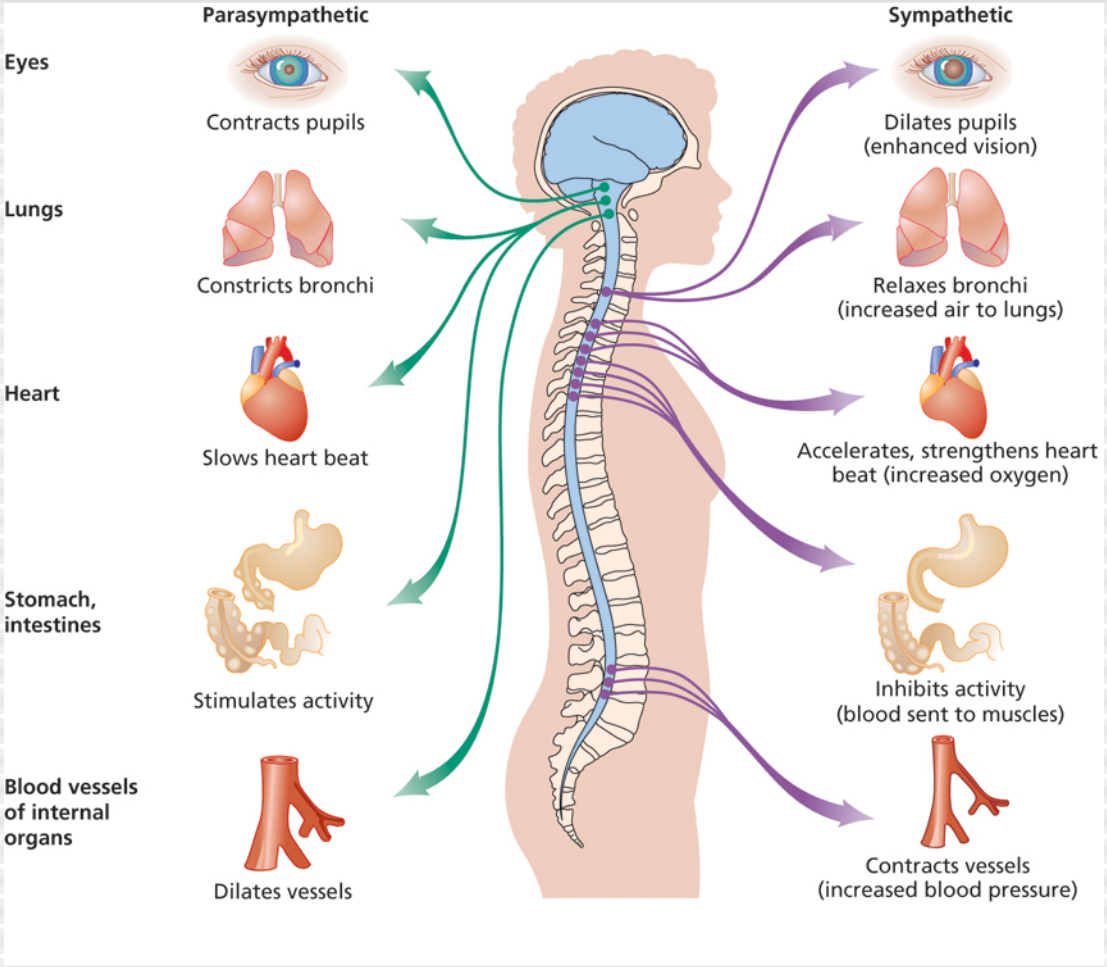
# The Nervous System

- Peripheral Nervous System contains all the neural structures that lie outside of the brain and spinal cord
  - Somatic Nervous System: a system of sensory and motor neurons that allows us to sense and respond to our environment
  - Autonomic Nervous System: a system that senses the body's internal functions and controls many glands and muscles

# The Nervous System

- Autonomic Nervous System has two divisions:
  - Sympathetic: activation or arousal function (fight or flight)
  - Parasympathetic: slows down the body; maintains a state of internal equilibrium
    - Homeostasis: a delicately balanced or steady internal state

