Chapter 37: pp. 679 - 700

Neurons & Nervous Systems

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BIOLOGY
10th Edition
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PowerPoint® Lecture Slides are prepared by Dr. Isaac Barjis, Biology Instructor

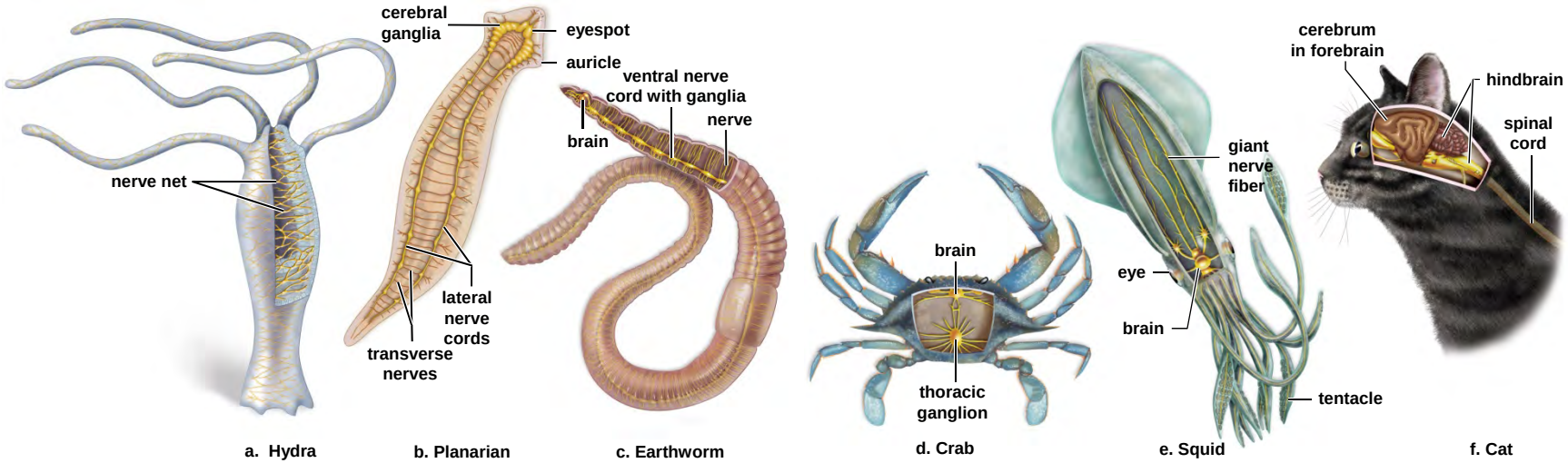
Outline

- EVOLUTION OF THE NERVOUS SYSTEM
  - Gradual increase in the complexity of the nervous system
  - All vertebrates have a well-developed brain
- NERVOUS TISSUE
  - Neurons
  - Nerve impulse
- BRAIN AND SPINAL CORD
  - Spinal cord
  - Cerebrum
    - Sensory input
    - Motor control
  - Homeostasis
  - Limbic system
- PERIPHERAL NERVOUS SYSTEM
  - Nerves
  - Somatic system
  - Autonomic system

Invertebrate Nervous Organization

- Hydras
  - Nerve net composed of neurons in contact with one another
  - Also in contact with contractile epitheliomuscular cells
- Planarians
  - Ladderlike nervous system
  - Cephalization - a concentration of ganglia and sensory receptors in the head
- Annelids, Arthropods and Mollusks
  - Complex animals
  - True nervous systems

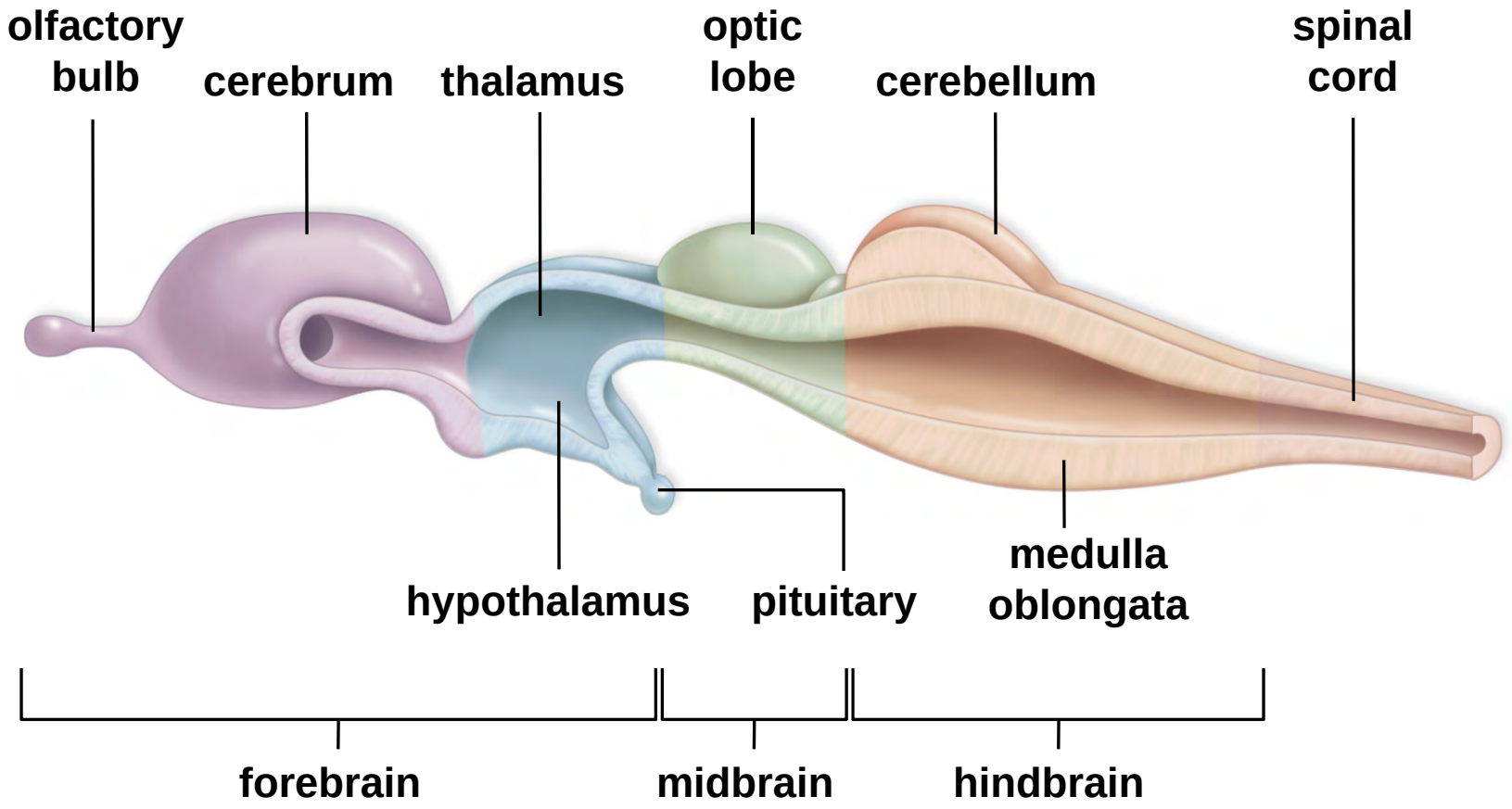
Evolution of the Nervous System



Vertebrate Nervous Organization

- Central nervous system
  - Develops from an embryonic dorsal tubular nerve cord
  - Cephalization and bilateral symmetry result in several paired sensory receptors
- Vertebrate brain is organized into three areas
  - Hindbrain
  - Midbrain
  - Forebrain

