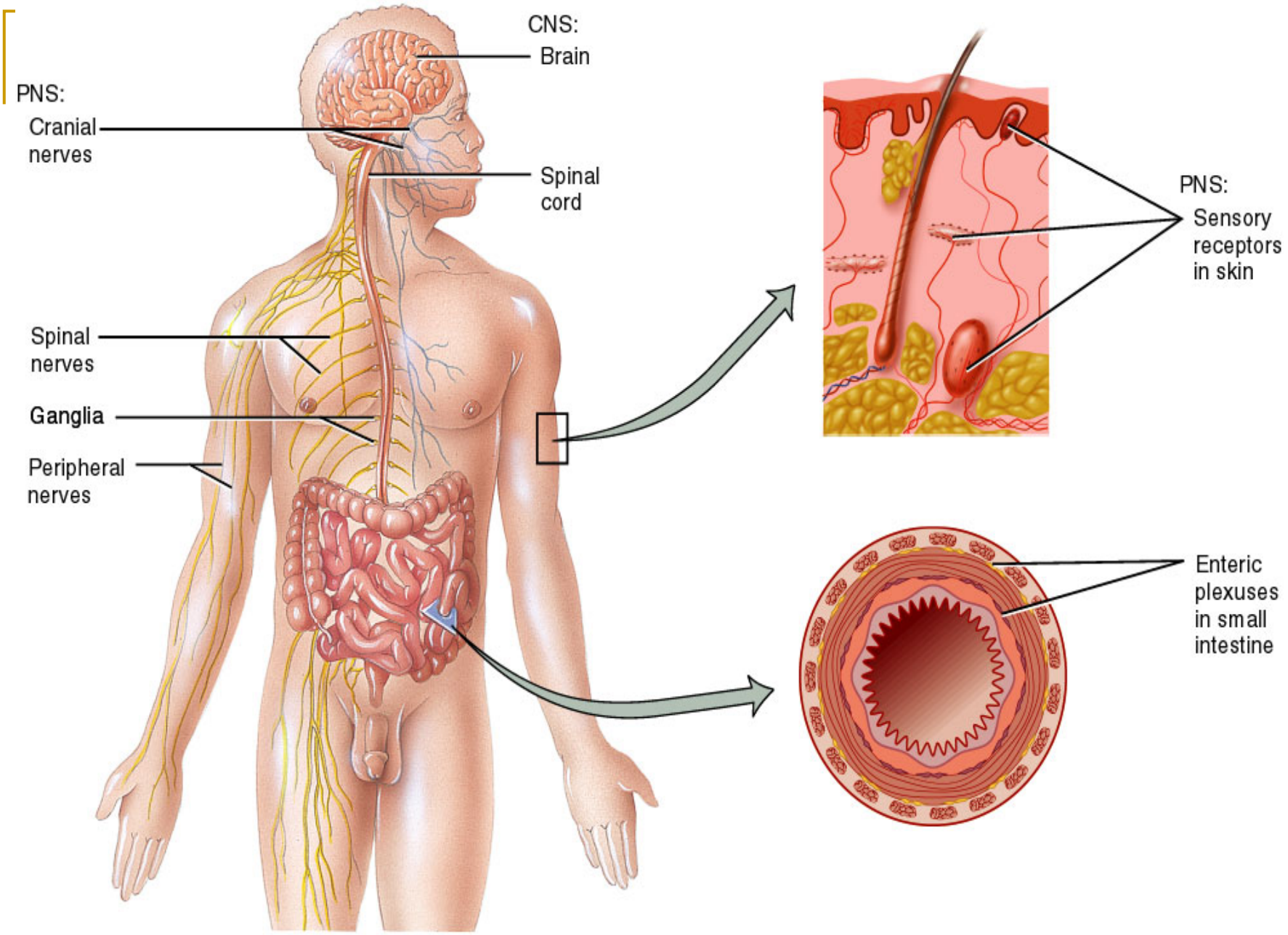
Nervous Tissue


CNS:
Brain
PNS:
Cranial nerves
Spinal cord
Spinal nerves
Ganglia
Peripheral nerves
PNS:
Sensory receptors in skin
Enteric plexuses in small intestine

12.01

Functional composition of the PNS.

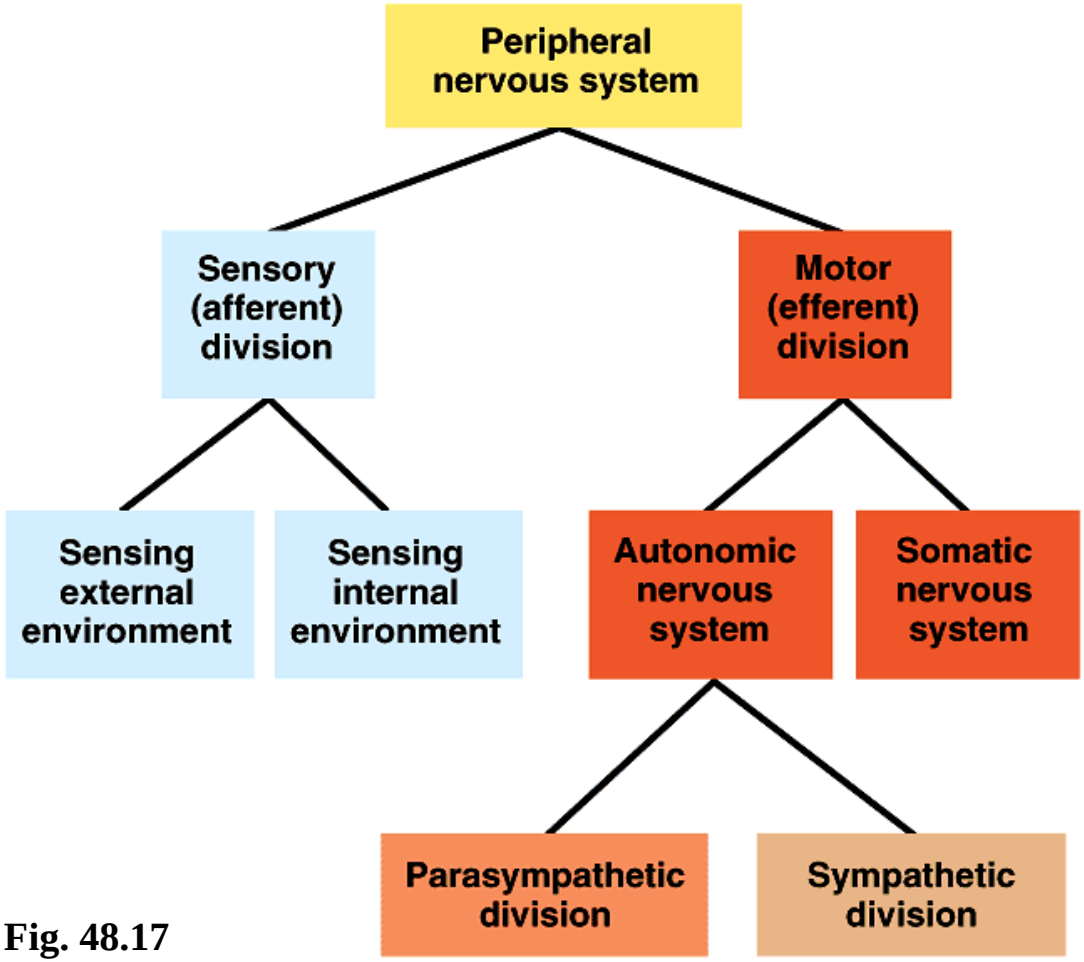


Fig. 48.17

- A closer look at the (often antagonistic) divisions of the **autonomic nervous system (ANS).**

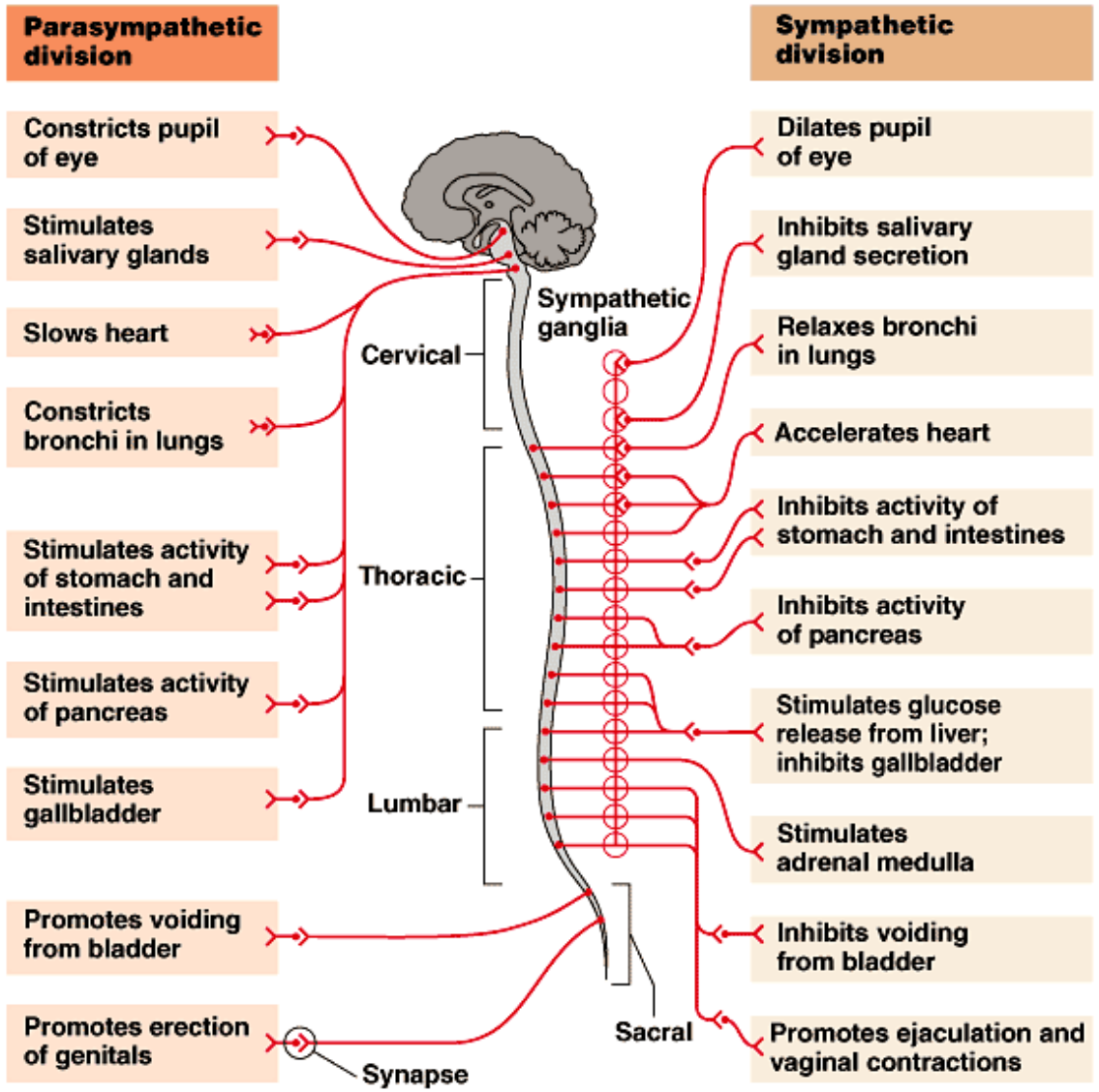
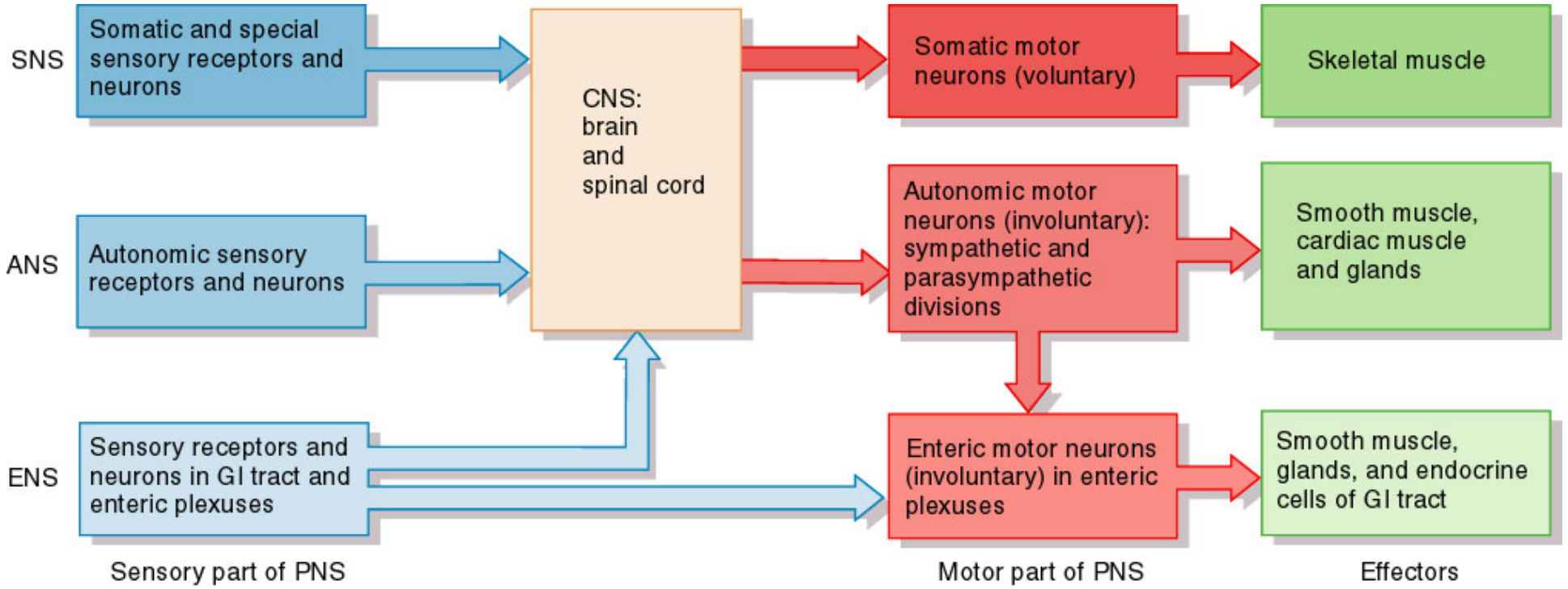


