Nervous System

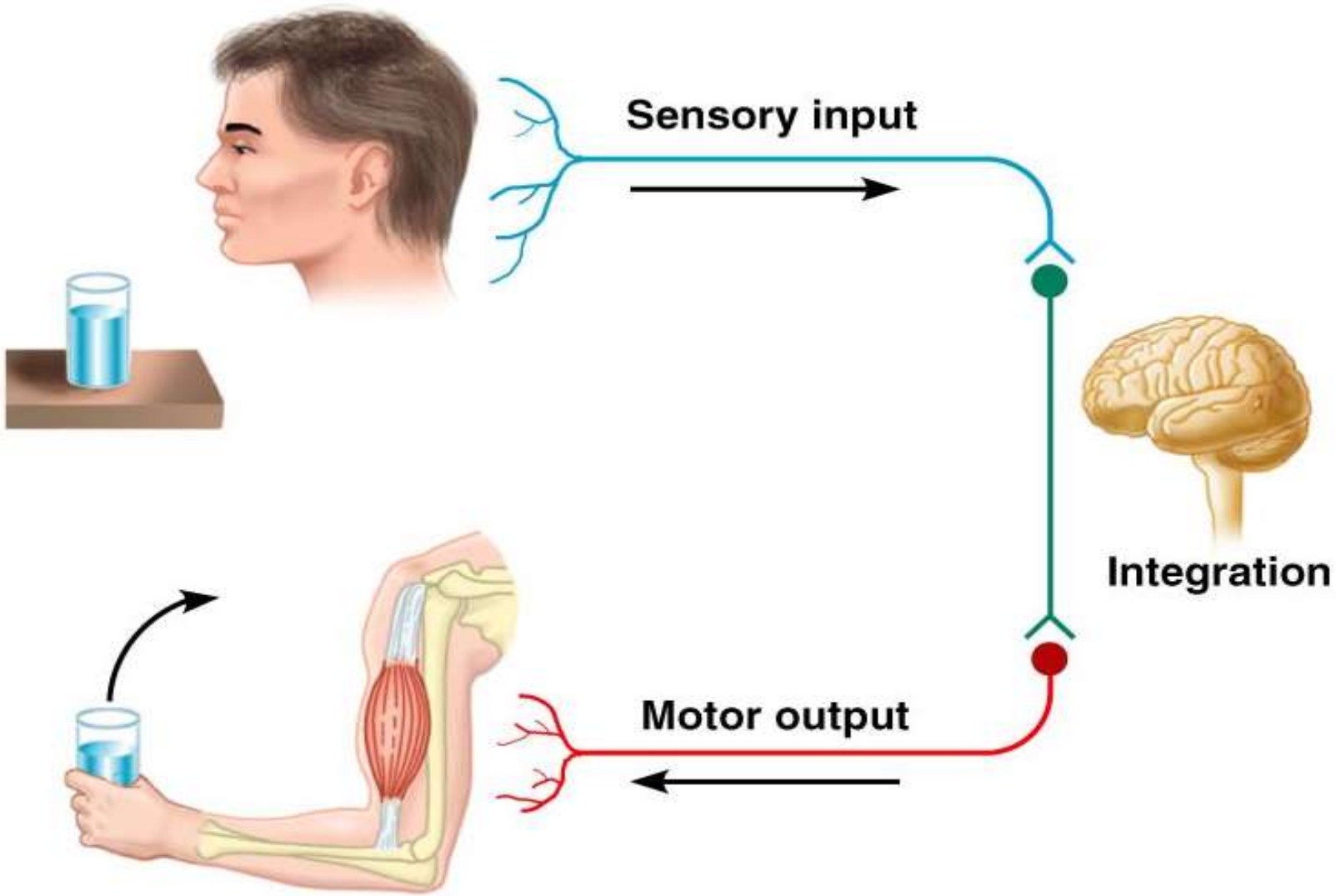
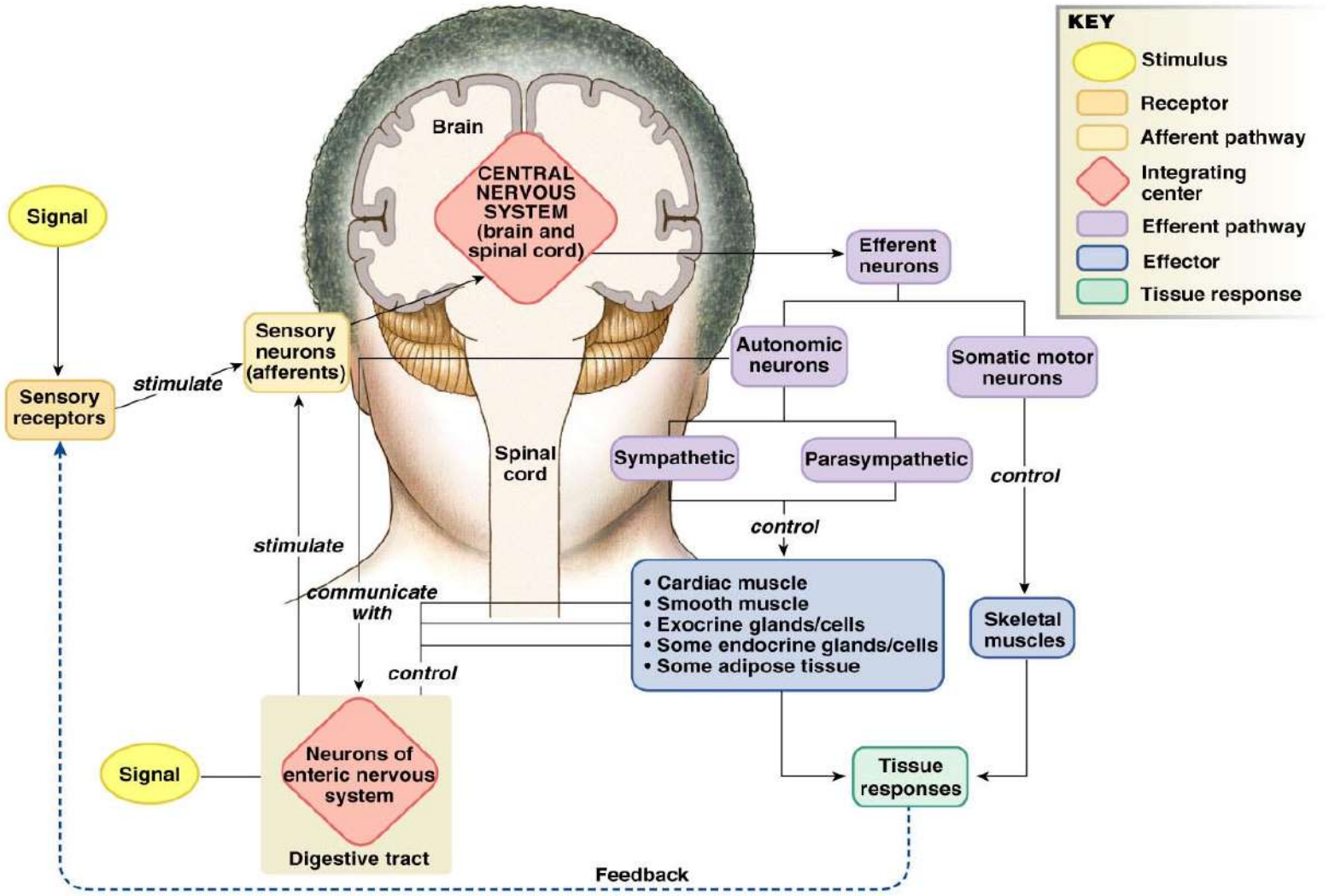
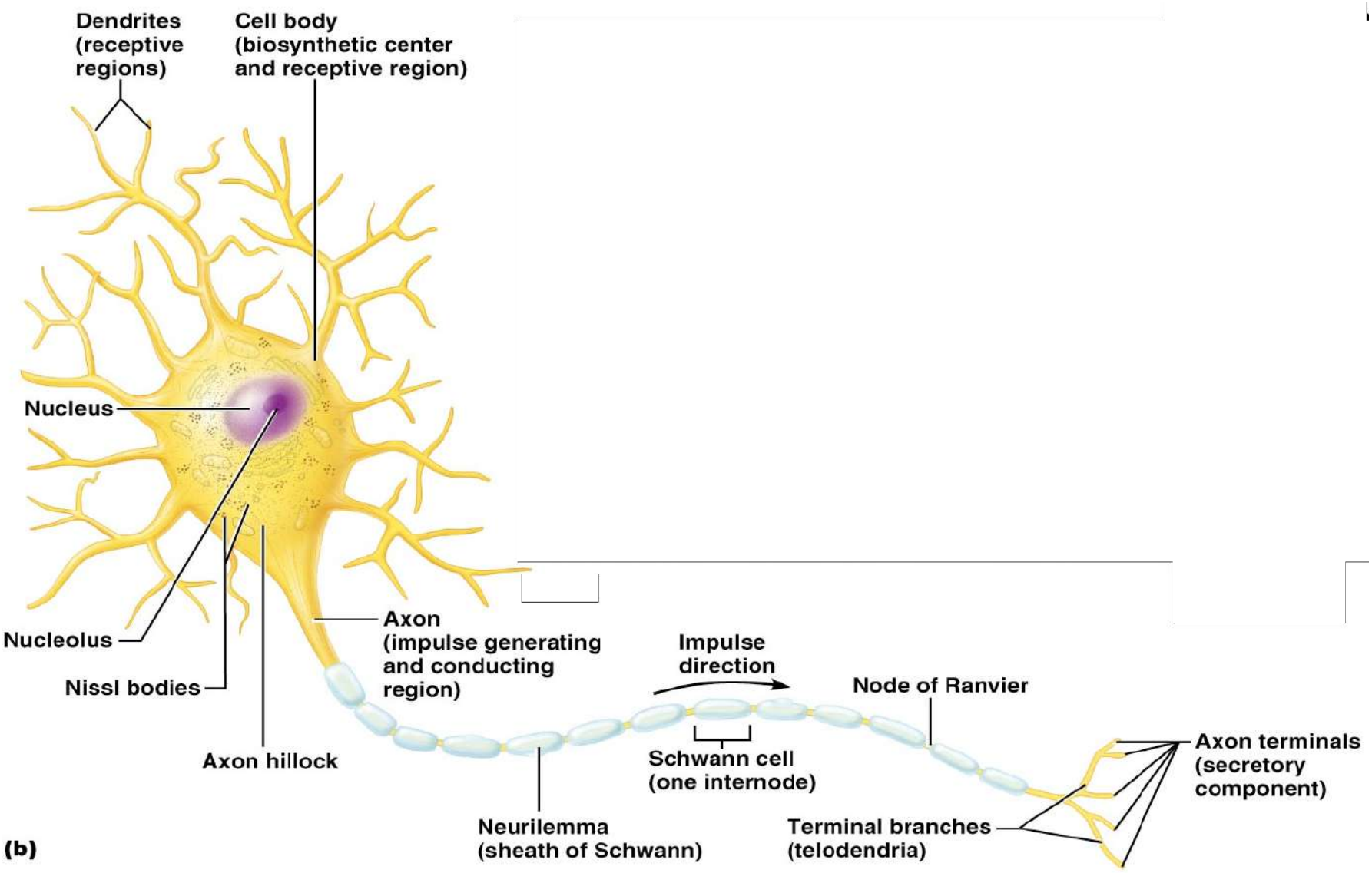


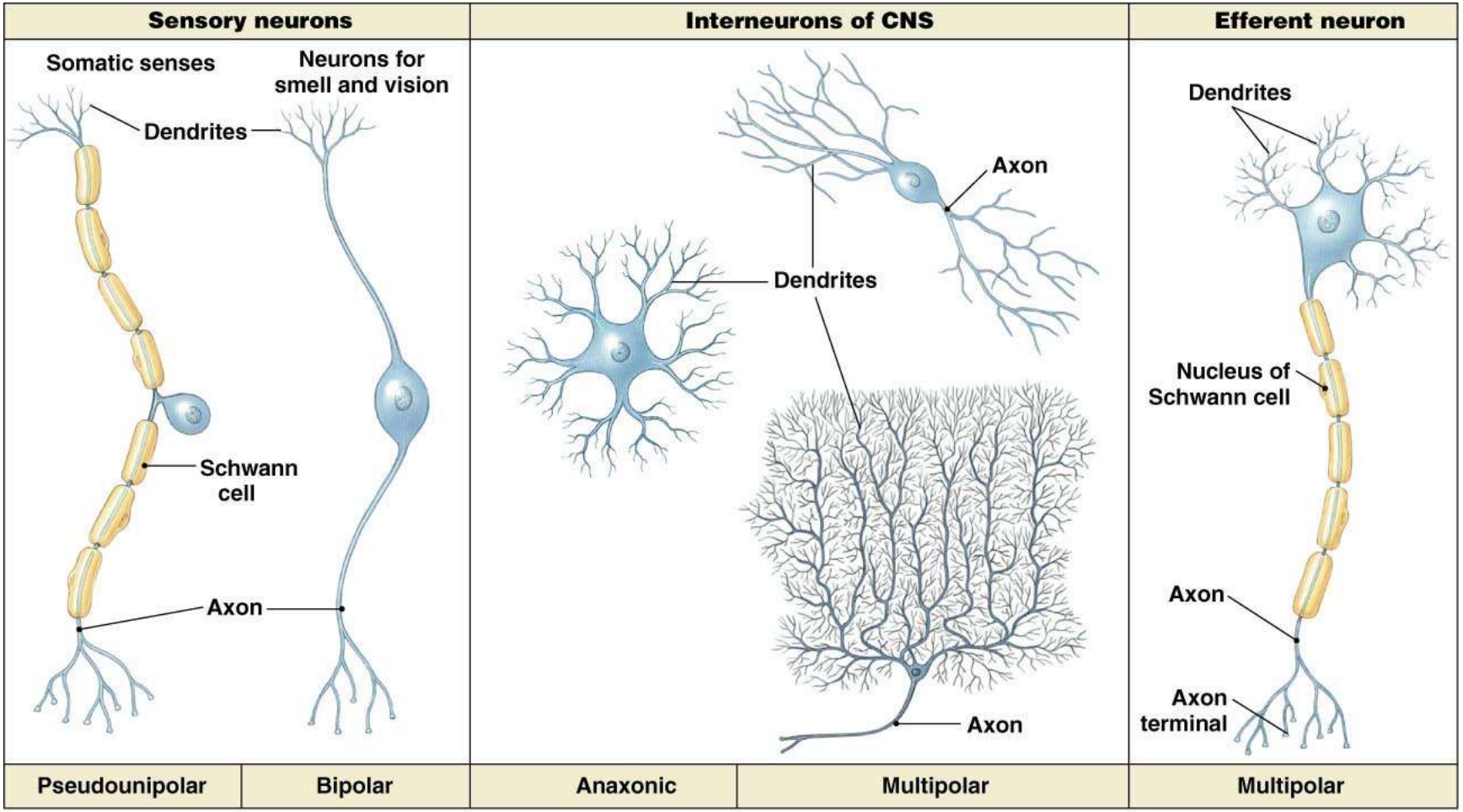
Figure 11.1

Nervous System



Neurons (Nerve Cells)





(a) Pseudounipolar neurons have a single process called the axon. During development, the dendrite fused with the axon.

(b) Bipolar neurons have two relatively equal fibers extending off the central cell body.

(c) Anaxonic CNS interneurons have no apparent axon.

(d) Multipolar CNS interneurons are highly branched but lack long extensions.

(e) A typical multipolar efferent neuron has five to seven dendrites, each branching four to six times. A single long axon may branch several times and end at enlarged axon terminals.