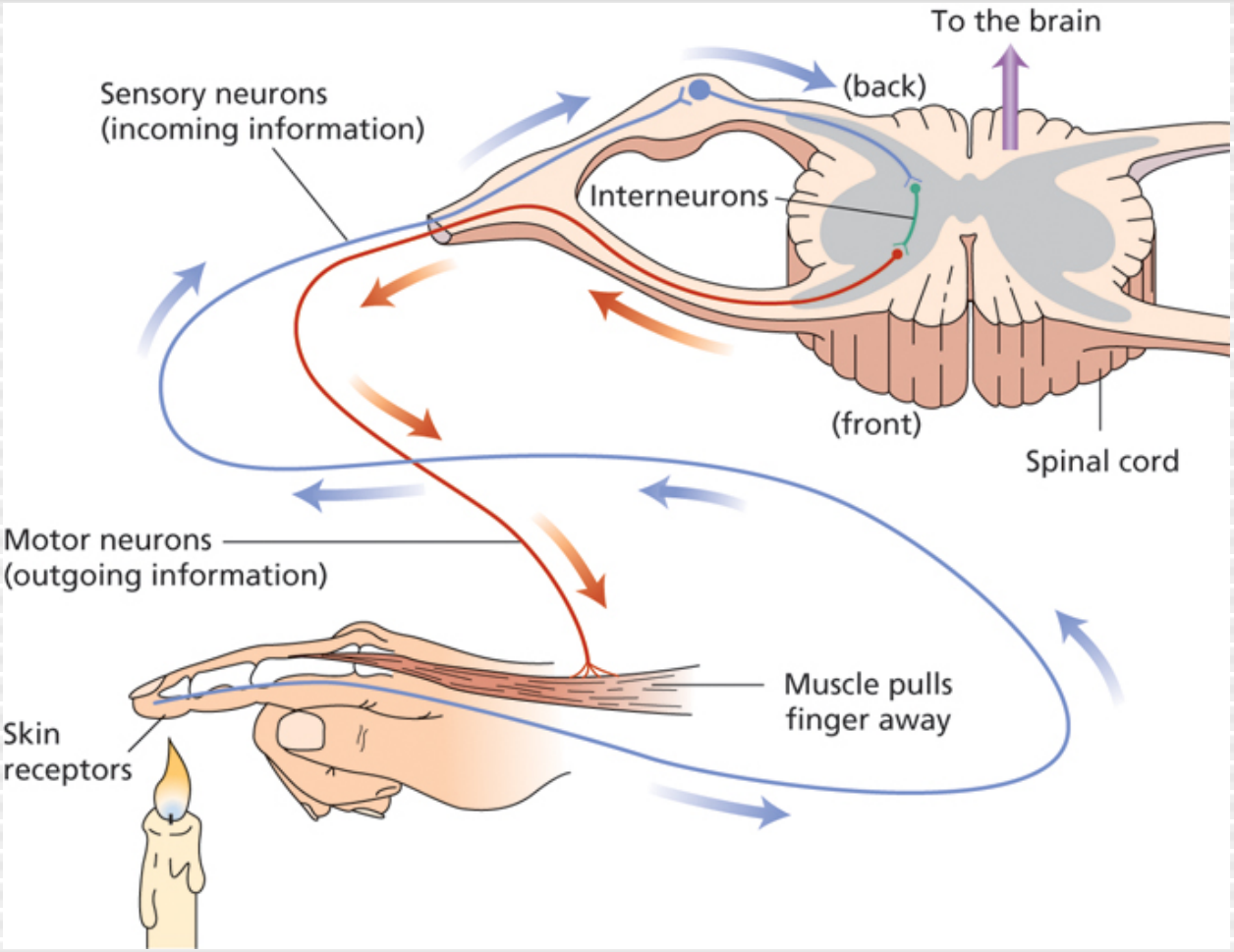
# The Nervous System



# The Nervous System

- Central Nervous System contains the brain and the spinal cord, which connects most parts of the peripheral nervous system with the brain
- Spinal Cord: a densely packed bundle of nerve fibers that transmits messages from sensory and motor neurons

# The Nervous System



# The Brain

- Several methods for studying the structure and function of the brain:
  - Neuropsychological tests measure verbal and nonverbal behaviors of brain-damage sufferers
  - Destruction and stimulation techniques
  - Electrical Recording
    - EEG measures the activity of large groups of neurons through a series of large electrodes placed on the scalp

