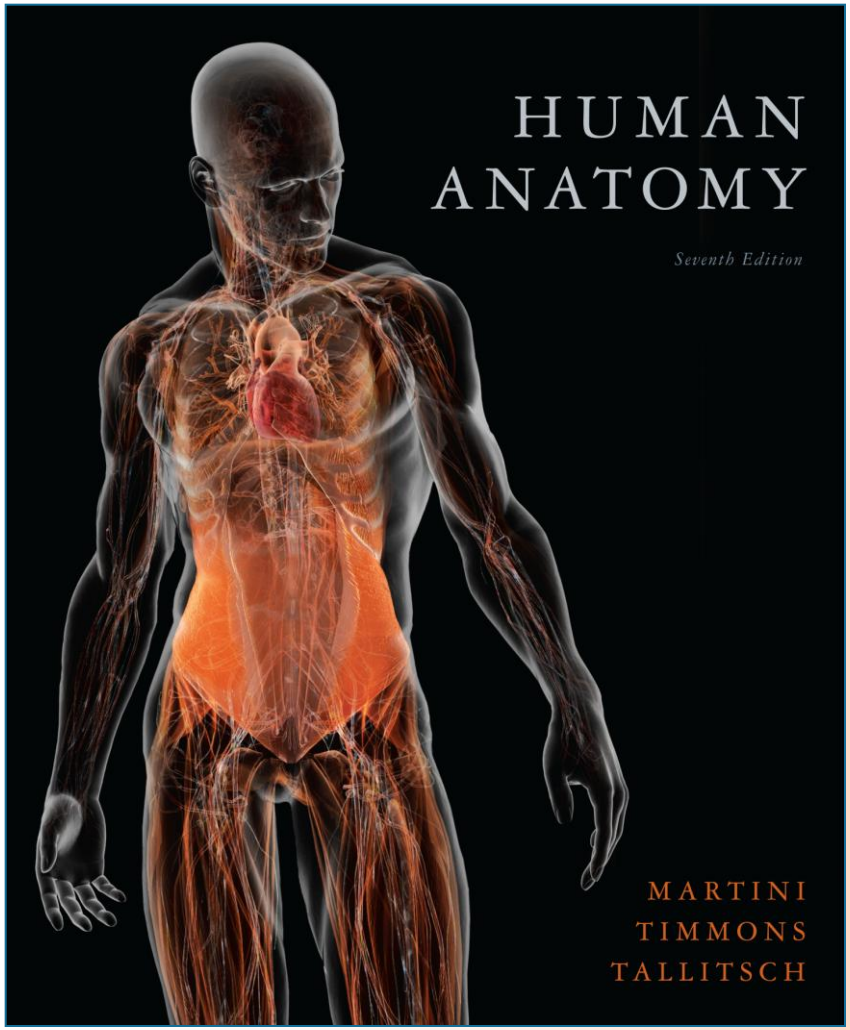


13

The Nervous System: Neural Tissue

PowerPoint® Lecture Presentations prepared by
Steven Bassett
Southeast Community College
Lincoln, Nebraska

Introduction

- Nervous System Characteristics
  - Controls and adjust the activity of the body
  - Provides swift but brief responses

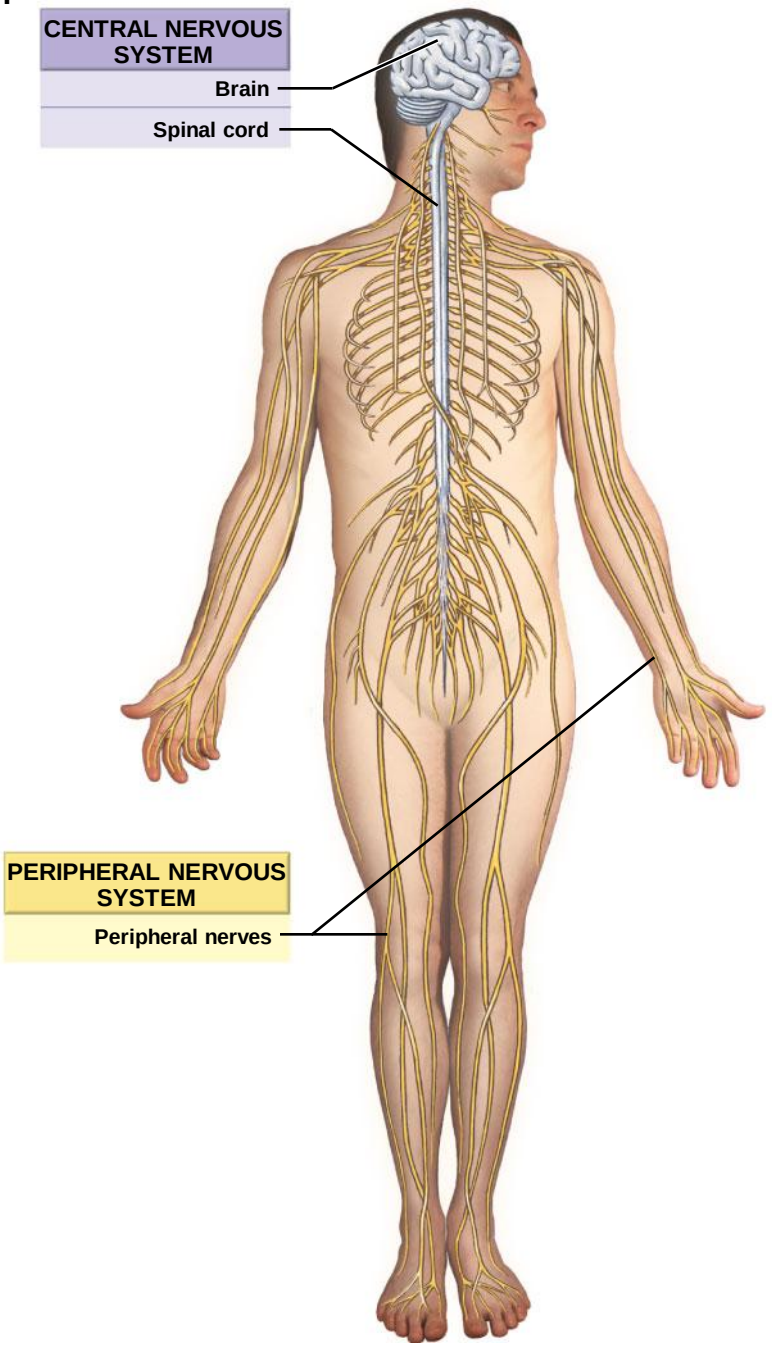
Introduction

- The nervous system includes:
  - **Central Nervous System (CNS)**
    - Associated with the brain and the spinal cord
  - **Peripheral Nervous System (PNS)**
    - Associated with the tissue outside the CNS

An Overview of the Nervous System

- The Peripheral Nervous System (PNS) can be subdivided into:
  - **Afferent**: Brings sensory information toward the CNS
    - Which can be further subdivided into **somatic** and **visceral**
  - **Efferent**: Carries motor commands away from the CNS
    - Which can be further subdivided into **somatic nerves** and **autonomic nerves**