Figure 8-3 - Overview

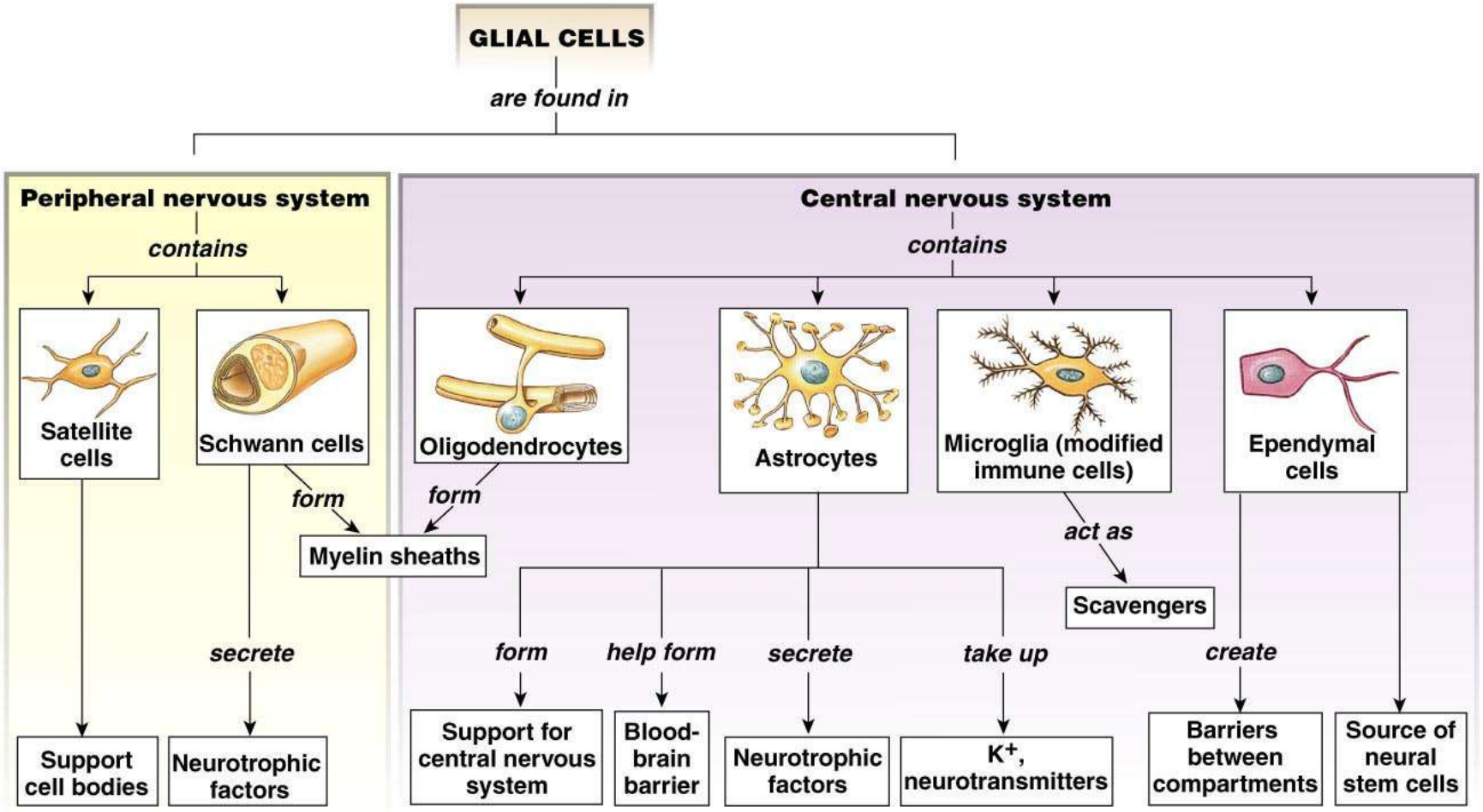


Figure 8-5 – Overview (1 of 3)

(a) Glial cells of the central nervous system

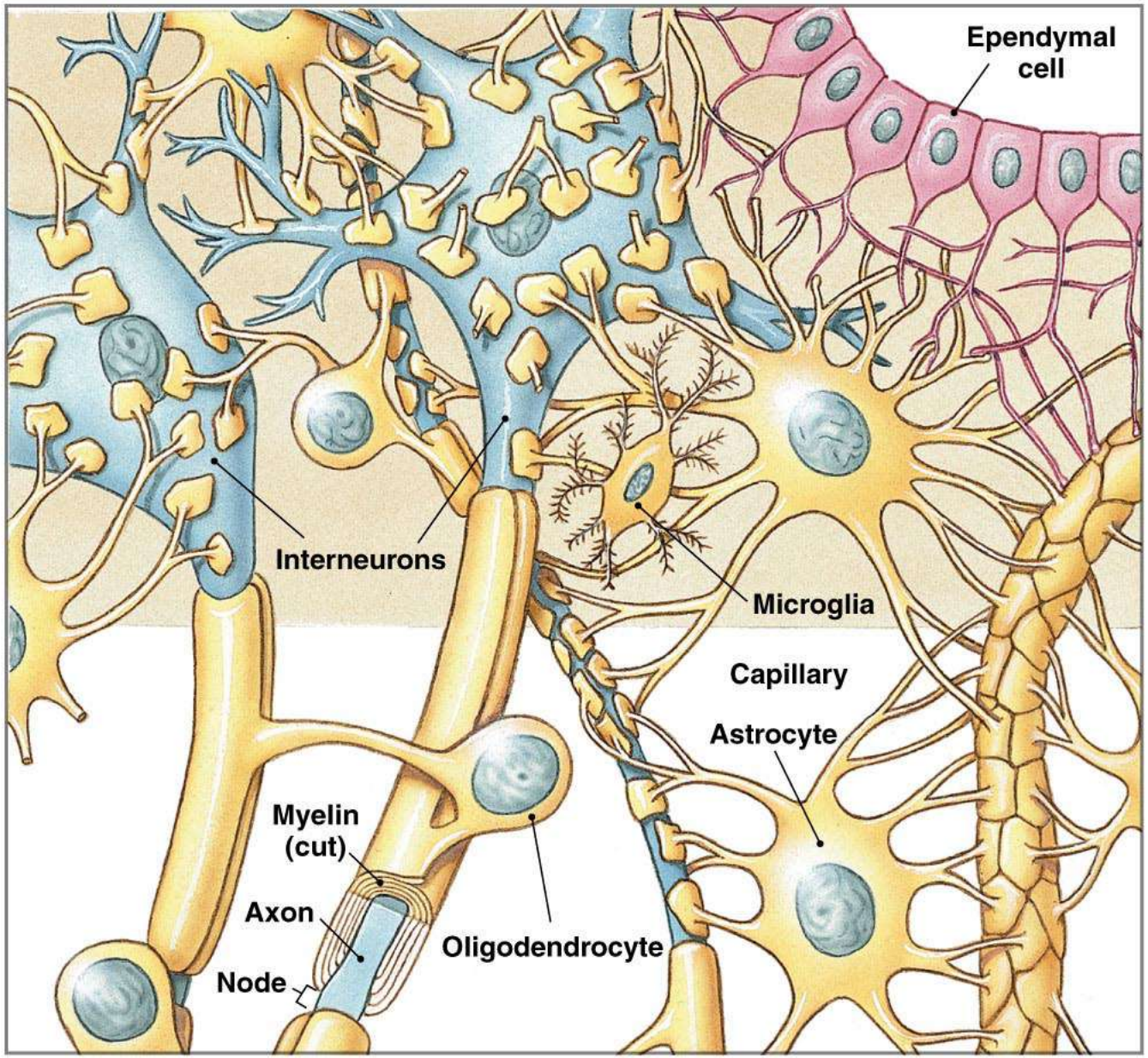


Figure 8-6a

Membrane Potential

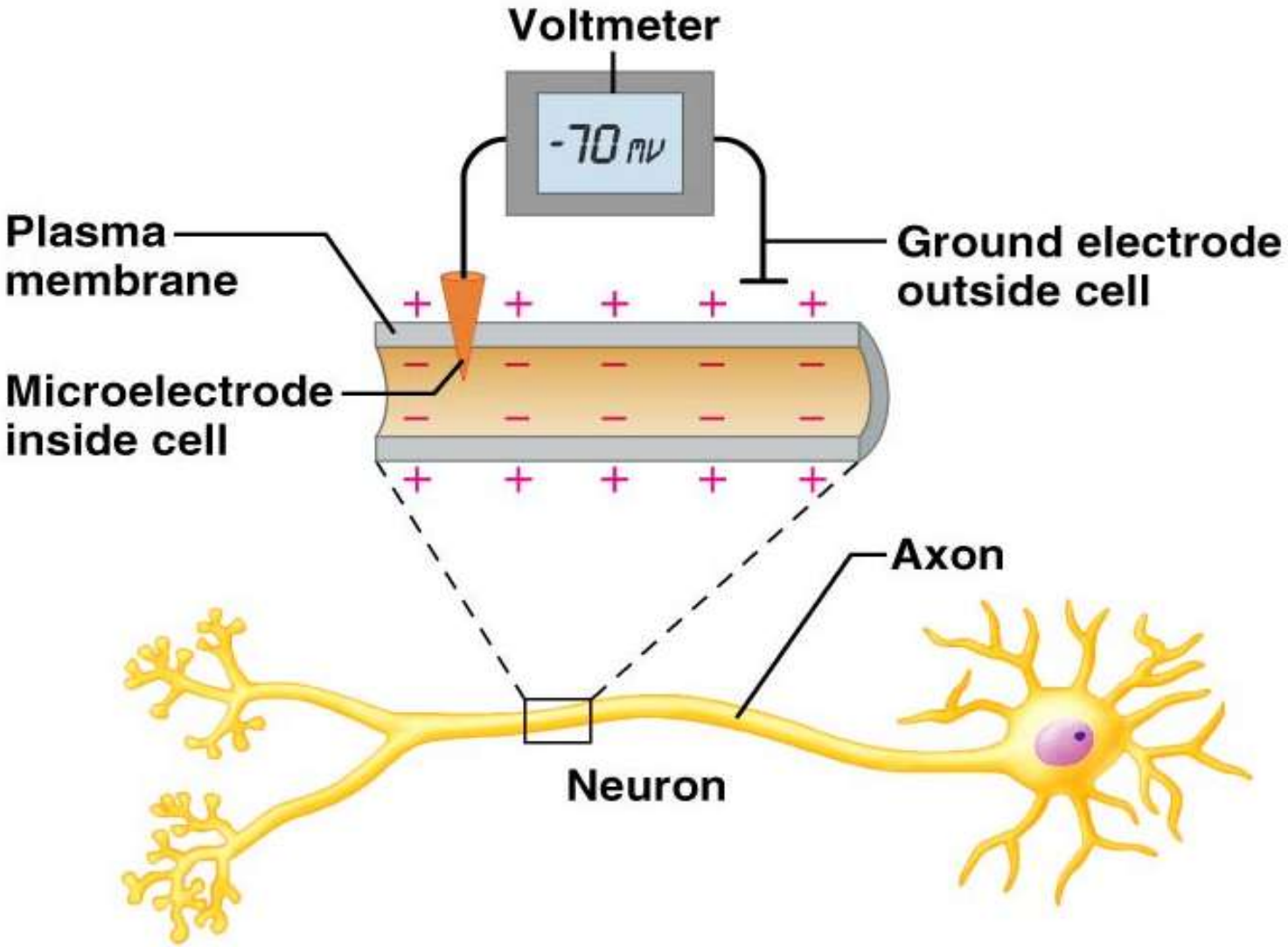


Figure 11.7

Resting Membrane Potential (V_r)