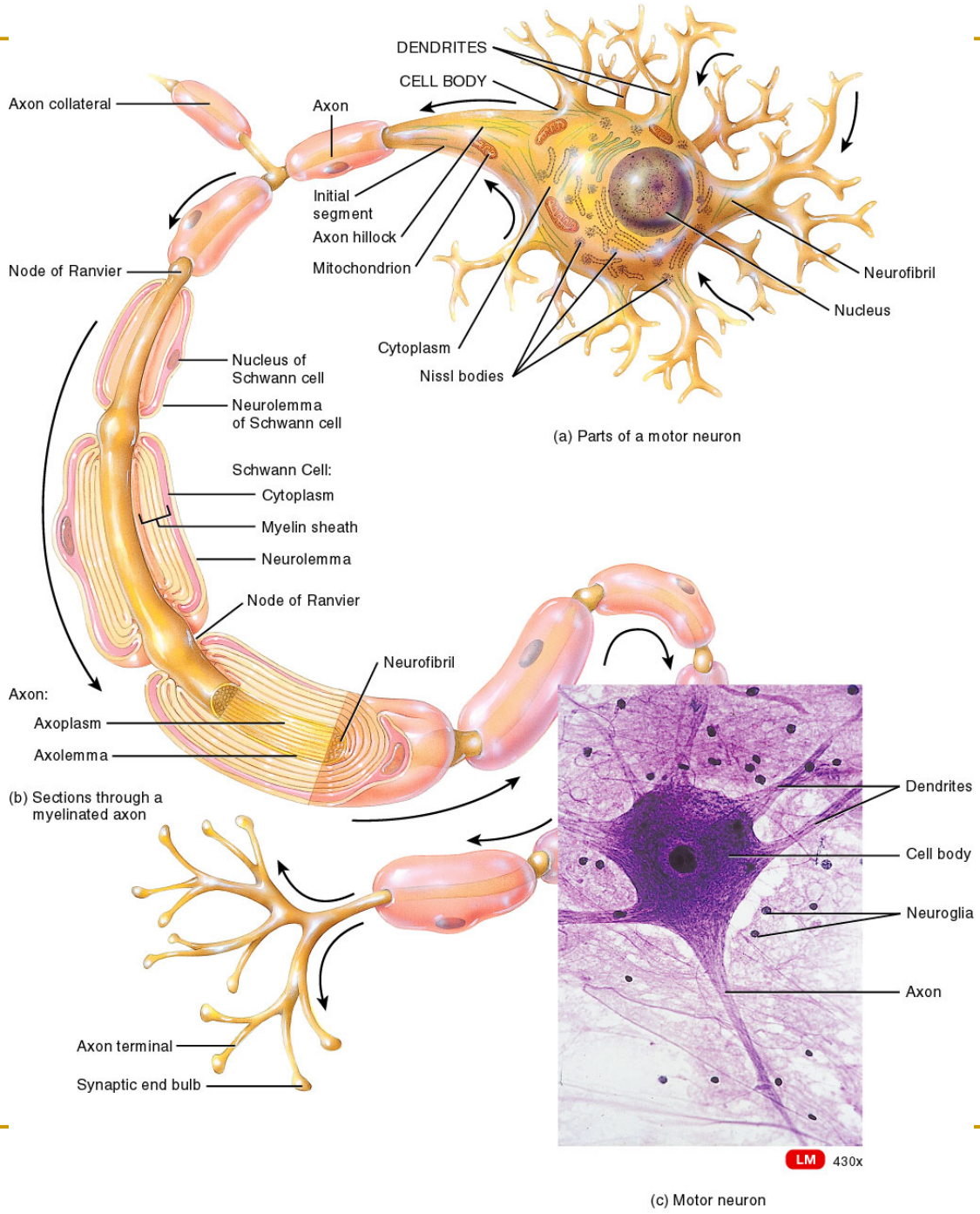
Fig. 48.18

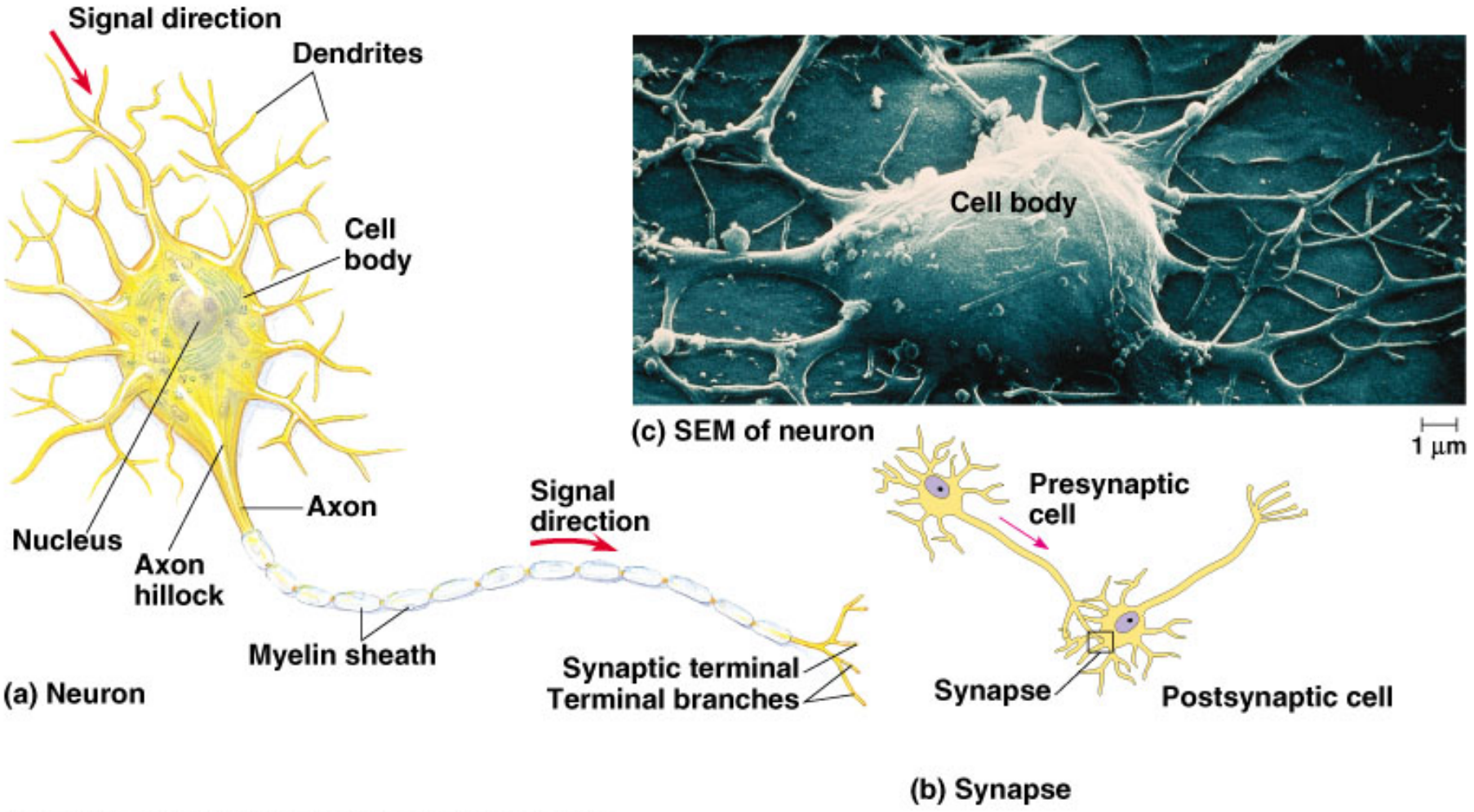

SNS
Somatic and special sensory receptors and neurons
ANS
Autonomic sensory receptors and neurons
ENS
Sensory receptors and neurons in GI tract and enteric plexuses
Sensory part of PNS
CNS: brain and spinal cord
Somatic motor neurons (voluntary)
Autonomic motor neurons (involuntary): sympathetic and parasympathetic divisions
Enteric motor neurons (involuntary) in enteric plexuses
Motor part of PNS
Skeletal muscle
Smooth muscle, cardiac muscle and glands
Smooth muscle, glands, and endocrine cells of GI tract
Effectors