Figure 13.1 The Nervous System



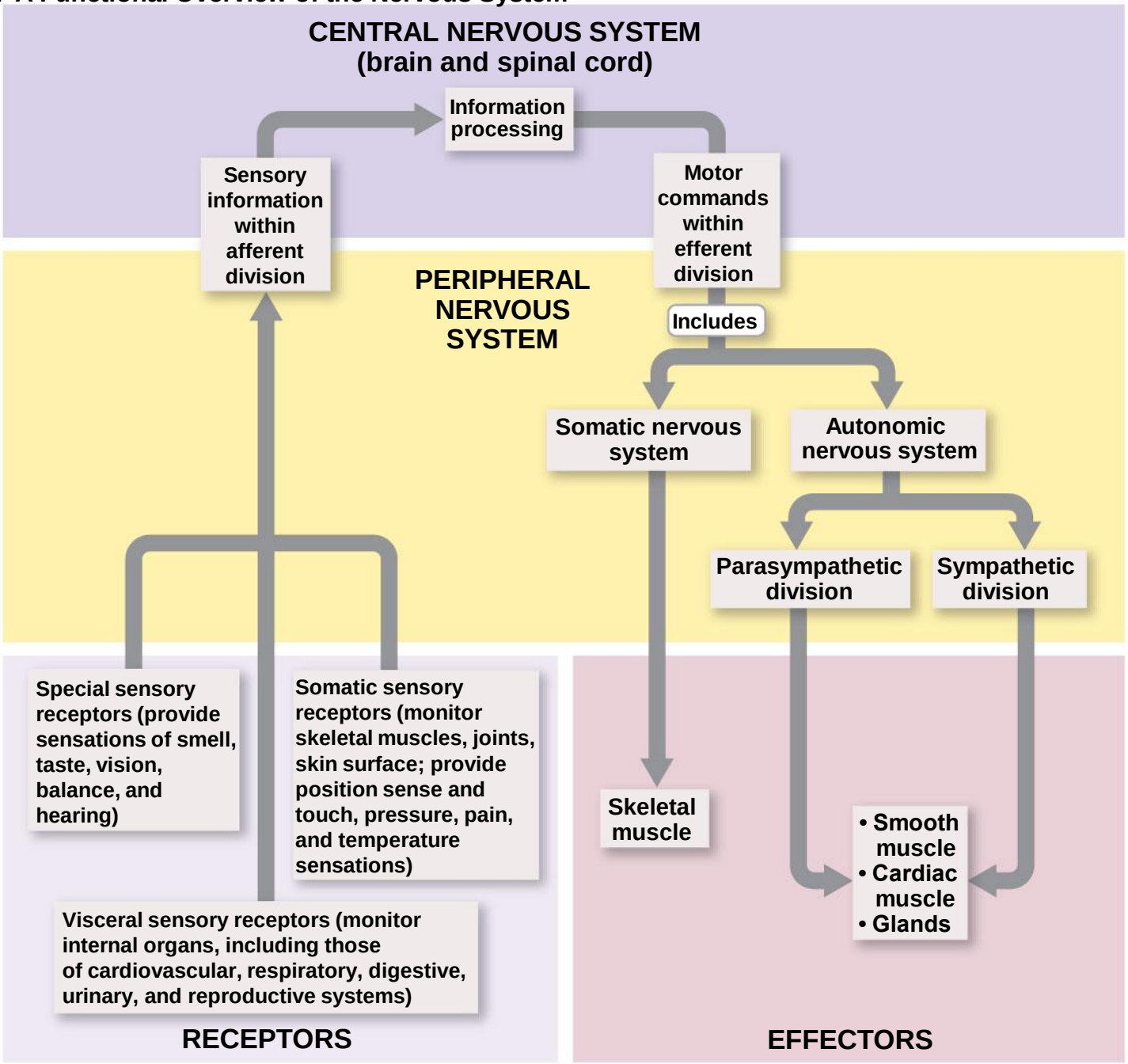
An Overview of the Nervous System

- The Peripheral Nervous System (PNS)
  - Afferent
    - **Sensory** portion: monitors skeletal muscles and joints
    - **Visceral** portion: monitors smooth muscles, cardiac muscle, and other internal organs
  - Efferent
    - **Somatic nerves**: controls skeletal muscle contraction
    - **Autonomic nerves**: controls internal organ activities

An Overview of the Nervous System

- The Peripheral Nervous System (PNS)
  - The autonomic nerves can be further subdivided to form:
    - **Parasympathetic nerves**: cause pupil constriction, decrease heart rate, and tense the urinary bladder (for example)
    - **Sympathetic nerves**: cause pupil dilation, increase heart rate, and relax urinary bladder (for example)

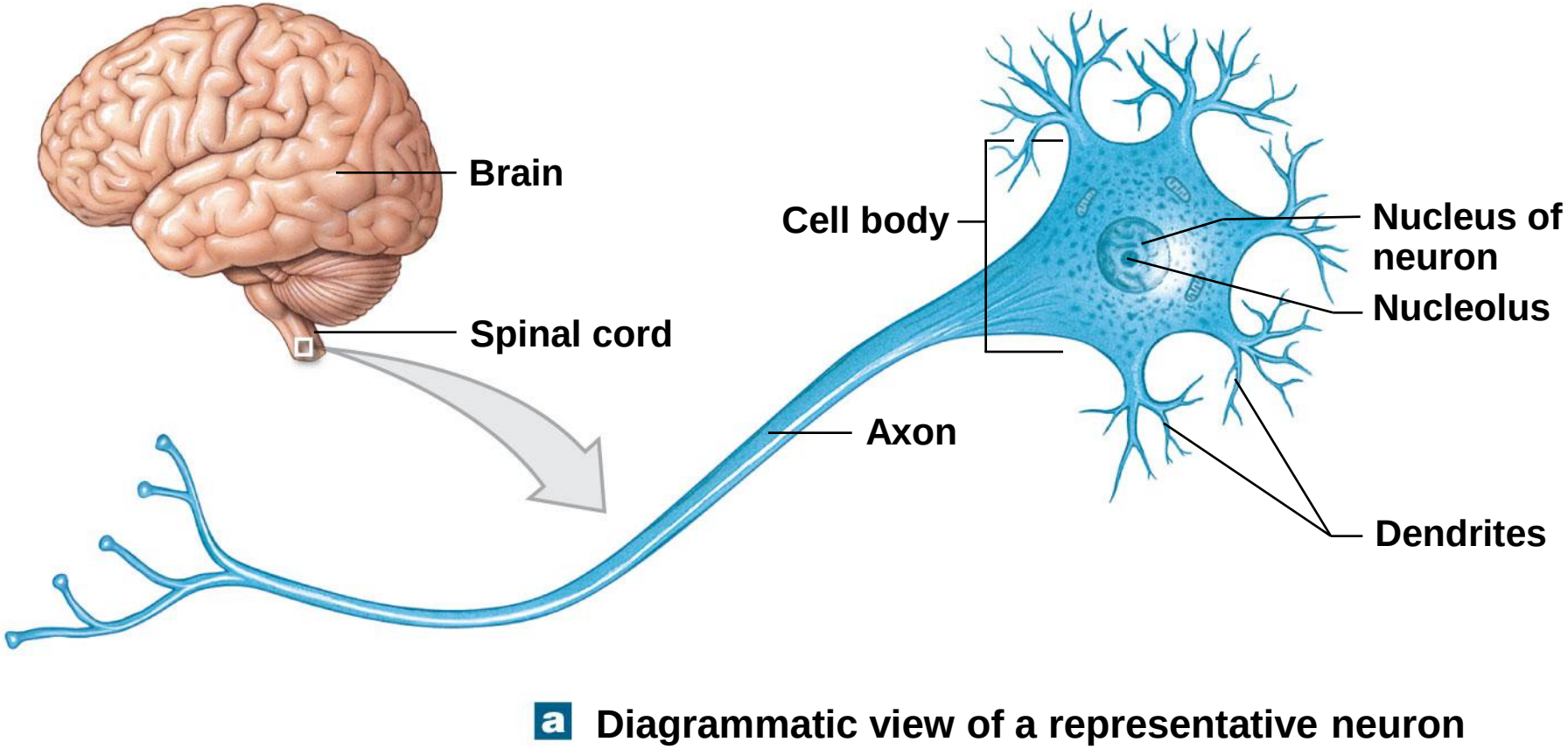
Figure 13.2 A Functional Overview of the Nervous System



Cellular Organization in Neural Tissue

- Neural tissue consists of two cell types:
  - **Neurons**
    - Nerve cells that are responsible for the transfer and processing of information in the nervous system
    - Consist of a soma, axon, and dendrites
  - **Neuroglia**
    - Supporting cells
    - Protect the neuron

Figure 3.23a Histology of Neural Tissue



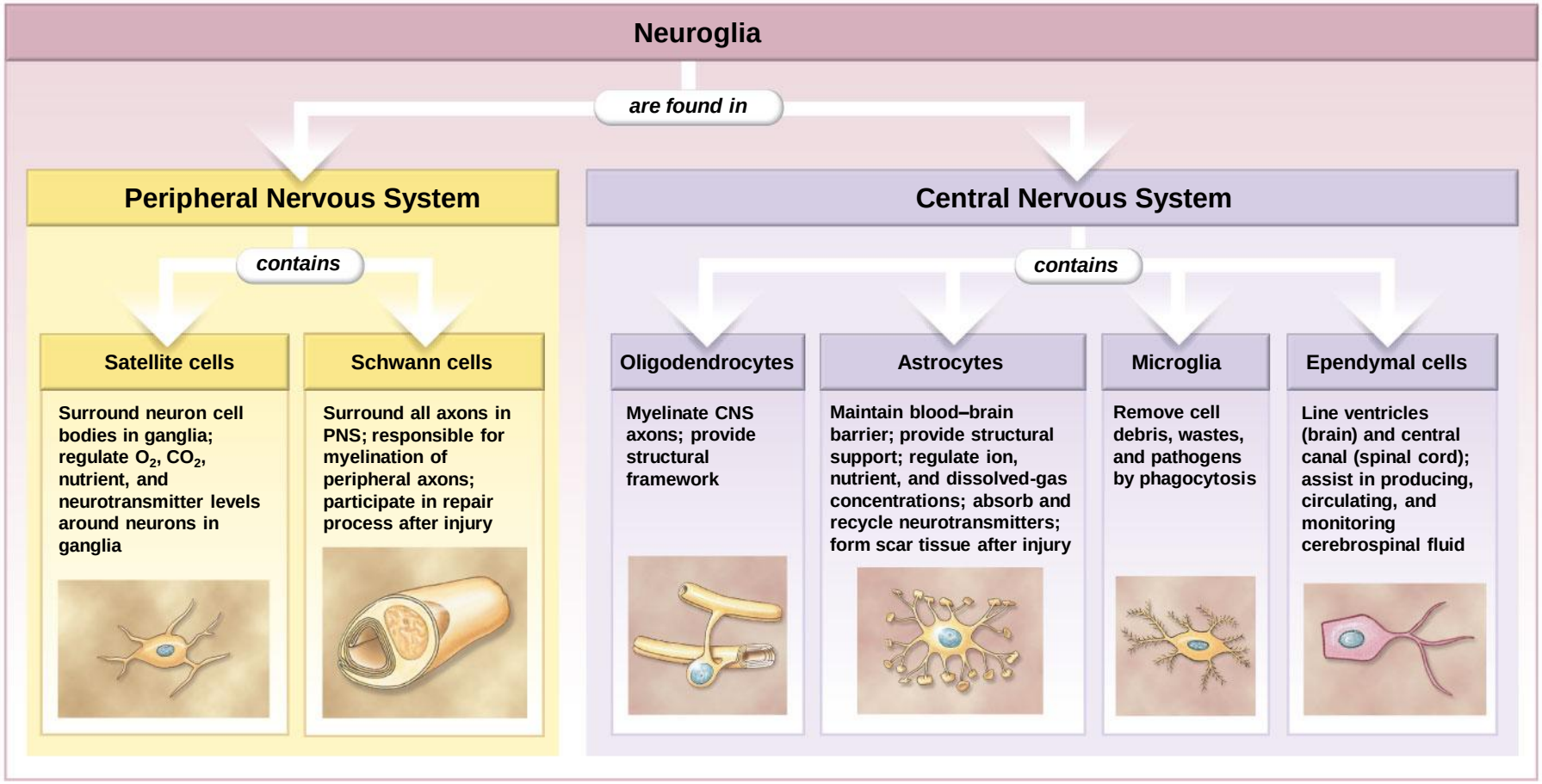
Cellular Organization in Neural Tissue

- Functions of Neuroglia
  - Provide the framework for the neural tissue
  - Maintain the intercellular environment
  - Act as phagocytes
  - Over 100 billion
  - Roughly five times the number of neurons
  - Also called glial cells
  - Have the ability to reproduce