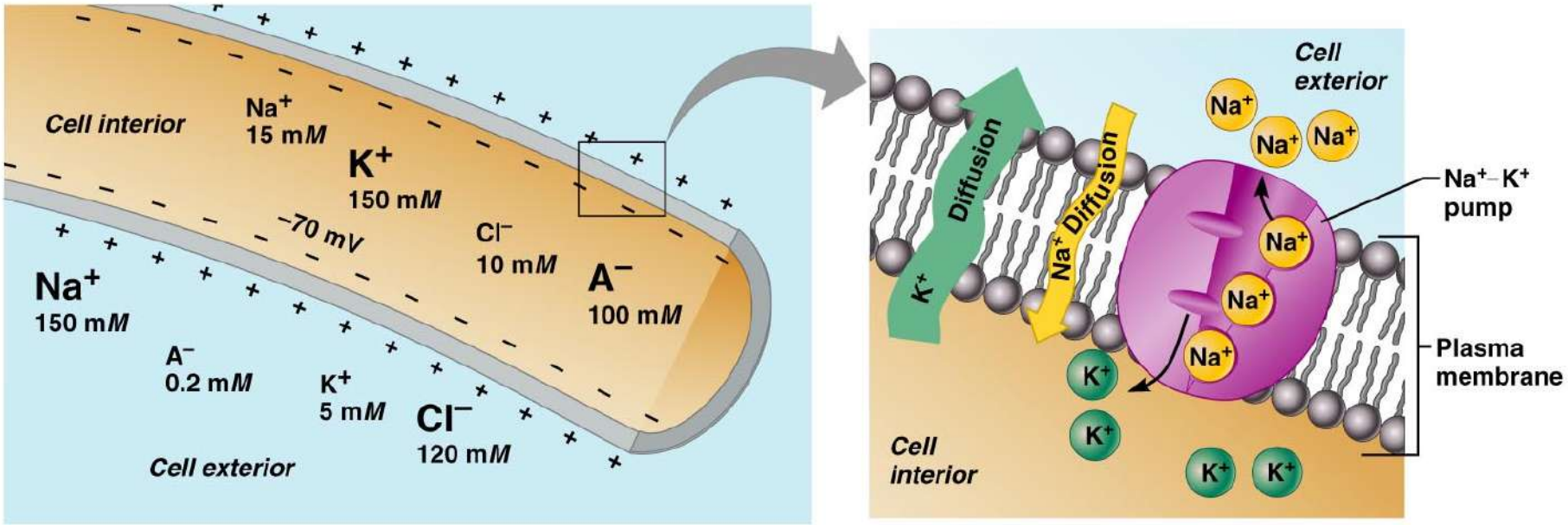


Figure 11.8

Changes in Membrane Potential

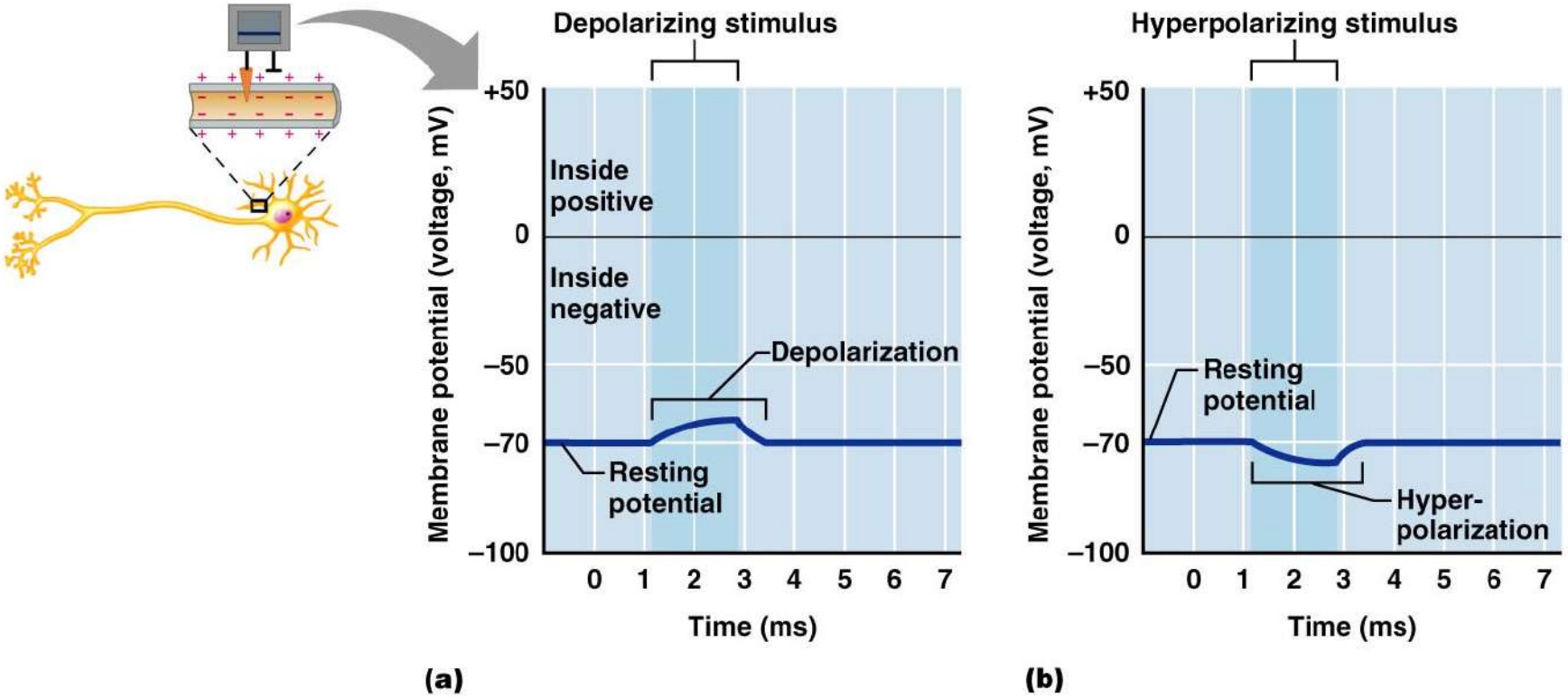


Figure 11.9

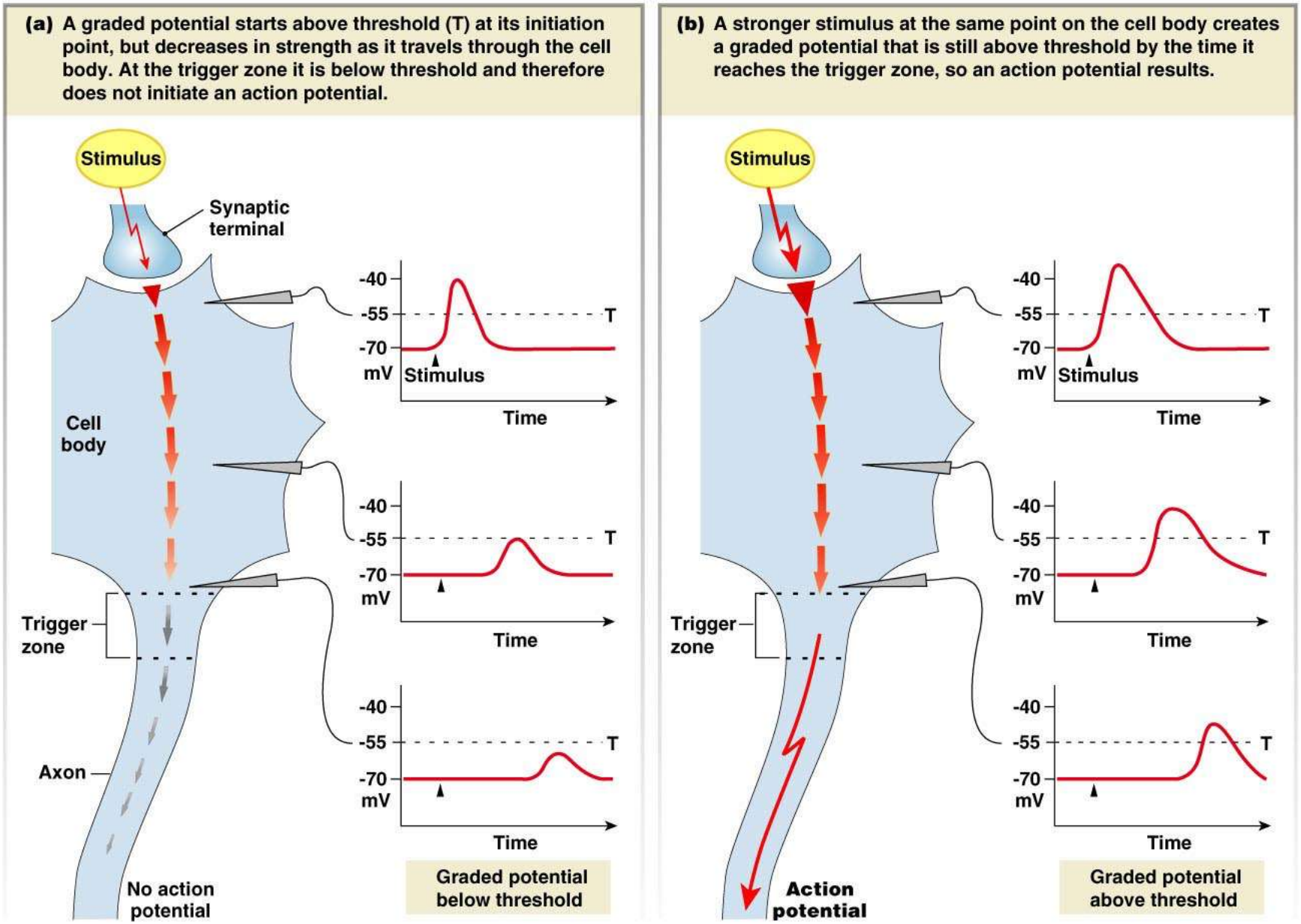
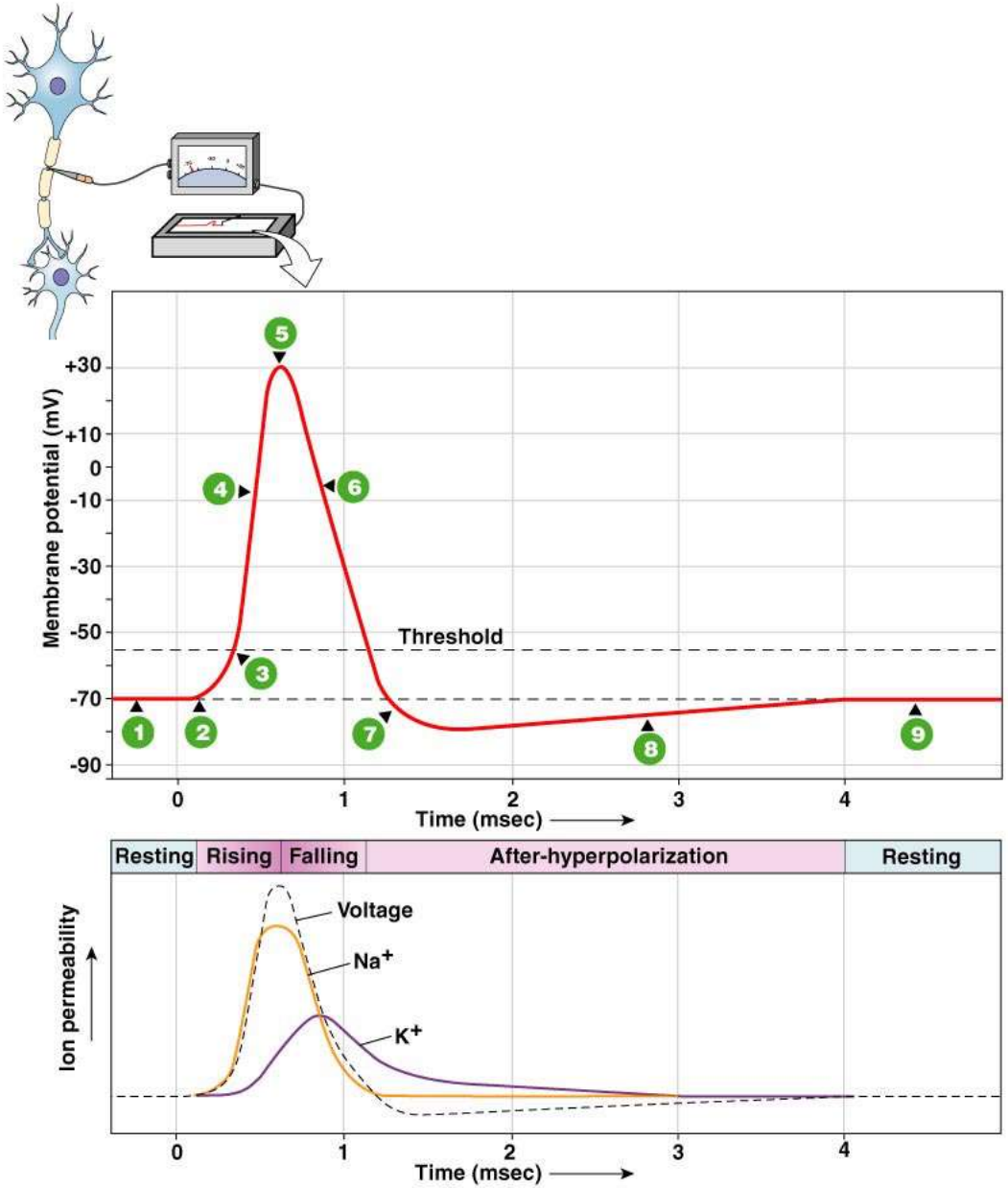


Figure 8-8 - Overview



1. Resting membrane potential
2. Depolarizing stimulus
3. Membrane depolarizes to threshold. Voltage-gated Na^+ channels open and Na^+ enters cell. Voltage-gated K^+ channels begin to open slowly.
4. Rapid Na^+ entry depolarizes cell.
5. Na^+ channels close and slower K^+ channels open.
6. K^+ moves from cell to extracellular fluid.
7. K^+ channels remain open and additional K^+ leaves cell, hyperpolarizing it.
8. Voltage-gated K^+ channels close, less K^+ leaks out of the cell.
9. Cell returns to resting ion permeability and resting membrane potential.

Figure 8-9 - Overview

Phases of the Action Potential

- 1 – resting state
- 2 – depolarization phase
- 3 – repolarization phase
- 4 – hyperpolarization

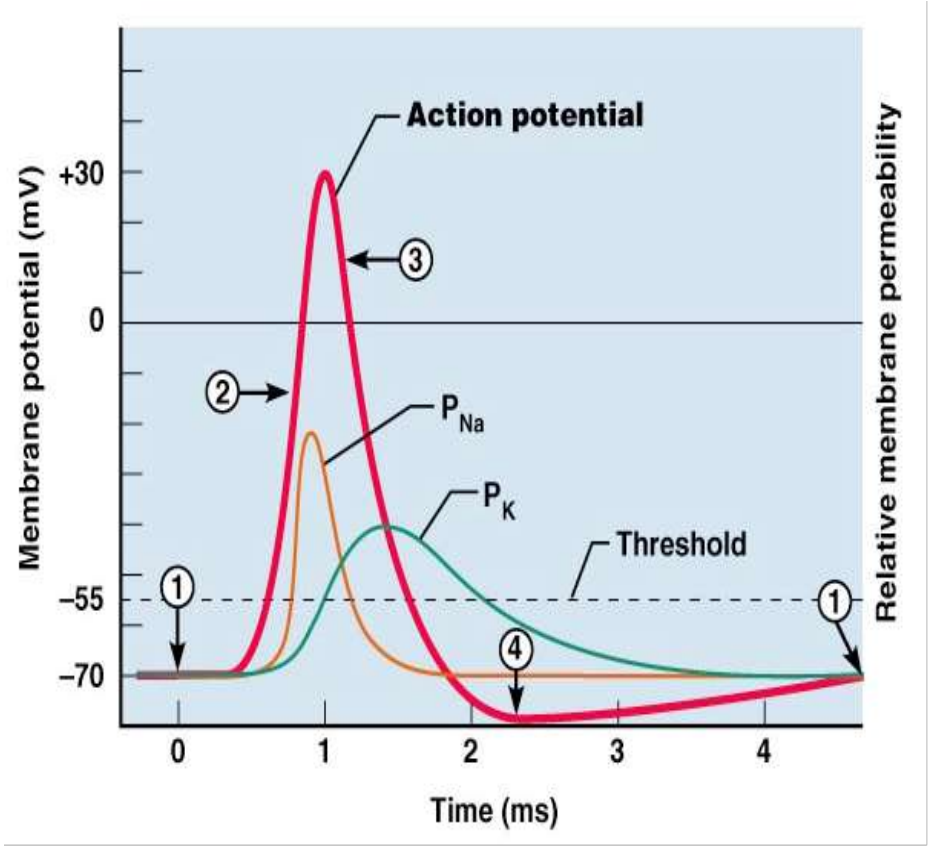
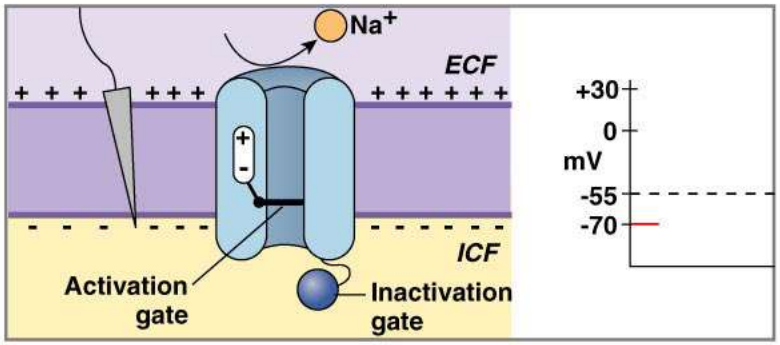
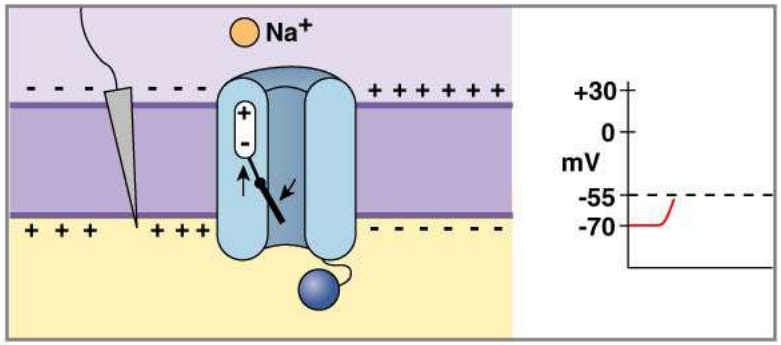


Figure 11.12

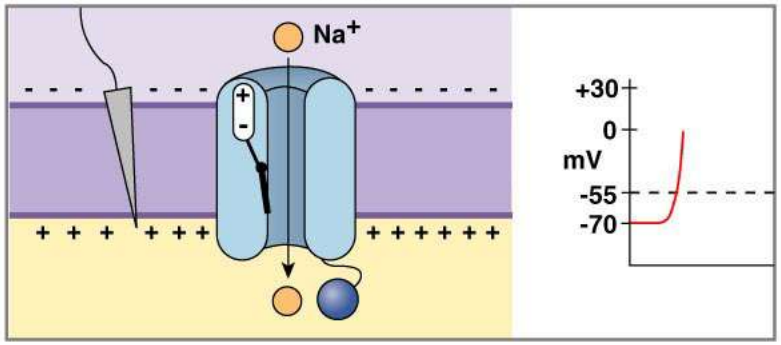
(a) At the resting membrane potential, the activation gate closes the channel.



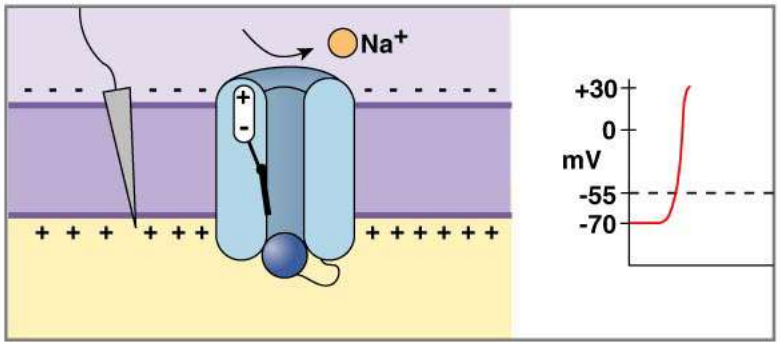
(b) Depolarizing stimulus arrives at the channel.



(c) With activation gate open, Na^+ enters the cell.



(d) Inactivation gate closes and Na^+ entry stops.



(e) During repolarization caused by K^+ leaving the cell, the two gates reset to their original positions.