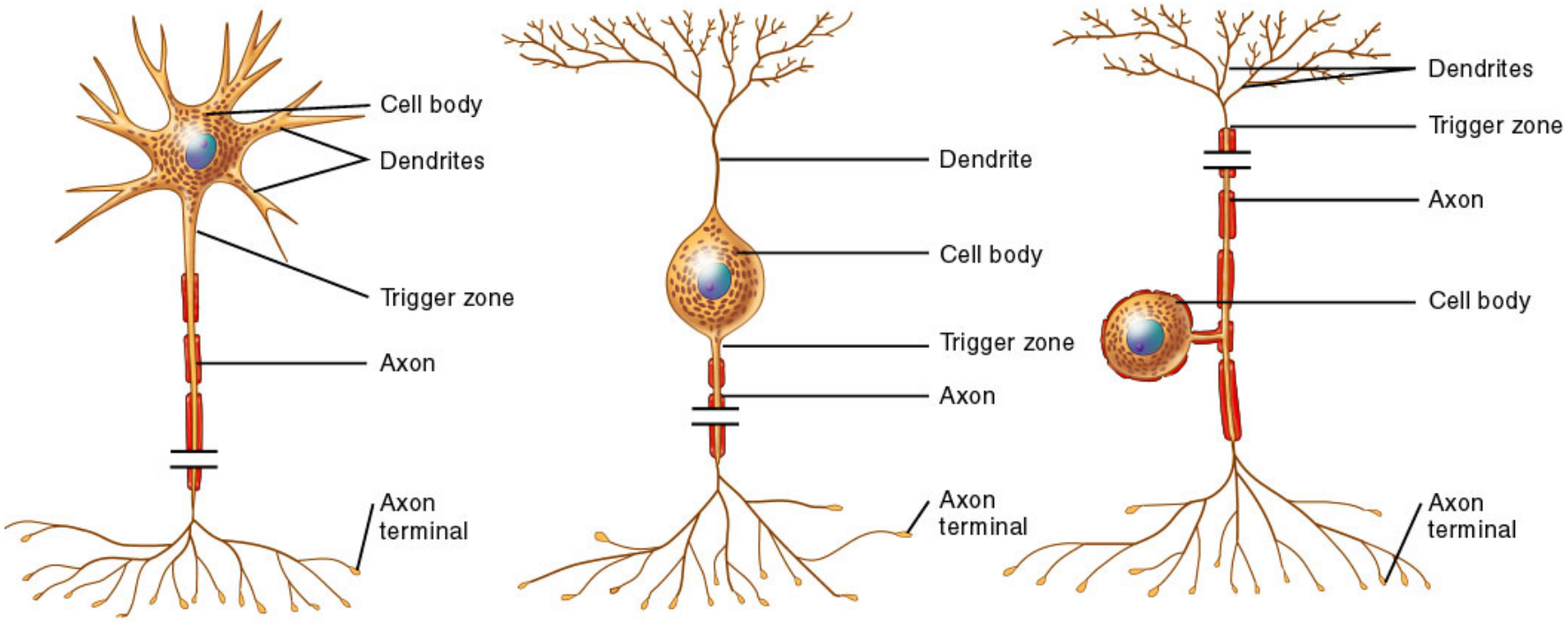
12.02

Functions of the Nervous System

- Sensory
- Motor
- Integrative / association

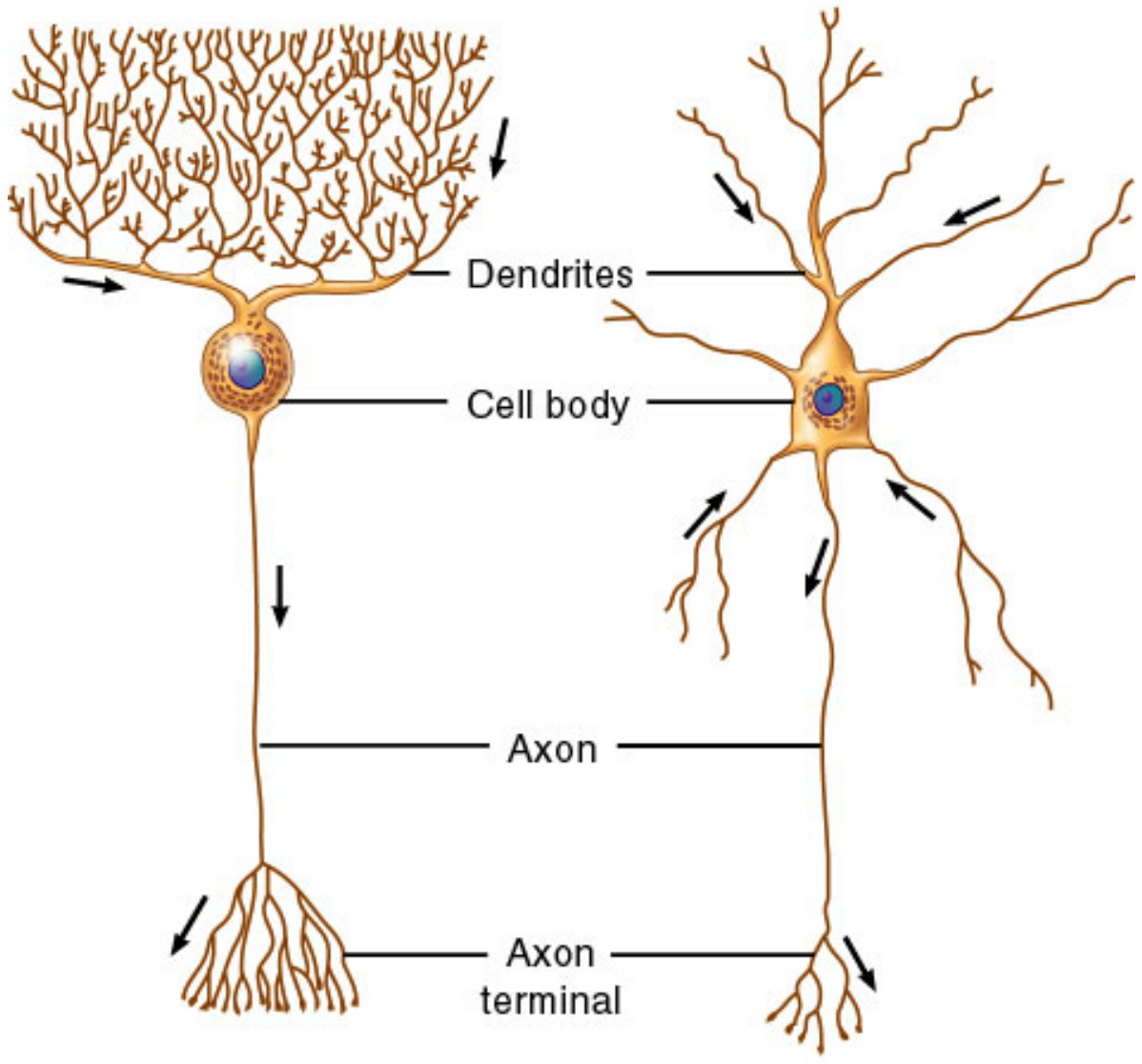

DENDRITES
CELL BODY
Axon collateral
Axon
Initial segment
Axon hillock
Mitochondrion
Node of Ranvier
Neurofibril
Nucleus
Cytoplasm
Nissl bodies
Nucleus of Schwann cell
Neurolemma of Schwann cell
(a) Parts of a motor neuron
Schwann Cell:
Cytoplasm
Myelin sheath
Neurolemma
Node of Ranvier
Neurofibril
Axon:
Axoplasm
Axolemma
(b) Sections through a myelinated axon
Dendrites
Cell body
Neuroglia
Axon
Axon terminal
Synaptic end bulb
LM
430x
(c) Motor neuron


Signal direction
Dendrites
Cell body
Nucleus
Axon hillock
Axon
Myelin sheath
Signal direction
Synaptic terminal
Terminal branches
(a) Neuron
Cell body
(c) SEM of neuron
1 µm
Presynaptic cell
Synapse
Postsynaptic cell
(b) Synapse



(a) Multipolar neuron (b) Bipolar neuron (c) Unipolar neuron

12.04

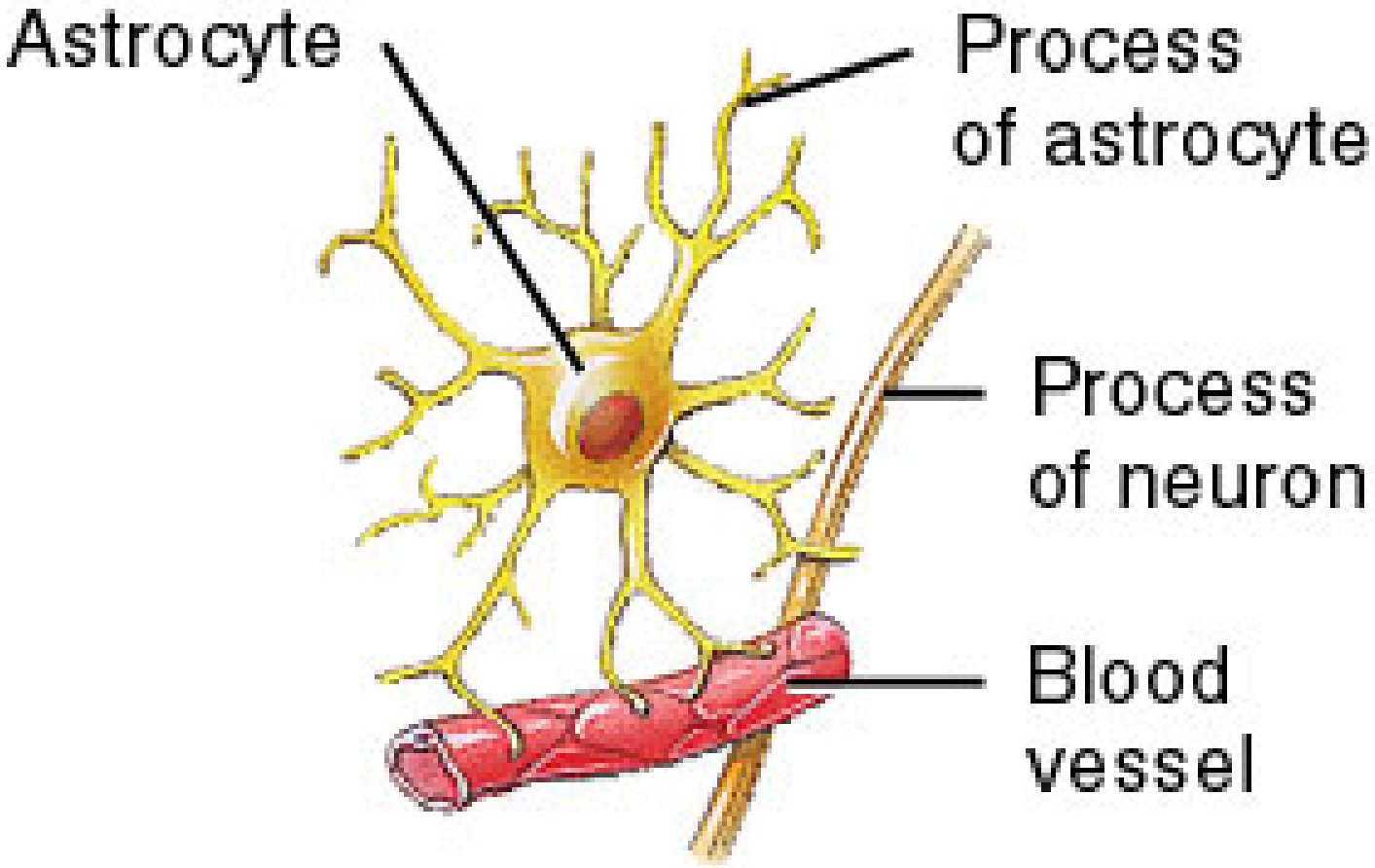


(a) Purkinje cell (b) Pyramidal cell

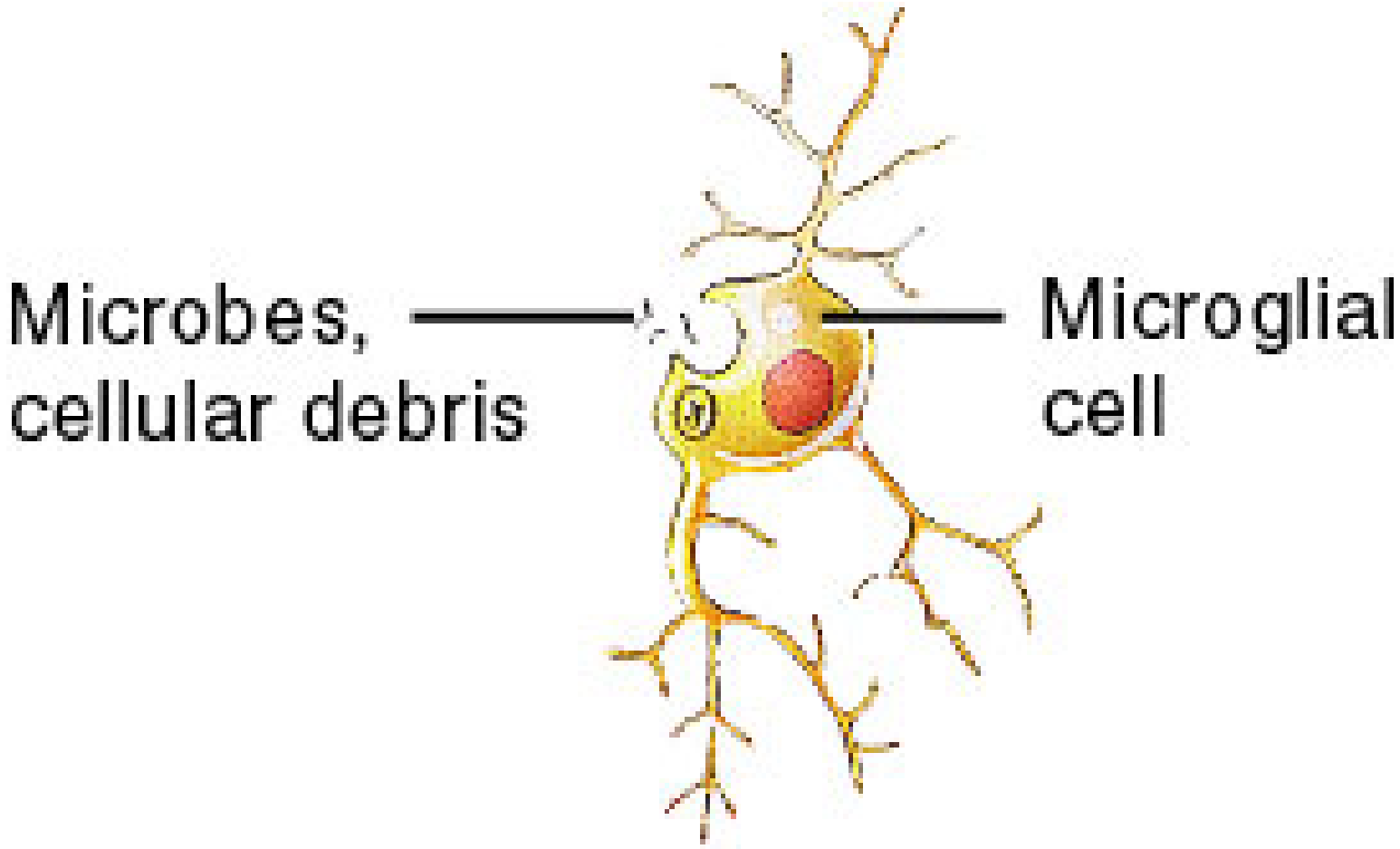
12.05

Neuroglia

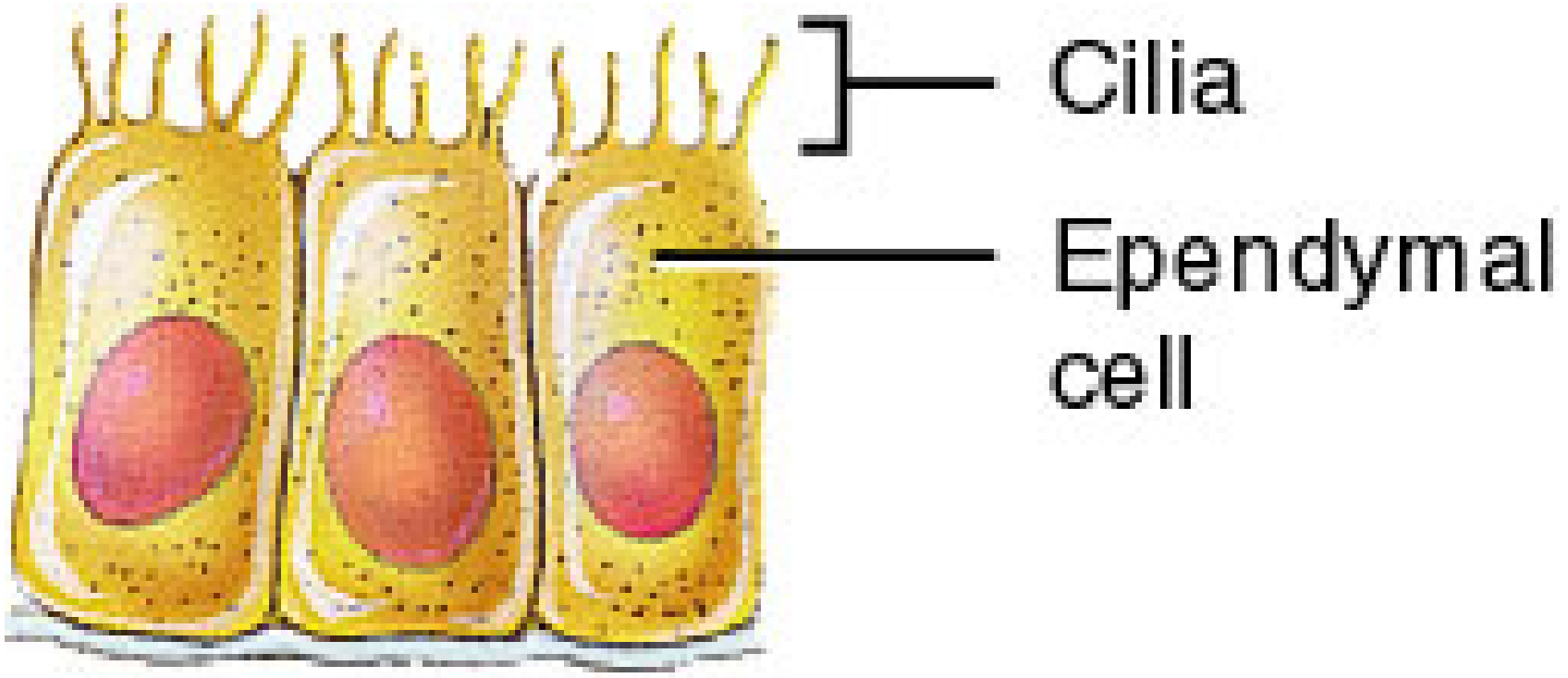
- Astrocytes
- Microglia
- Ependymal Cells
- Oligodendrocytes
- Schwann Cells
- Satellite cells