Cellular Organization in Neural Tissue

- Neuroglia Cells
  - Neuroglia cells of the CNS
    - **Astrocytes**
    - **Oligodendrocytes**
    - **Microglia**
    - **Ependymal cells**
  - Neuroglia cells of the PNS
    - **Satellite cells**
    - **Schwann cells**

Figure 13.4 The Classification of Neuroglia



Cellular Organization in Neural Tissue

- Neuroglia of the CNS
  - **Astrocytes**
    - Have a large number of cytoplasmic processes
    - Control the chemical content of the interstitial environment
    - Maintain the **blood–brain barrier**
    - Isolate the neurons from general circulation

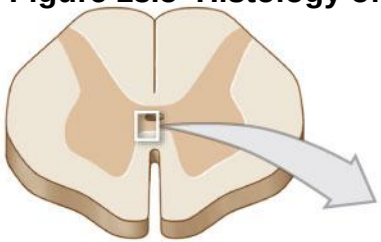
Cellular Organization in Neural Tissue

- Neuroglia of the CNS
  - **Oligodendrocytes**
    - Cytoplasmic extensions contact the somas or axons
    - Cytoplasmic extensions tie axons together in a sheath of myelin
  - **Microglia**
    - Phagocytic cells
    - Protect the neuron by removing waste and debris

Cellular Organization in Neural Tissue

- Neuroglia of the CNS
  - **Ependymal cells**
    - Line the ventricles of the brain
    - Line the central canal of the spinal cord
    - Monitor the CSF (**cerebrospinal fluid**) composition
    - Some ependymal cells secrete CSF

Figure 13.5 Histology of Neural Tissue in the CNS



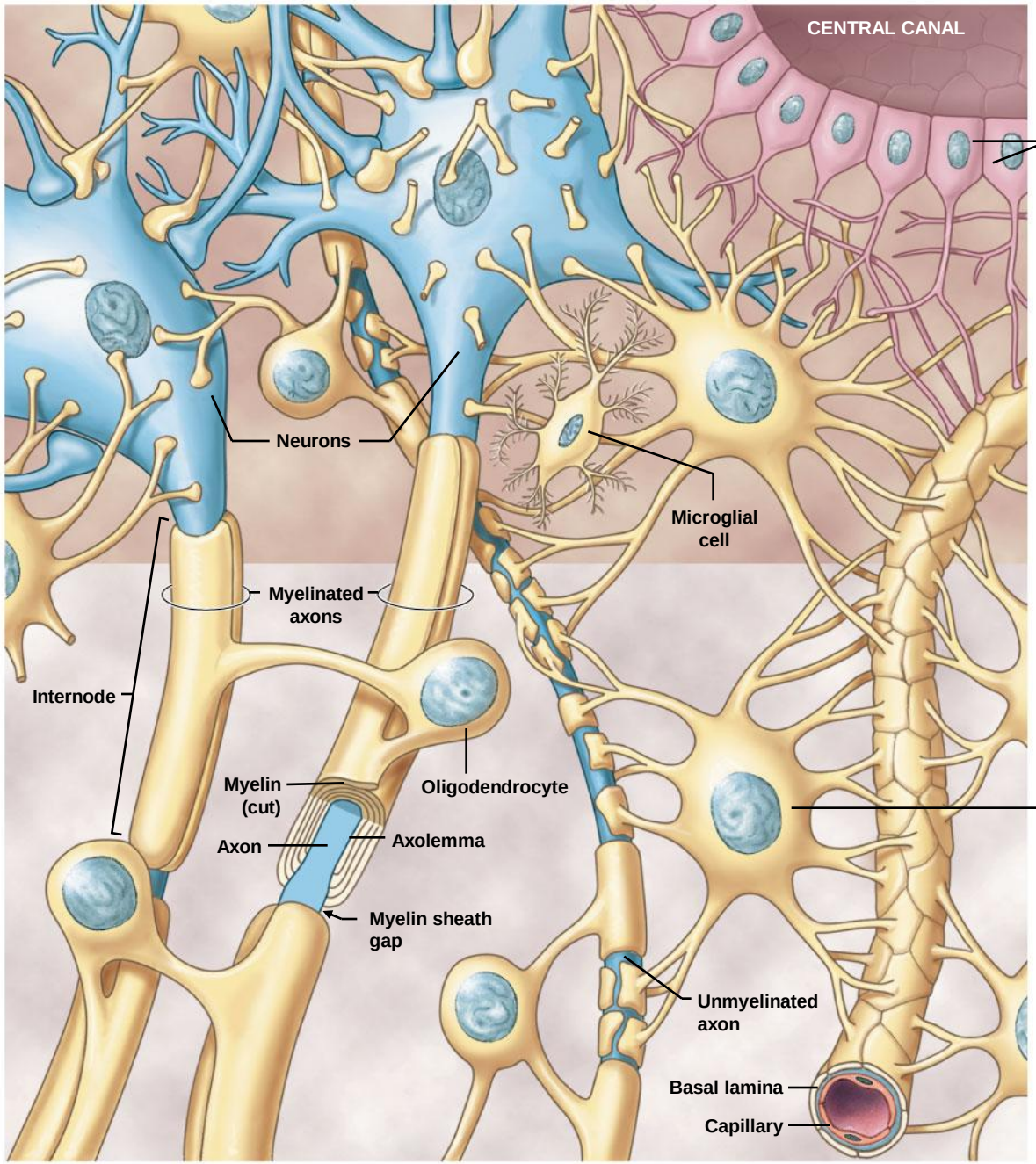
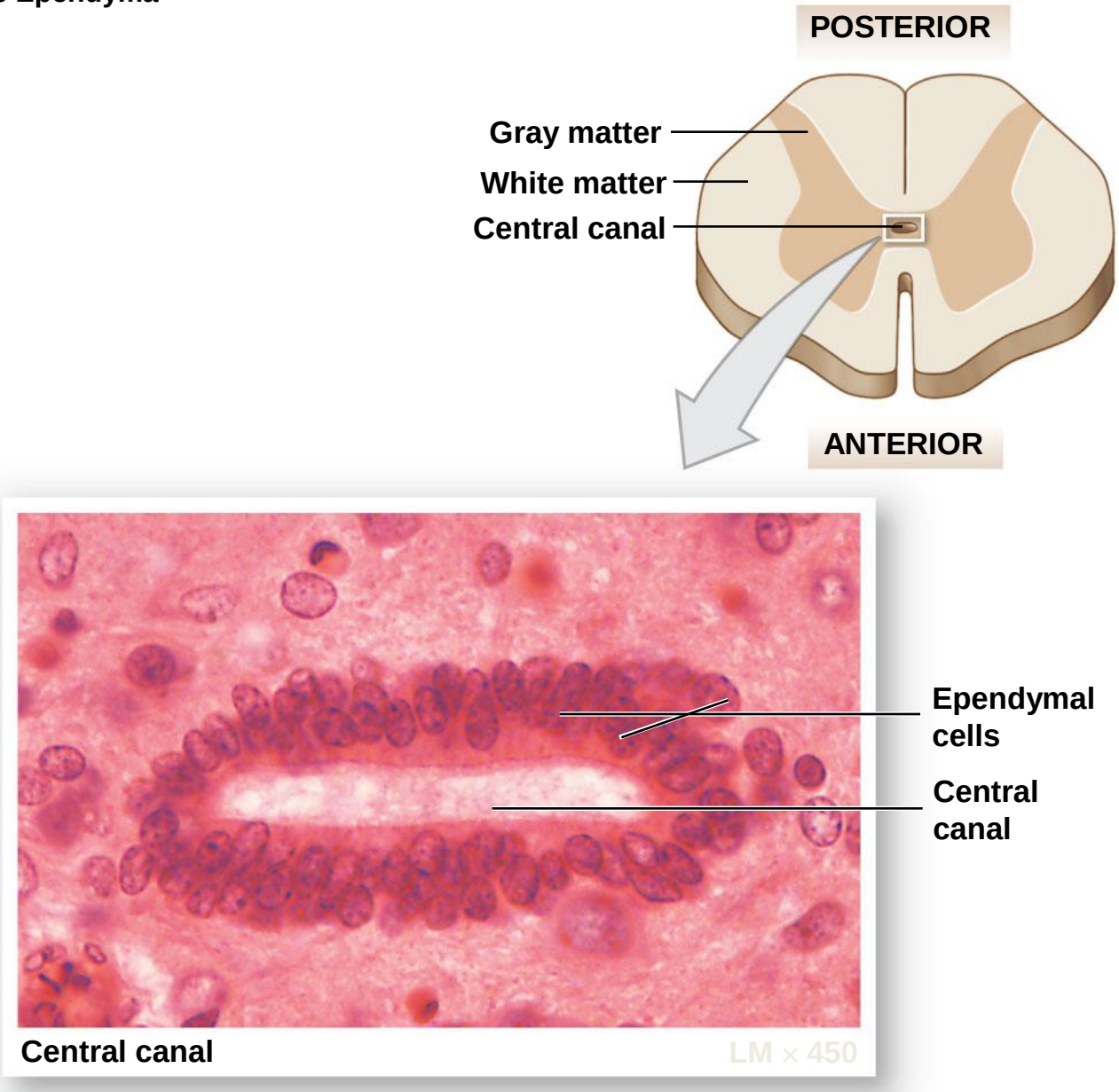