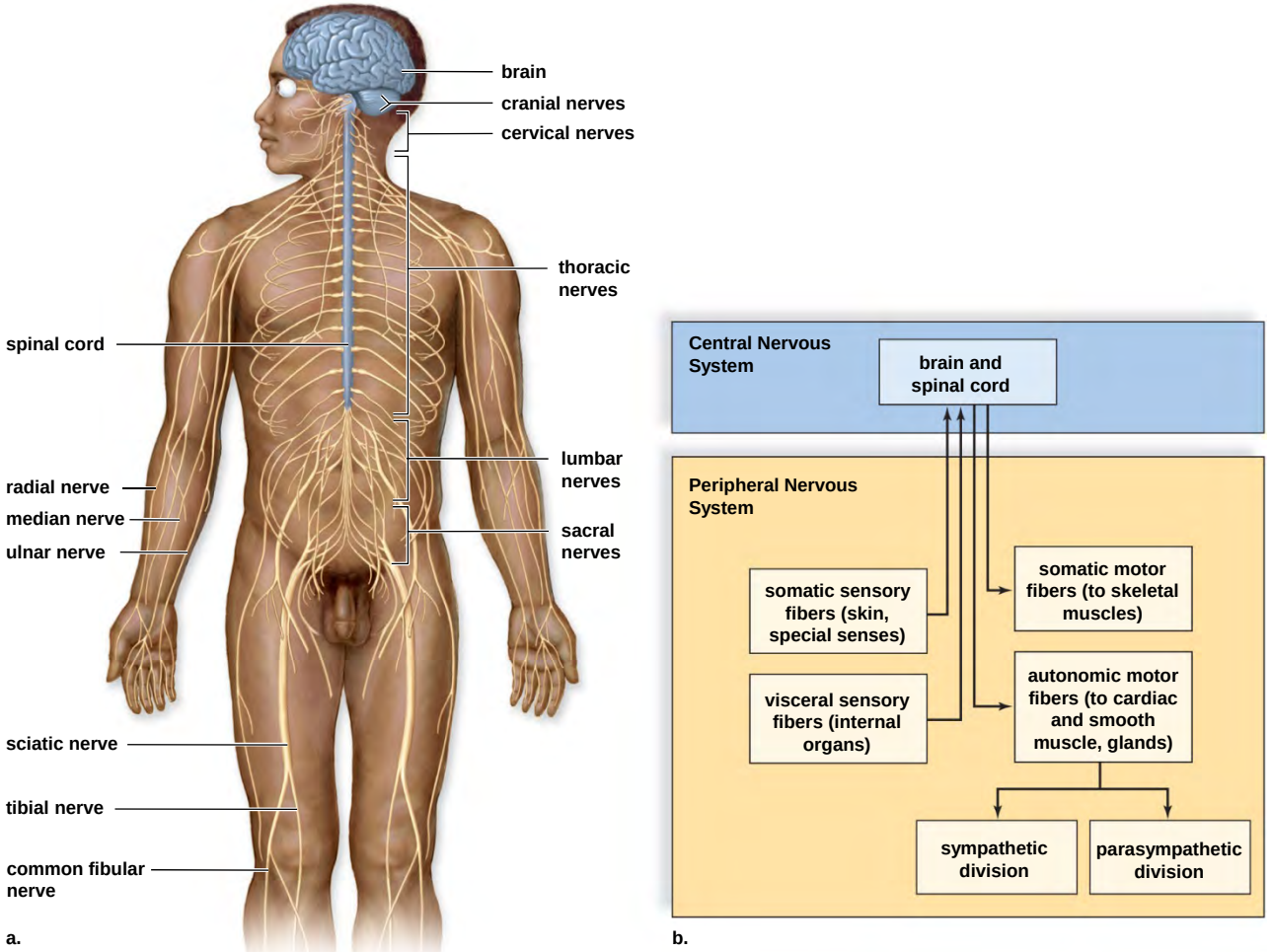
Organization of the Vertebrate Brain



Human Nervous System

- Nervous system has three specific functions
  - Receiving sensory input
  - Performing integration
  - Generating motor output

Organization of the Human Nervous System



Human Nervous System

- Division of Nervous System:
  - Central nervous system (CNS)
    - Includes the brain and spinal cord
    - Lies in the midline of the body
  - The peripheral nervous system (PNS)
    - Contains cranial nerves and spinal nerves that:
      - Gather info from sensors and conduct decisions to effectors
      - Lies outside the CNS

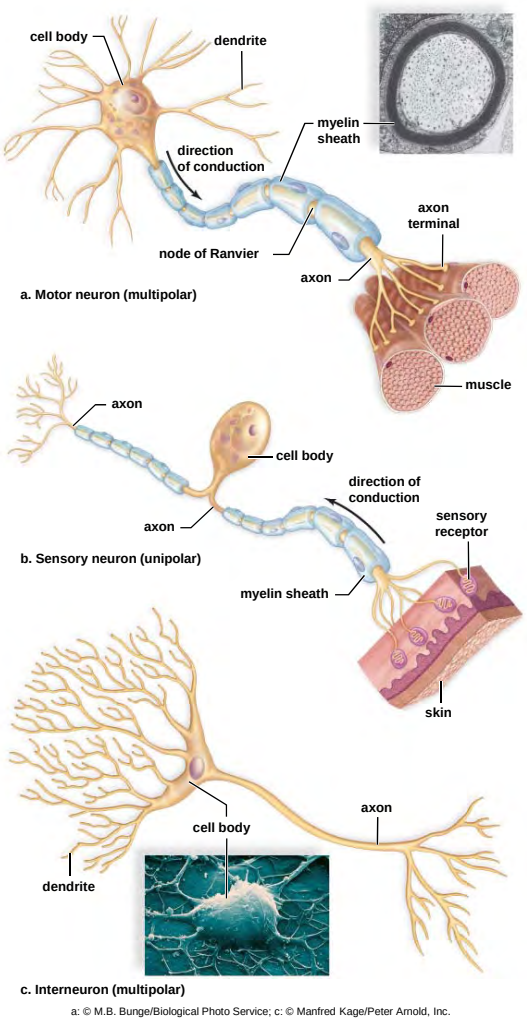
Nervous Tissue

- Neurons
  - Cell body contains nucleus
  - Dendrites receive signals from sensory receptors
  - Axon conducts nerve impulses
    - Covered by myelin sheath
    - Any long axon is also called a nerve fiber

Types of Neurons

- Motor Neurons
  - Accept nerve impulses from the CNS
  - Transmit them to muscles or glands
- Sensory Neurons
  - Accept impulses from sensory receptors
  - Transmit them to the CNS
- Interneurons
  - Convey nerve impulses between various parts of the CNS