Astrocyte
Process of astrocyte
Process of neuron
Blood vessel

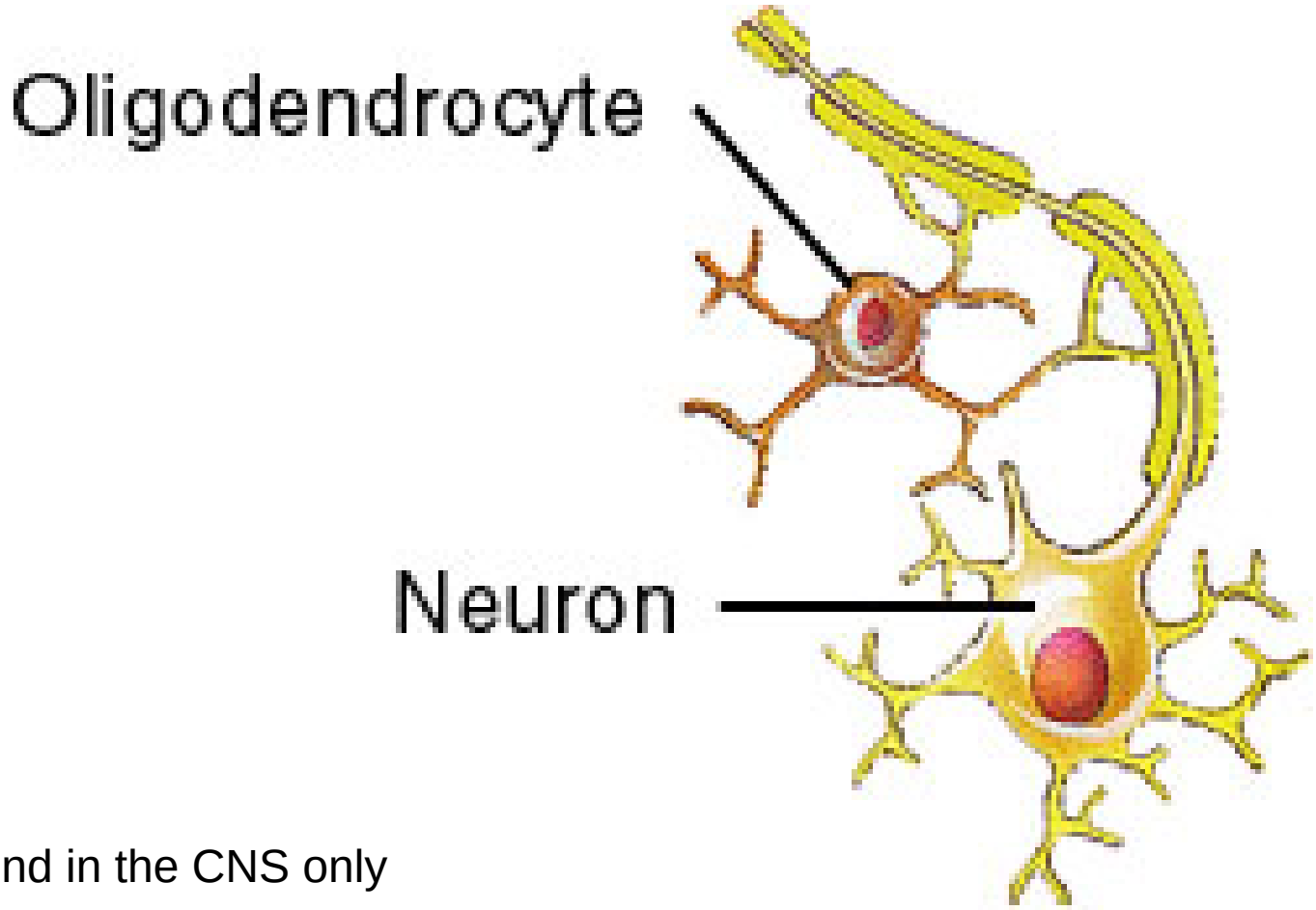
12.T01a



12.T01c



12.T01d



Found in the CNS only

12.T01b

- **Schwann cells** are found within the PNS.
  - Form a myelin sheath by insulating axons.

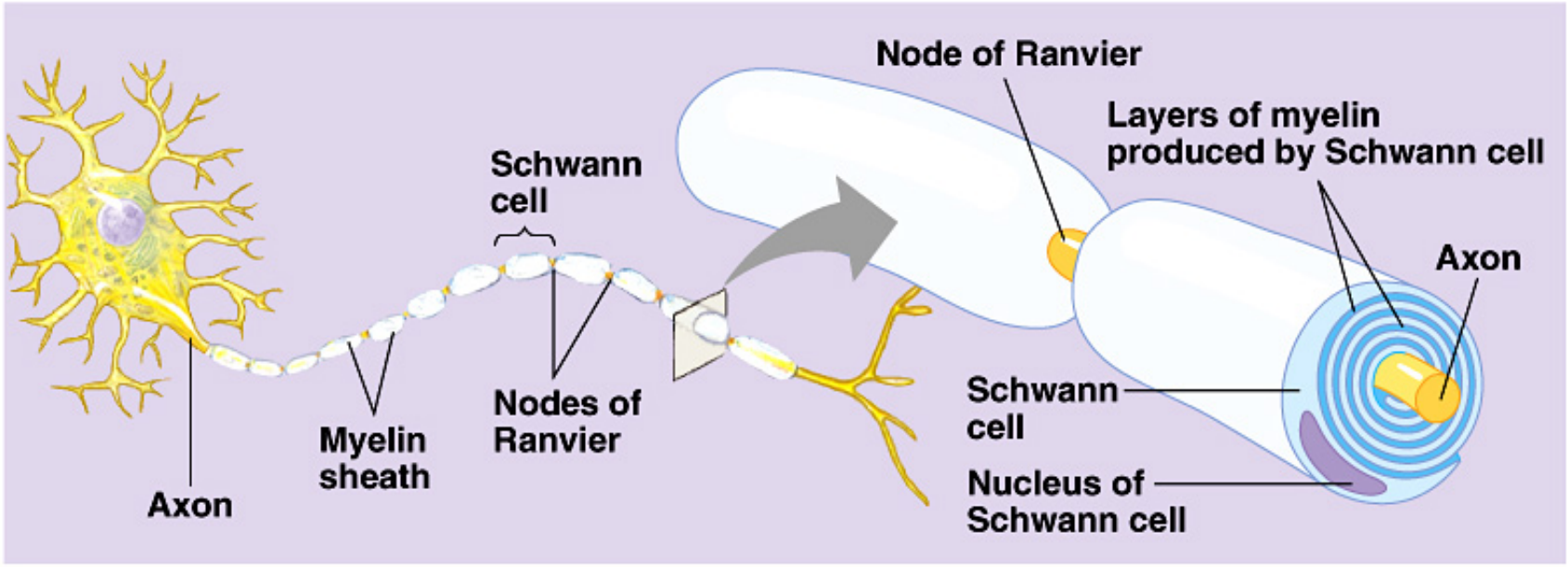
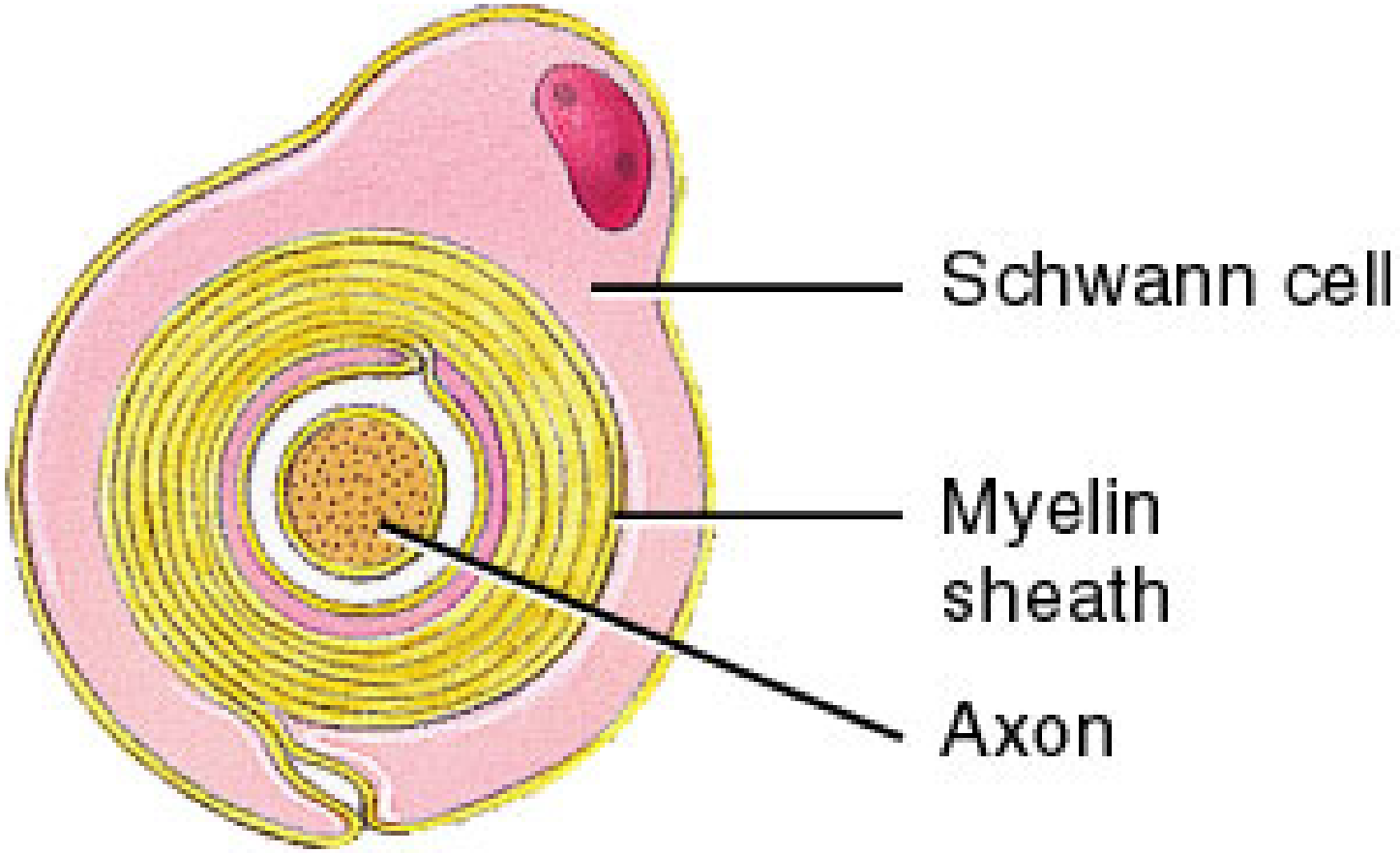
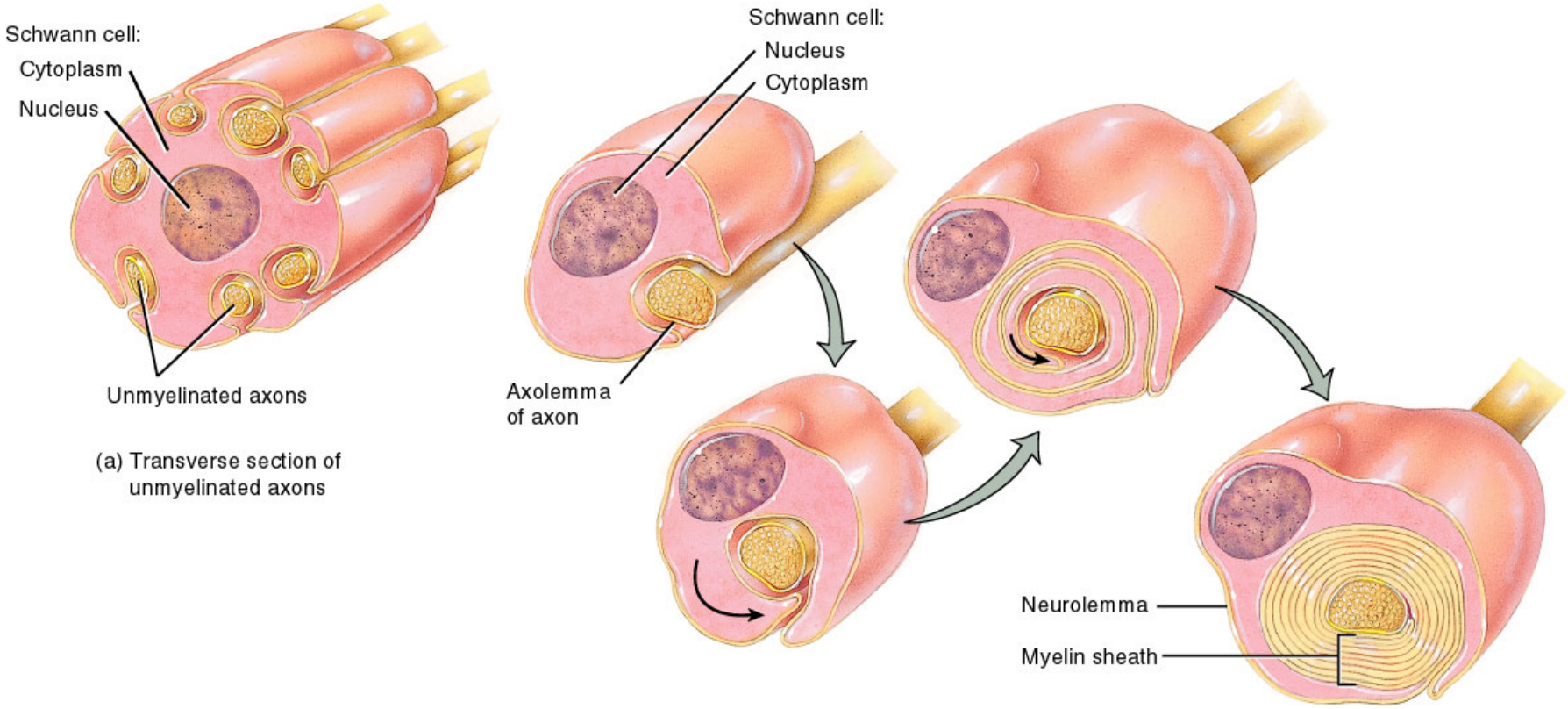