Figure 13.6a The Ependyma



a Light micrograph showing the ependymal lining of the central canal

Cellular Organization in Neural Tissue

- Neuroglia of the PNS
  - **Satellite cells**
    - Regulate the exchange of material between the cell body and the environment
  - **Schwann cells**
    - Also called **neurolemmocytes**
    - Form a myelin sheath

Figure 13.7 Satellite Cells and Peripheral Neurons

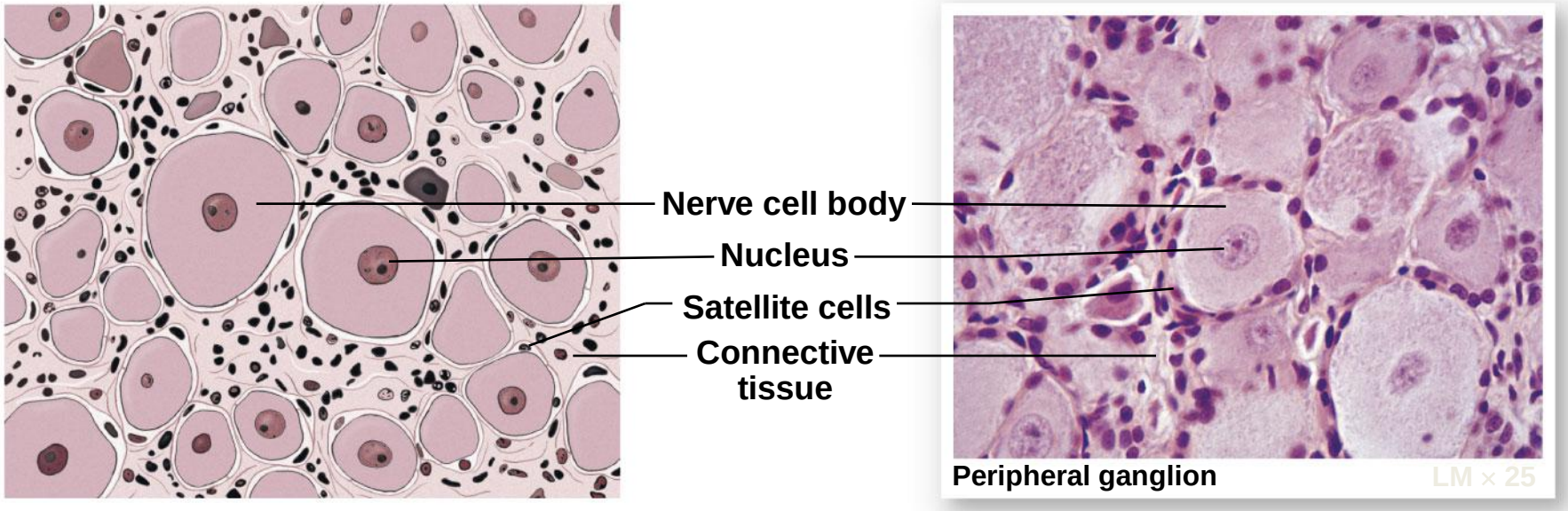
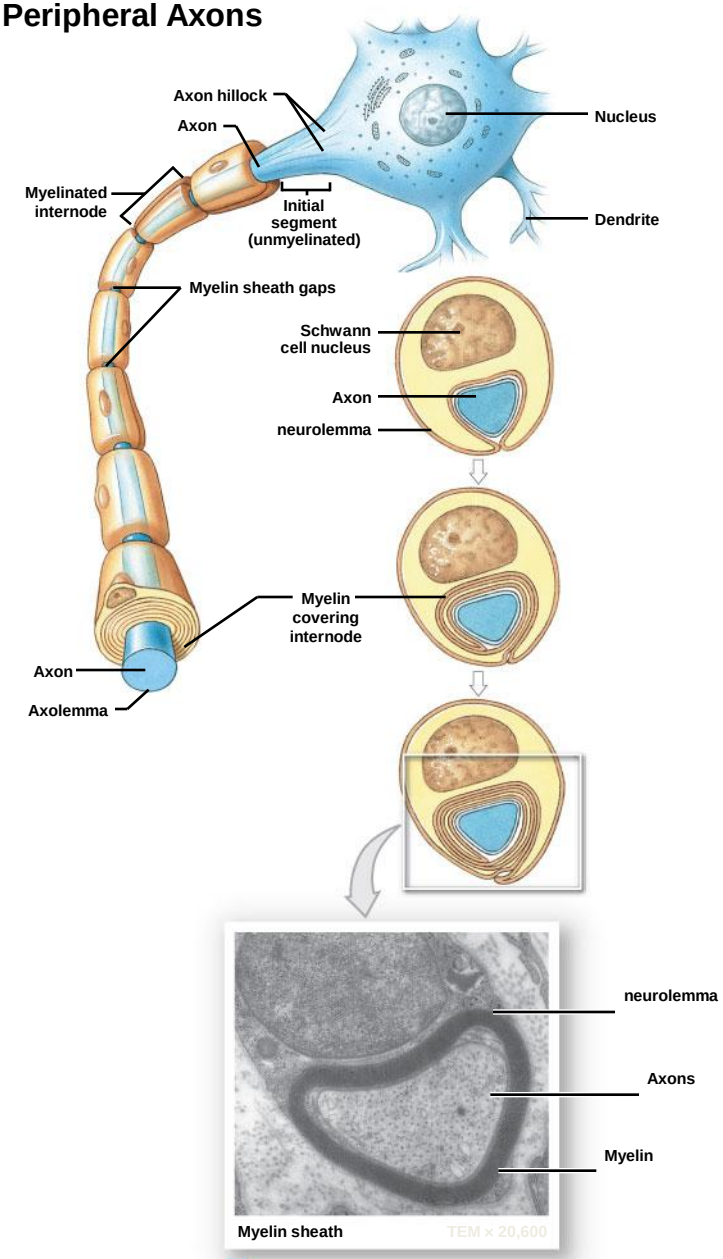
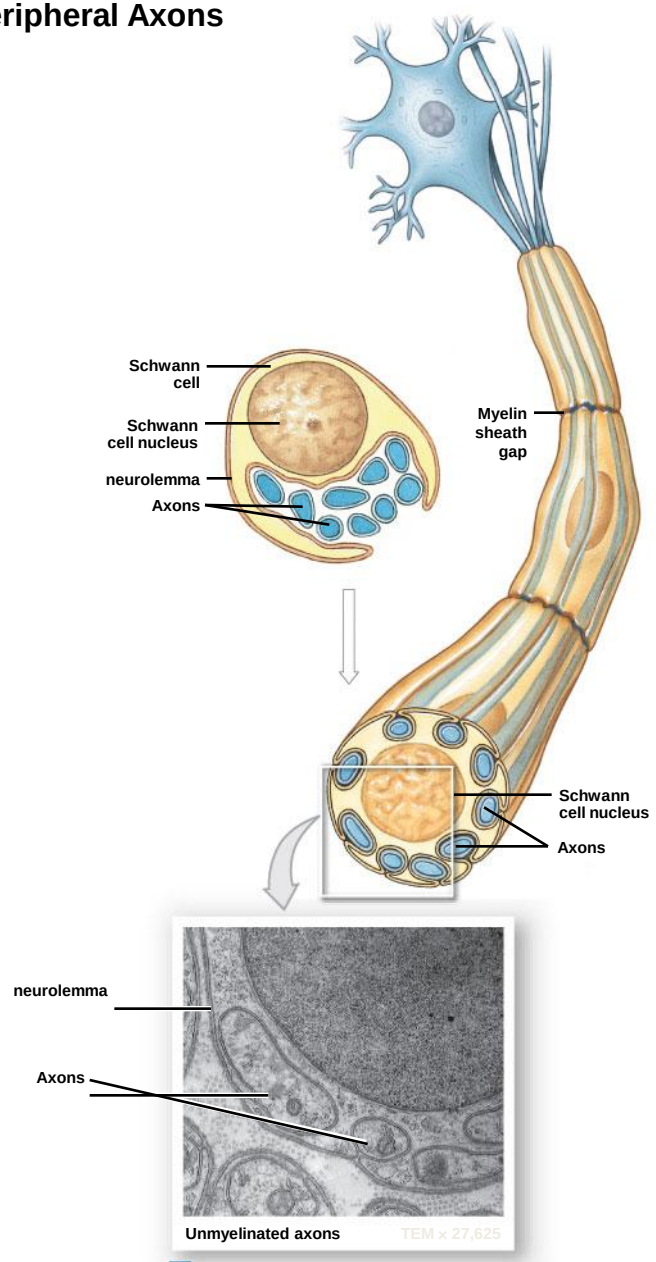


Figure 13.8a Schwann Cells and Peripheral Axons



a A single Schwann cell forms the myelin sheath around a portion of a single axon. This situation differs from the way myelin forms inside the CNS. Compare with Figure 13.5.