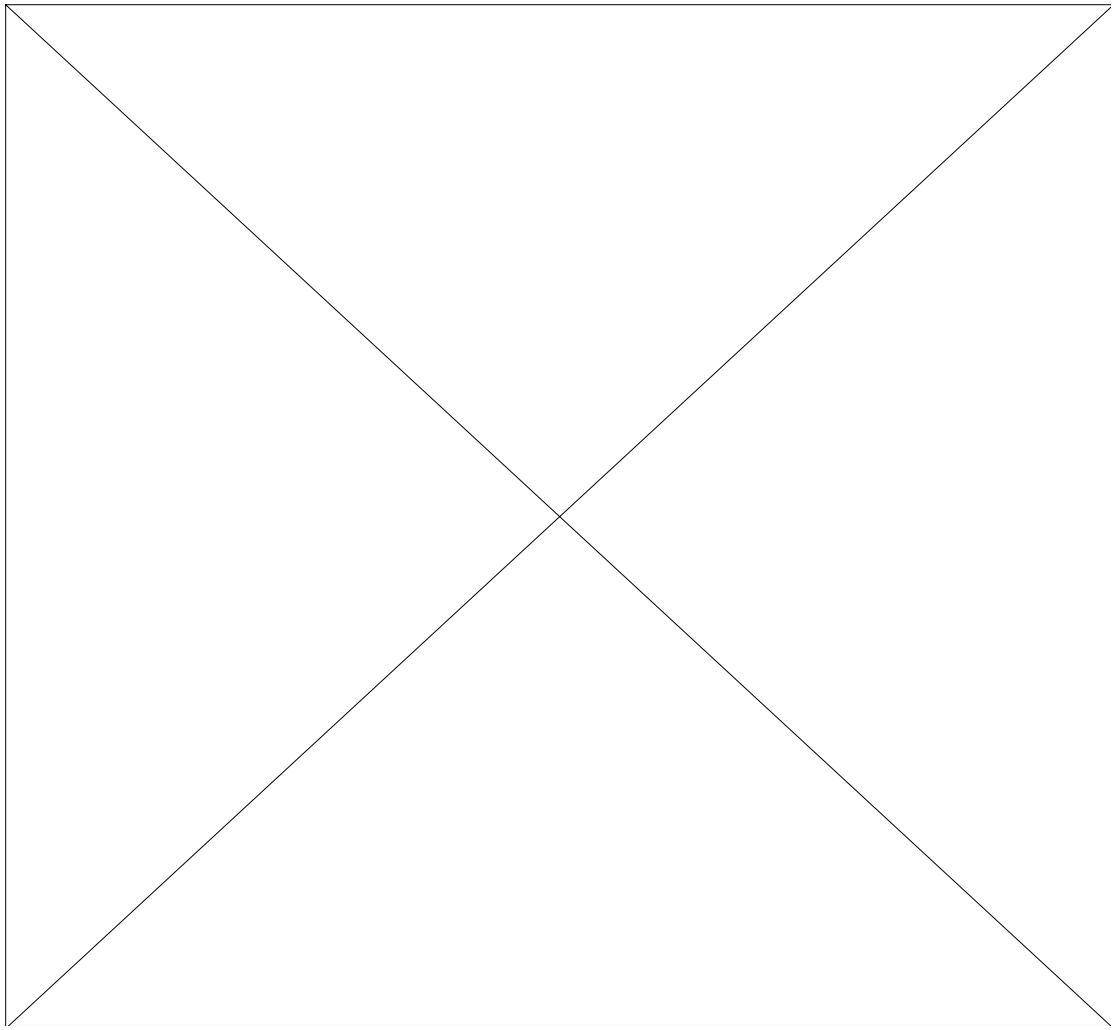
Neuron Anatomy



Nerve Impulses: Resting Potential

- Resting Potential
  - The membrane potential (voltage) when the axon is not conducting an impulse
    - The inside of a neuron is more negative than the outside -65 mV
    - Due in part to the action of the sodium-potassium pump

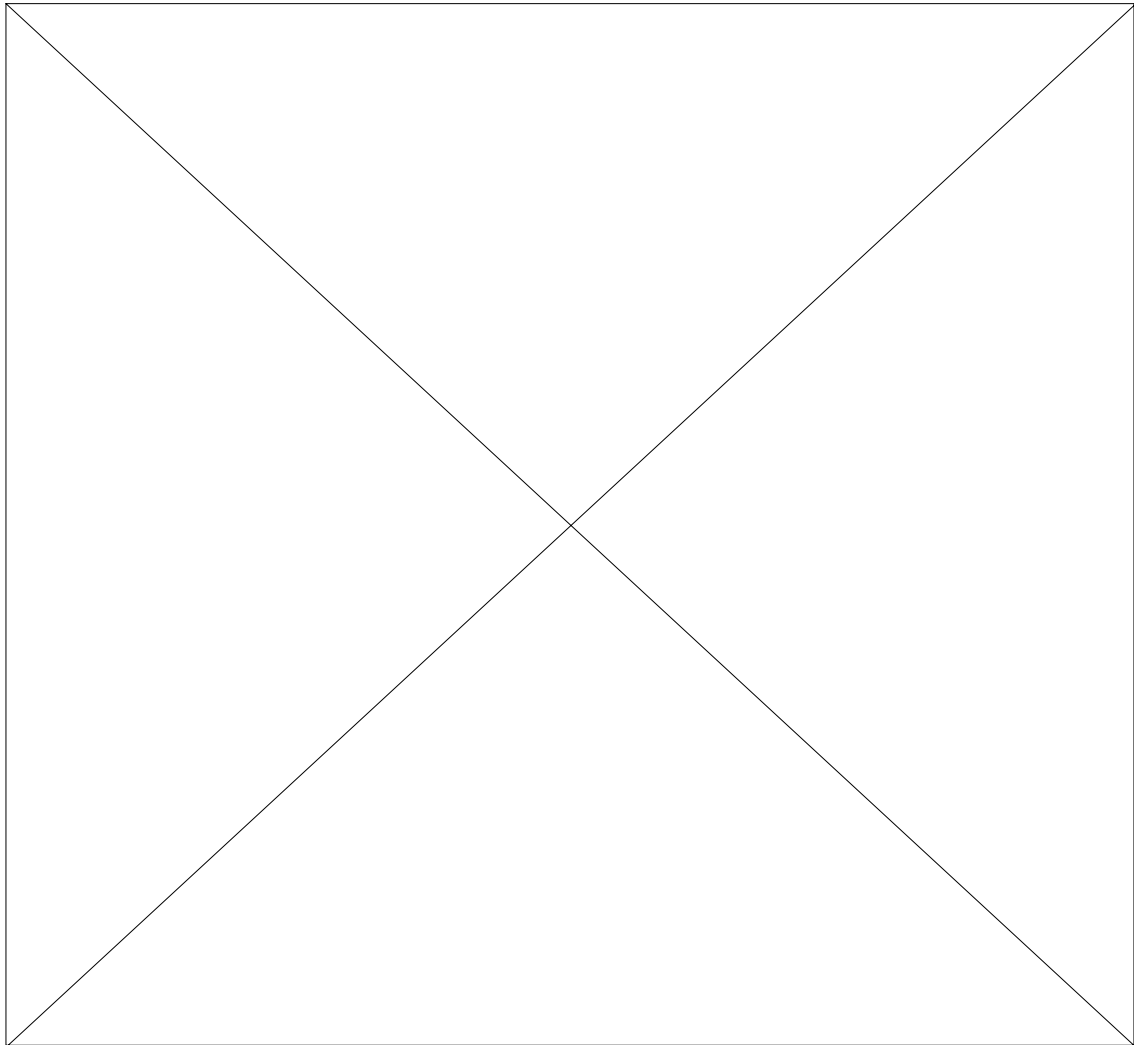
Animation



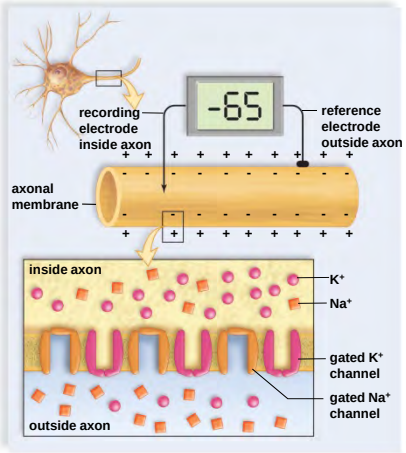
Action Potential

- An action potential is generated only after a stimulus larger than the threshold
- Gated channel proteins
  - Suddenly allows sodium to pass through the membrane
  - Another allows potassium to pass through other direction

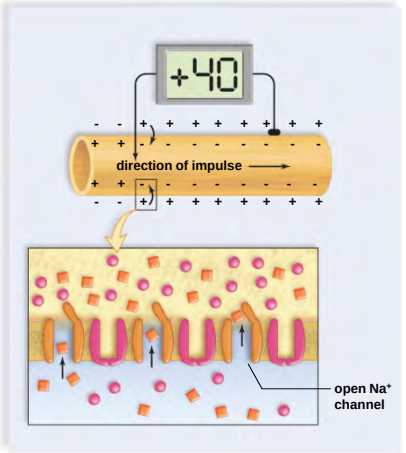
Animation



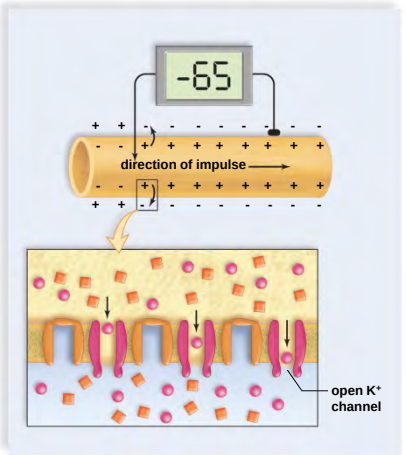
Resting and Action Potential of the Axonal Membrane



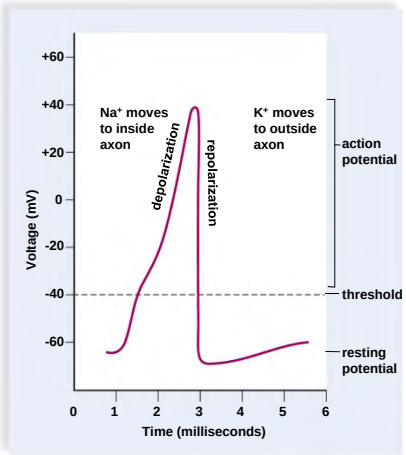
a. Resting potential: more Na^+ outside the axon and more K^+ inside the axon causes polarization.



b. Action potential begins: depolarization occurs when Na^+ gates open and Na+ moves to inside the axon.



c. Action potential ends: repolarization occurs when K^+ gates open and K^+ moves to outside the axon.