Fig. 48.5



Myelinated axon

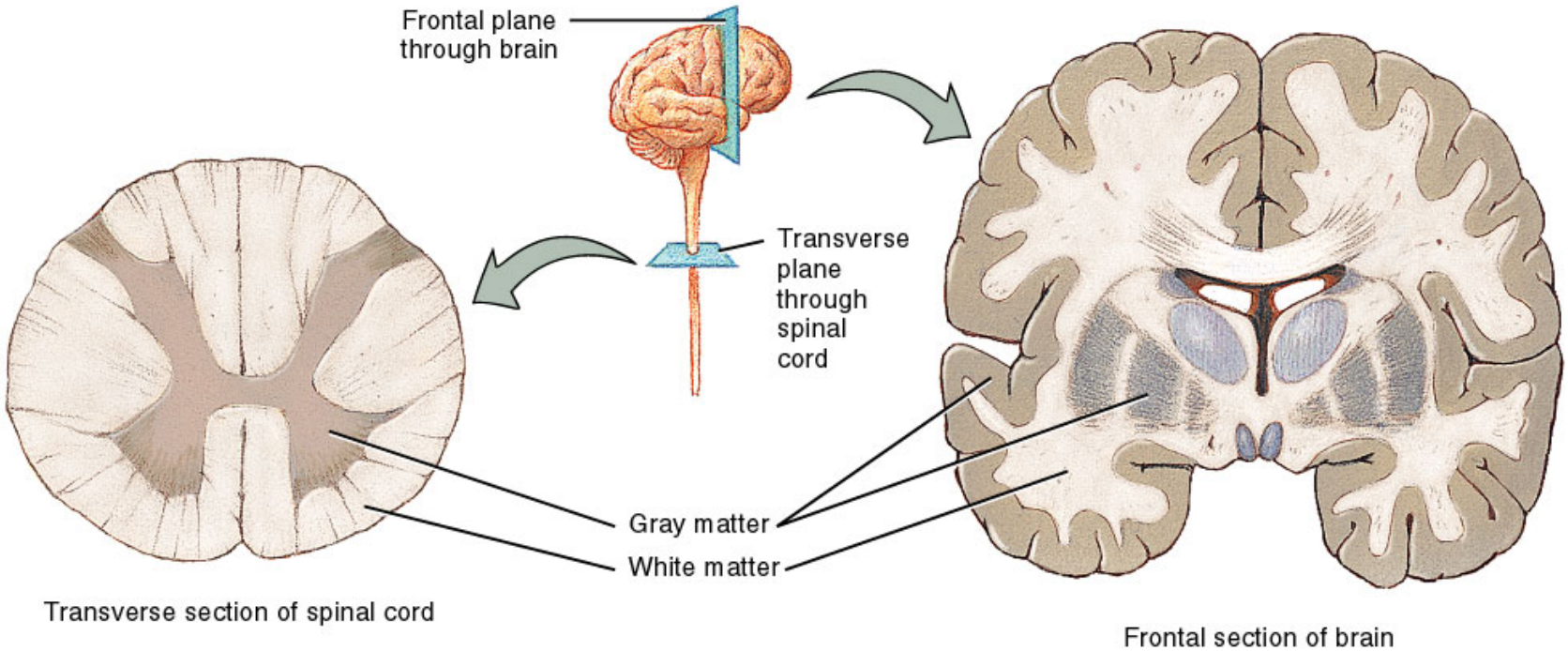
12.T01f



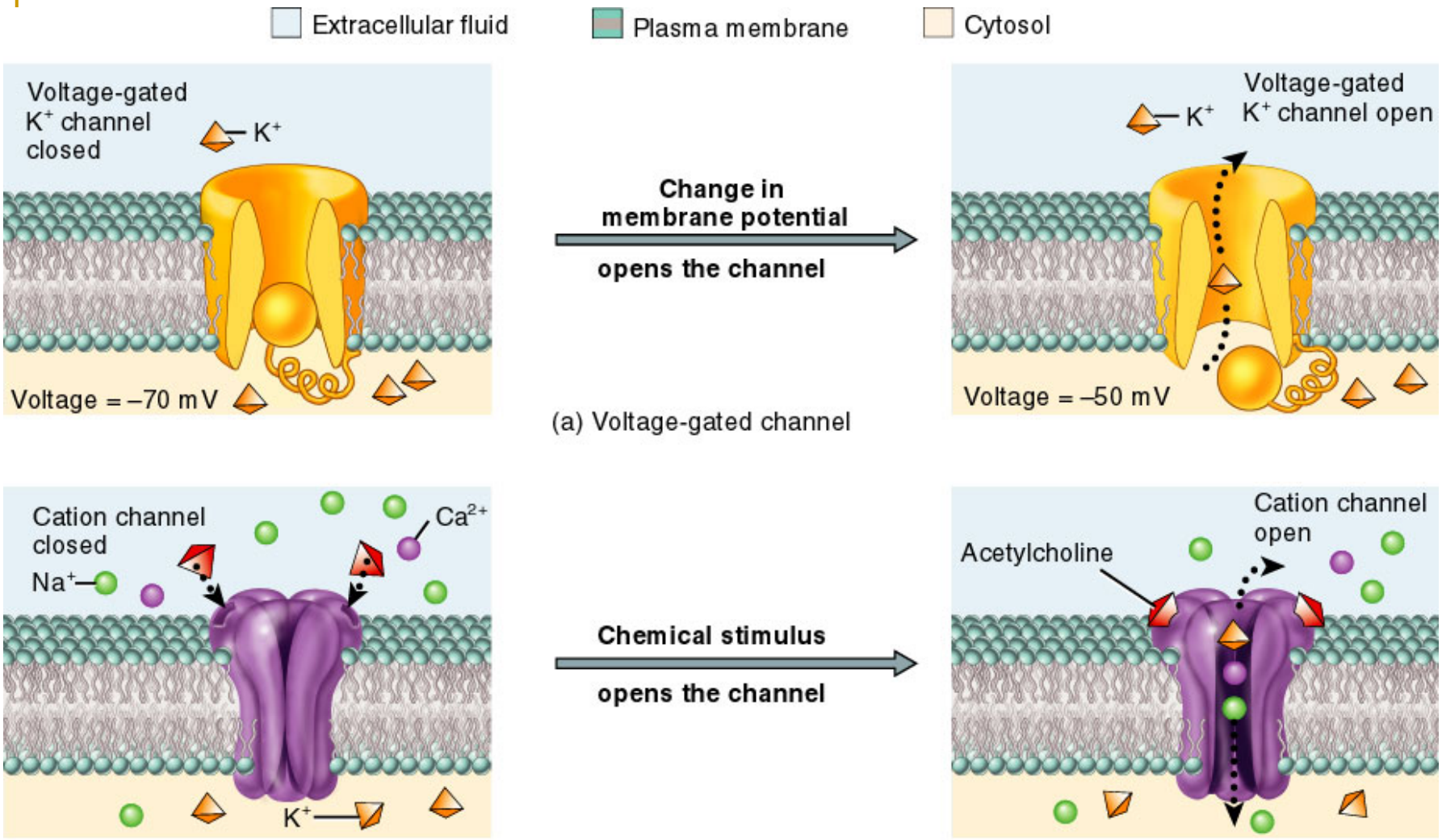
(a) Transverse section of unmyelinated axons

(b) Transverse sections of stages in the formation of a myelin sheath

12.06ab



12.07


Extracellular fluid
Plasma membrane
Cytosol
Voltage-gated
K+ channel
closed
K+
Voltage = –70 mV
Change in
membrane potential
opens the channel
Voltage-gated
K+ channel open
K+
Voltage = –50 mV
(a) Voltage-gated channel
Cation channel
closed
Ca2+
Na+
K+
Chemical stimulus
opens the channel
Cation channel
open
Acetylcholine
(b) Ligand-gated channel

12.08

Measuring Membrane Potentials.

- An unstimulated cell usually have a **resting potential** of -70mV.

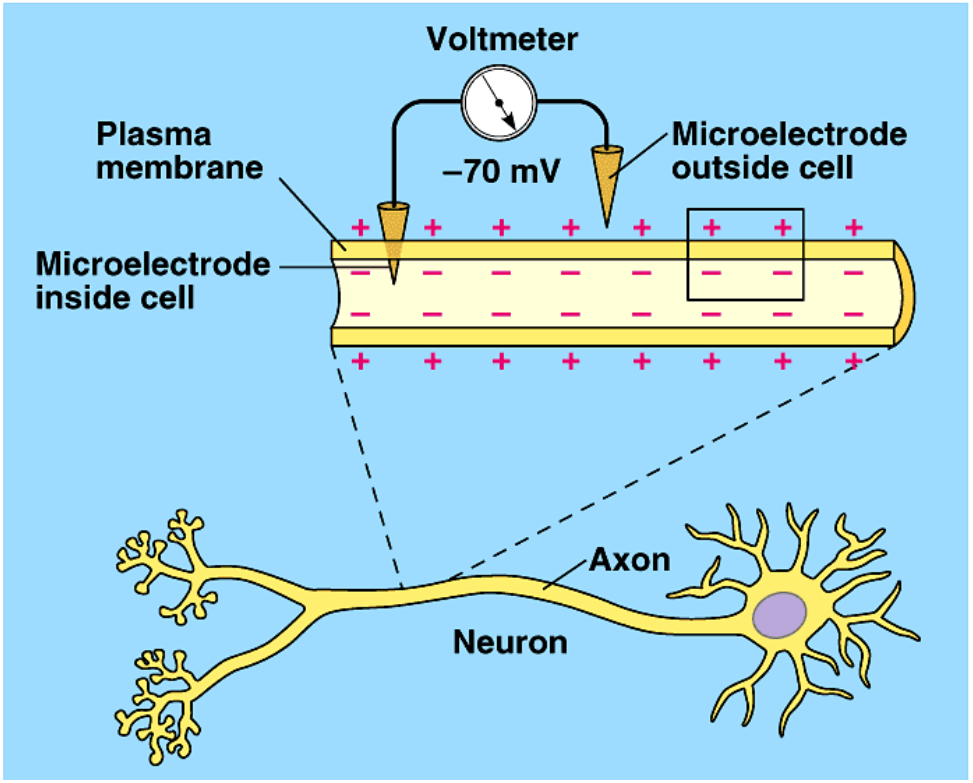
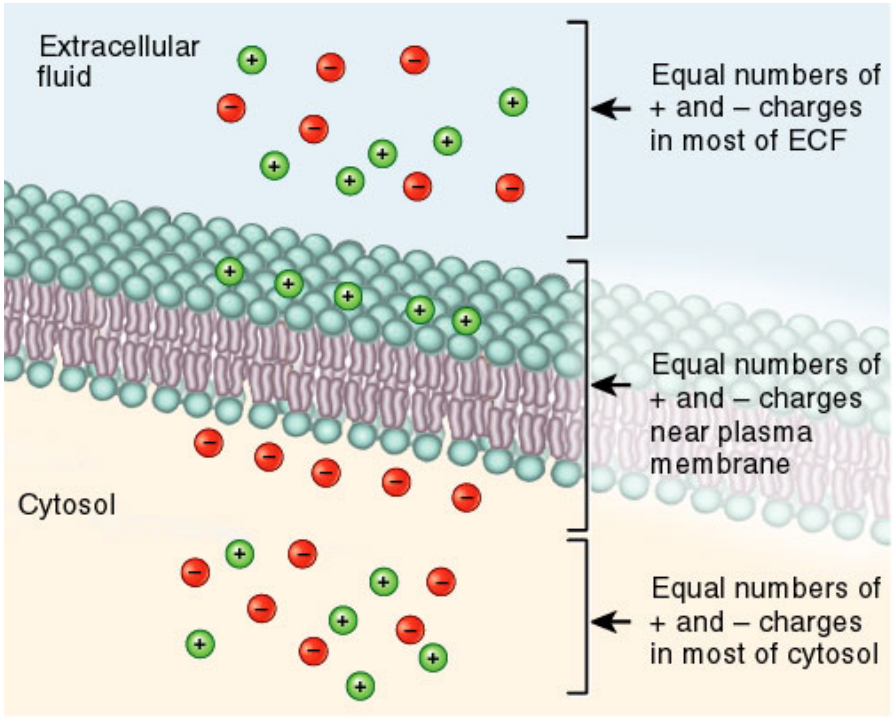
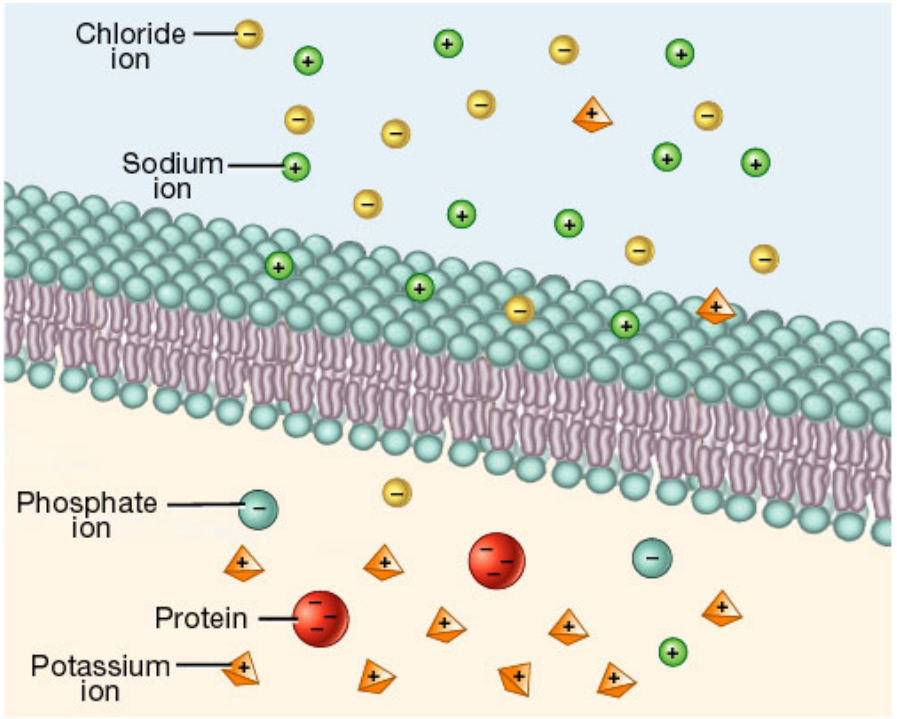