Figure 13.8b Schwann Cells and Peripheral Axons

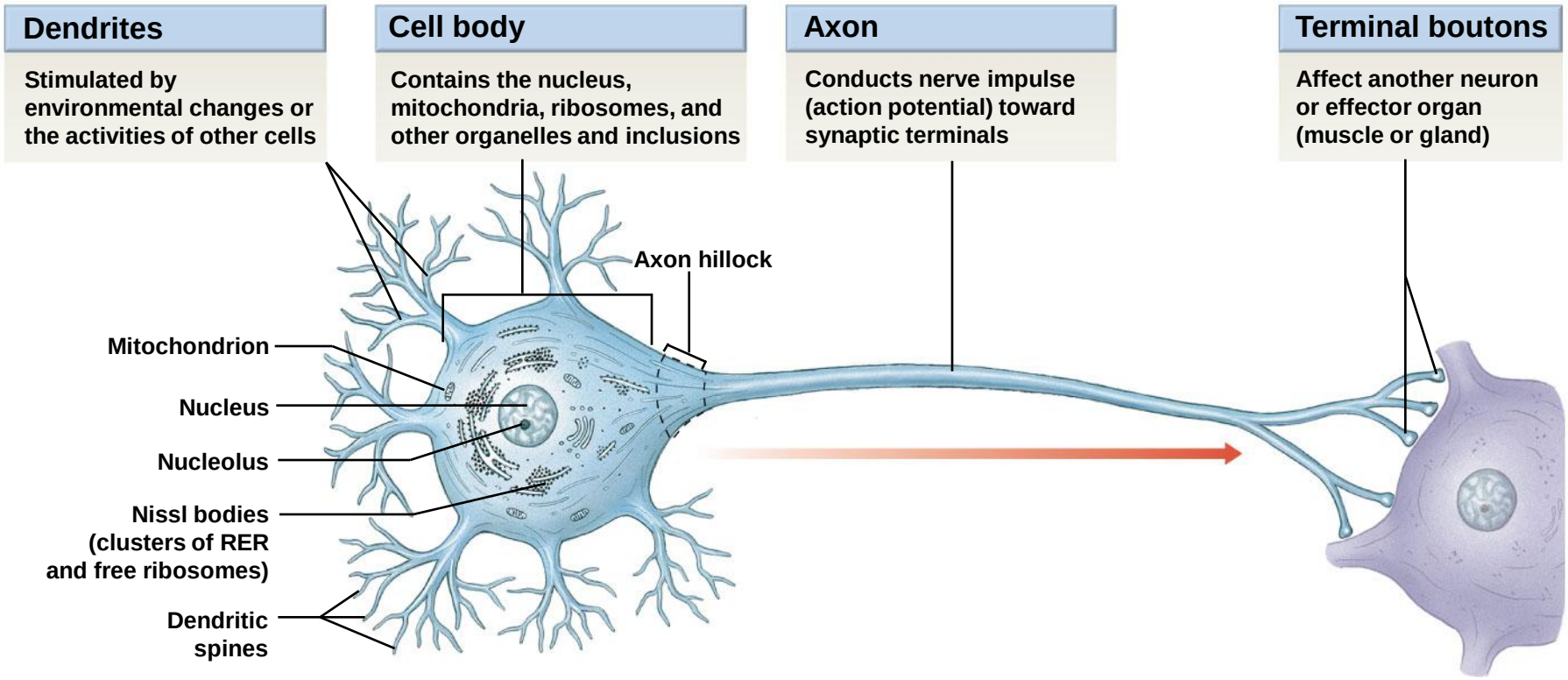


b A single Schwann cell can encircle several unmyelinated axons. Unlike the situation inside the CNS, every axon in the PNS has a complete neurolemmal sheath.

Cellular Organization in Neural Tissue

- Neuron Structure
  - Neurons consist of:
    - **Axons**
    - **Soma (cell body)**
    - **Dendrites**
    - **Terminal boutons**

Figure 13.3 A Review of Neuron Structure



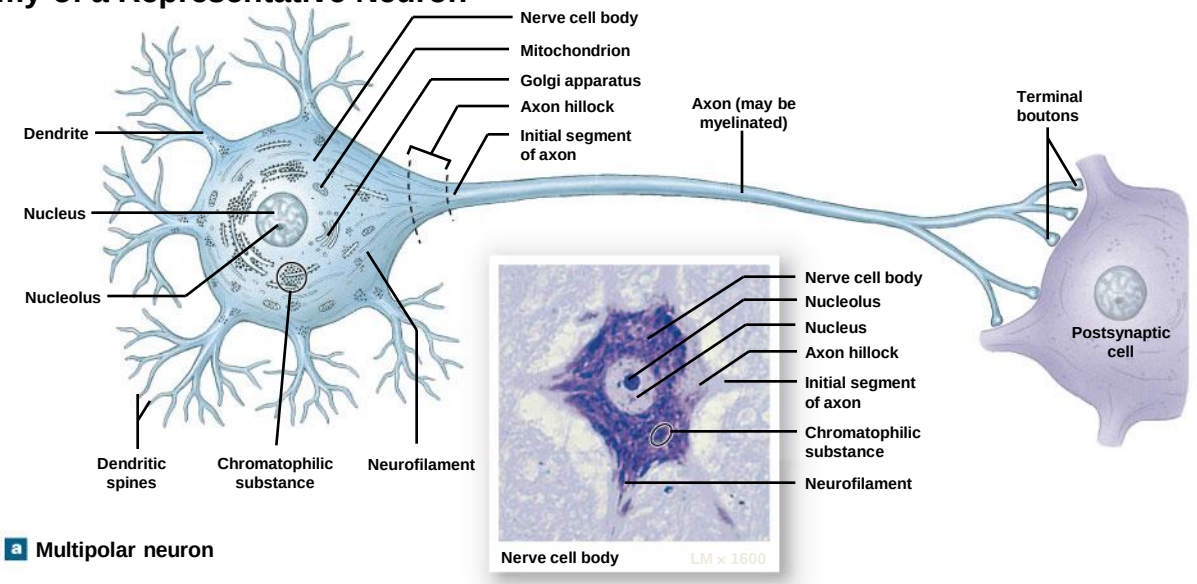
Cellular Organization in Neural Tissue

- Details of Neuron Structure
  - Soma consists of:
    - Nucleus
    - Nucleolus
    - Ribosomes (clusters are called **Nissl bodies** or **chromatophilic substances** – create gray matter)
    - Mitochondria
    - Golgi apparatus
    - Lack centrosomes – cannot reproduce

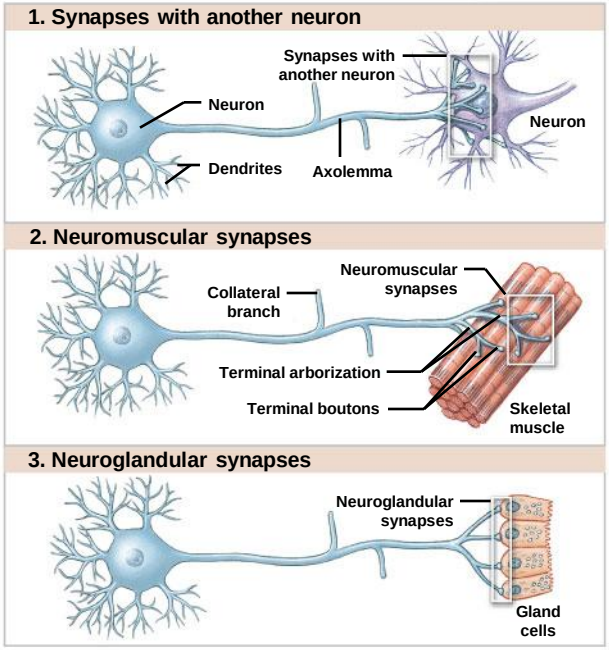
Cellular Organization in Neural Tissue

- Details of Neuron Structure
  - Axon (nerve fiber) consists of:
    - **Axon hillock area**
    - **Axoplasm**
    - Axon vesicles containing **neurotransmitters**

Figure 13.9 Anatomy of a Representative Neuron



a Multipolar neuron



b A neuron may innervate (1) other neurons, (2) skeletal muscle fibers, or (3) gland cells. Synapses are shown in boxes for each example. A single neuron would not innervate all three.