# The Brain

- Brain Imaging
  - CT scans use x-ray technology to study brain structures
  - MRIs create images based on how atoms in living tissue respond to a magnetic pulse delivered by the device
  - PET scans measure brain activity, including metabolism, blood flow, and neurotransmitter activity
  - fMRIs produce pictures of blood flow in the brain taken less than a second apart

# Brain Structure and Function

- Three major subdivisions of the brain:
  - Hindbrain
  - Midbrain
  - Forebrain
- Hindbrain: lowest and most primitive level of the brain
  - Brain Stem
  - Cerebellum

# Brain Structure and Function

- Brain stem: supports vital life functions
  - Medulla: plays an important role in vital body functions such as heart rate and respiration
  - Pons: carries nerve impulses between higher and lower levels of the nervous system

# Brain Structure and Function

- Cerebellum: concerned with muscular movement coordination, learning, and memory
  - Regulates complex movements that require precise timing
  - Cerebellum functions are easily disrupted by alcohol

# Brain Structure and Function

- Midbrain: contains clusters of sensory and motor neurons
  - Reticular Formation: alerts higher centers of the brain that messages are coming and then either blocks or allows those messages

# Brain Structure and Function

- Forebrain: the brain's most advanced portion from an evolutionary standpoint
  - Cerebrum: the major structure of the forebrain
    - Consists of two large hemispheres that wrap around the brain stem

# Brain Structure and Function

- Forebrain structures:
  - Thalamus: "switchboard" that organizes inputs from sensory organs and routes them to the appropriate areas of the brain
  - Hypothalamus: plays a major role in motivation and emotion
    - Controls hormonal secretions that regulate sexual behavior, metabolism, reactions to stress, and pleasure/pain