Fig. 48.6a

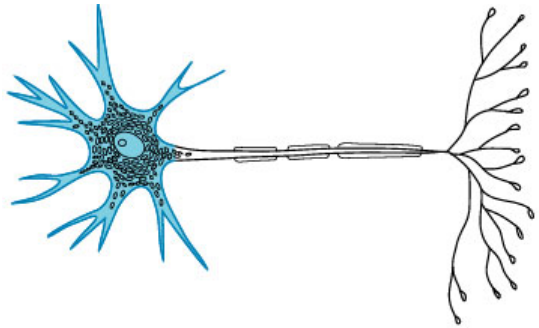


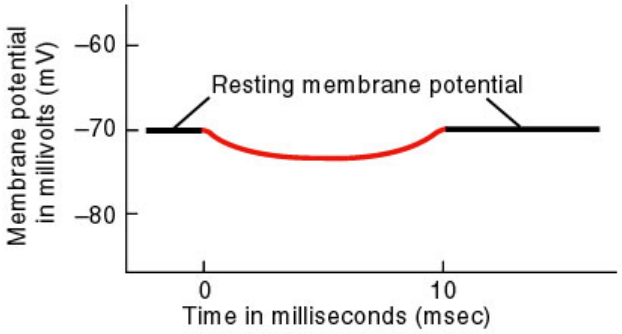
(a) Distribution of charges



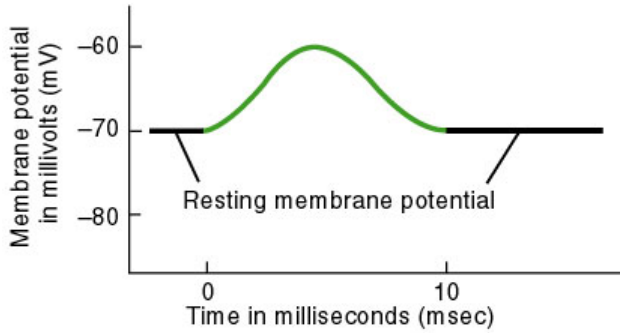
(b) Distribution of ions

12.09ab

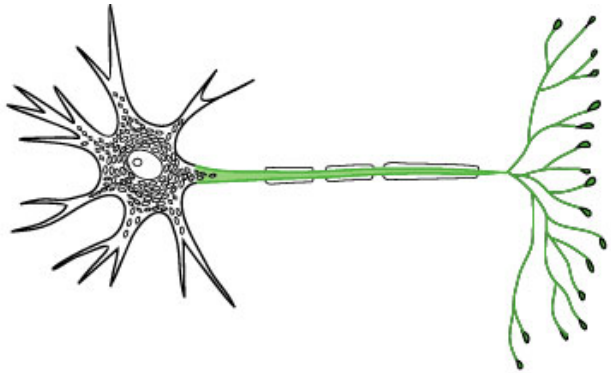


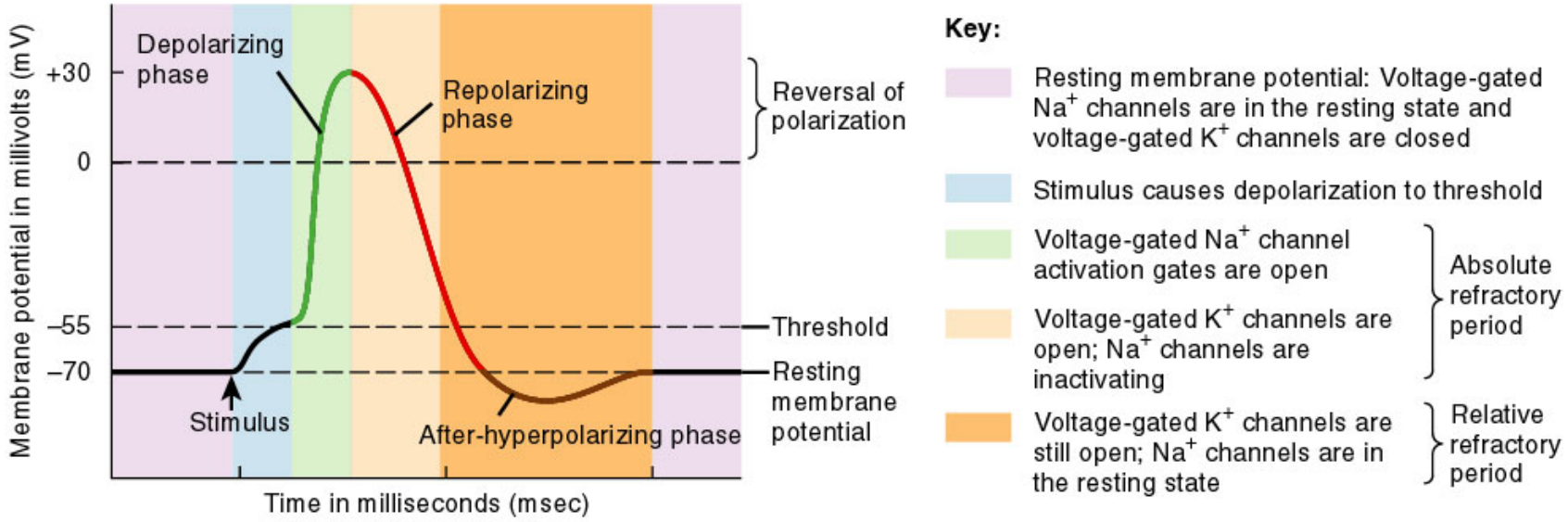


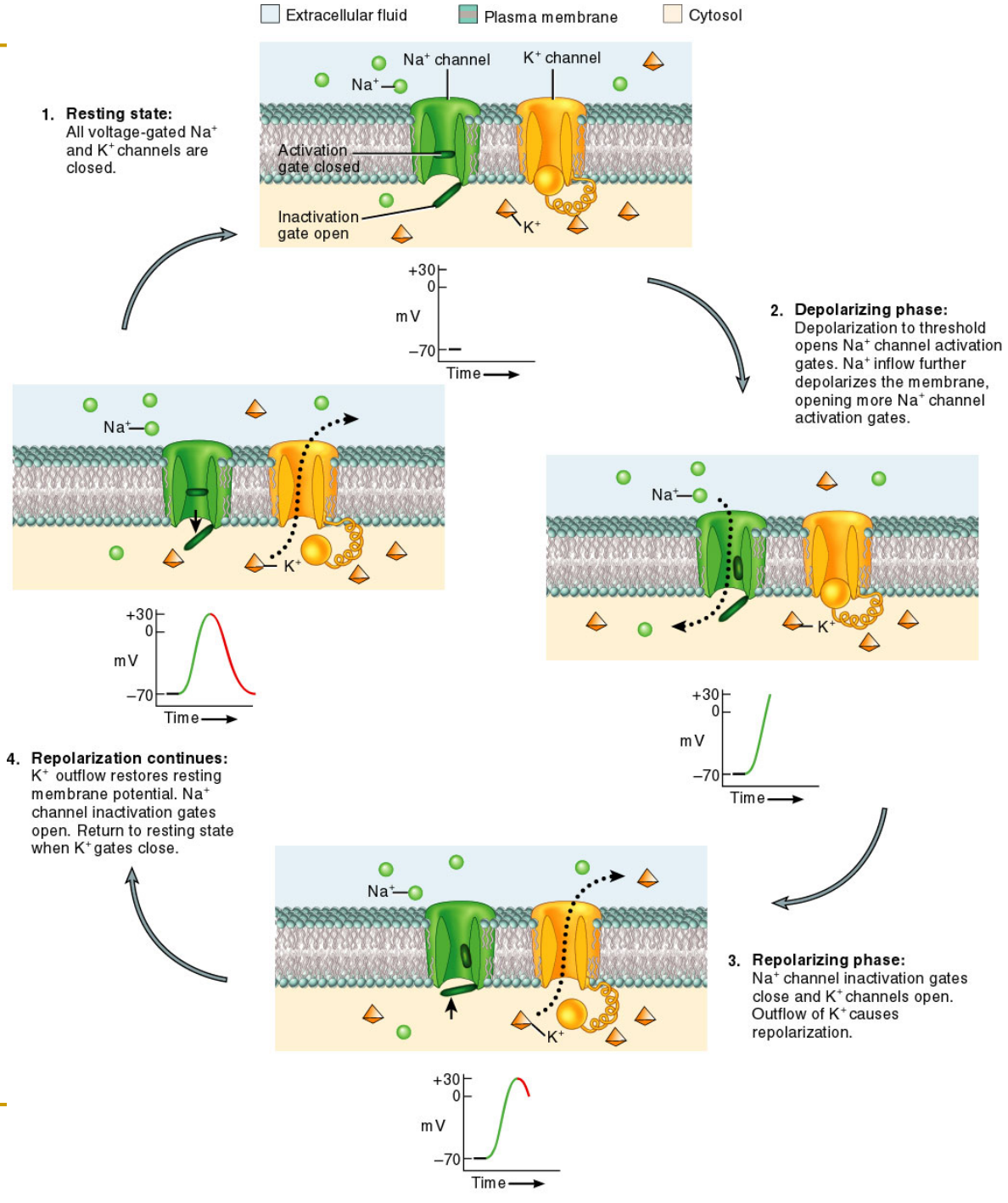
(a) Hyperpolarizing graded potential



(b) Depolarizing graded potential

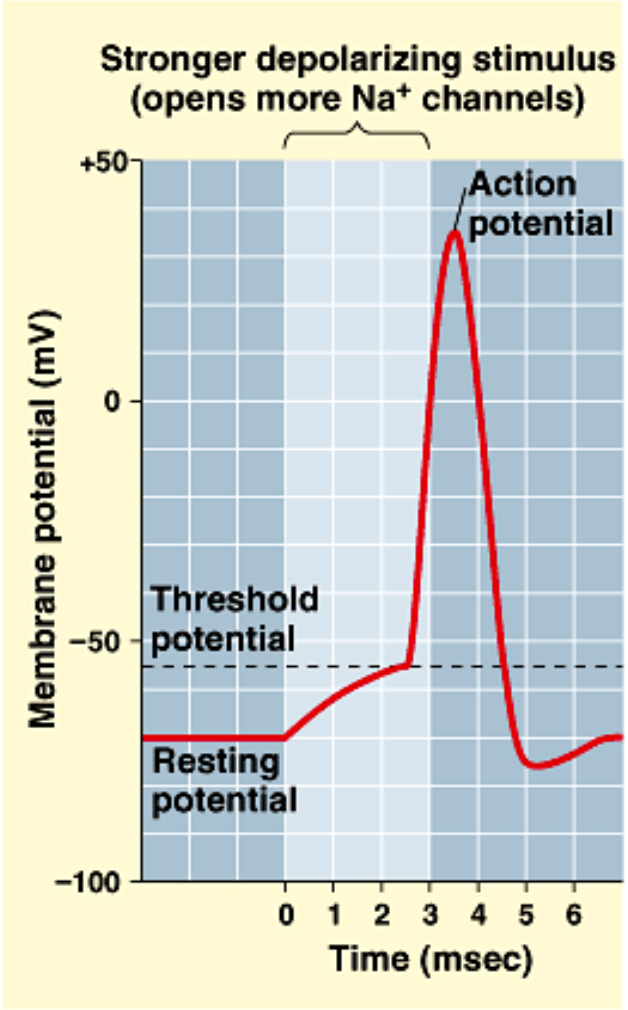



Membrane potential in millivolts (mV)
+30
0
–55
–70
Depolarizing phase
Repolarizing phase
Reversal of polarization
Threshold
Resting membrane potential
Stimulus
After-hyperpolarizing phase
Time in milliseconds (msec)
Key:
Resting membrane potential: Voltage-gated Na+ channels are in the resting state and voltage-gated K+ channels are closed
Stimulus causes depolarization to threshold
Voltage-gated Na+ channel activation gates are open
Voltage-gated K+ channels are open; Na+ channels are inactivating
Absolute refractory period
Voltage-gated K+ channels are still open; Na+ channels are in the resting state
Relative refractory period


Extracellular fluid
Plasma membrane
Cytosol
Na+ channel
K+ channel
Na+
Activation gate closed
Inactivation gate open
K+
+30
0
mV
–70
Time
1. Resting state: All voltage-gated Na+ and K+ channels are closed.
2. Depolarizing phase: Depolarization to threshold opens Na+ channel activation gates. Na+ inflow further depolarizes the membrane, opening more Na+ channel activation gates.
3. Repolarizing phase: Na+ channel inactivation gates close and K+ channels open. Outflow of K+ causes repolarization.
4. Repolarization continues: K+ outflow restores resting membrane potential. Na+ channel inactivation gates open. Return to resting state when K+ gates close.