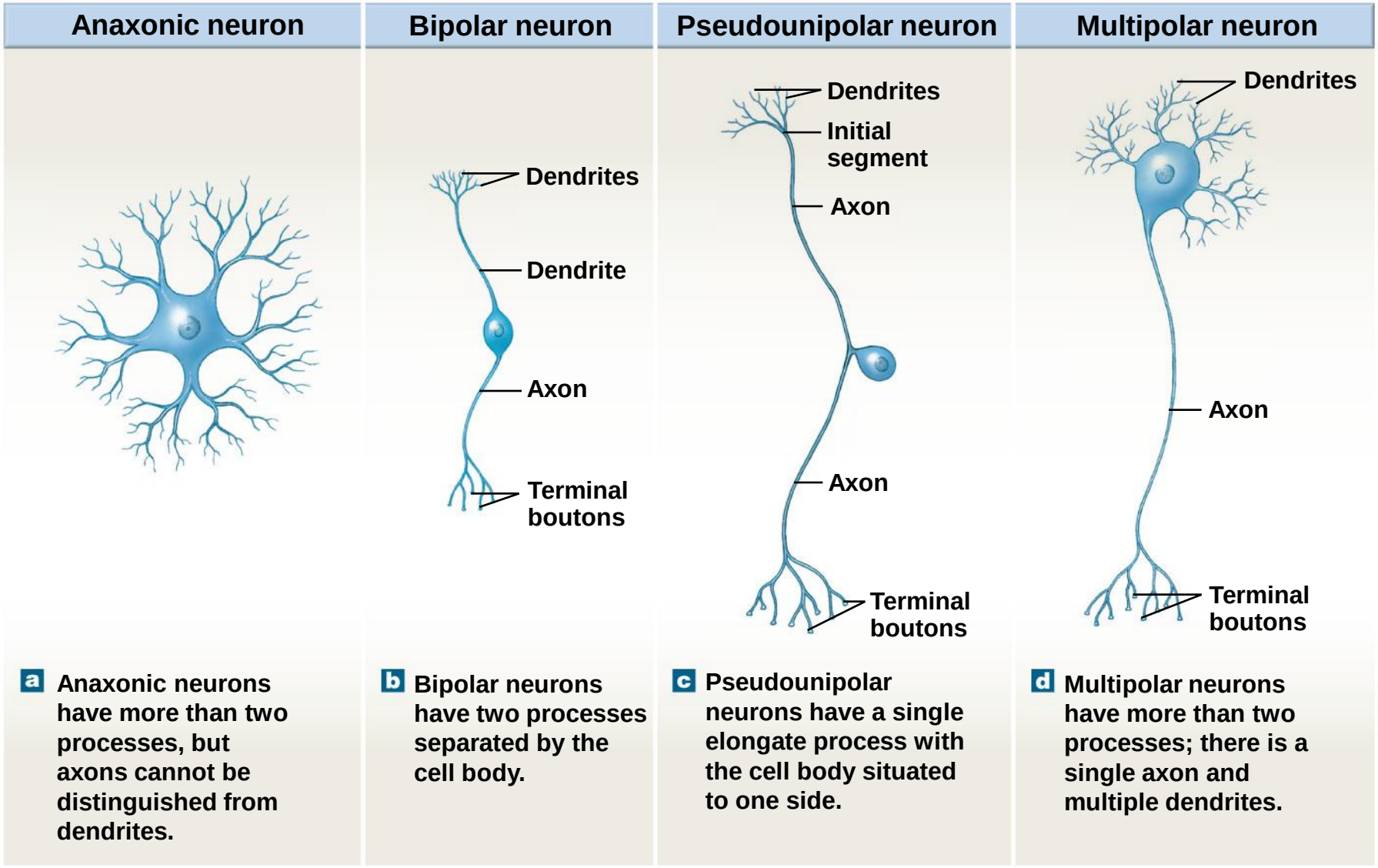
Cellular Organization in Neural Tissue

- Neuron Classification
  - Can be classified based on structure or function
  - **Structural classification**
    - Based on the placement of the cell body
    - Based on the number of processes extending from the cell body
  - **Functional classification**
    - Sensory
    - Motor
    - Interneuron (involved with both sensory and motor)

Cellular Organization in Neural Tissue

- Structural Classification of Neurons
  - **Anaxonic**
    - Has many processes but cannot differentiate between axons and dendrites
  - **Bipolar**
    - The cell body is between two axons
  - **Pseudounipolar**
    - The cell body is off to one side of the axon
  - **Multipolar**
    - Typically has a single axon and multiple dendrites

Figure 13.10 A Structural Classification of Neurons



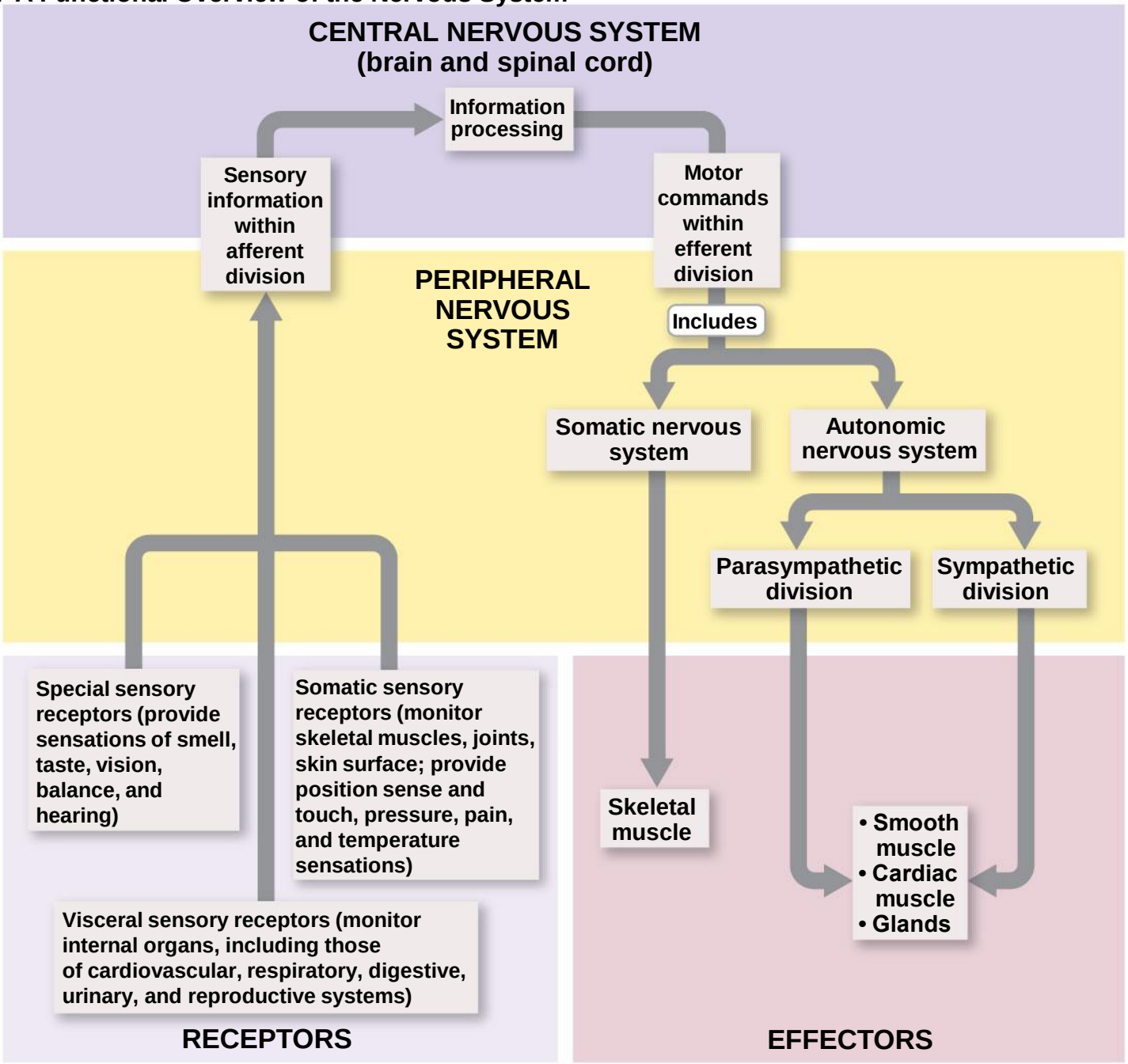
Cellular Organization in Neural Tissue

- Functional Classification of Neurons
  - **Sensory**
    - Sends information from the PNS to the CNS
    - **Somatic sensory** and **visceral sensory**
  - **Motor**
    - Sends information from the CNS to the periphery
  - **Interneurons**
    - Situated between the motor and sensory neurons
    - Analyze sensory input and coordinate motor outputs
    - Can be excitatory or inhibitory

Cellular Organization in Neural Tissue

- Functional Classification of Neurons (cont.)
  - **Sensory neurons**
    - Pick up information from **receptors** and send it to the CNS
  - **Motor neurons**
    - Send information to the **effectors** of the periphery or organs