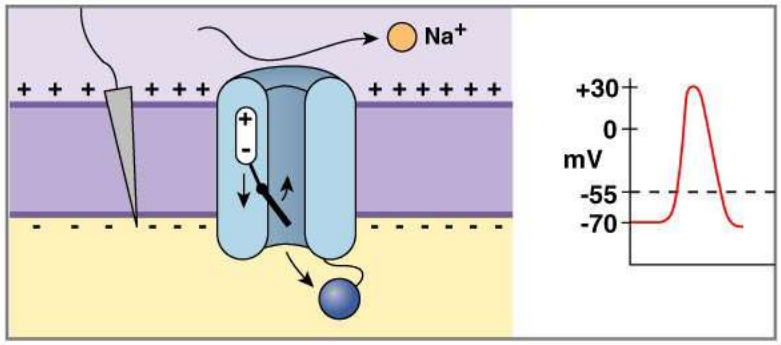


Figure 8-10 - Overview

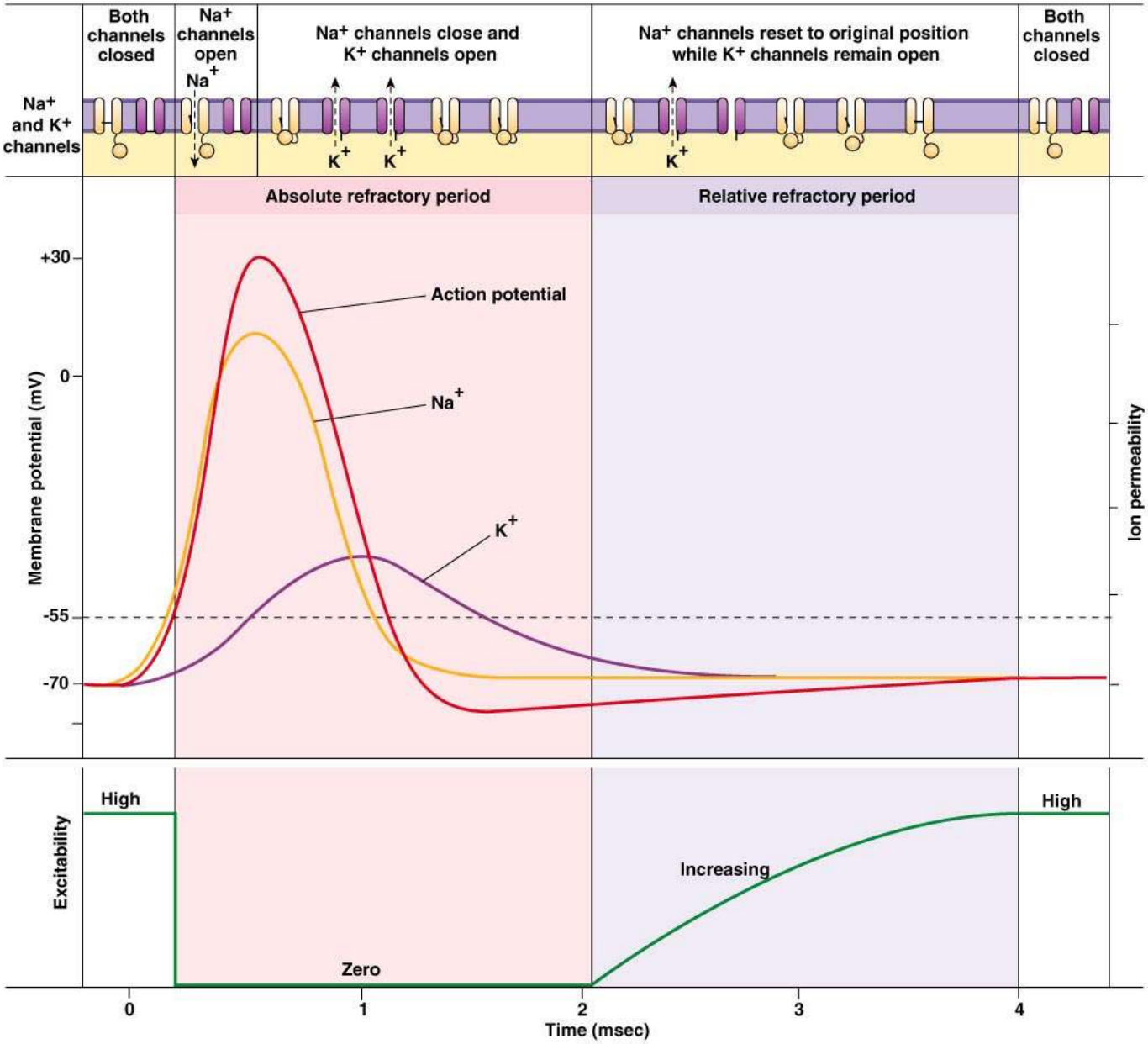


Figure 8-12

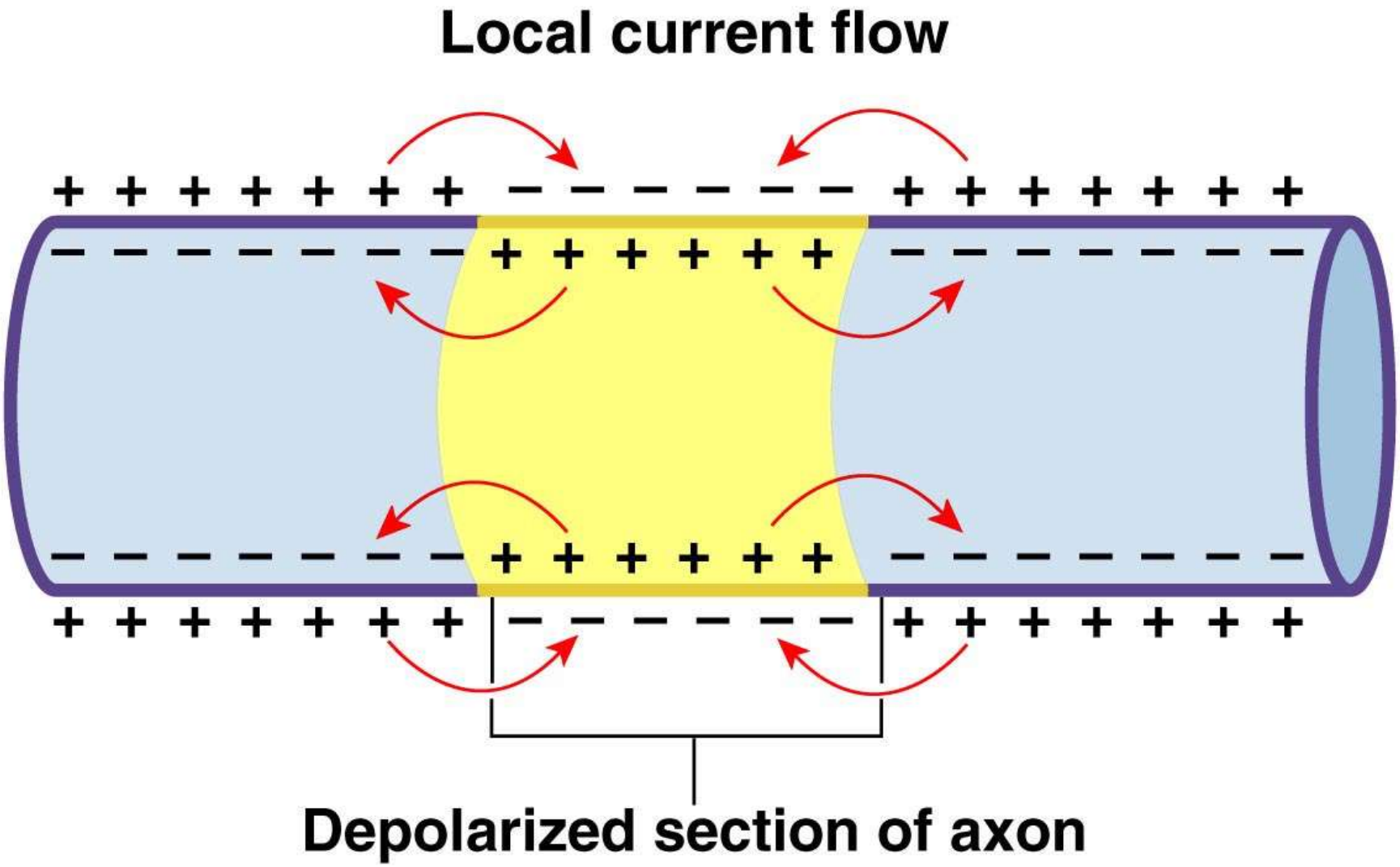


Figure 8-14

Saltatory Conduction

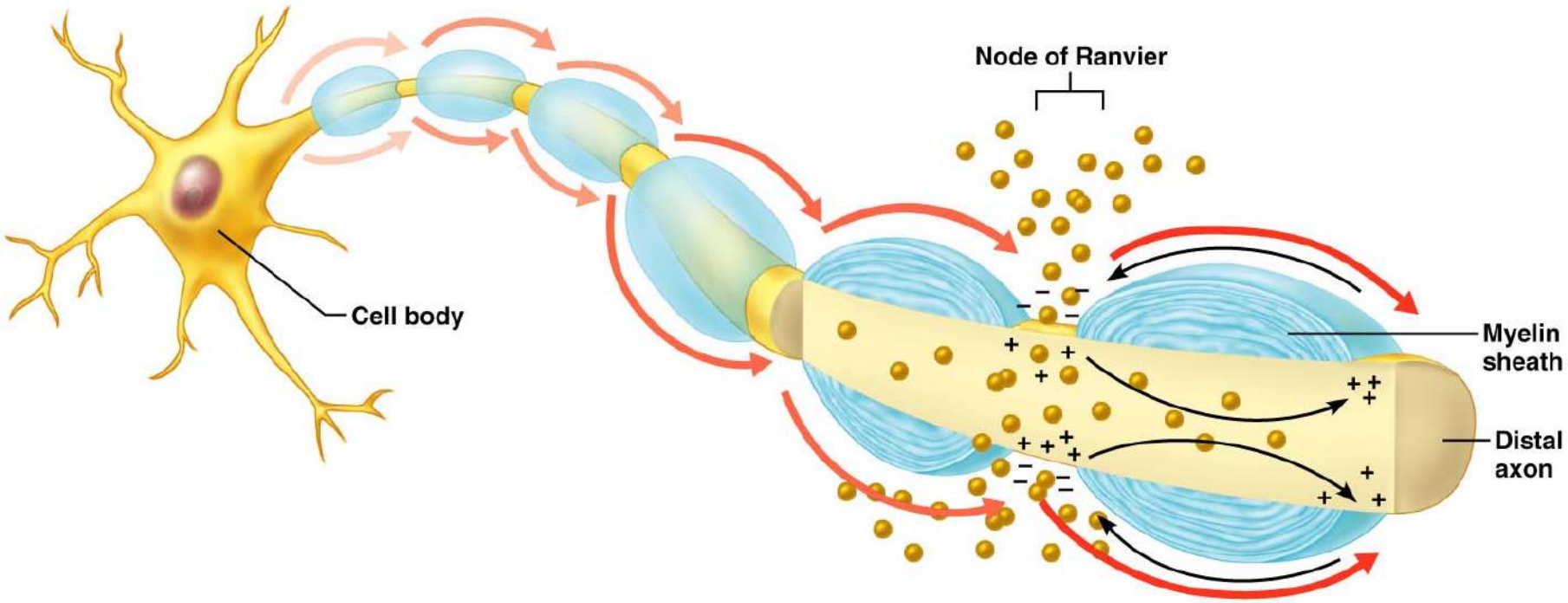


Figure 11.16

Synapses

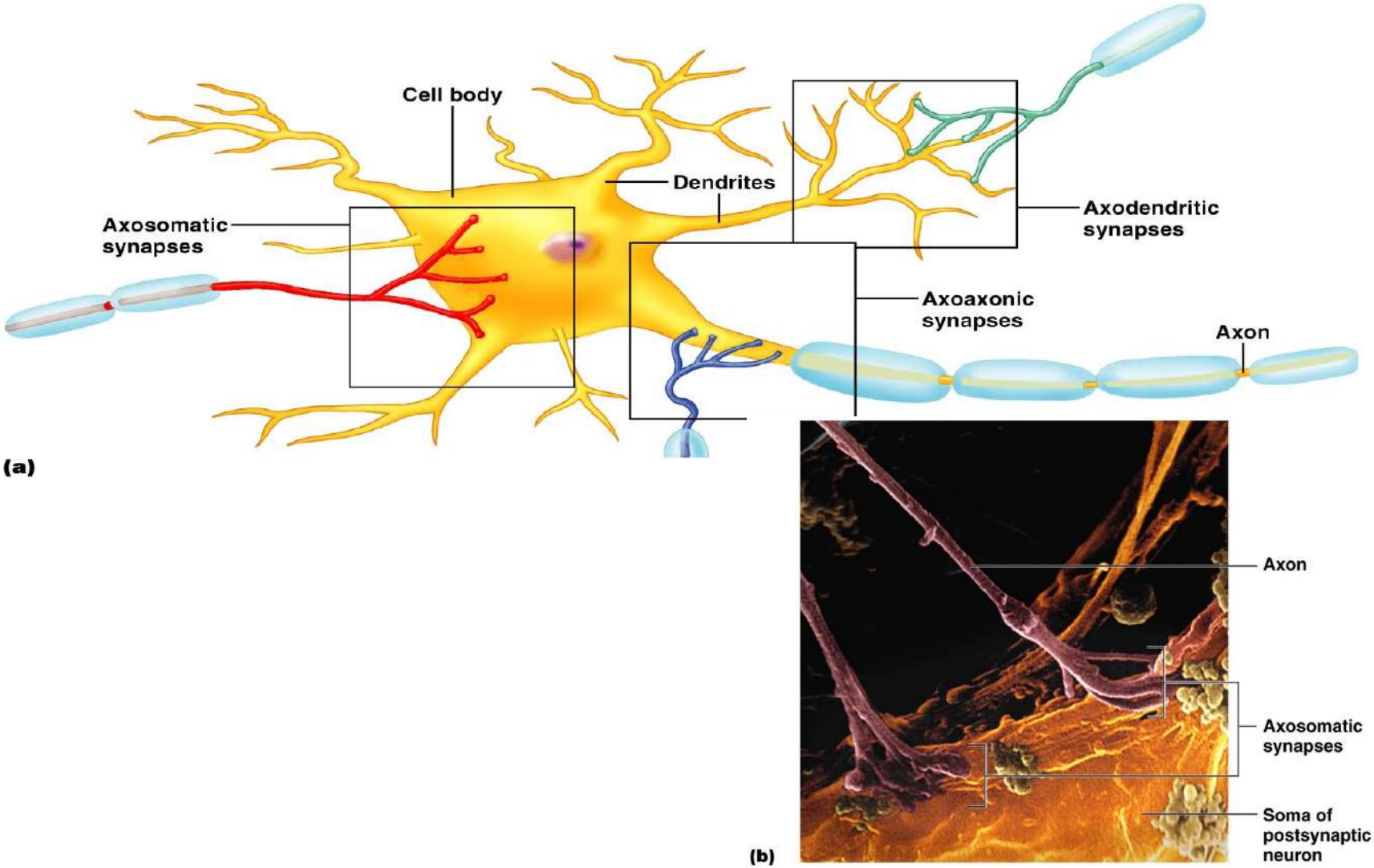


Figure 11.17

Synapse

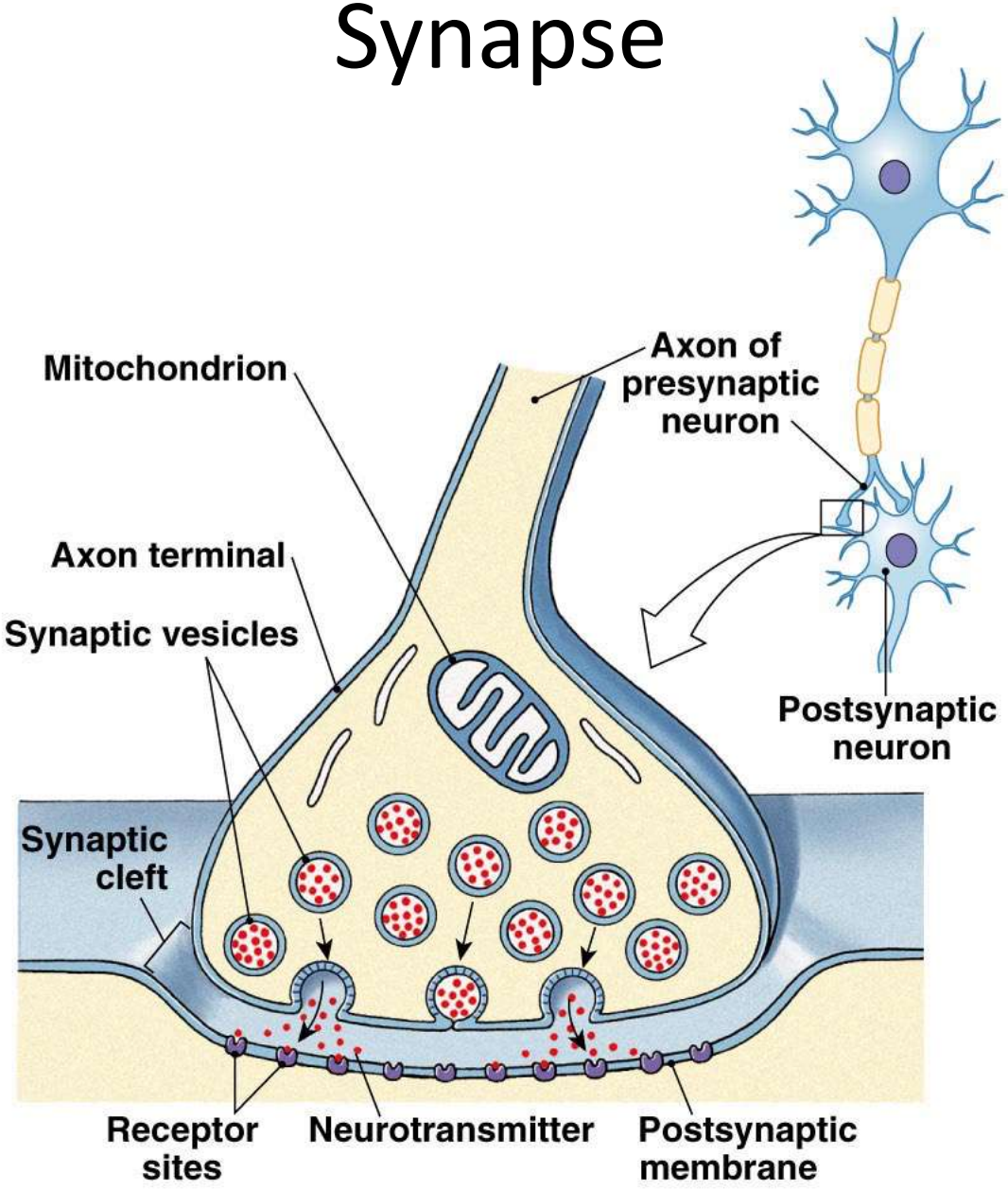


Figure 8-20

Synaptic Transmission

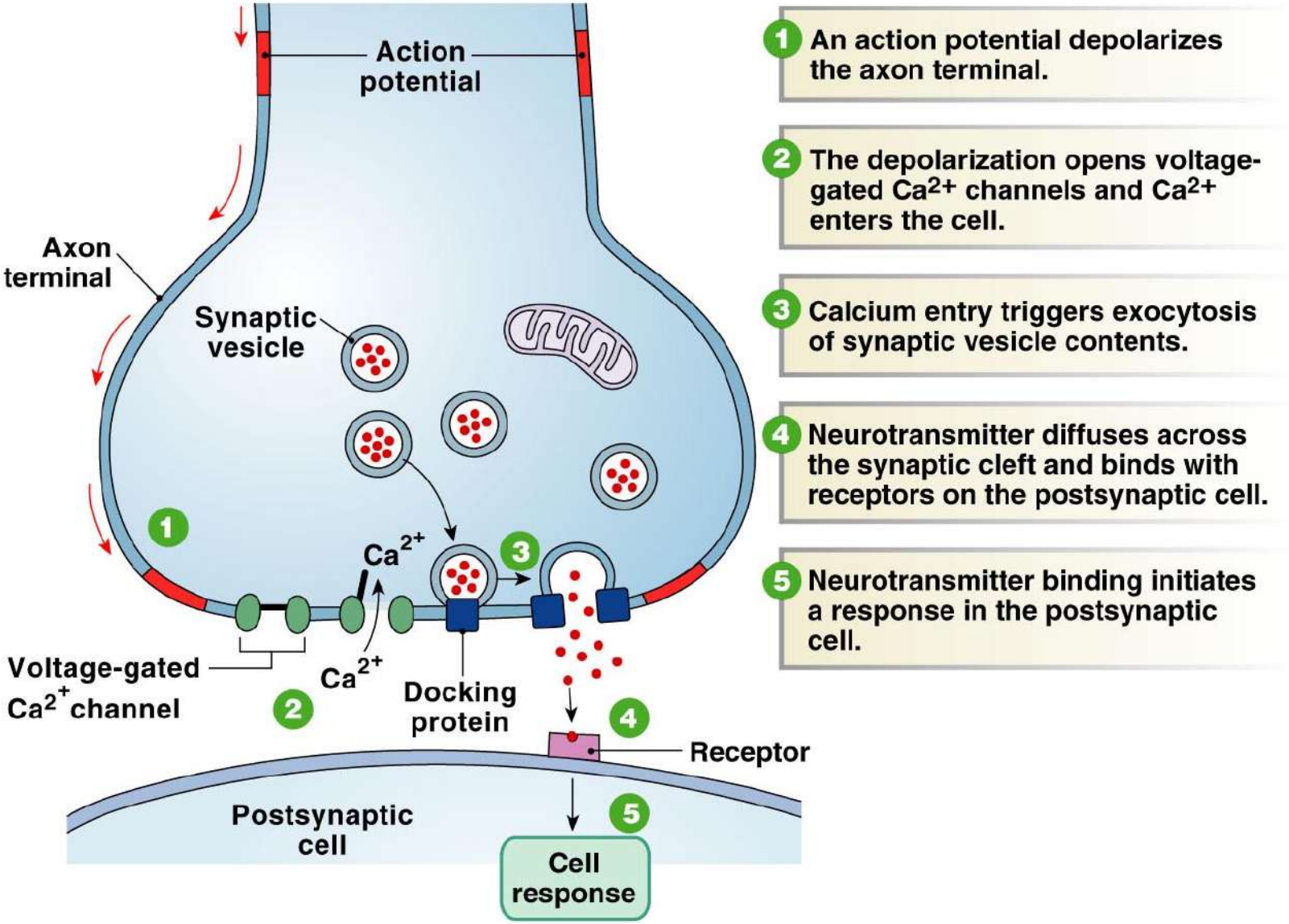


Figure 8-21 - Overview

Inactivation of Neurotransmitters

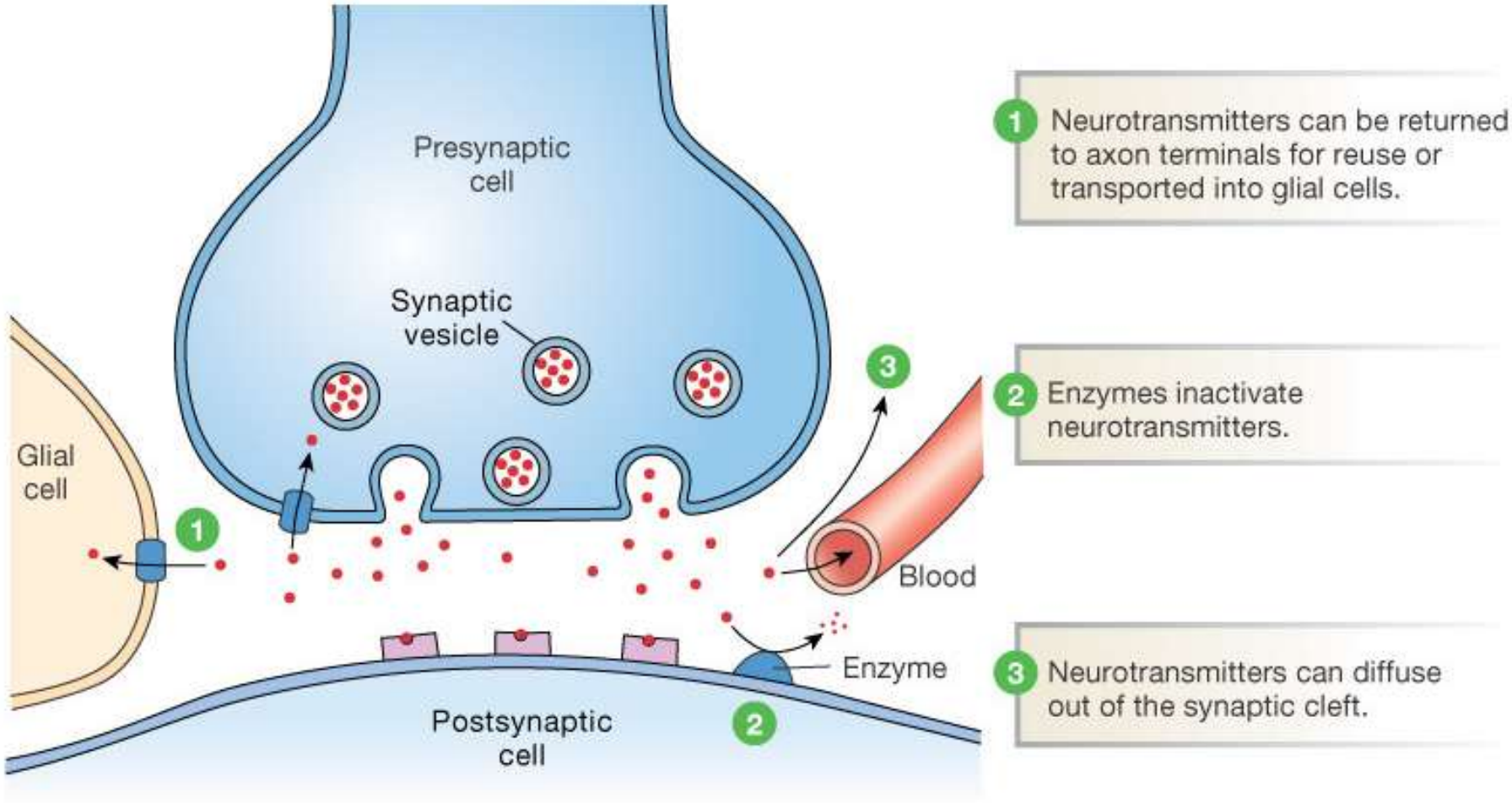
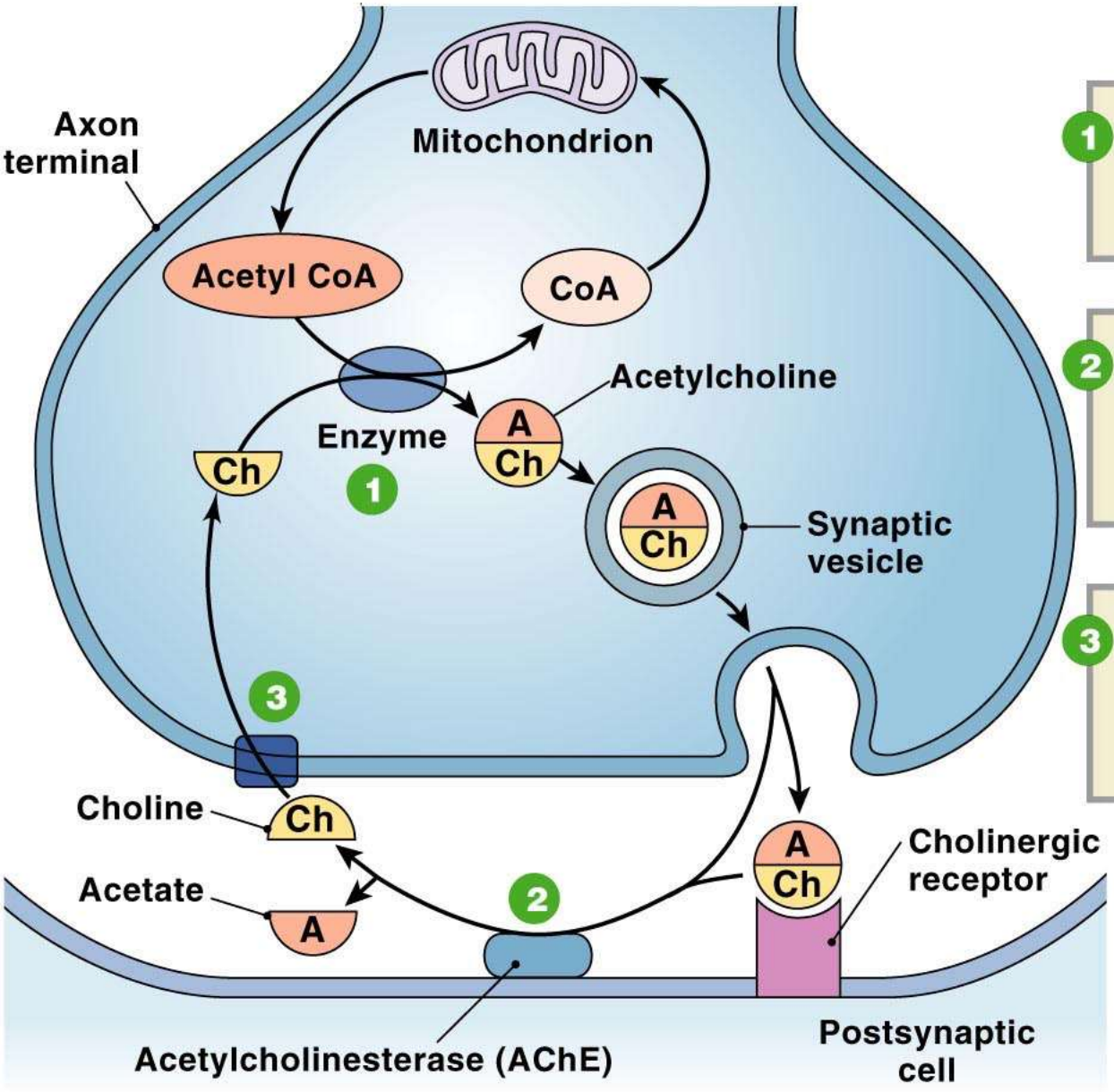


Figure 8-23: Inactivation of neurotransmitters



1 **Acetylcholine** (ACh) is made from choline and acetyl CoA.

2 In the synaptic cleft ACh is rapidly broken down by the enzyme **acetylcholinesterase.**

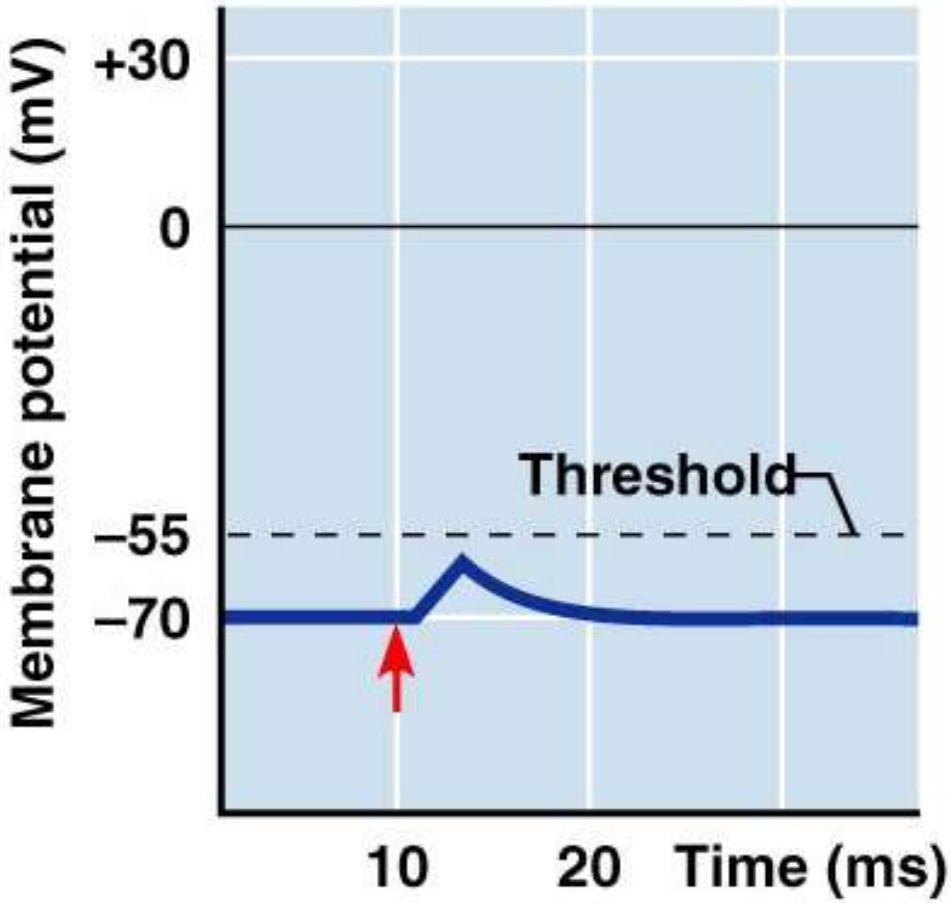
3 Choline is transported back into the axon terminal and is used to make more ACh.

Figure 8-22 - Overview

Excitatory Postsynaptic Potentials