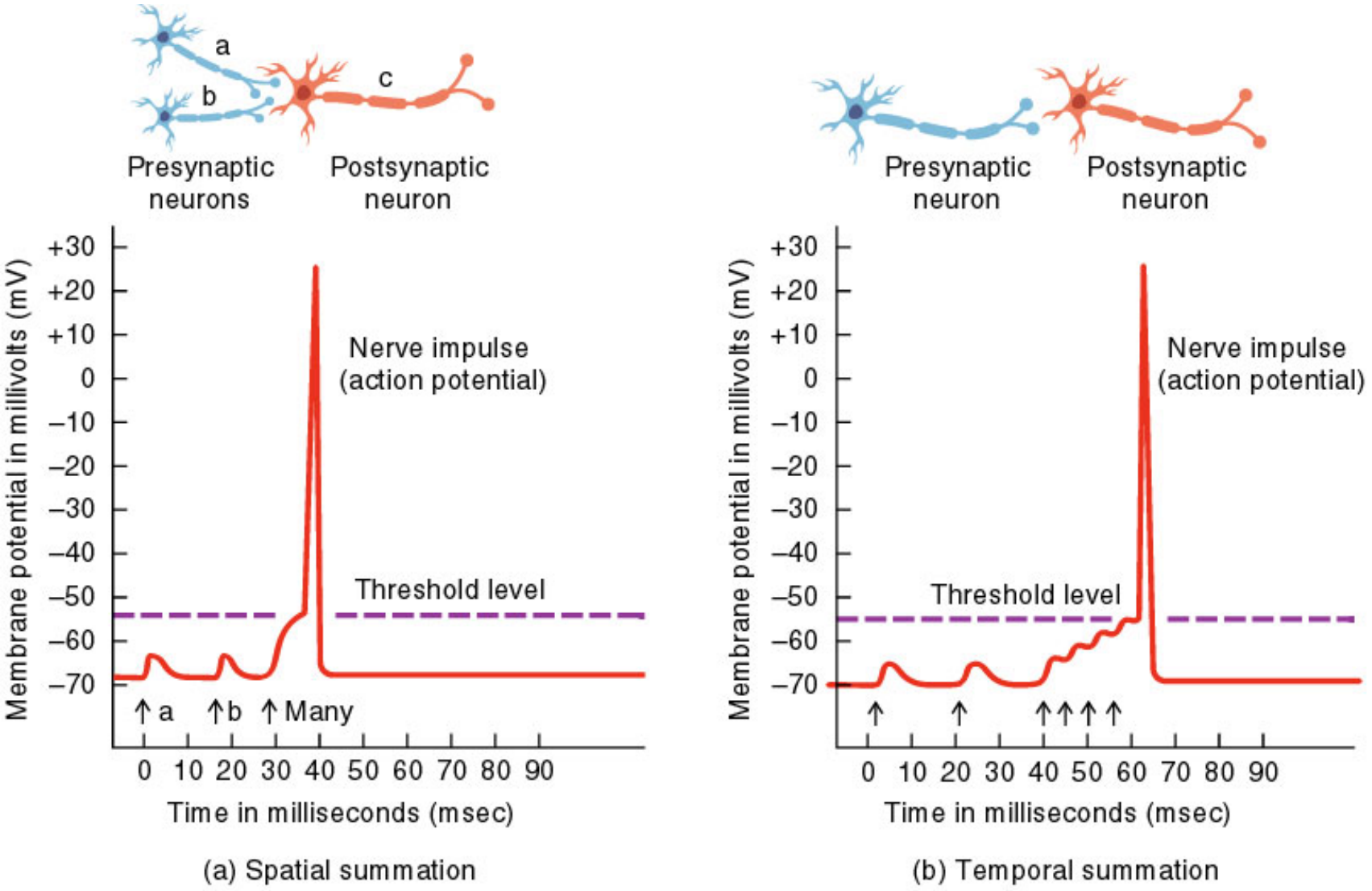
12.12

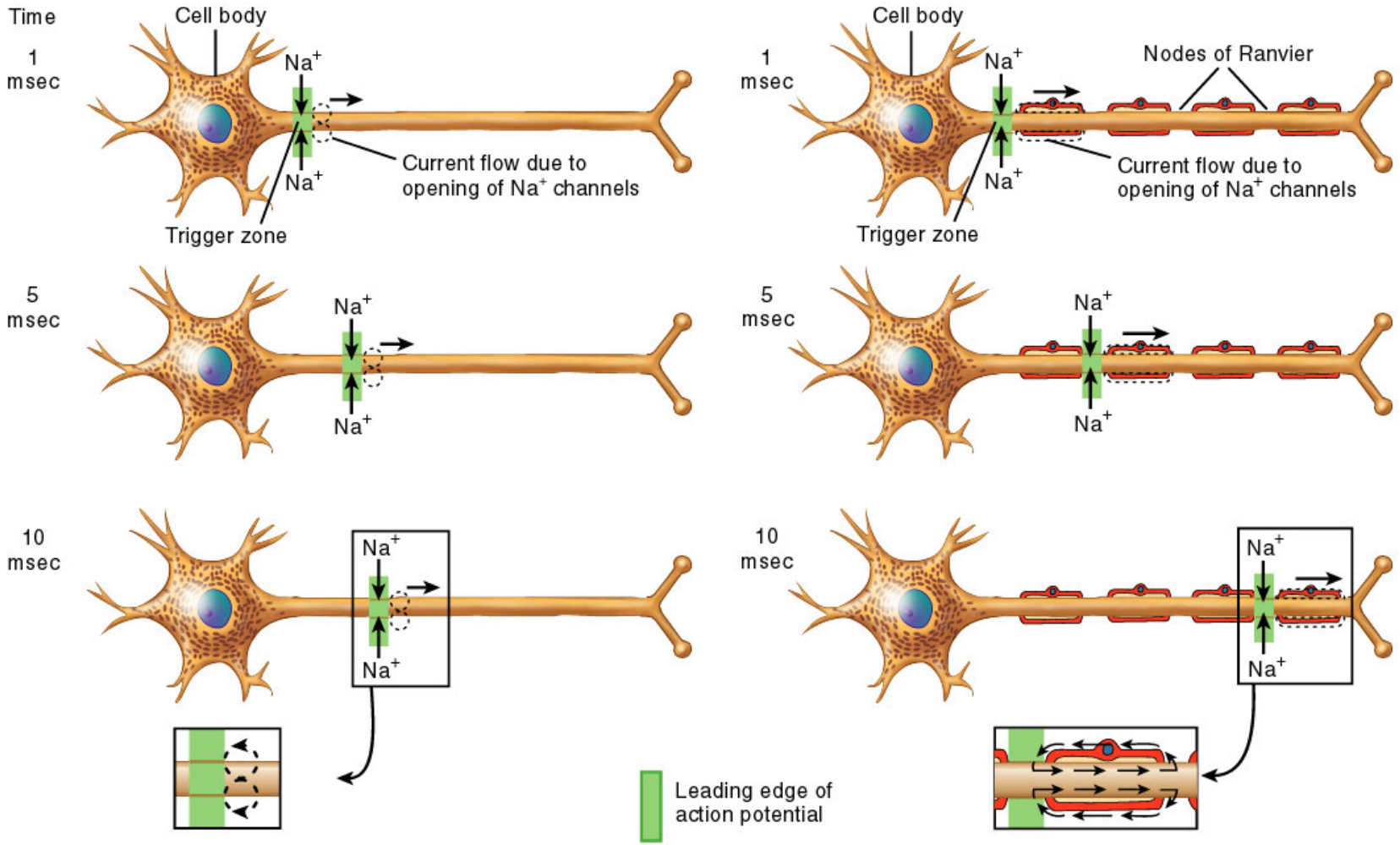
- The Action Potential: All or Nothing Depolarization.
  - If graded potentials sum to ≈-55mV a **threshold potential** is achieved.
    - This triggers an **action potential**.
      - Axons only.