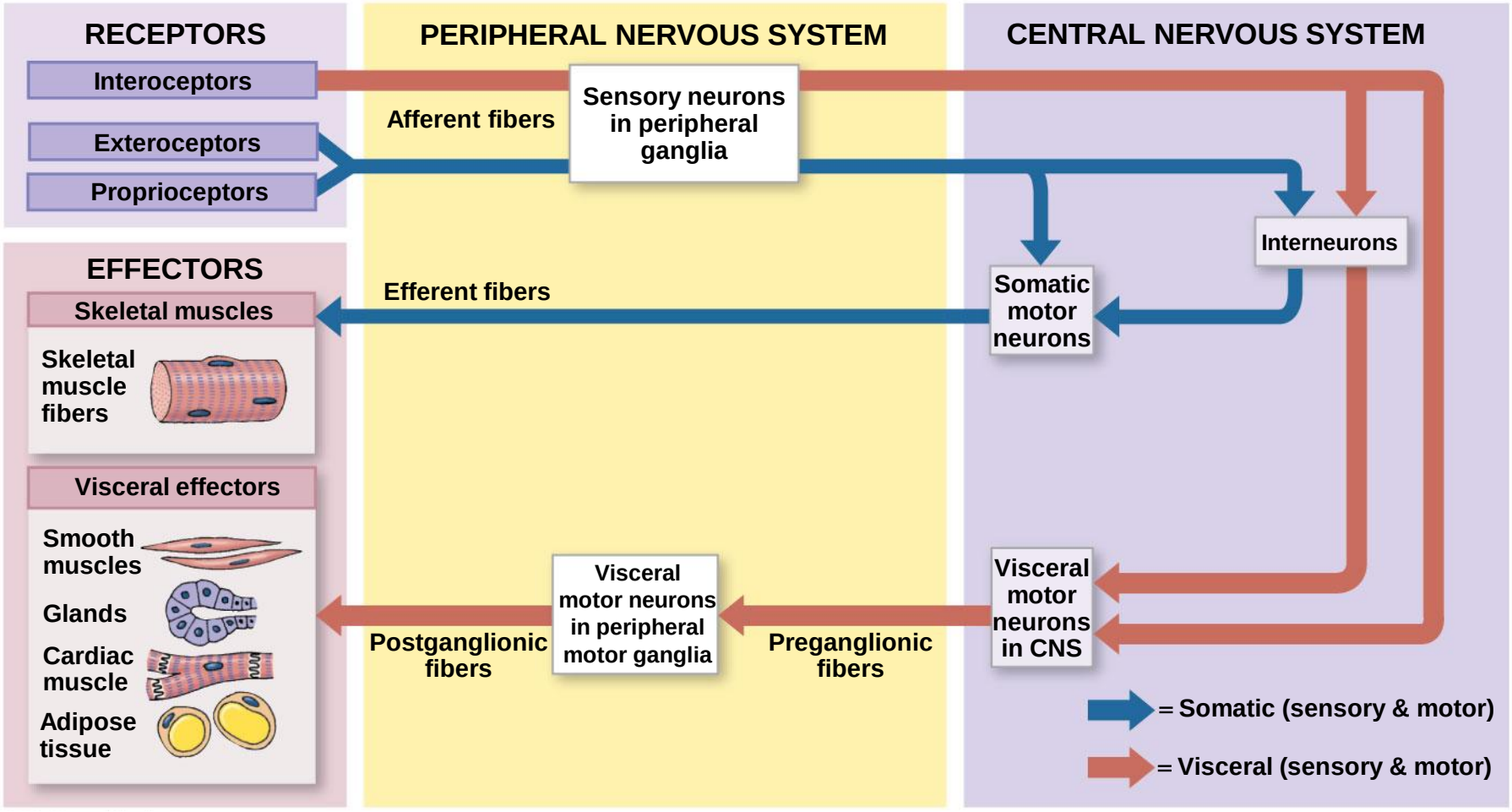
Figure 13.2 A Functional Overview of the Nervous System



Cellular Organization in Neural Tissue

- There are three major types of receptors
  - **Exteroceptors**
    - Provide information about the external environment such as:
      - Touch, temperature, pressure, sight, smell, and hearing
  - **Proprioceptors**
    - Monitor position and movement of the body
  - **Interoceptors**
    - Monitor internal organ activity

Figure 13.11 A Functional Classification of Neurons



Neural Regeneration

- Neural Regeneration
  - Steps involved in the limited ability to repair
    - Schwann cells grow into the cut area
    - Axons begin to grow into the Schwann cells

The Nerve Impulse

- A nerve impulse is the **action potential** of a nerve
- The action potential is due to the **exchange of ions** across the membrane
- The ability to conduct the impulse is known as **excitability**
- A **stimulus** is anything that causes an action potential to occur
- The stimulus has to overcome the **threshold level** of that particular neuron
- The threshold level is the amount of stimuli required to create the action potential

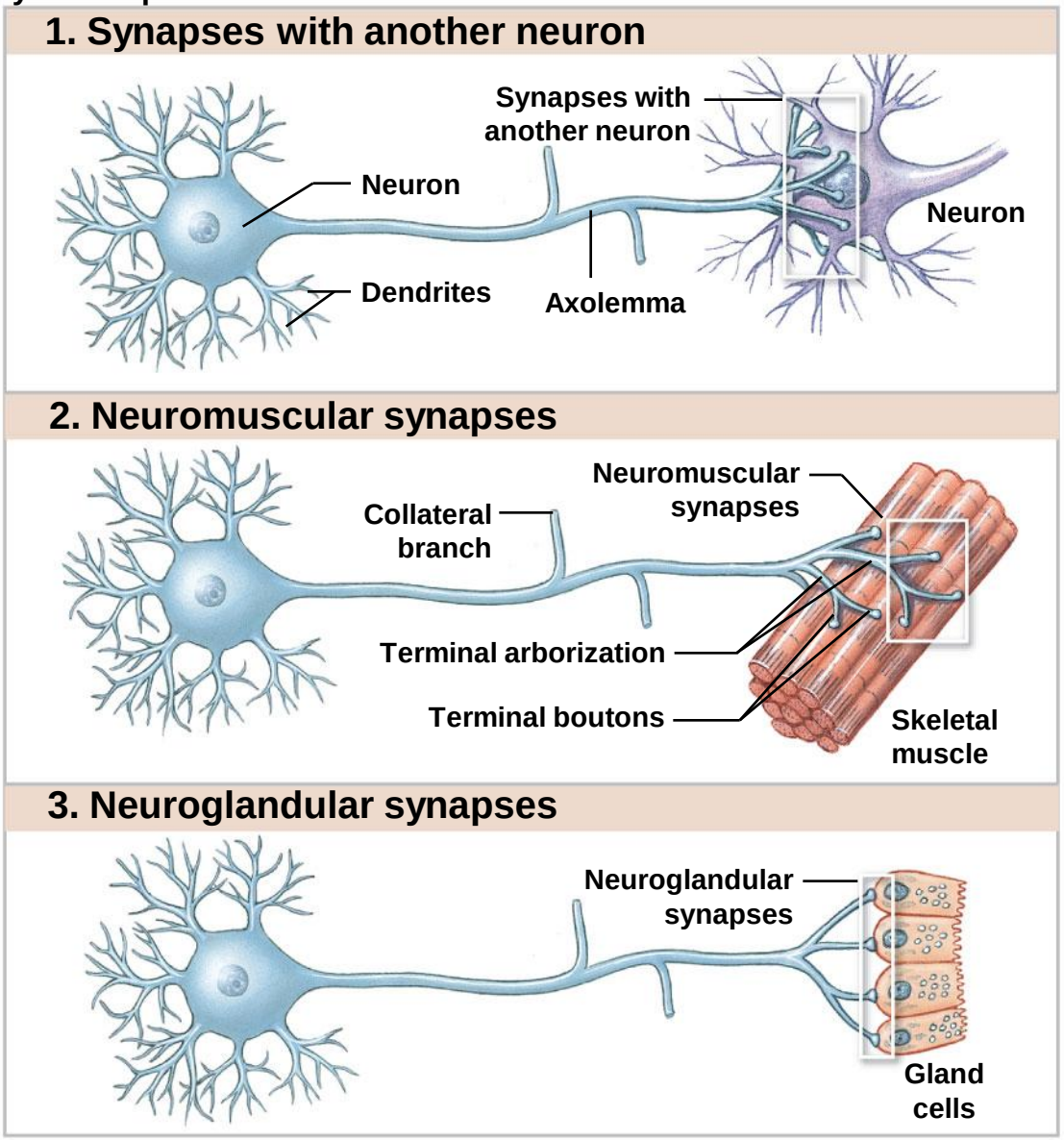
The Nerve Impulse

- The “speed” of the impulse depends on:
  - Presence of a myelin sheath
    - Fast impulse
  - Lack of a myelin sheath
    - Slow impulse
  - Axon with a large diameter
    - Fast impulse
    - Up to 140 m/sec
  - Axon with a small diameter
    - Slow impulse
    - Less than 1 m/sec

Synaptic Communication

- A synapse is the junction between:
  - The axon of one neuron and the dendrite of another neuron (**axodendritic**)
  - The axon of one neuron and the soma of another neuron (**axosomic**)
  - The axon of one neuron and the axon of another neuron (**axoaxonic**)
  - The axon of a neuron and a muscle (**neuromuscular**)
  - The axon of a neuron and a gland (**neuroglandular**)