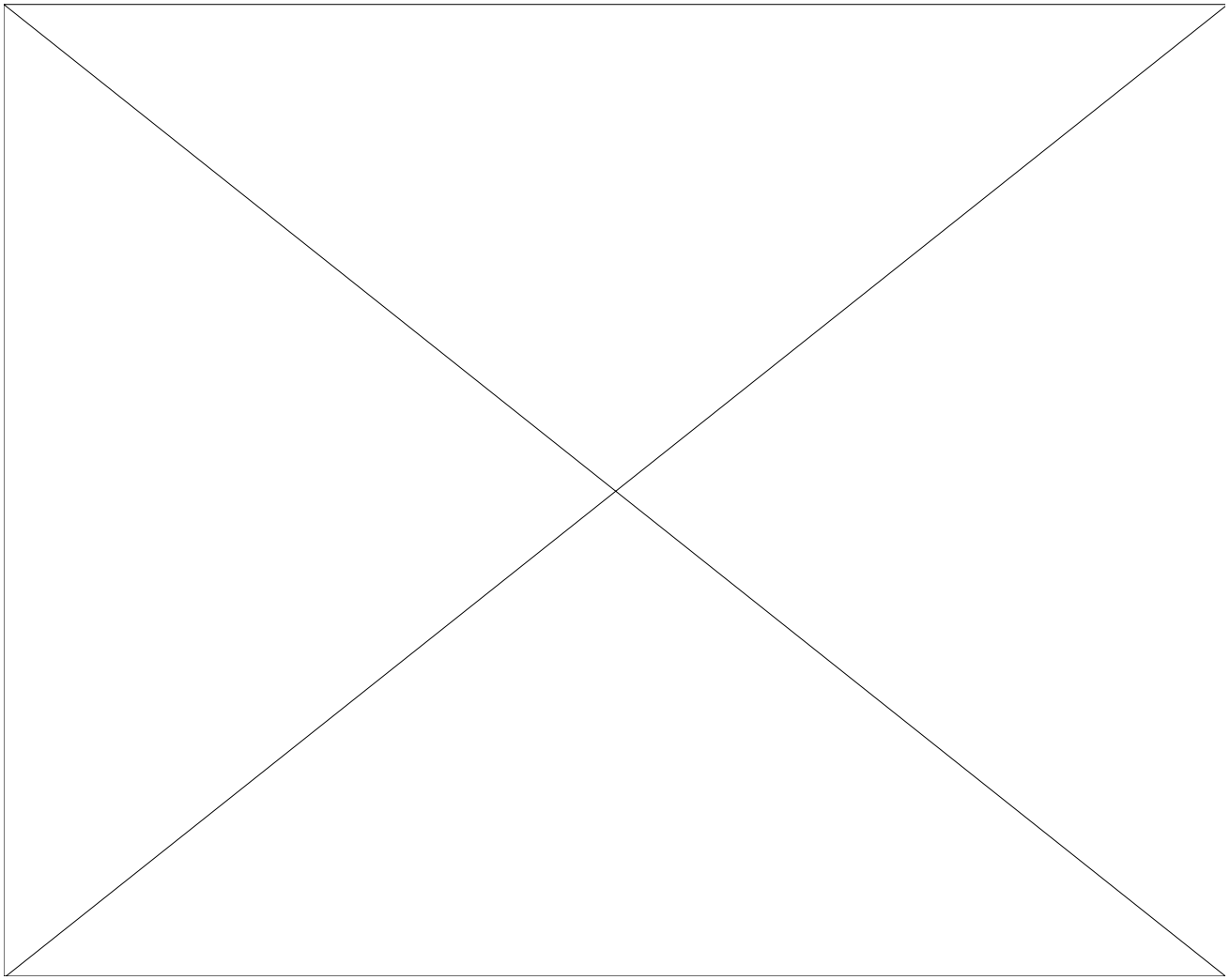
d. An action potential can be visualized if voltage changes are graphed over time.

- http://youtu.be/YP_P6bYvEjE

Propagation of Action Potentials

- In myelinated fibers, an action potential at one node causes an action potential at the next node
  - Saltatory (jumping) Conduction
- Conduction of a nerve impulse is an all-or-nothing event
  - Intensity of signal is determined by how many impulses are generated within a given time span

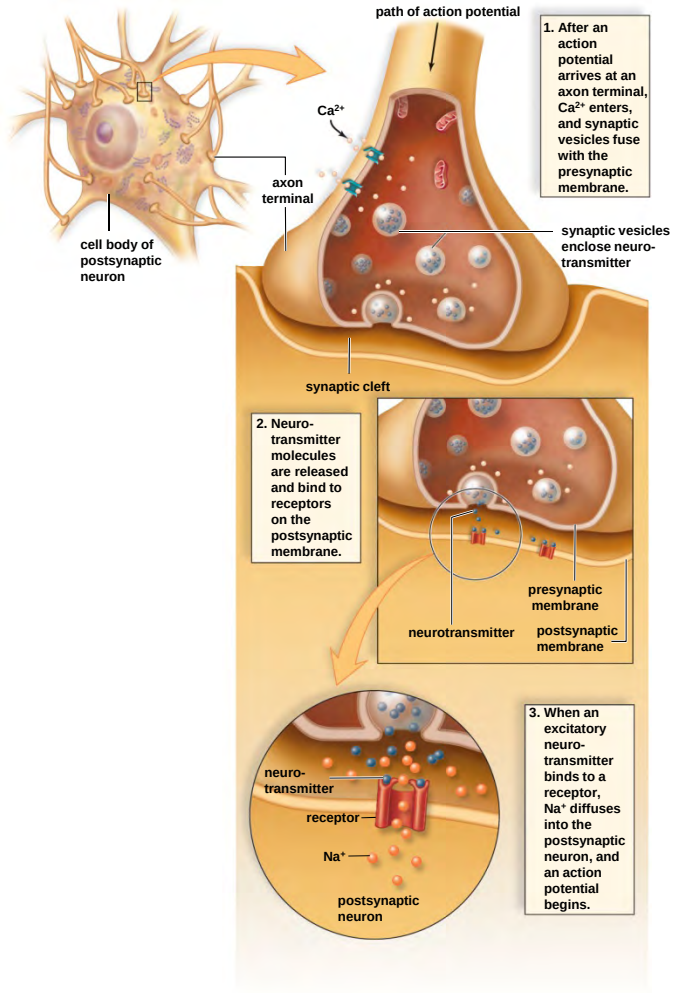
Animation



Transmission Across a Synapse

- A synapse is a region where neurons nearly touch
- Small gap between neurons is the synaptic cleft
- Transmission across a synapse is carried out by neurotransmitters
  - Sudden rise in calcium at end of one neuron
  - Stimulates synaptic vesicles to merge with the presynaptic membrane
  - Neurotransmitter molecules are released into the synaptic cleft

Synapse Structure and Function



- http://youtu.be/LT3VKAr4roo

Synaptic Integration

- A single neuron is on the receiving end of
  - Many excitatory signals, and
  - Many inhibitory signals
- Integration
- The summing of signals from
  - Excitatory signals, and
  - Inhibitory signals

CNS: Brain and Spinal Cord

- Spinal cord and brain are wrapped in three protective membranes, meninges
  - Spaces between meninges are filled with cerebrospinal fluid
  - Fluid is continuous with that of central canal of spinal cord and the ventricles of the brain