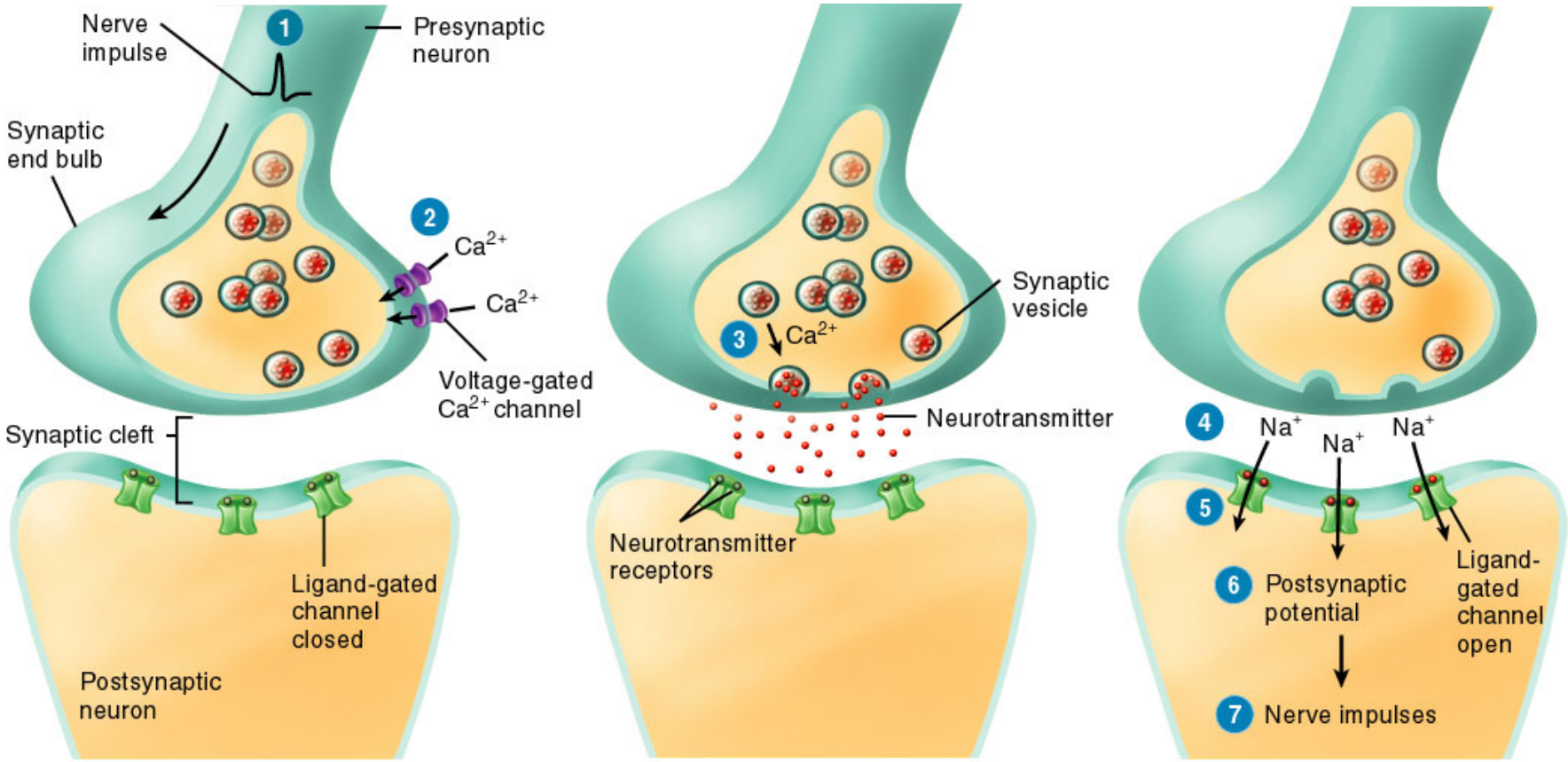


(c) Action potential

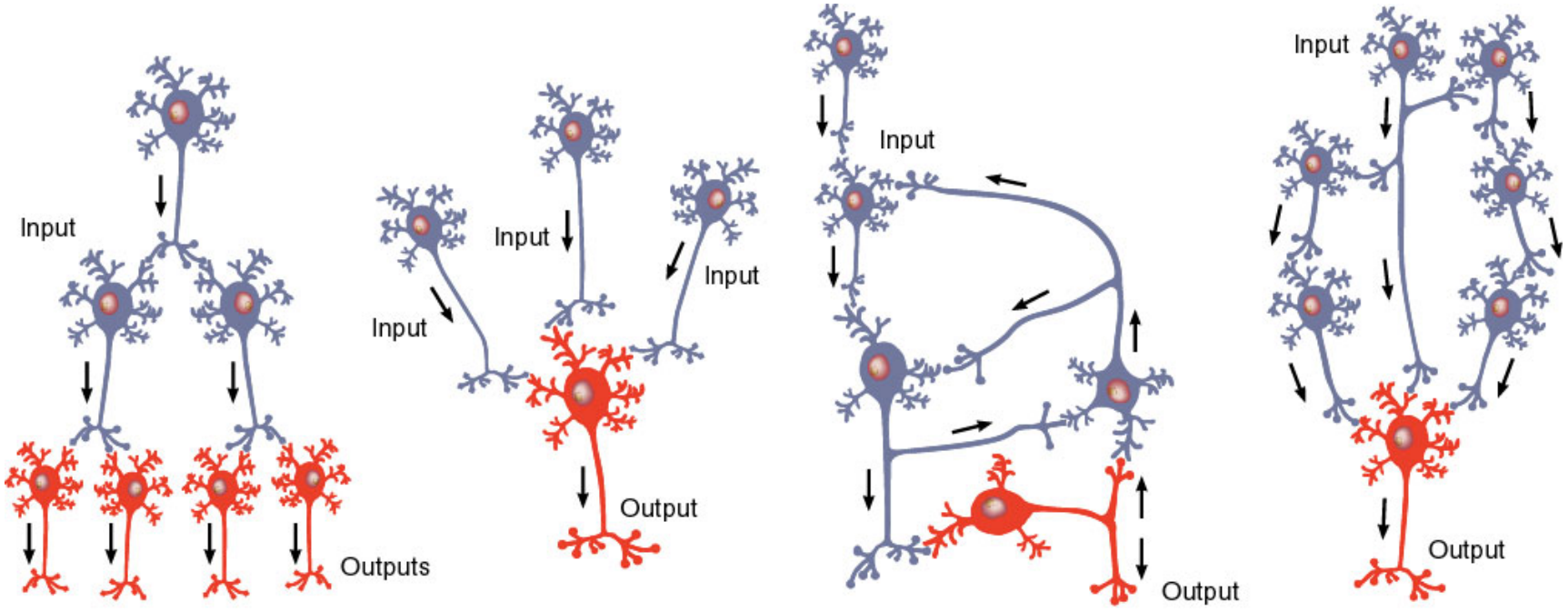
Fig. 48.8c


a
b
c
Presynaptic neurons
Postsynaptic neuron
Membrane potential in millivolts (mV)
+30
+20
+10
0
–10
–20
–30
–40
–50
–60
–70
Nerve impulse (action potential)
Threshold level
↑a ↑b ↑Many
0 10 20 30 40 50 60 70 80 90
Time in milliseconds (msec)
(a) Spatial summation
Presynaptic neuron
Postsynaptic neuron
Membrane potential in millivolts (mV)
Nerve impulse (action potential)
Threshold level
↑ ↑ ↑↑↑↑
0 10 20 30 40 50 60 70 80 90
Time in milliseconds (msec)
(b) Temporal summation


Time
1 msec
Cell body
Na+
Na+
Current flow due to opening of Na+ channels
Trigger zone
5 msec
Na+
Na+
10 msec
Na+
Na+
Leading edge of action potential
(a) Continuous conduction
Cell body
Nodes of Ranvier
Na+
Na+
Current flow due to opening of Na+ channels
Trigger zone
(b) Saltatory conduction



12.14



(a) Diverging circuit (b) Converging circuit (c) Reverberating circuit (d) Parallel after-discharge circuit

12.16

Saltatory conduction.

- In myelinated neurons only unmyelinated regions of the axon depolarize.
  - Thus, the impulse moves faster than in unmyelinated neurons.

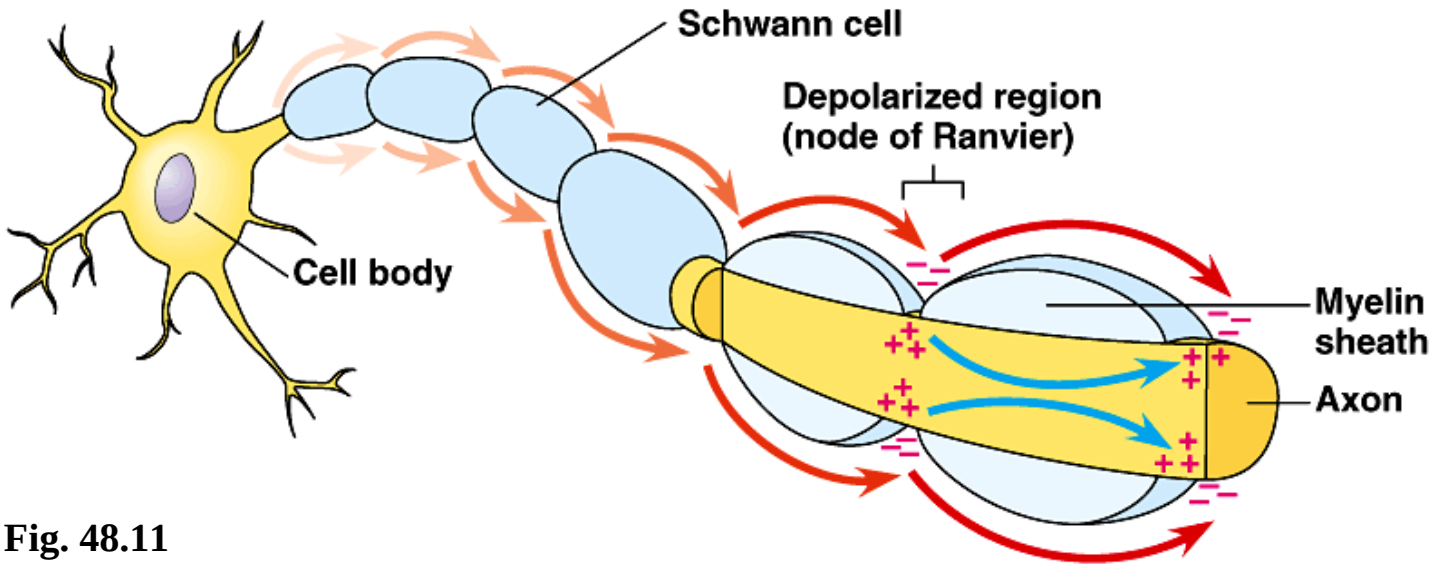
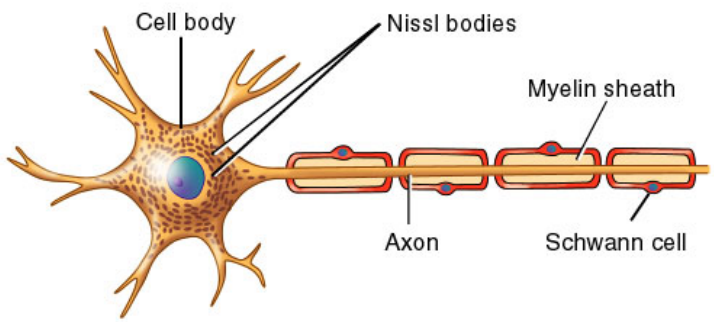
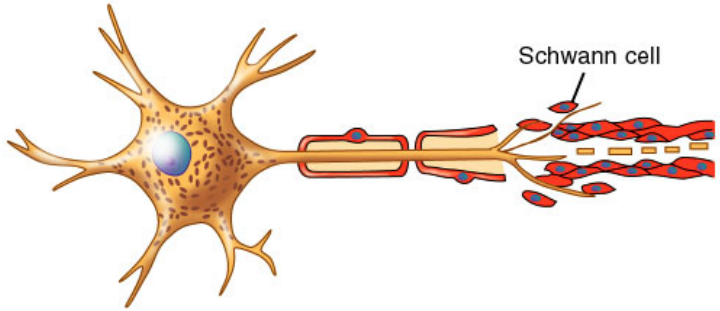


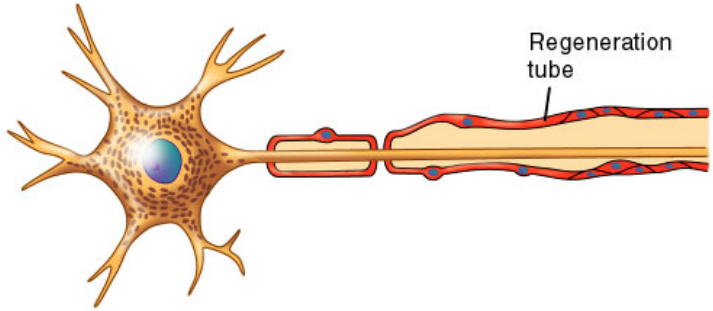
Fig. 48.11



(a) Normal neuron



(b) Chromatolysis and
Wallerian degeneration



(c) Regeneration

Words to Know

- Wallerian degeneration
- Multiple sclerosis
- Epilepsy
- Neuropathy
- Guillain-Barre Syndrome
- Rabies

- **Summation**: graded potentials (EPSPs and IPSPs) are summed to either depolarize or hyperpolarize a postsynaptic neuron.

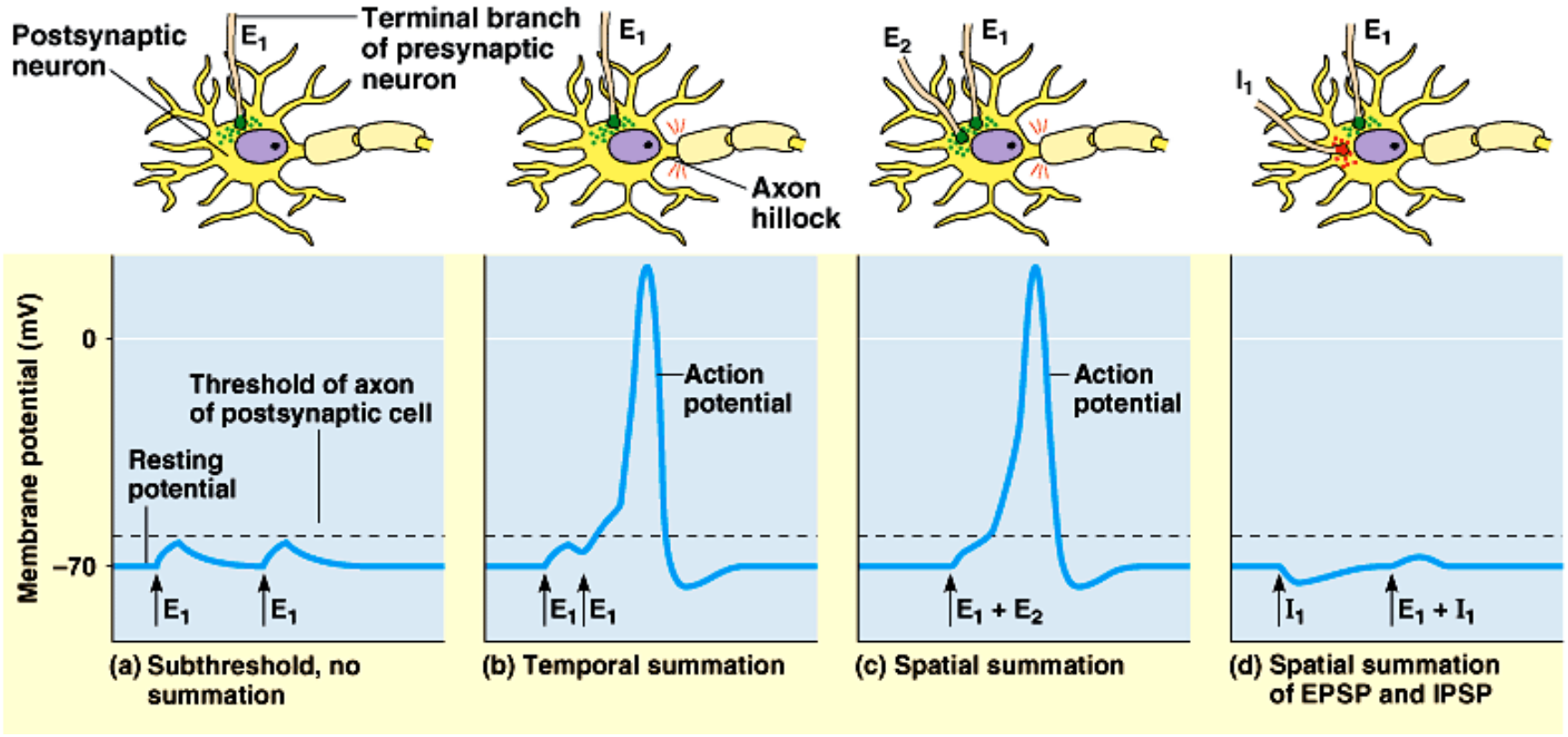


Fig. 48.14

produce different effects on different types of cells

- **Acetylcholine.**
  - Excitatory to skeletal muscle.
  - Inhibitory to cardiac muscle.
  - Secreted by the CNS, PNS, and at vertebrate neuromuscular junctions.

- **Biogenic Amines**.
  - **Epinephrine** and **norepinephrine**.
    - Can have excitatory or inhibitory effects.
    - Secreted by the CNS and PNS.
    - Secreted by the adrenal glands.

- **Dopamine**
  - Generally excitatory; may be inhibitory at some sites.
    - Widespread in the brain.
    - Affects sleep, mood, attention, and learning.
  - Secreted by the CNS and PNS.
  - A lack of dopamine in the brain is associated with Parkinson's disease.
  - Excessive dopamine is linked to schizophrenia.

- **Serotonin**.
  - Generally inhibitory.
    - Widespread in the brain.
    - Affects sleep, mood, attention, and learning
  - Secreted by the CNS.