- EPSPs are graded potentials that can initiate an action potential in an axon
  - Use only chemically gated channels
  - Na^+ and K^+ flow in opposite directions at the same time
- Postsynaptic membranes do not generate action potentials

Excitatory Postsynaptic Potential



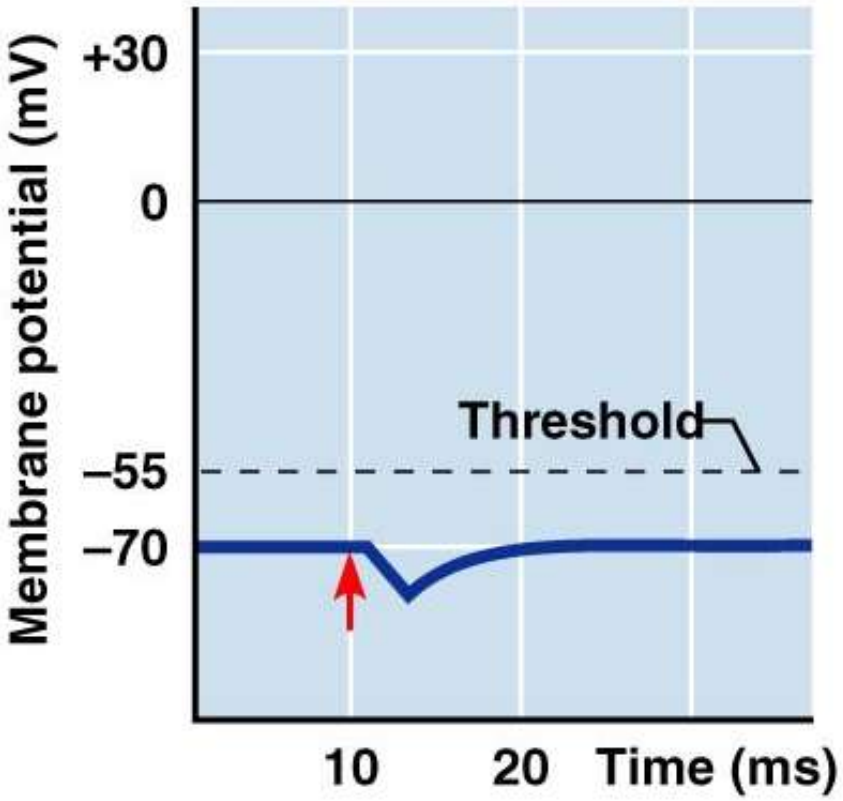
(a) Excitatory postsynaptic potential (EPSP)

Figure 11.19a

Inhibitory Synapses and IPSPs

- Neurotransmitter binding to a receptor at inhibitory synapses:
  - Causes the membrane to become more permeable to potassium and chloride ions
  - Leaves the charge on the inner surface negative
  - Reduces the postsynaptic neuron's ability to produce an action potential

Inhibitory Postsynaptic (IPSP)



(b) Inhibitory postsynaptic potential (IPSP)

Figure 11.19b

Chemical Neurotransmitters

- Acetylcholine (ACh)
- Biogenic amines
- Amino acids
- Peptides
- Novel messengers: ATP and dissolved gases NO and CO

Central Nervous System (CNS)