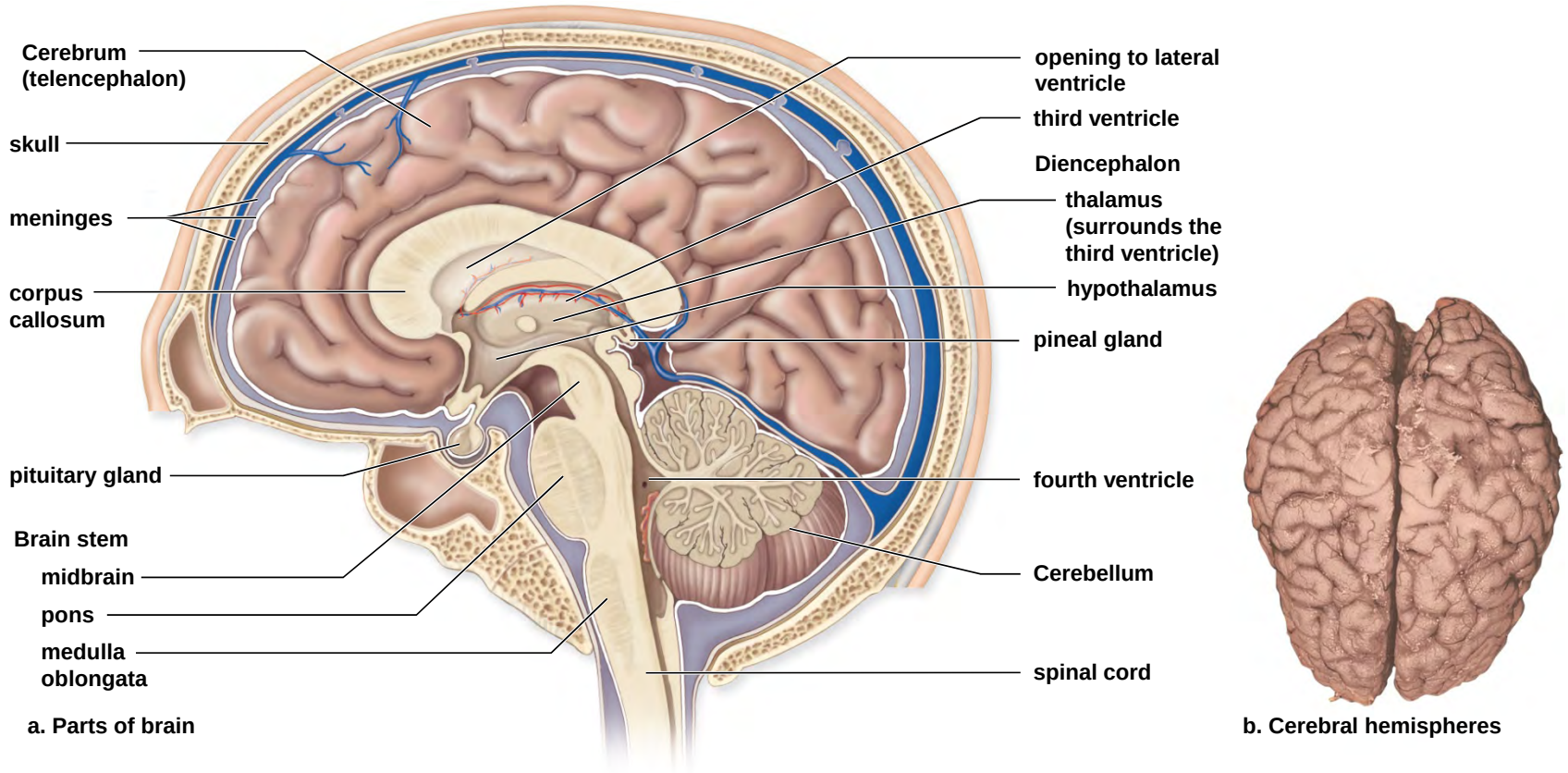
Spinal Cord

- The spinal cord has two main functions
  - Center for many reflex actions
  - Means of communication between the brain and spinal nerves
- The spinal cord is composed of gray matter and white matter
  - Cell bodies and short unmyelinated fibers give the gray matter its color
  - Myelinated long fibers of interneurons running in tracts give white matter its color

The Brain

- Cerebrum is the largest portion of the brain in humans
  - Communicates with, and coordinates the activities of, the other parts of the brain
  - Longitudinal fissure divides into left and right cerebral hemispheres

The Human Brain



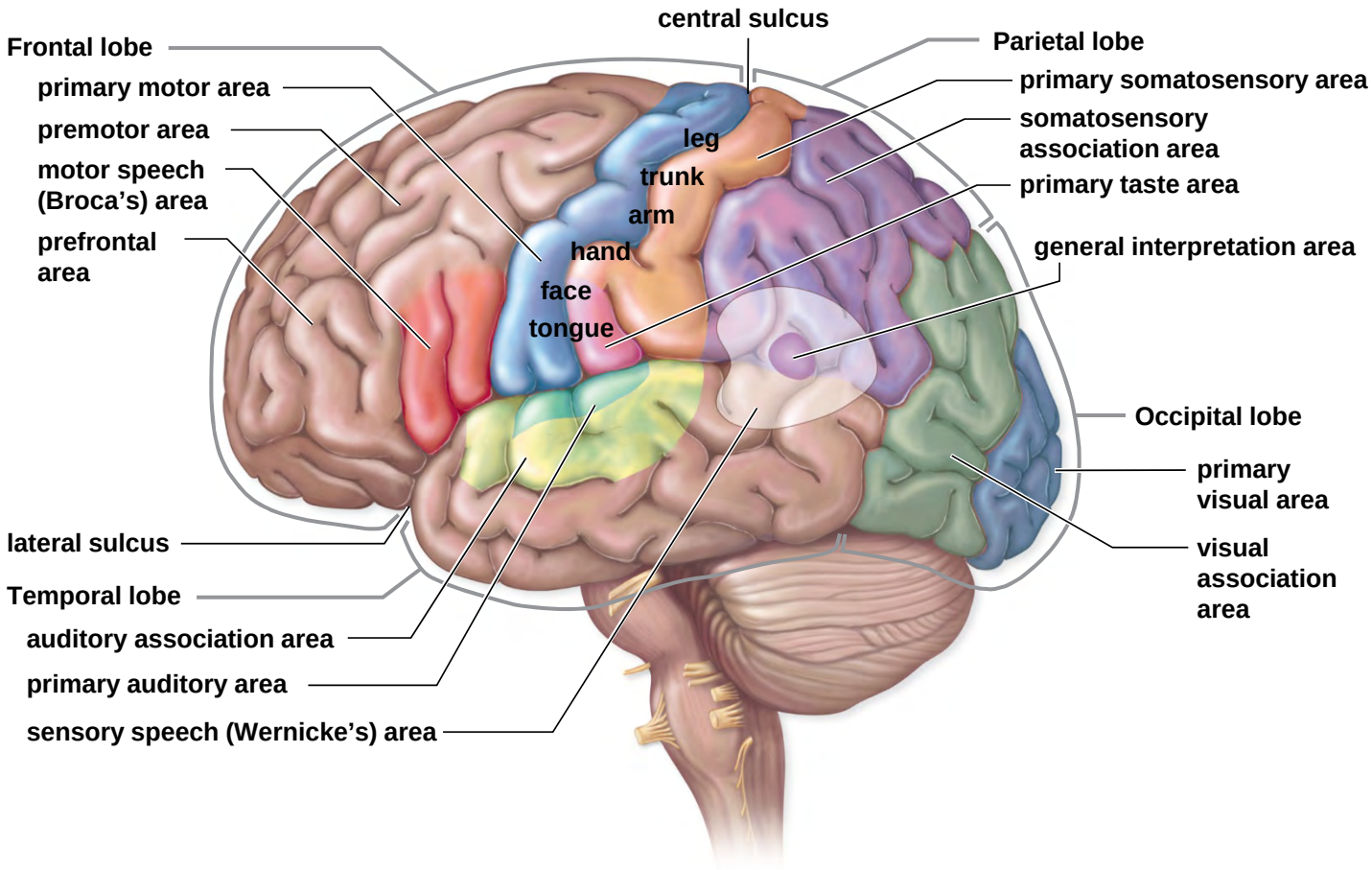
a. Parts of brain

b. Cerebral hemispheres

Cerebral Cortex

- A thin but highly convoluted outer layer of gray matter
- Covers the cerebral hemispheres
- Contains motor areas and sensory areas as well as association areas
  - Primary motor area is in the frontal lobe just ventral to central sulcus
  - Primary somatosensory area is just dorsal to central sulcus