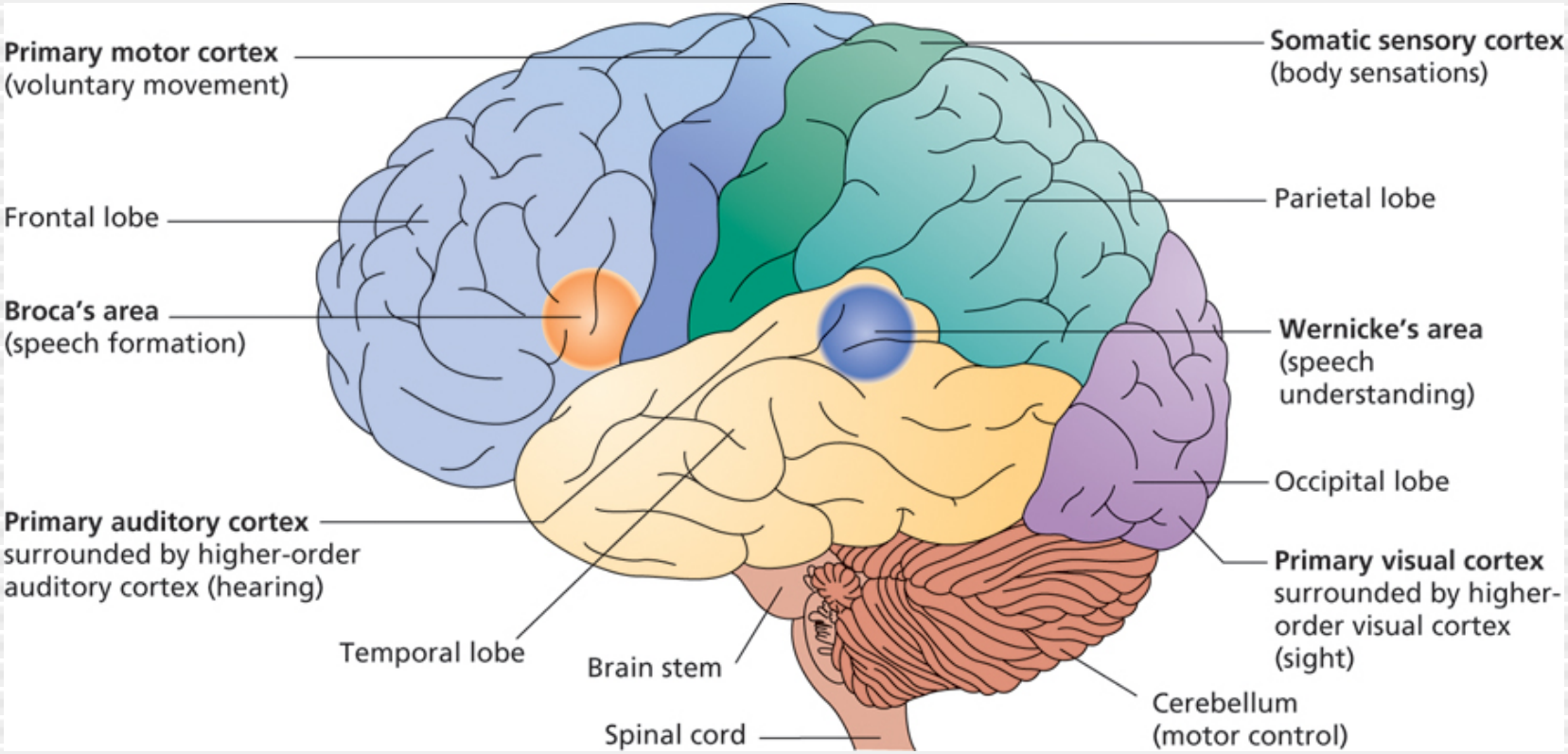
# Brain Structure and Function

- Limbic System: helps coordinate behaviors needed to satisfy motivational and emotional urges that arise in the hypothalamus
  - Hippocampus: involved in forming and retrieving memories
  - Amygdala: organizes motivational and emotional response patterns
    - Aggression and fear

# Brain Structure and Function

- Cerebral Cortex: a 1/4 in. sheet of gray, unmyelinated cells that form the outermost layer of the human brain
  - Fissures: folds in the cerebral cortex; allows greater surface area in a smaller space
    - Fissures separate the brain into four lobes (frontal, parietal, occipital, and temporal)