Figure 13.9b Anatomy of a Representative Neuron

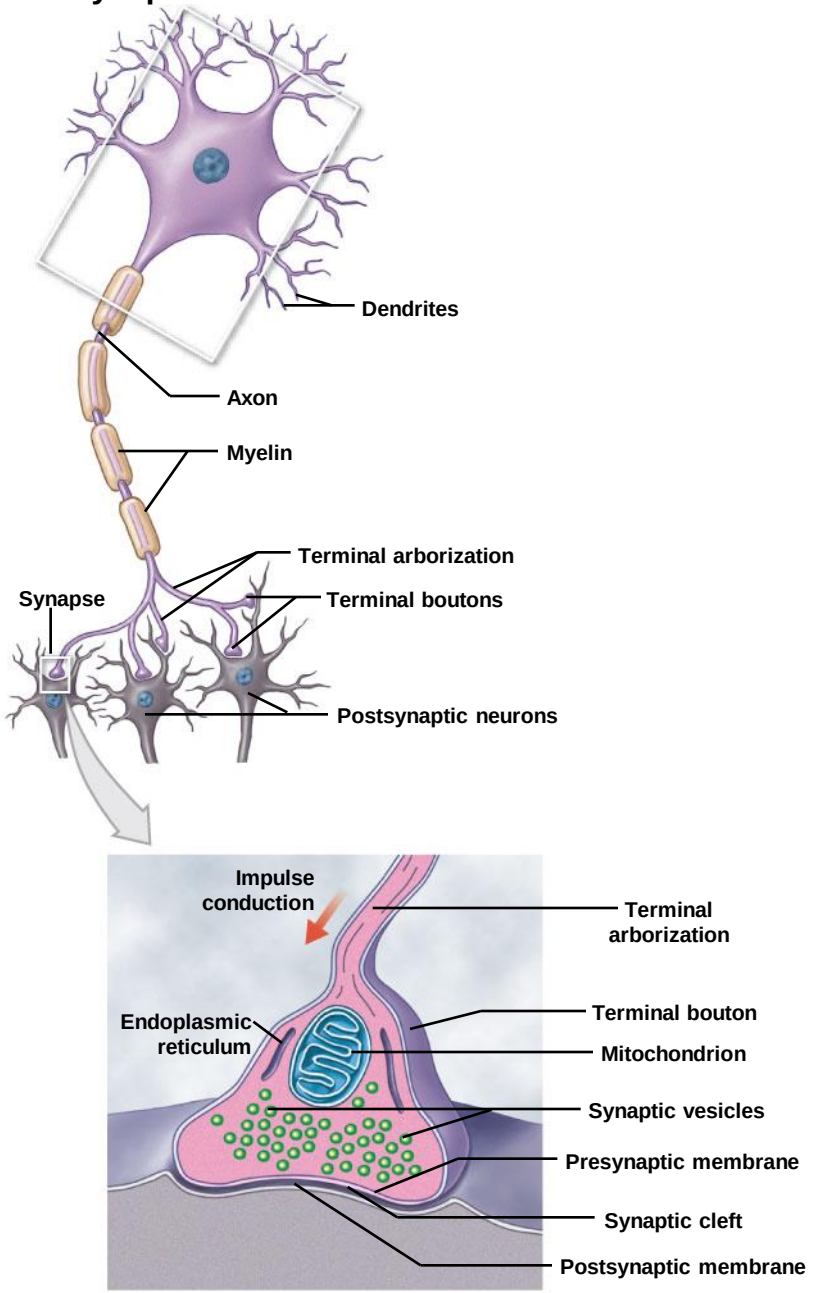


b **A neuron may innervate (1) other neurons, (2) skeletal muscle fibers, or (3) gland cells. Synapses are shown in boxes for each example. A single neuron would not innervate all three.**

Synaptic Communication

- At a synaptic terminal, a nerve impulse triggers events at a synapse that transfers information across the synapse
- This transfer process is accomplished by:
  - **Vesicular synapses** (chemical synapses)
    - Involve a neurotransmitter
  - **Nonvesicular synapses**
    - Involve the flow of ions

Figure 13.13a The Structure of a Synapse



a Diagrammatic view of a vesicular synapse between two neurons

Synaptic Communication

- **Vesicular synapse** events
  - Impulses are conveyed in one direction only
  - Sequence of events:
    - An action potential arrives at the presynaptic membrane
    - This triggers the release of a neurotransmitter from the axon vesicles
    - The neurotransmitter diffuses across the synapse
    - The neurotransmitter binds to the postsynaptic membrane
    - This binding action causes a change in the permeability of the postsynaptic membrane
    - This change in permeability results in an action potential of the next neuron

Synaptic Communication

- **Nonvesicular synapse** events
  - Impulses can be conveyed in any direction
  - Sequence of events:
    - The presynaptic membrane of one neuron is tightly bound to the postsynaptic membrane of another neuron
    - This binding permits the passage of ions from one neuron to the next

Neuron Organization and Processing

- Neurons can be organized into smaller organized groups called **neuronal pools**
- The neuronal pools are identified by their neural circuitry such as:
  - **Divergence**
  - **Convergence**
  - **Serial processing**
  - **Parallel processing**
  - **Reverberation**

Neuron Organization and Processing

- **Divergence**
  - The spread of information from one neuron to several neurons
  - Permits broad distribution of a specific input
  - Information enters the CNS and then spreads to the brain and spinal cord at the same time
- **Convergence**
  - Information going from several neurons to a single neuron
  - Movements of the diaphragm muscle are involuntary, but yet at times we can move the diaphragm muscle voluntarily

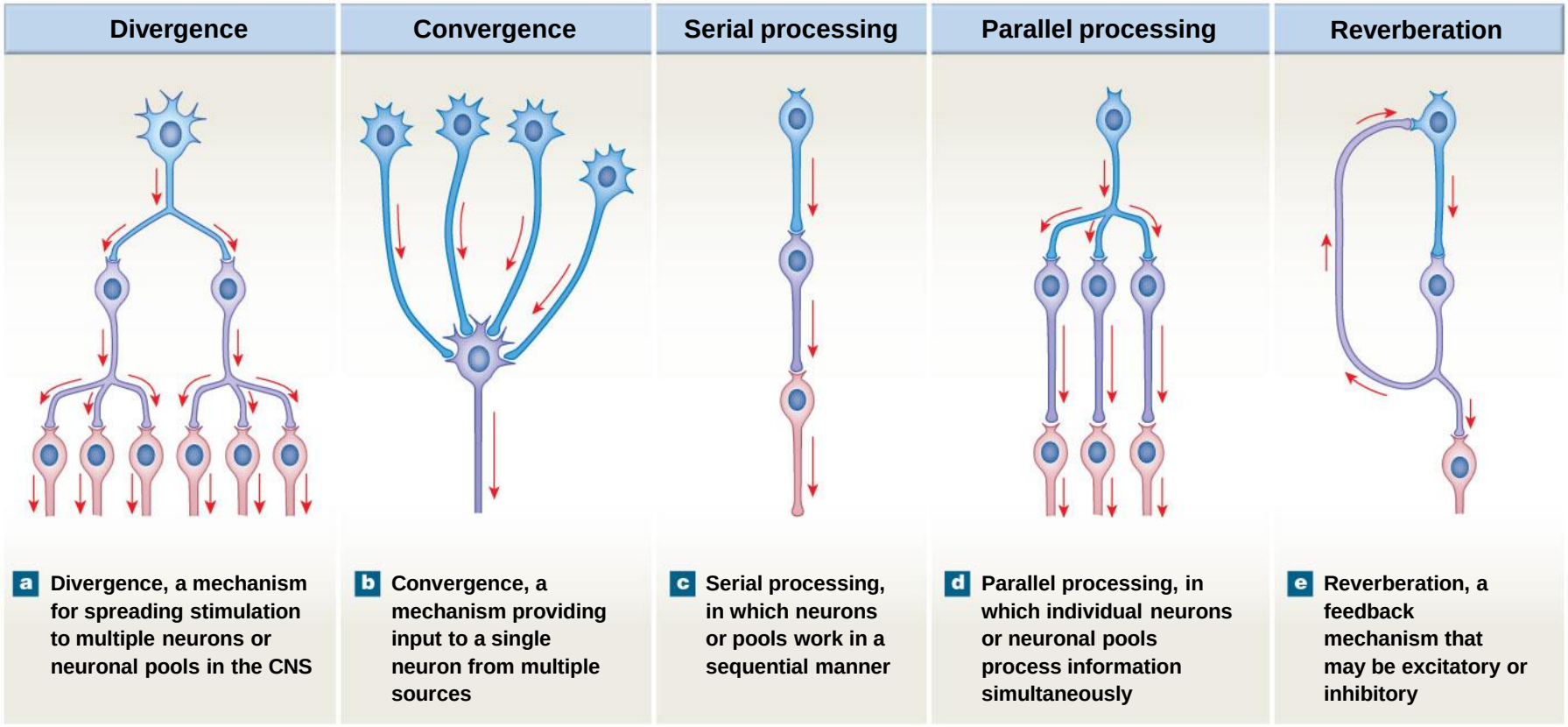
Neuron Organization and Processing

- **Serial processing**
  - Information going from one neuron to the next in a sequence
  - Information going to one part of the brain then, to another part, and then to another part, etc.
- **Parallel processing**
  - Several neurons are processing the information at the same time
  - If you step on a nail, you typically move your foot, shout “ouch,” and dance a bit, all at the same time

Neuron Organization and Processing

- **Reverberation**
  - Collateral axons extend back toward the origin of the impulse to cause an enhancement or a continuation of the impulse

Figure 13.14 Organization of Neuronal Circuits



Anatomical Organization of the Nervous System

- The organization of the neurons in the CNS and PNS is not random
  - Organization in the CNS
    - A collection of cell bodies in one area creates gray matter
    - Bundles of axons in an area create white matter; these are called **tracts** and **columns**
  - Organization in the PNS
    - The cell bodies are found in **ganglia**
    - Axons are bundled together to form **spinal nerves** and **cranial nerves**

Figure 13.15 Anatomical Organization of the Nervous System