The Lobes of a Cerebral Hemisphere



Cerebrum

- Rest of cerebrum is composed of white matter
  - Descending tracts communicate with lower brain centers
  - Ascending tracts send sensory information to primary somatosensory area
  - Basal nuclei
    - Integrate motor commands
    - Ensure that the proper muscle groups are either activated or inhibited

Diencephalon

- A region encircling the third ventricle
- Consists of hypothalamus and thalamus
  - Hypothalamus forms floor of the third ventricle
  - Thalamus consists of two masses of gray matter located in the sides and roof of the third ventricle
- Pineal gland
  - Also located in the diencephalon
  - Secretes melatonin

Cerebellum

- Separated from the brain stem by the fourth ventricle
  - Receives sensory input from the eyes, ears, joints, and muscles
  - Sends motor impulses out the brain stem to the skeletal muscles

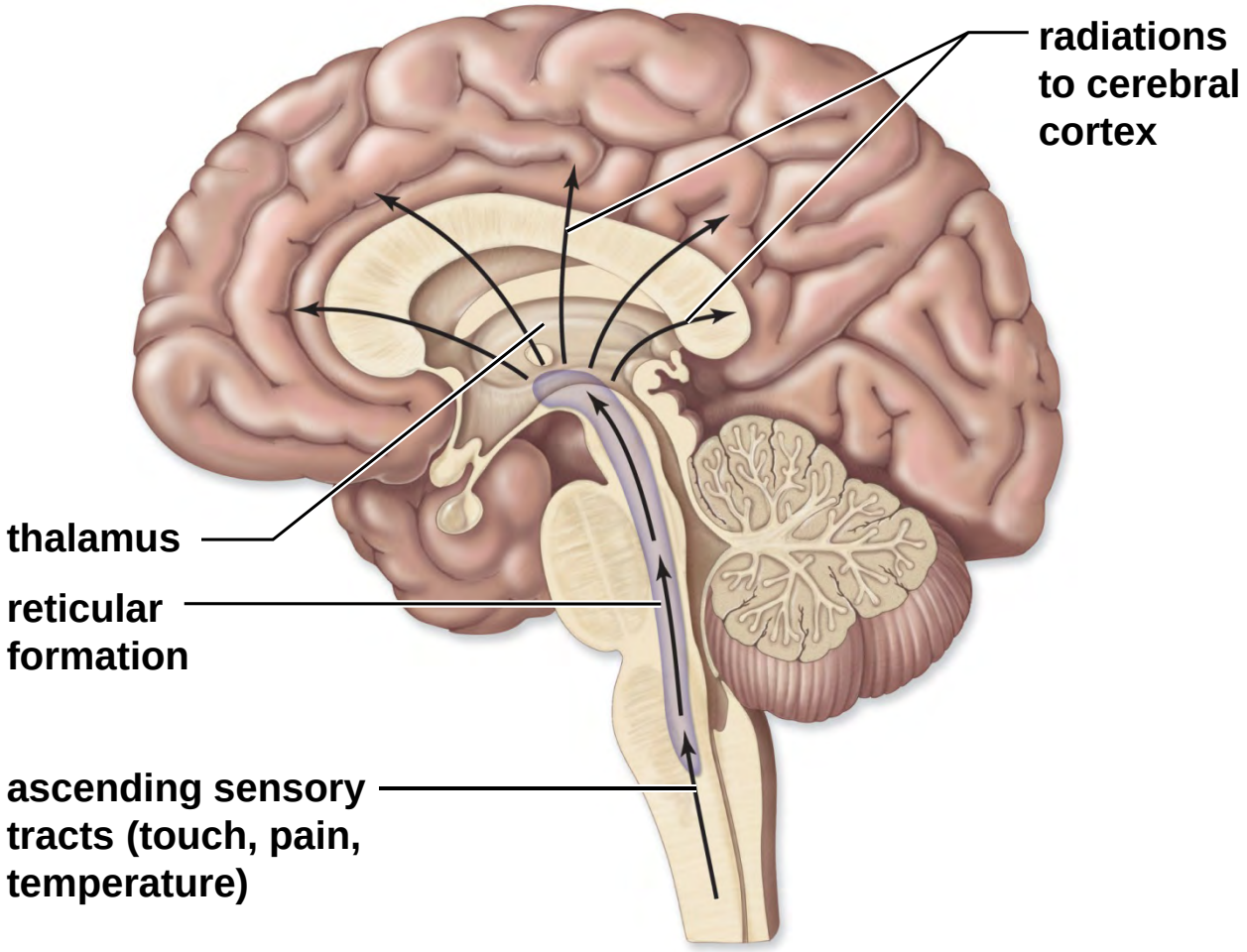
Brain Stem

- Contains the midbrain, the pons, and the medulla oblongata
  - Midbrain
    - Acts as a relay station for tracts passing between
      - The cerebrum, and
      - The spinal cord or cerebellum
  - Pons
    - Helps regulate breathing and head movements
  - Medulla oblongata
    - Contains reflex centers for vomiting, coughing, sneezing, hiccuping, and swallowing

The Reticular Activating System (RAS)

- It is a complex network of:
  - Nuclei (masses of gray matter)
  - Nerve fibers that extend the length of the brain stem
- The reticular formation is a major component of RAS
- The RAS arouses the cerebrum via the thalamus and causes a person to be alert

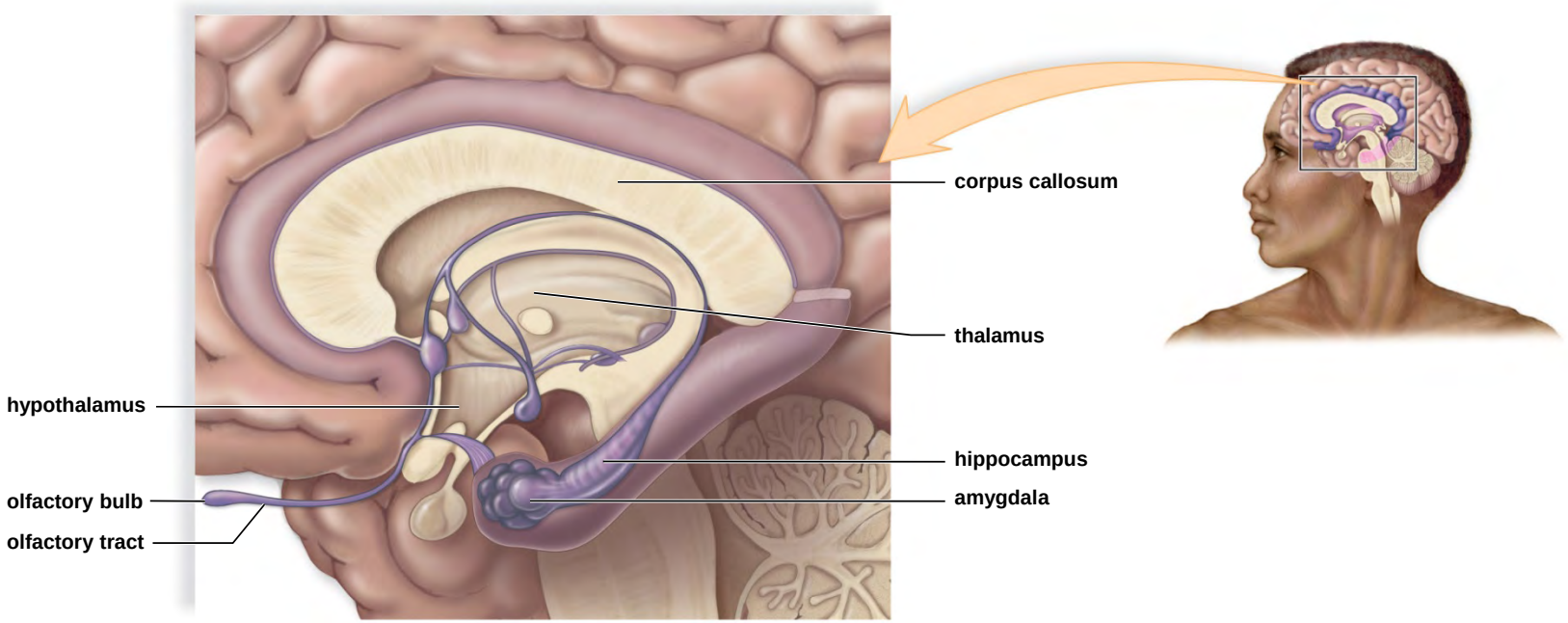
The Reticular Activating System



Limbic System

- Complex network of tracts and “nuclei”
- Incorporates medial portions of
  - The cerebral lobes,
  - The subcortical basal nuclei, and
  - The dicenephalon
- Integrates higher mental functions and primitive emotions
  - Hippocampus
  - Amygdala