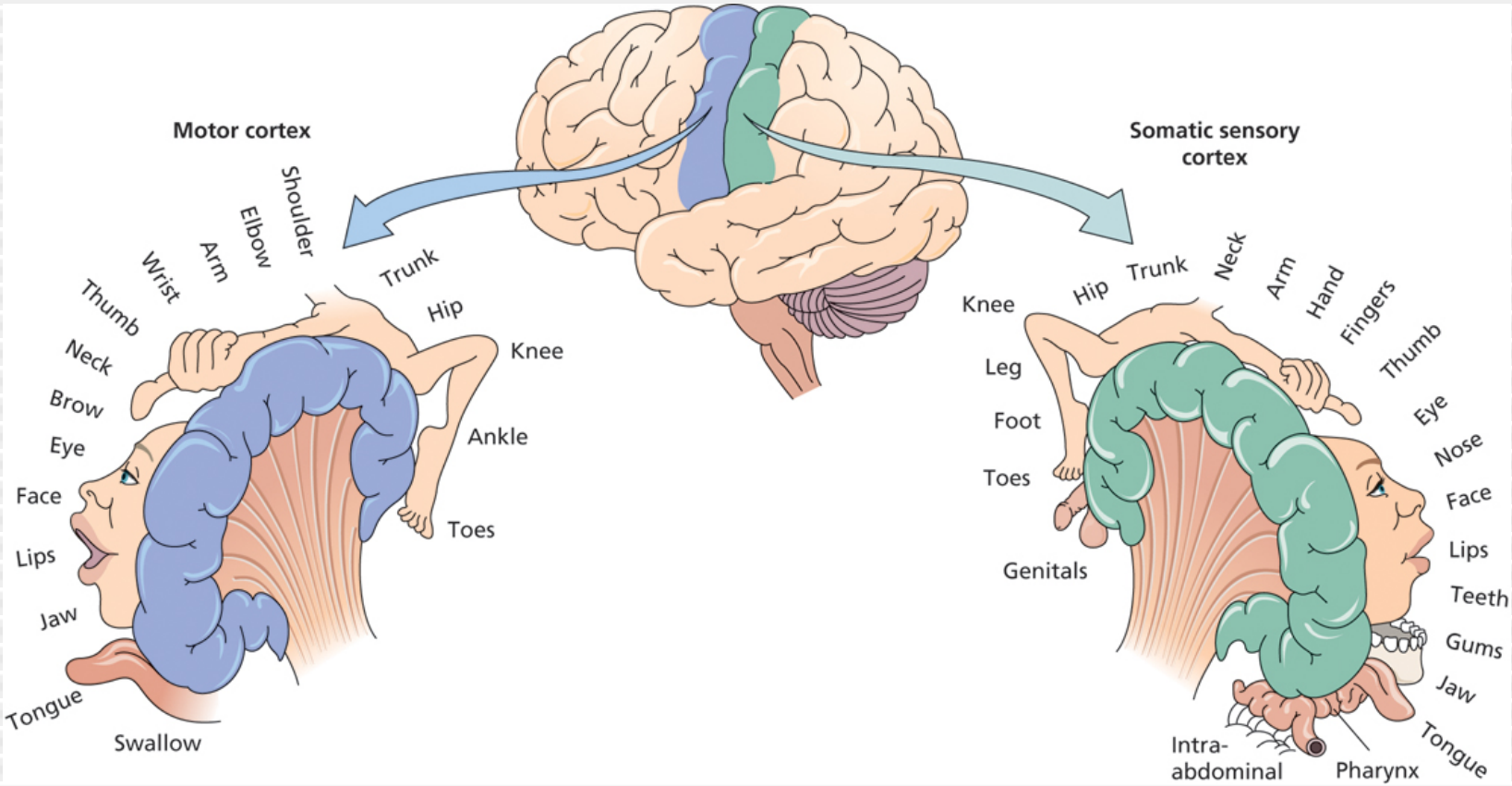
# Brain Structure and Function



# Brain Structure and Function

- Motor Cortex: controls the 600 or more muscles involved in voluntary body movements
  - Each hemisphere governs movement on the opposite side of the body
  - The amount of cortex devoted to each body area depends on the complexity of movement carried out by the body part

# Brain Structure and Function



# Brain Structure and Function

- Sensory Cortex: receives input from our sensory receptors
  - Somatic sensory cortex: receives sensory input that gives rise to our sensations of heat, touch, and cold and to our senses of balance and body movement
    - Amount of area allotted is proportionate to complexity

# Brain Structure and Function

- Speech Comprehension and Production
  - Wernicke's area: an area in the temporal lobe that is primarily involved in speech comprehension
  - Broca's Area: an area in the frontal lobe that is involved in the production of speech through its connections with the motor cortex region

# Brain Structure and Function

- Association Cortex: involved in many important mental functions, including perception, language, and thought
  - Stimulation does not cause specific sensory or motor reactions
  - Damage can cause disruption or loss of speech, understanding, thinking, and problem solving
    - Agnosia: the inability to identify familiar objects

# Brain Structure and Function

- Frontal Lobes:
  - 29% of human brain; less in all other mammals
  - Least understood part of the brain
  - Damage can result in loss of intellectual abilities, such as planning and carrying out action sequences
    - Involved in emotional experience

# Brain Structure and Function

- Prefrontal Cortex: the seat of the "executive functions"
  - Executive Functions: mental abilities that allow people to direct their behavior in an adaptive fashion
    - Goal setting, judgment, strategic planning, impulse control
    - Damage results in an inability to understand and anticipate future consequences

# Hemispheric Lateralization

- Corpus Callosum: a neural bridge that acts as a major communication link between the two hemispheres and allows them to function as a single unit
- Lateralization: the relatively greater localization of a function in one hemisphere or the other