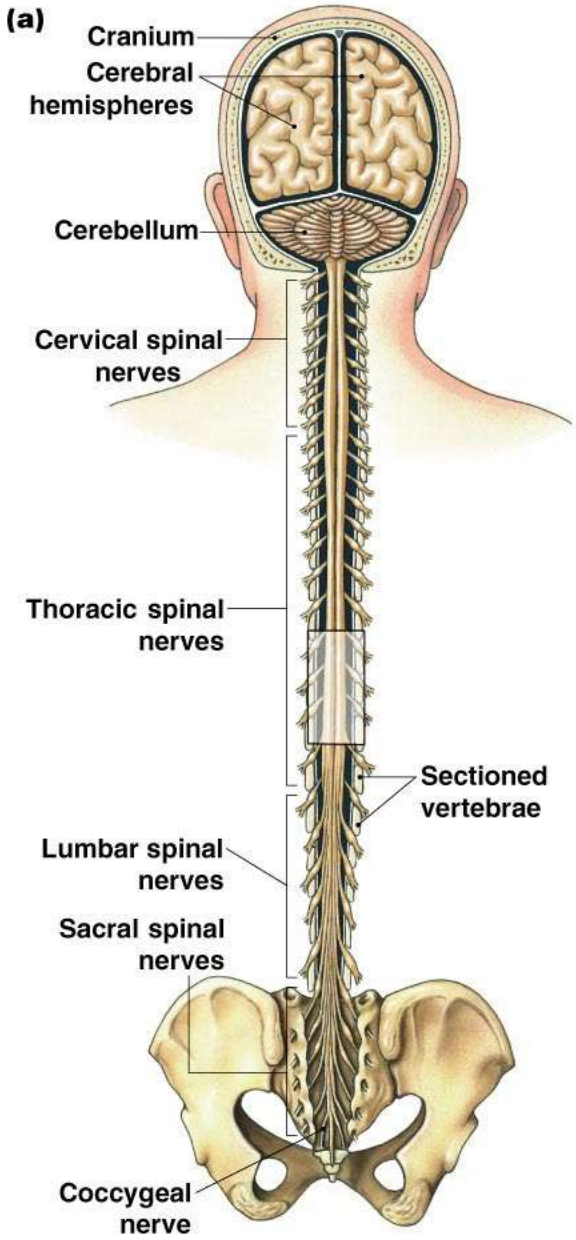


Figure 9-4a

Human Brain: Ventral Aspect

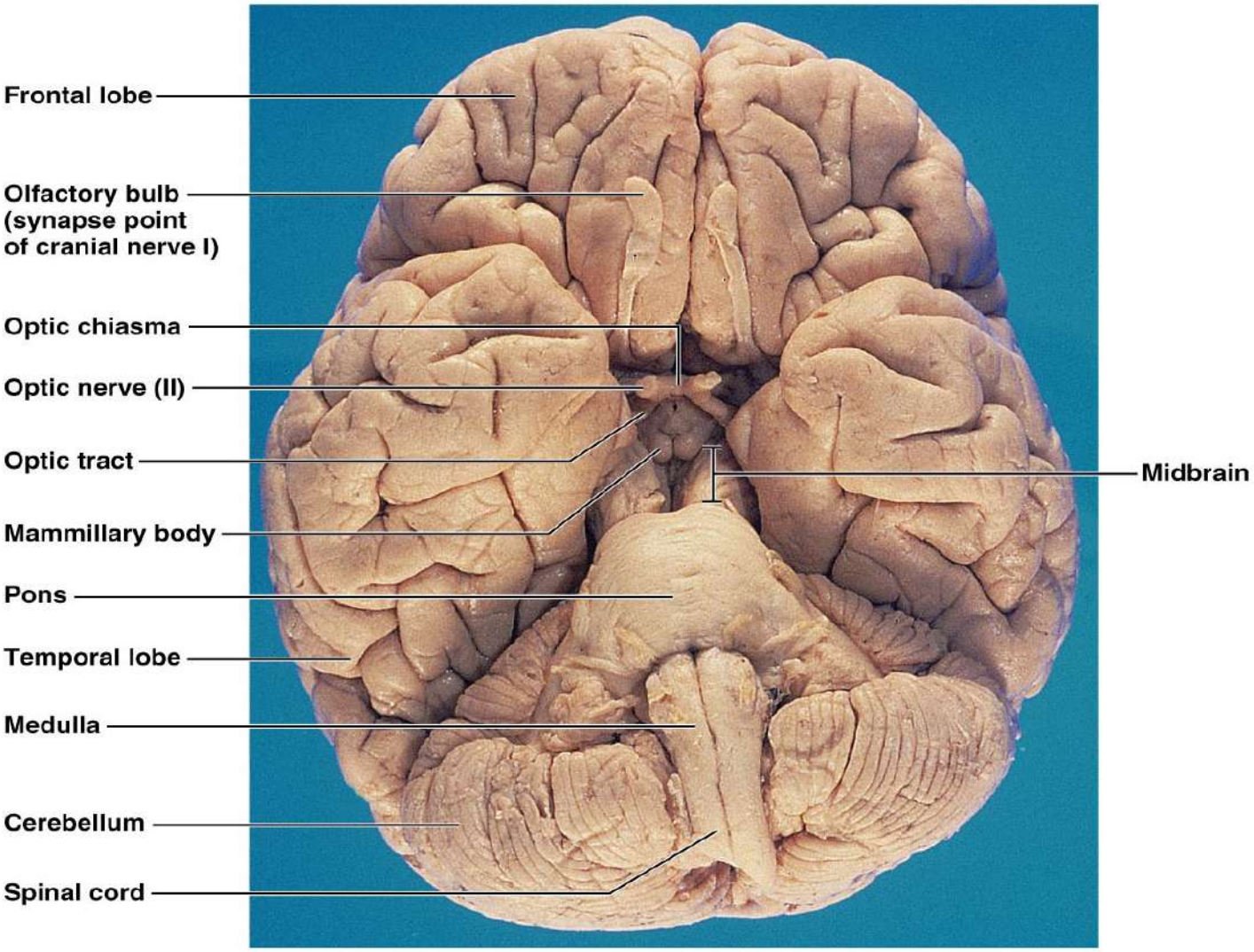


Figure 12.14

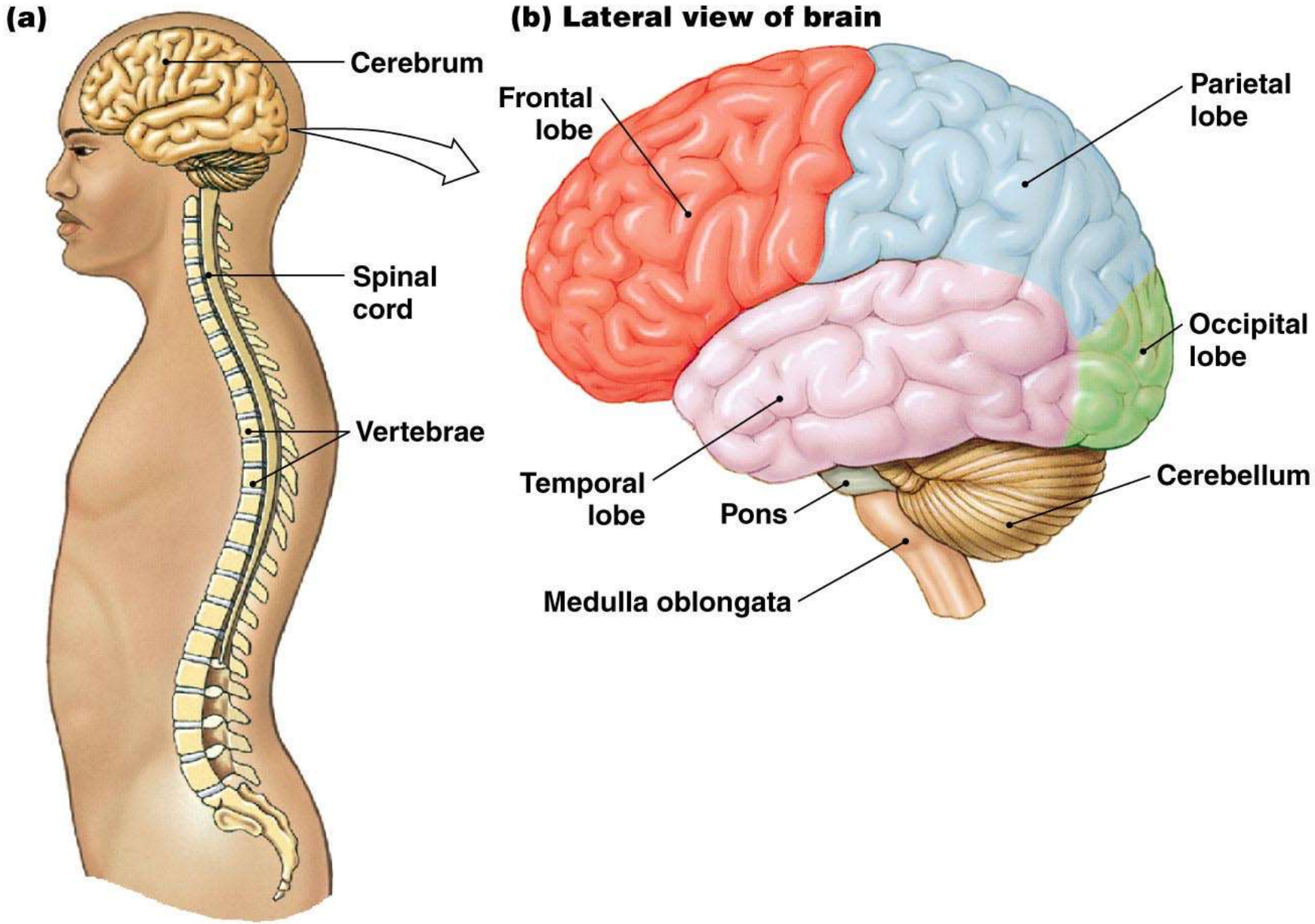
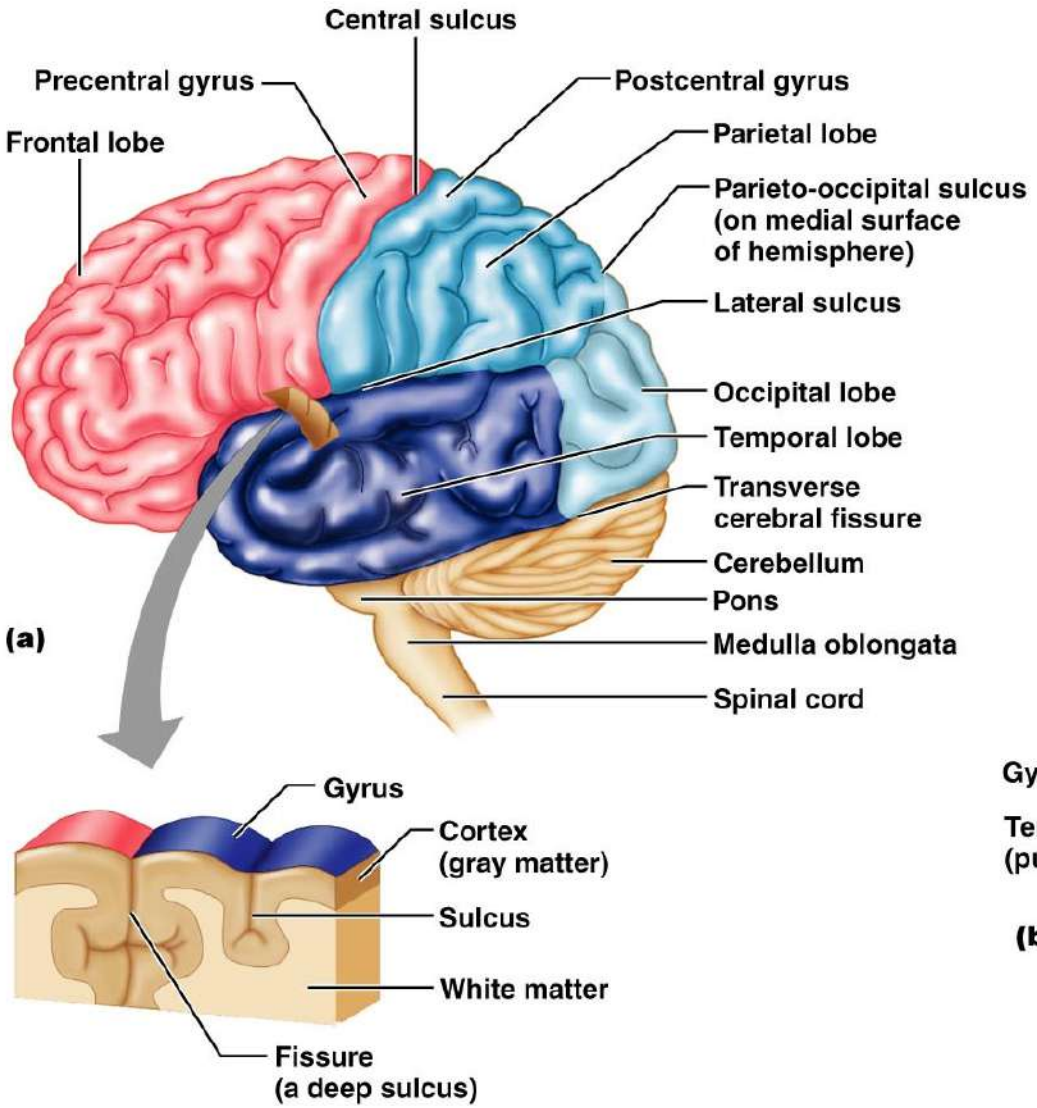
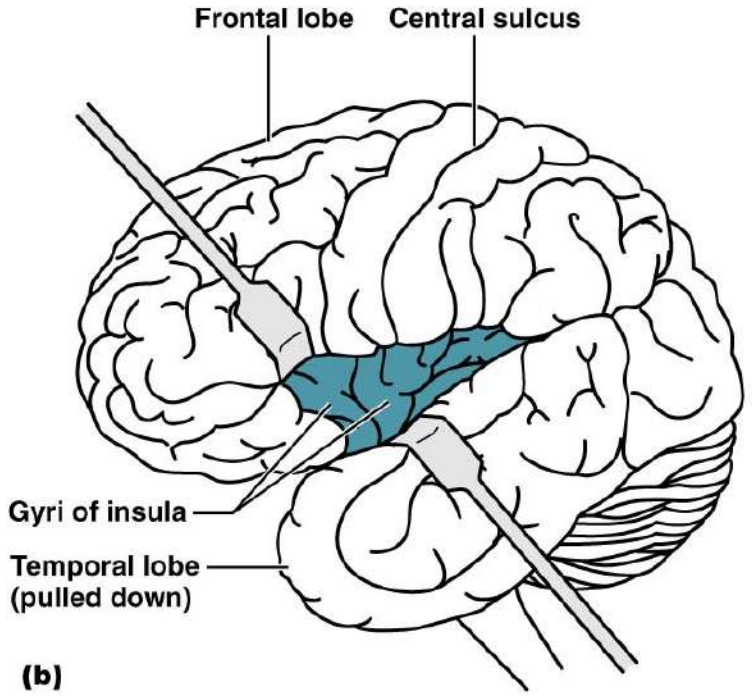


Figure 9-9a–b (1 of 5)