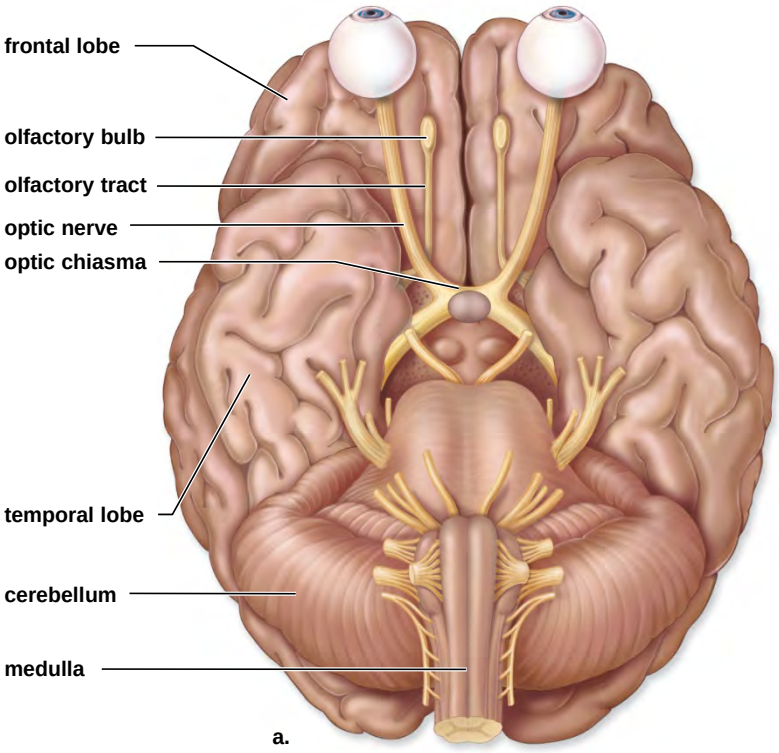
The Limbic System



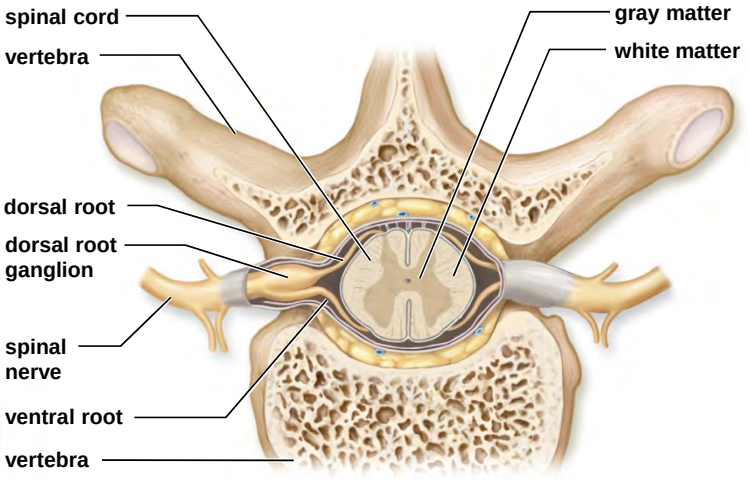
Peripheral Nervous System

- Somatic system
  - Contains cranial nerves and spinal nerves
    - Gather info from sensors and conduct decisions to effectors
    - Controls the skeletal muscles
  - Conscious of its activity
- Autonomic system
  - Controls the smooth muscles, cardiac muscles, and glands
  - Usually unaware of its actions
  - Divided into two divisions
    - Sympathetic division
    - Parasympathetic division

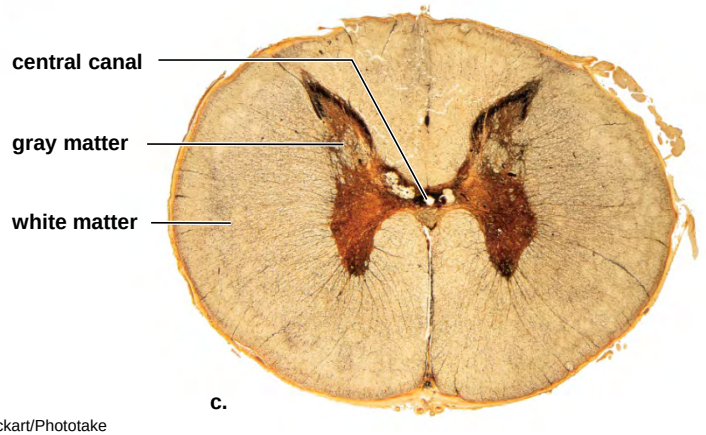
Cranial and Spinal Nerves



a.

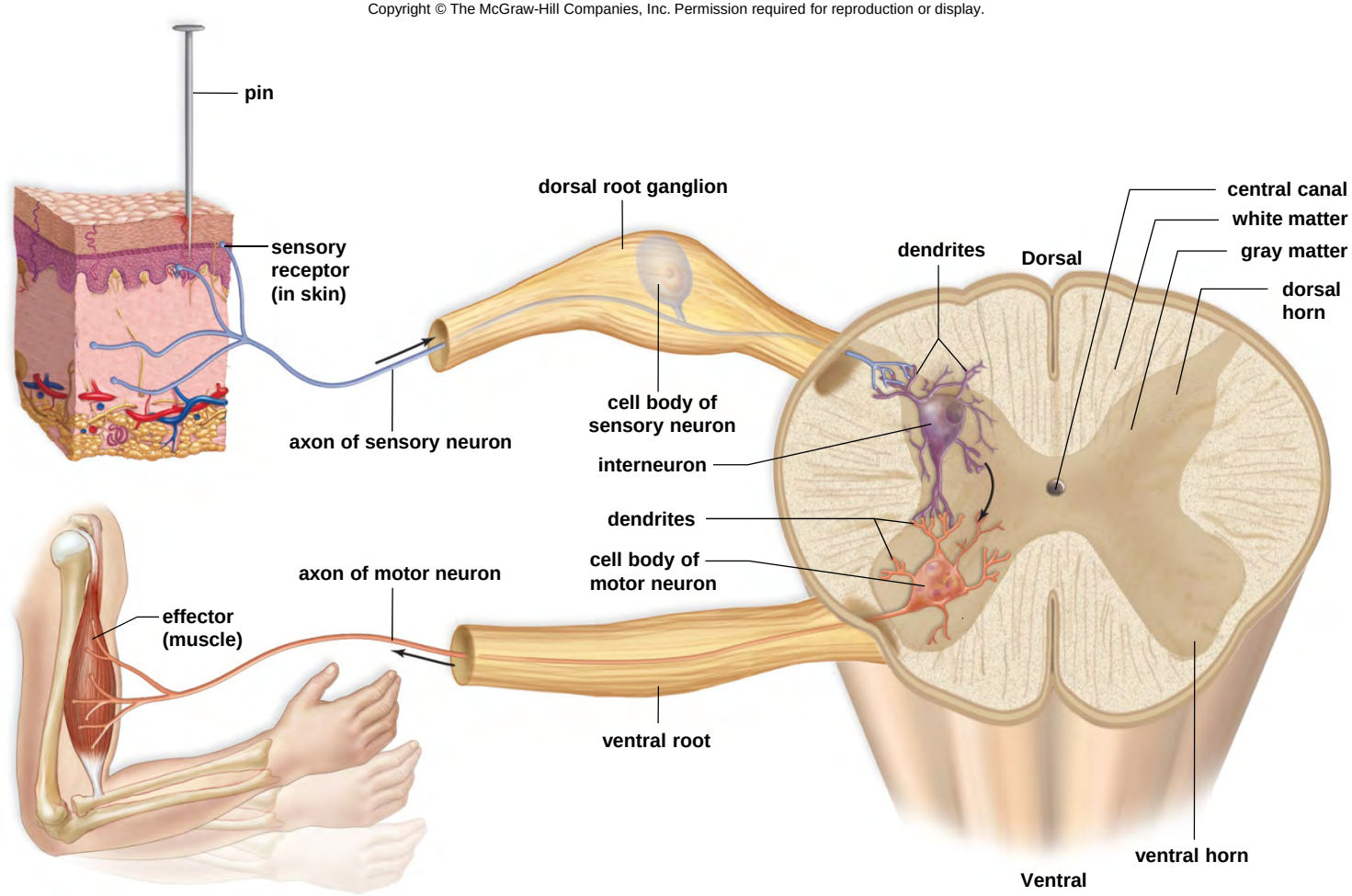


b.