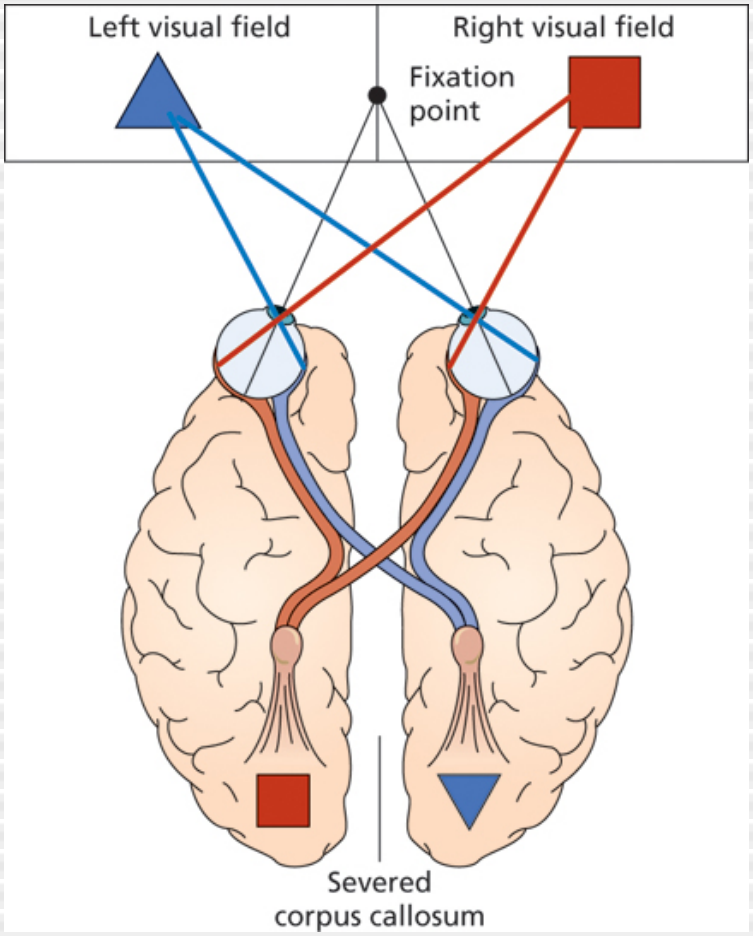
# Hemispheric Lateralization

- Left hemisphere:
  - Verbal abilities, speech, mathematical and logical abilities
    - Aphasia: the partial or total loss of the ability to communicate; results from damage to Broca's or Wernicke's areas in the left hemisphere
- Right hemisphere: spatial relations, faces, mental imagery, musical and artistic abilities

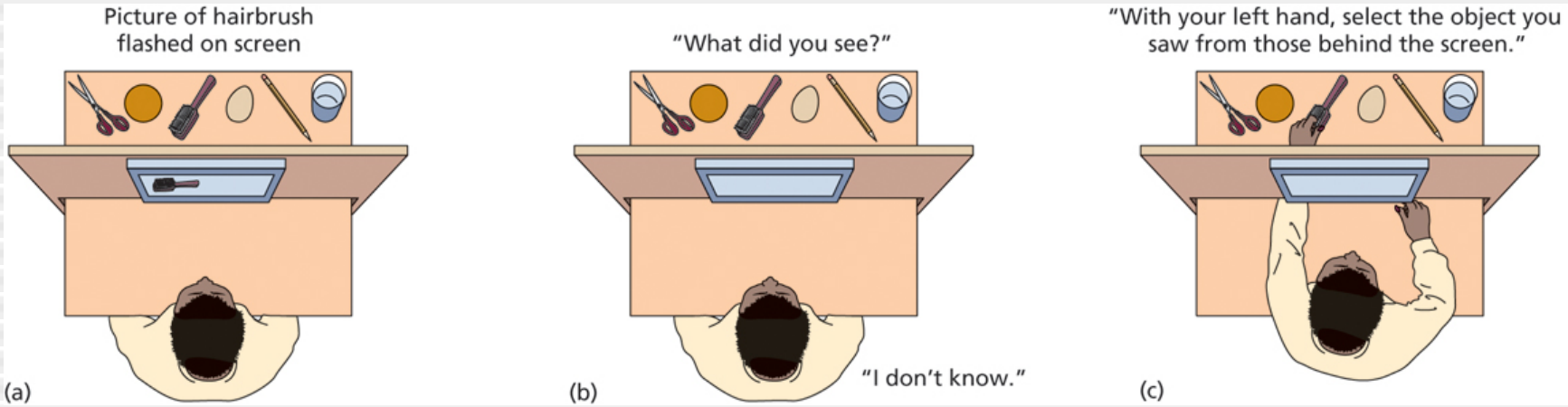
# Hemispheric Lateralization

- The Split Brain:
  - Split-brain research is conducted on people with severed corpus callosa
    - Demonstrates that visual input is not unified in these individuals
      - Input on right side is sent to left hemisphere and vice-versa