Brain Lobes





b

Functional Areas of the Cerebral

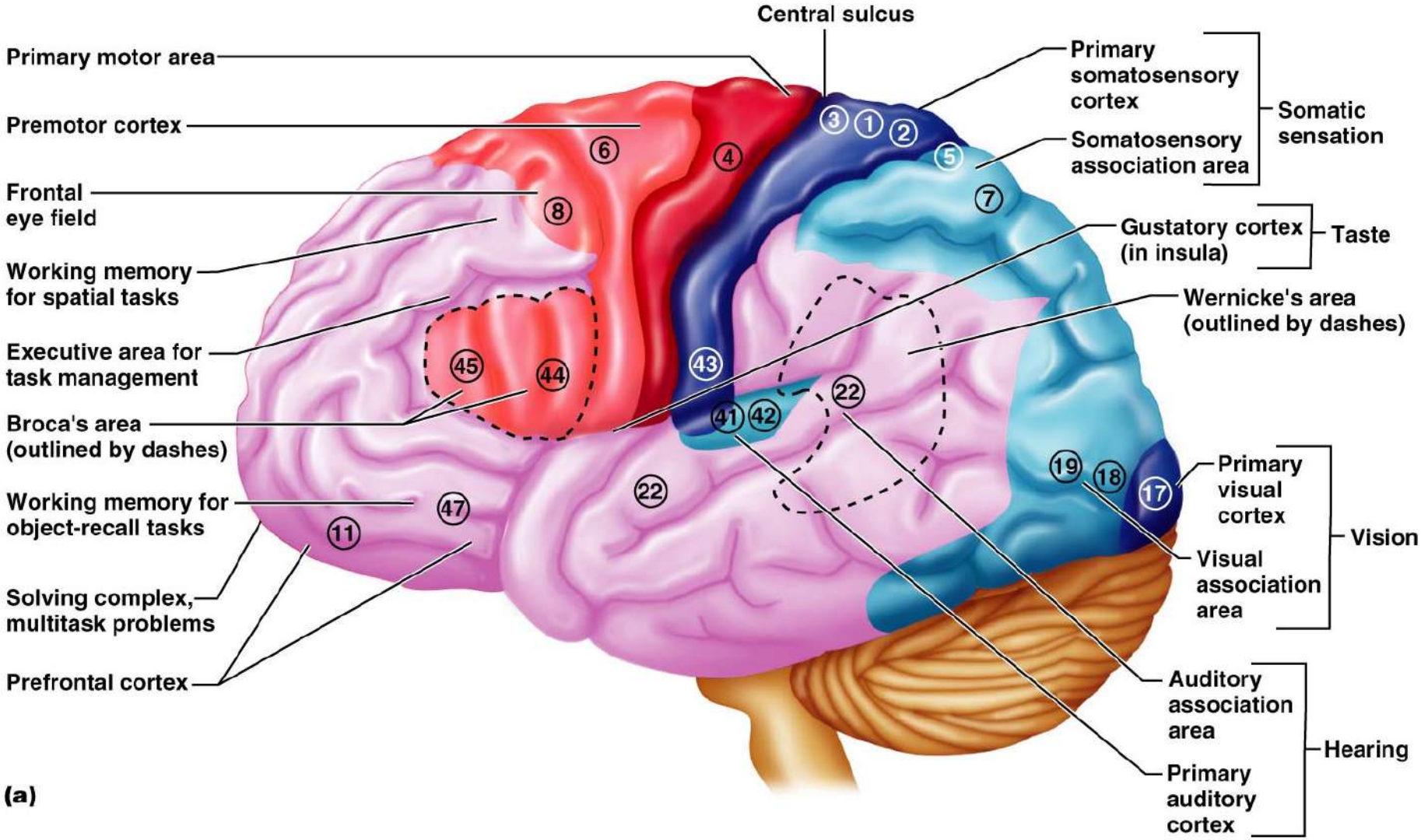


Figure 12.8a

Primary Motor Cortex Homunculus

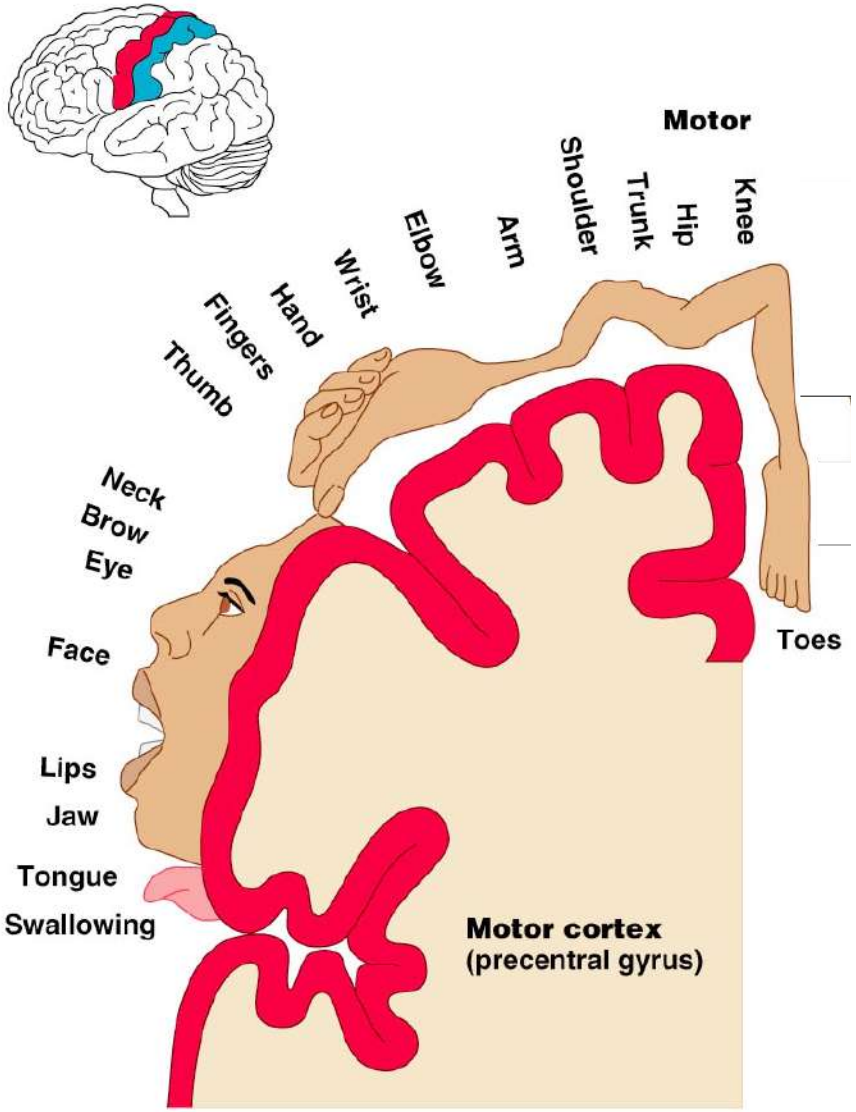


Figure 12.9.1

Primary Somatosensory Cortex

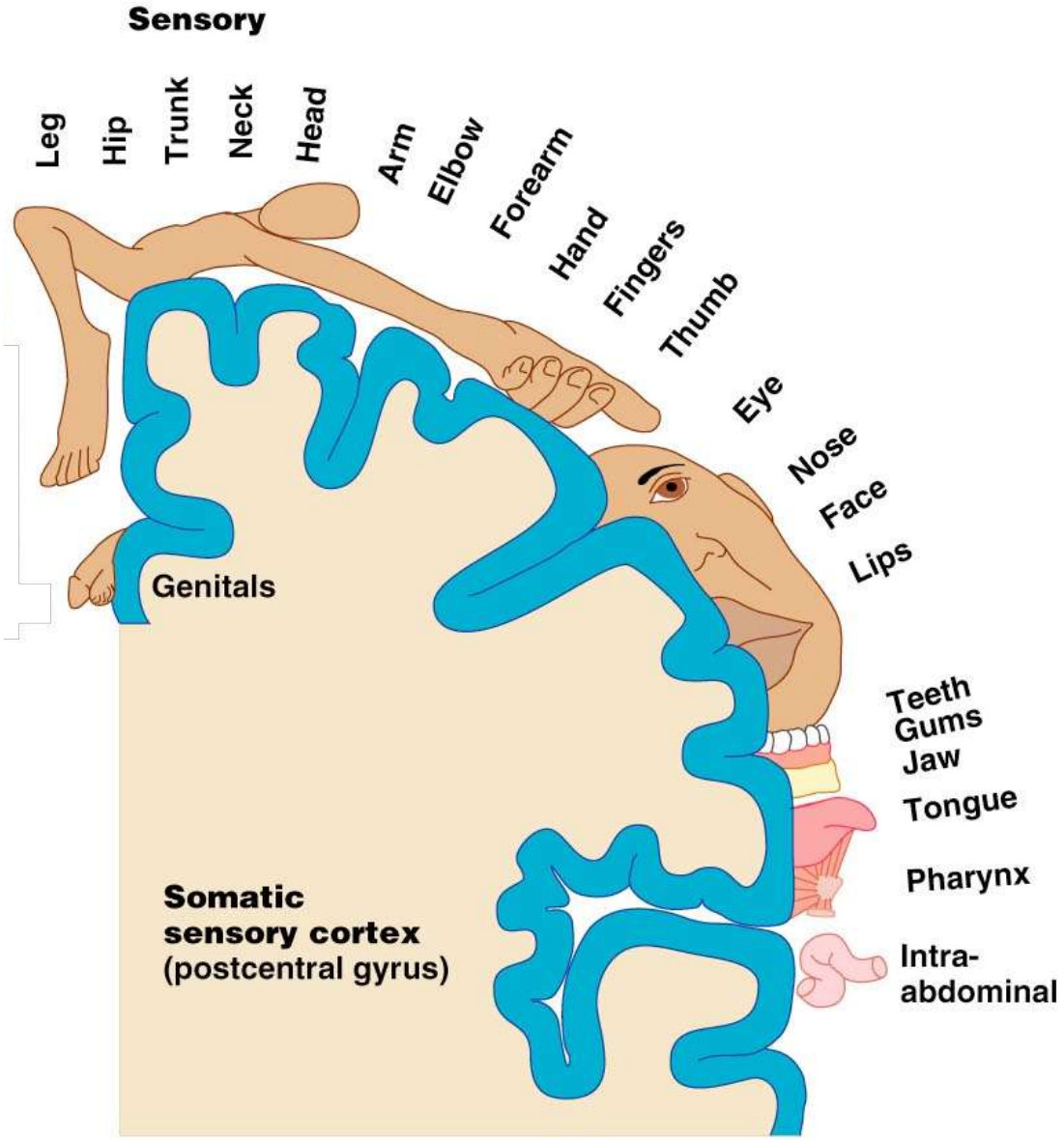


Figure 12.9.2

Fiber Tracts in White Matter

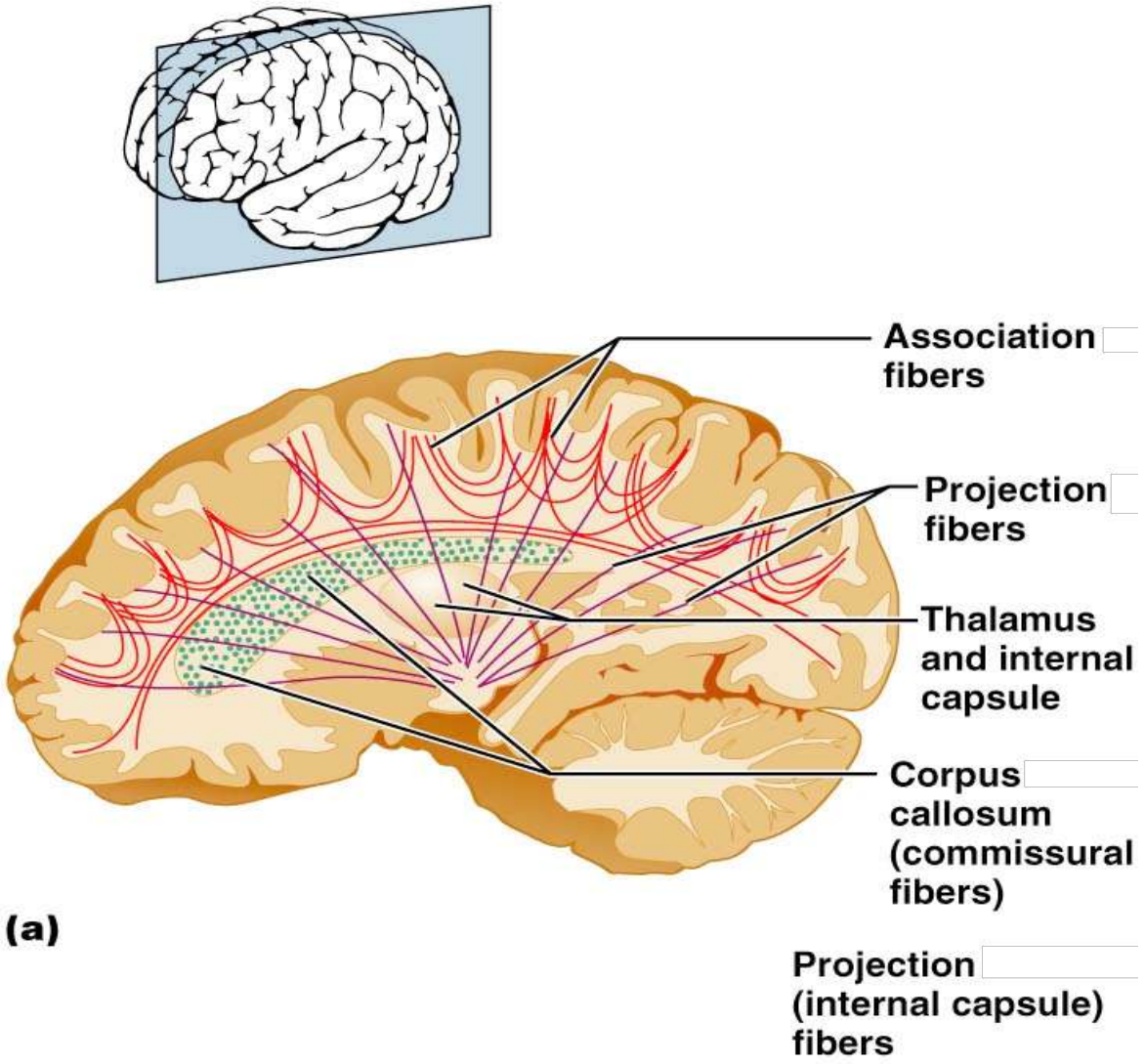


Figure 12.10a

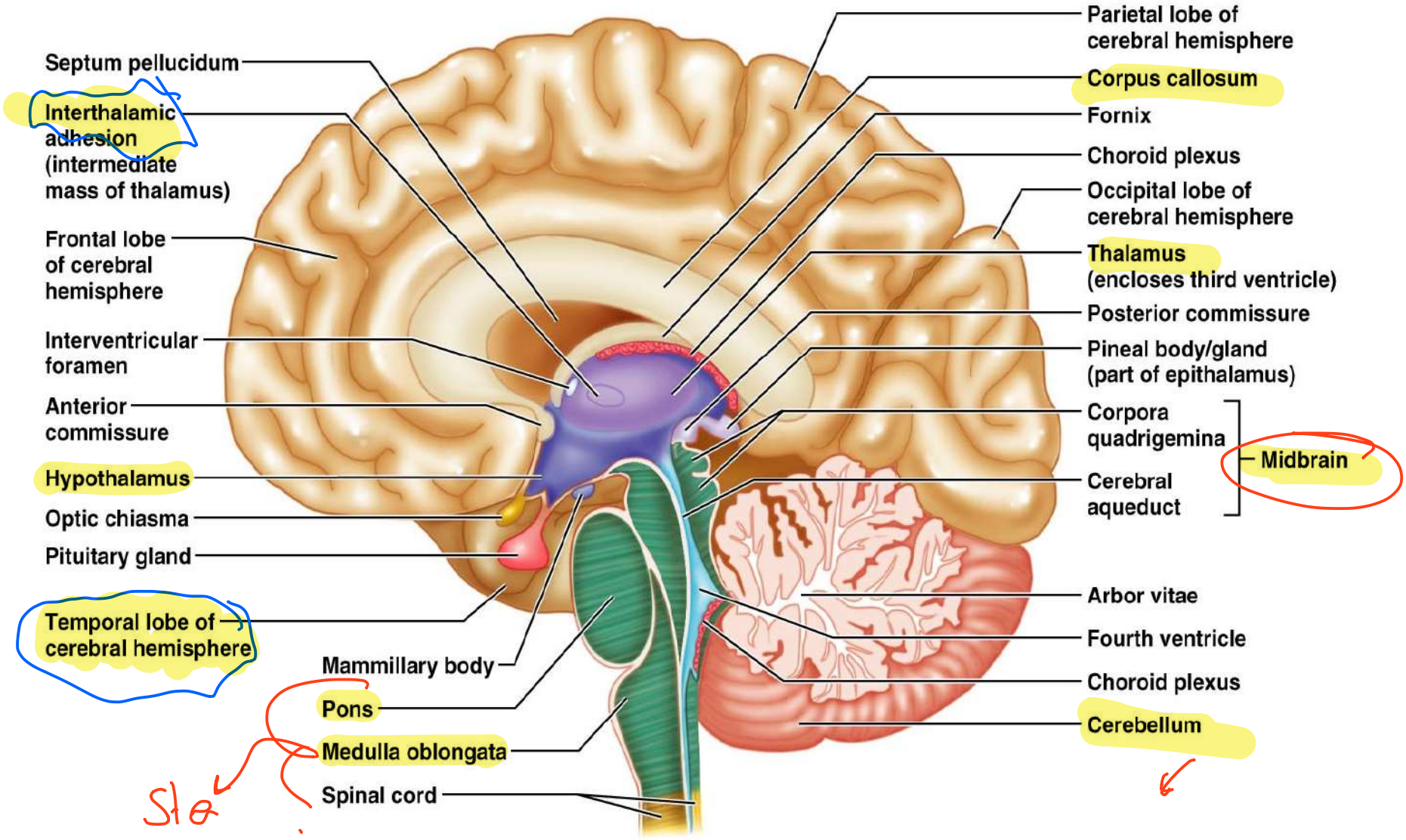

Septum pellucidum
Interthalamic adhesion (intermediate mass of thalamus)
Frontal lobe of cerebral hemisphere
Interventricular foramen
Anterior commissure
Hypothalamus
Optic chiasma
Pituitary gland
Temporal lobe of cerebral hemisphere
Mammillary body
Pons
Medulla oblongata
Spinal cord
Parietal lobe of cerebral hemisphere
Corpus callosum
Fornix
Choroid plexus
Occipital lobe of cerebral hemisphere
Thalamus (encloses third ventricle)
Posterior commissure
Pineal body/gland (part of epithalamus)
Corpora quadrigemina
Cerebral aqueduct
Midbrain
Arbor vitae
Fourth ventricle
Choroid plexus
Cerebellum

Figure 12.12

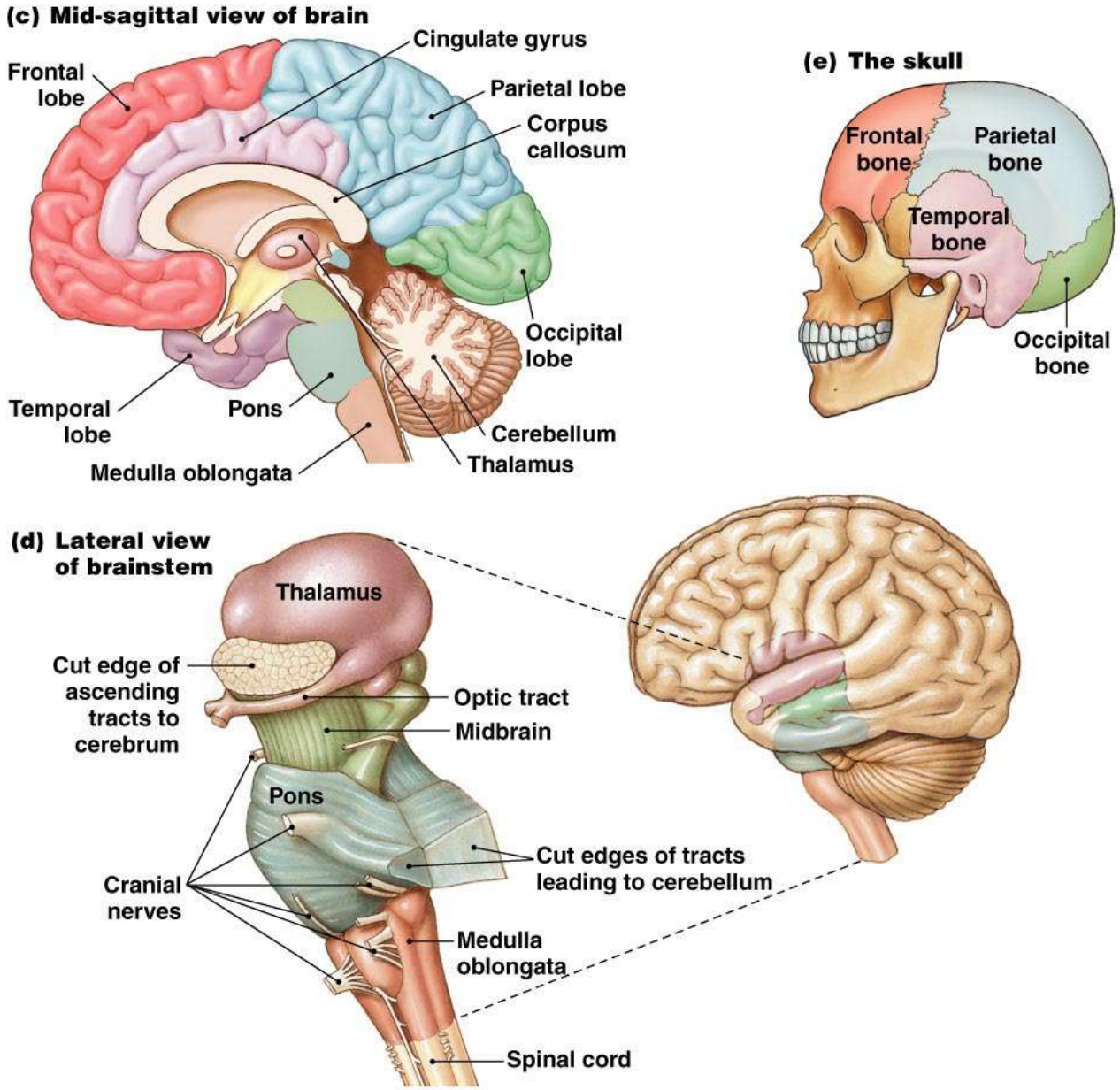


Figure 9-9c–e (2 of 5)