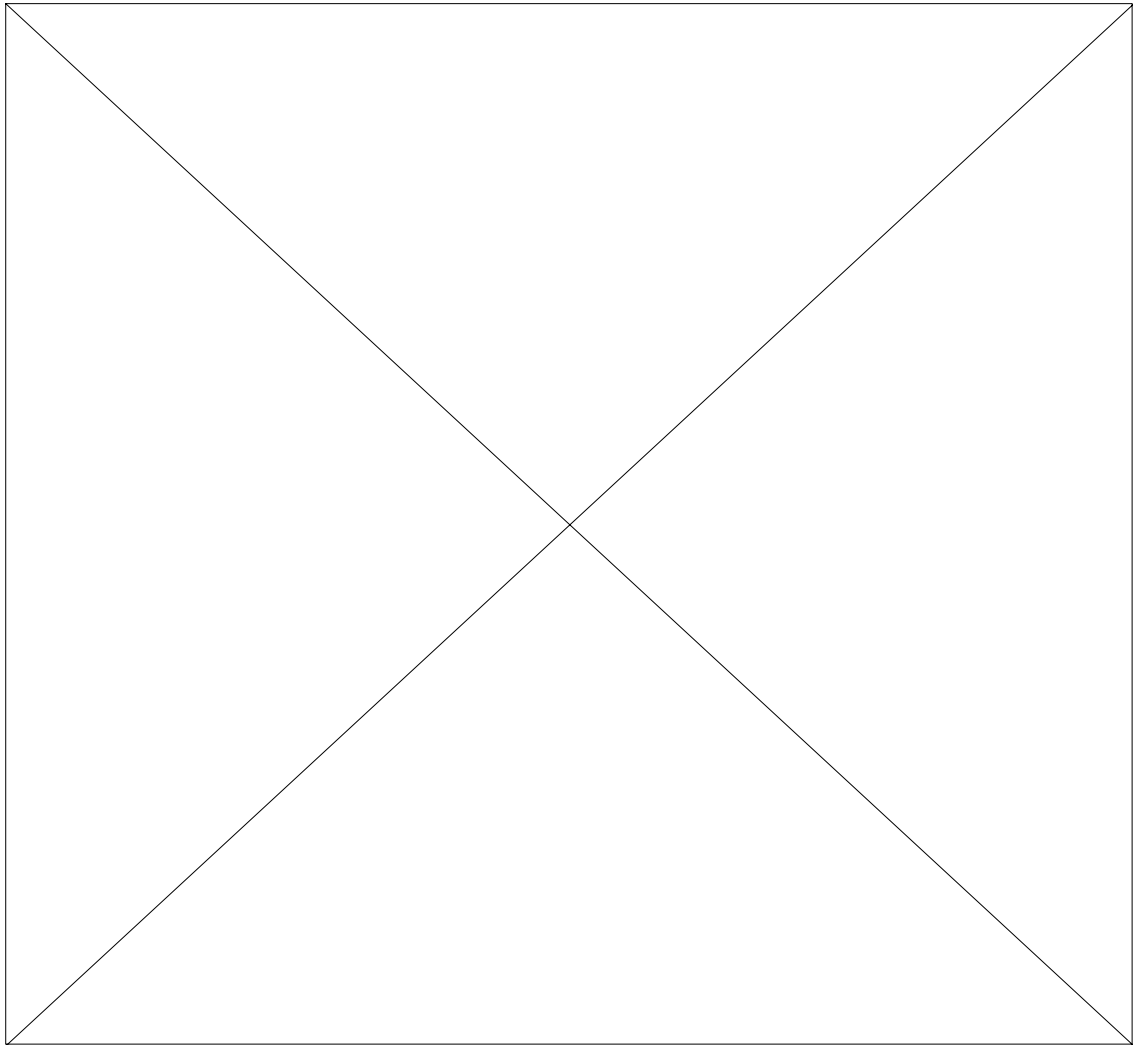


c.

A Reflex Arc Showing the Path of a Spinal Reflex



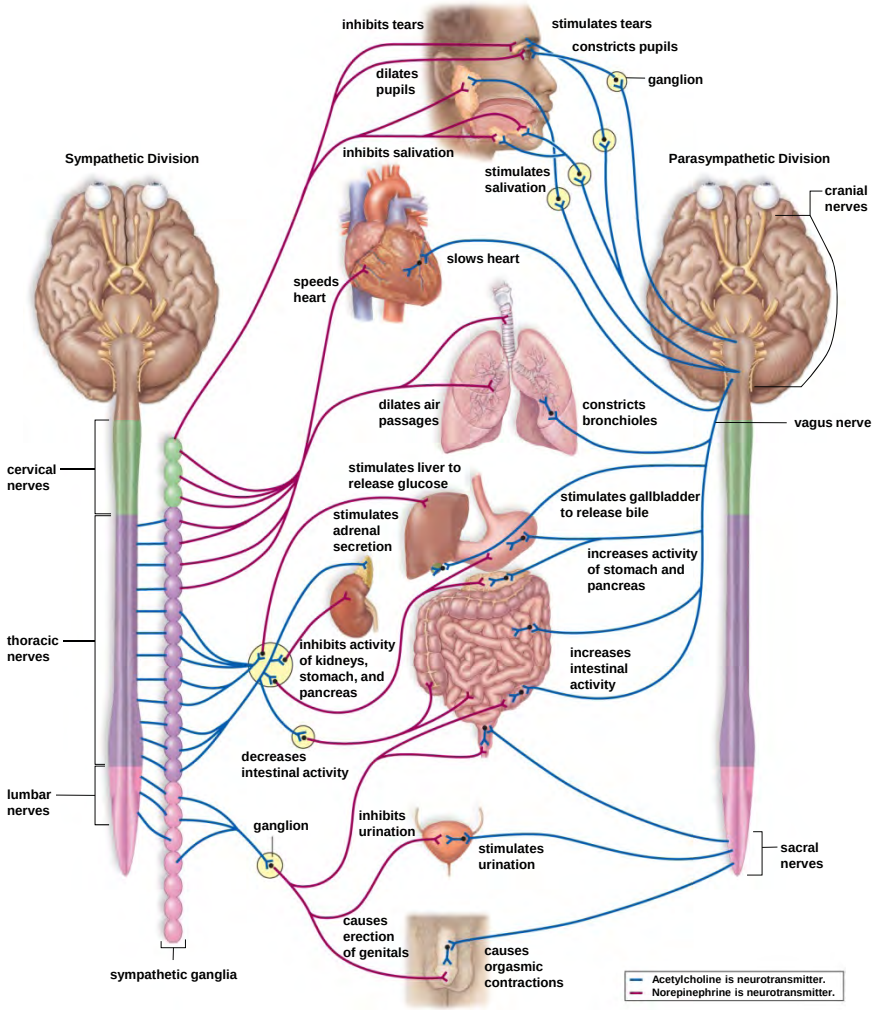
Animation



Autonomic System

- Regulates activity of cardiac and smooth muscle, and glands
- Divided into sympathetic and parasympathetic divisions
  - Function automatically and usually in an involuntary manner
  - Innervate all internal organs
  - Utilize two neurons and one ganglion for each impulse

Autonomic System Structure and Function



Sympathetic and Parasympathetic Divisions

- Sympathetic division
  - Especially important during fight or flight responses
  - Accelerates heartbeat and dilates bronchi
- Parasympathetic division
  - Promotes all internal responses associated with a relaxed state
  - Promotes digestion and retards heartbeat

Review

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  - Gradual increase in the complexity of the nervous system
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- BRAIN AND SPINAL CORD
  - Spinal cord
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