# Hemispheric Lateralization



# Hemispheric Lateralization



# Brain Plasticity

- Neural Plasticity: the ability of neurons to change in structure and function
- Effects of early experience:
  - Exposure to harmful substances
  - Stimulating environment
  - Cultural factors

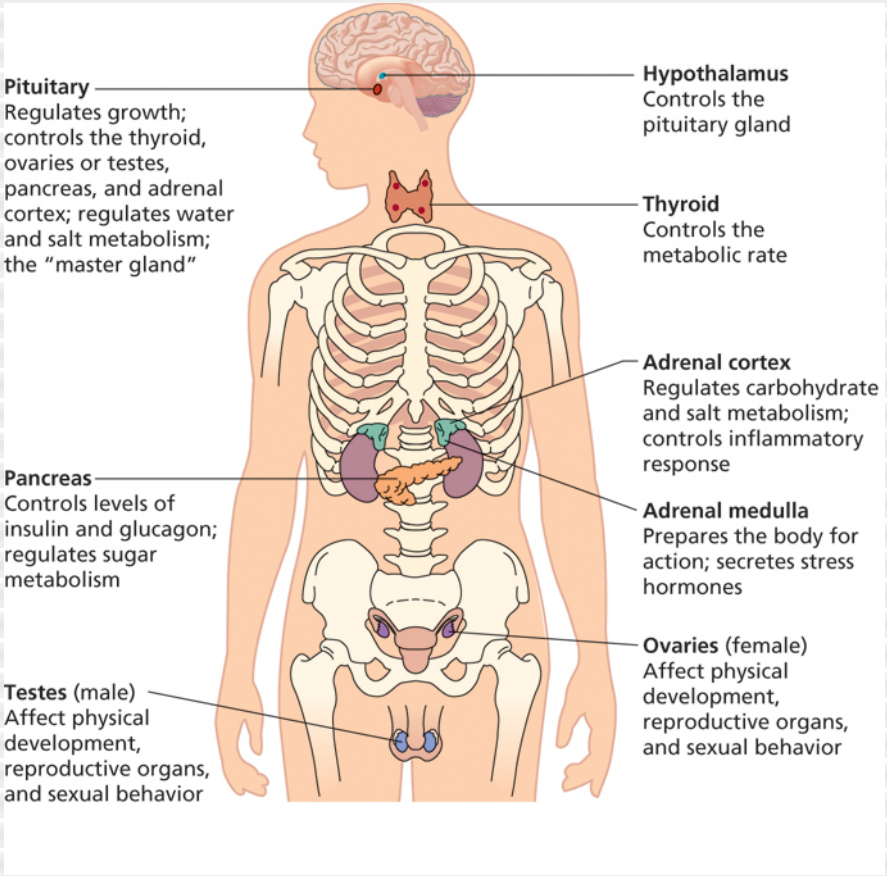
# Brain Plasticity

- Healing the Nervous System:
  - Neurons can modify themselves in two ways:
    - Structurally: sprouting enlarged networks of dendrites; extending axons from surviving neurons
    - Biochemically: increasing neurotransmitter volume
  - Neurogenesis: the production of new neurons in the nervous system
  - Neural Stem Cells: immature "uncommitted" cells that can mature into any type of neuron or glial cell needed by the brain

# Endocrine & Immune Systems

- Endocrine System: numerous hormone-secreting glands distributed throughout the body
  - Hormones: chemical messengers that are secreted from the glands into the bloodstream
    - Slower, more widespread messages

# Endocrine & Immune Systems



# Endocrine & Immune Systems

- Hormones affect reproductive structures, sexual behaviors, gender differences
- Adrenal Glands: twin structures that serve as hormone factories, producing and secreting about 50 different hormones
  - Regulate many metabolic processes within the body

# Endocrine & Immune Systems

- Immune System:
  - Antigens: foreign substances that trigger a biochemical response from the immune system
  - Antibodies: biochemical weapons needed to destroy the antigens

# Endocrine & Immune Systems