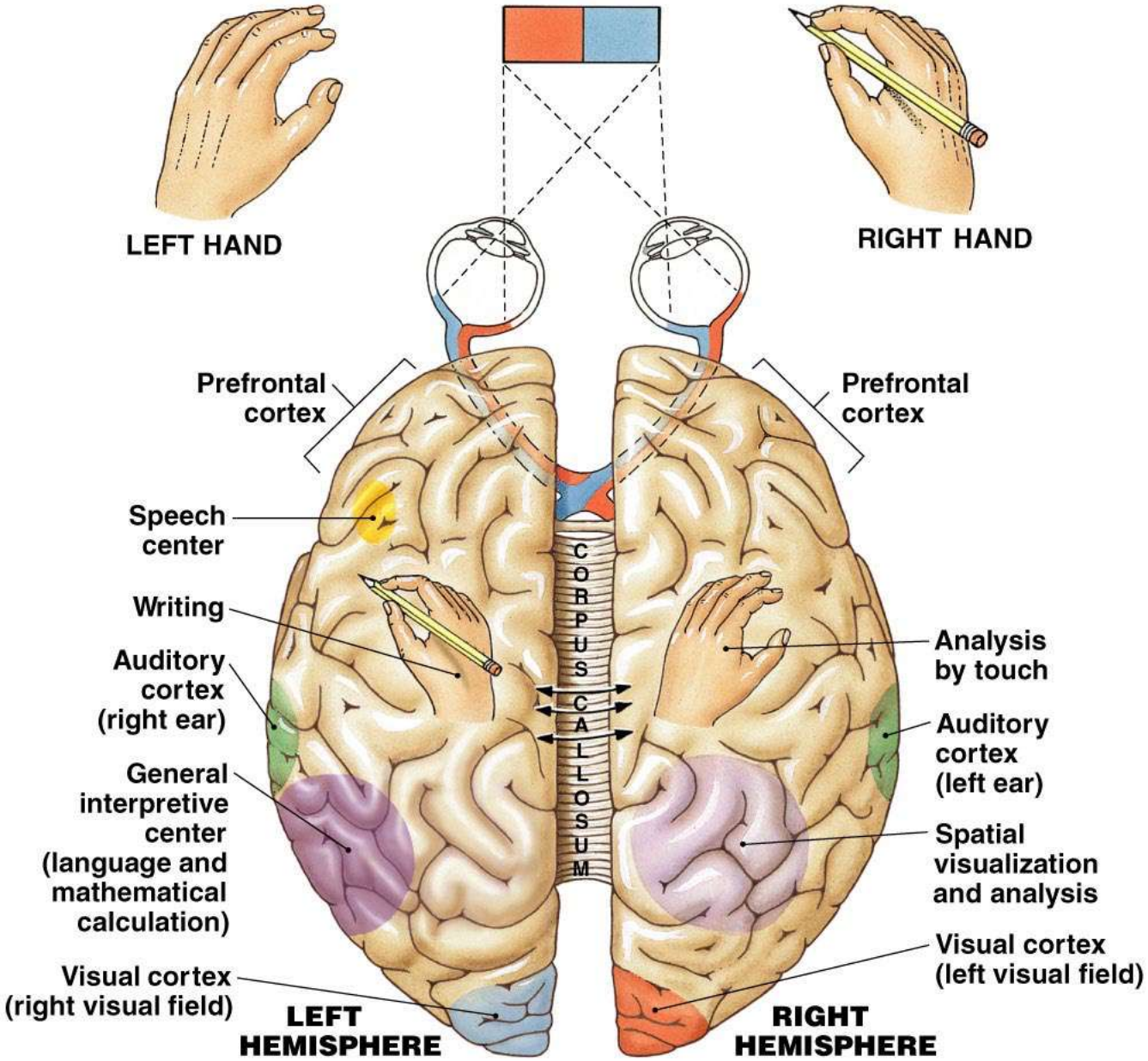


Figure 9-16

Spinal Cord

↳ part of the CNS

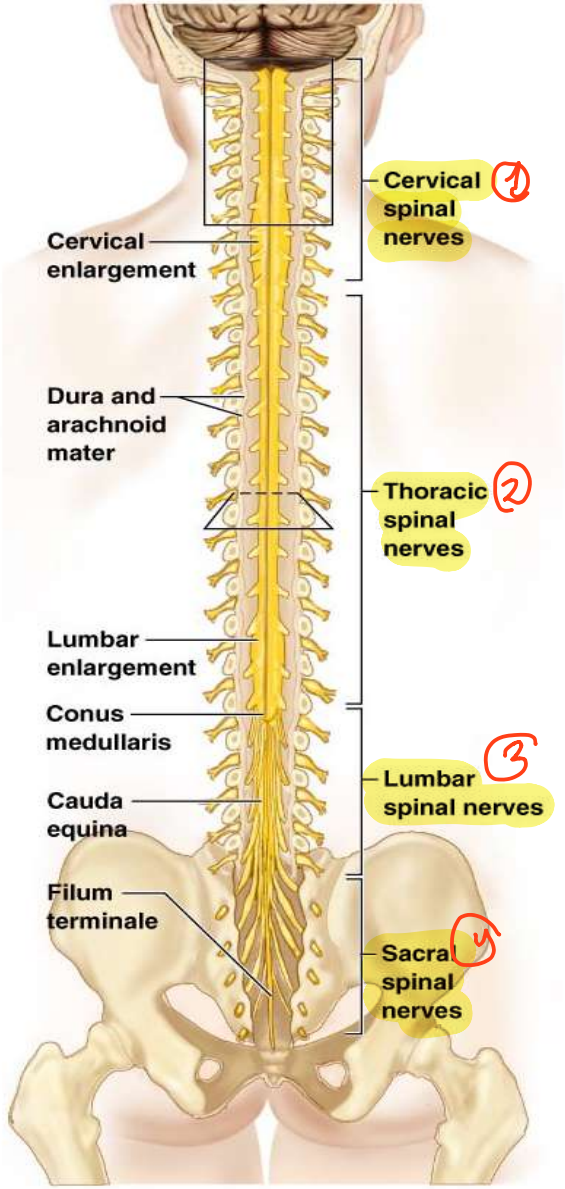


Figure 12.29a

Gray Matter and Spinal Roots

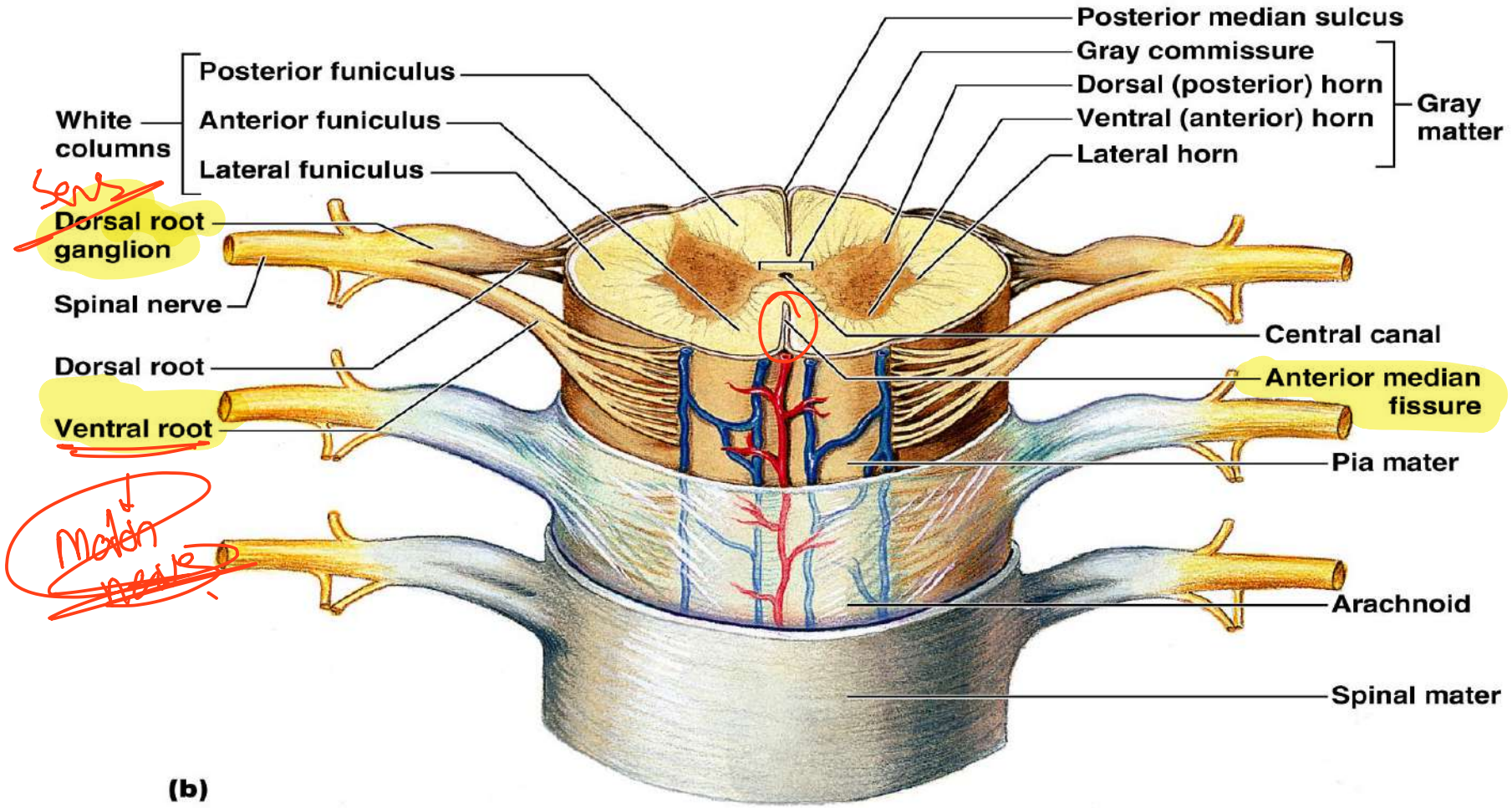
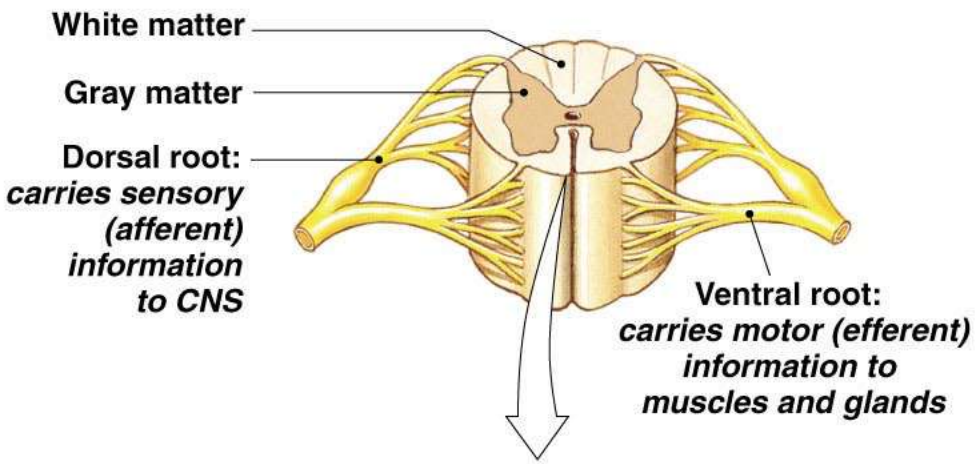
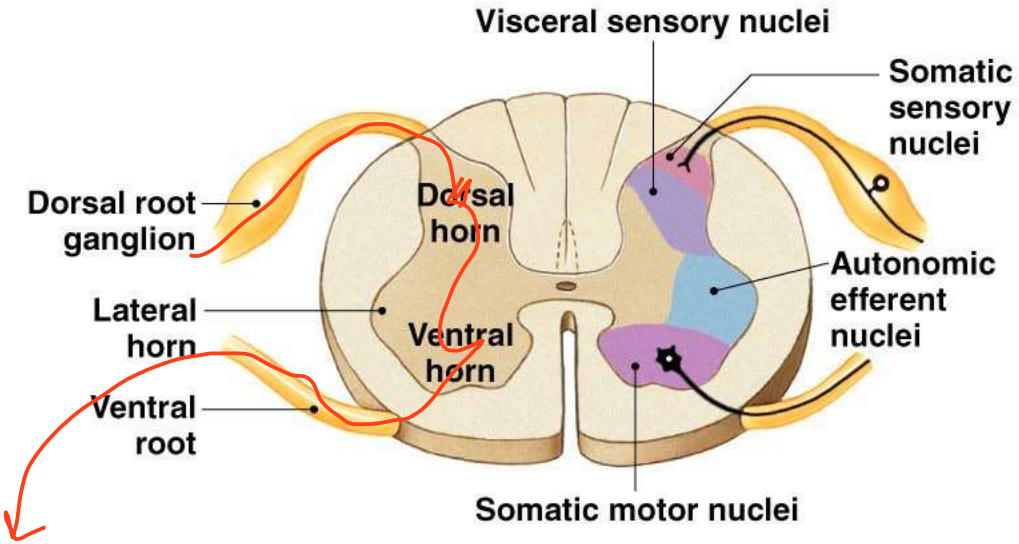


Figure 12.31b

(a) One segment of spinal cord, ventral view, showing its pair of nerves



(b) Gray matter consists of sensory and motor nuclei



(c) White matter in the spinal cord consists of axons carrying information to and from the brain.

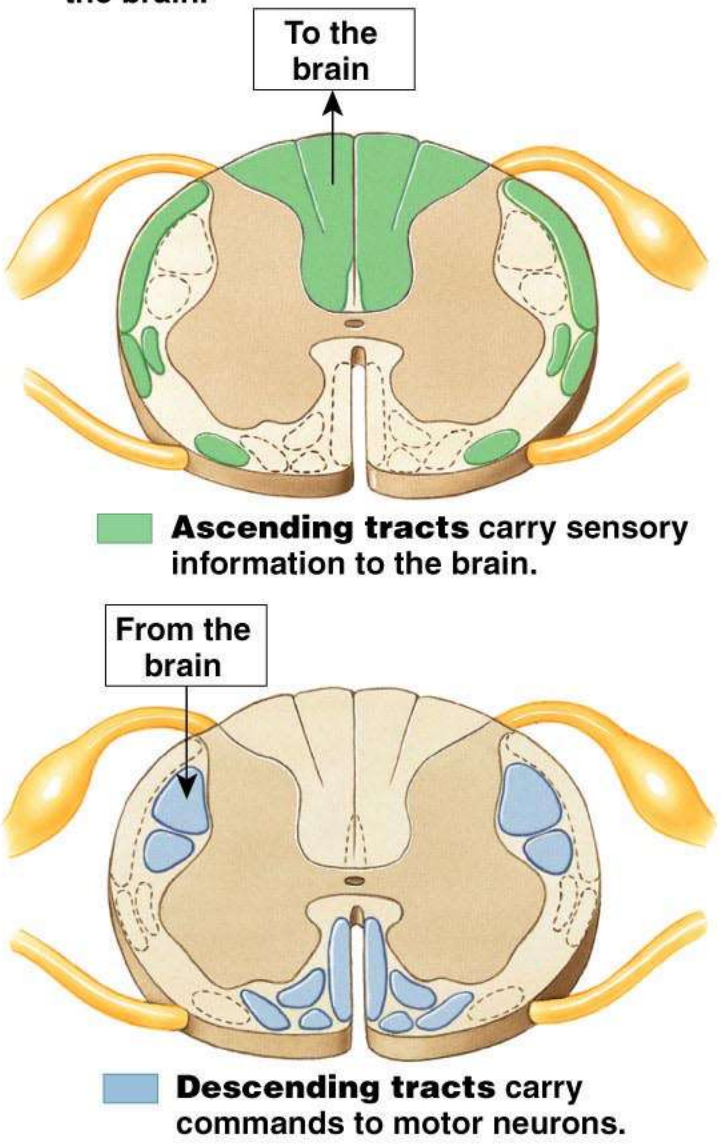


Figure 9-7 - Overview

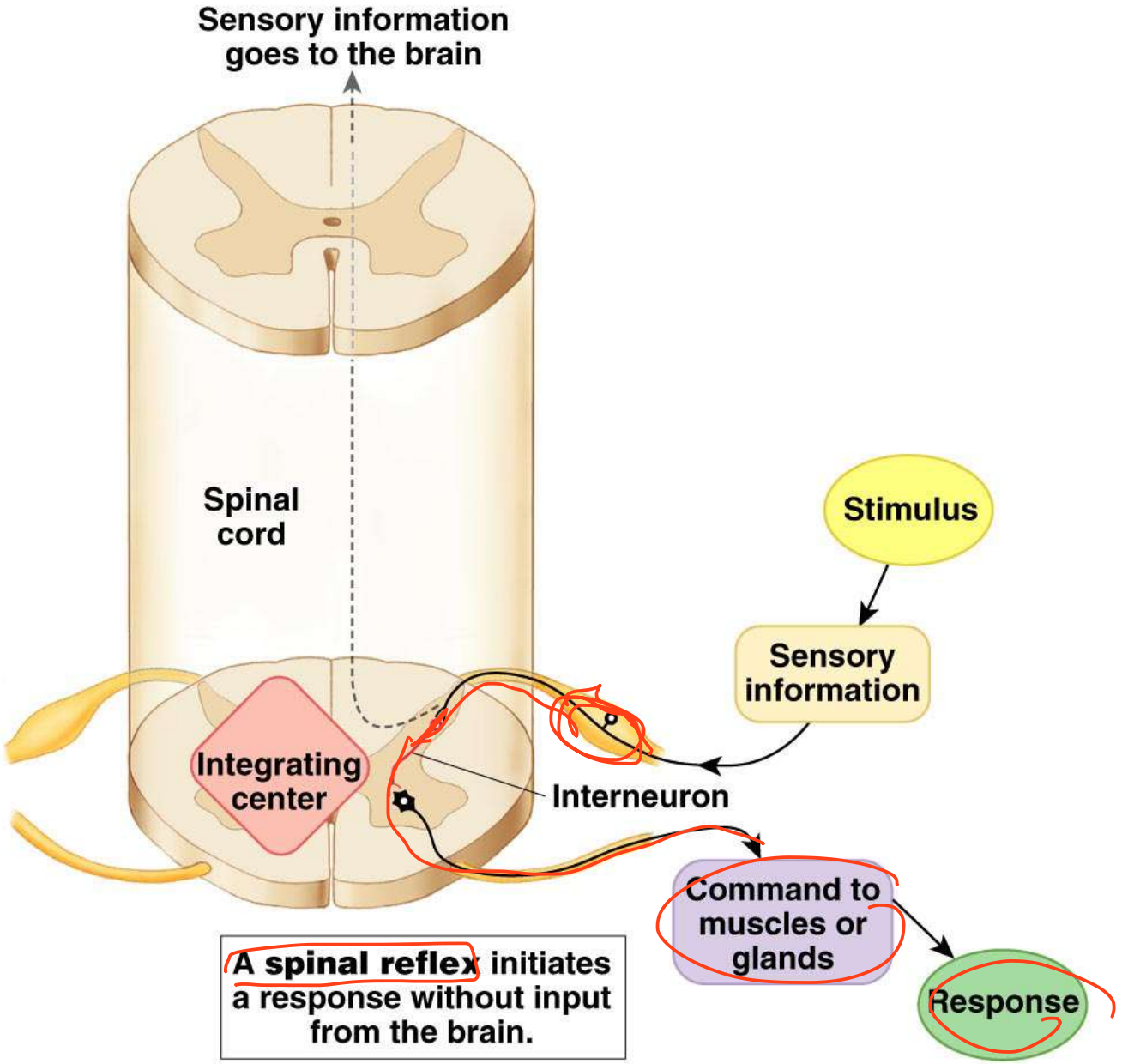


Figure 9-8

Dura matter ⇒ 2 layer

Meninges

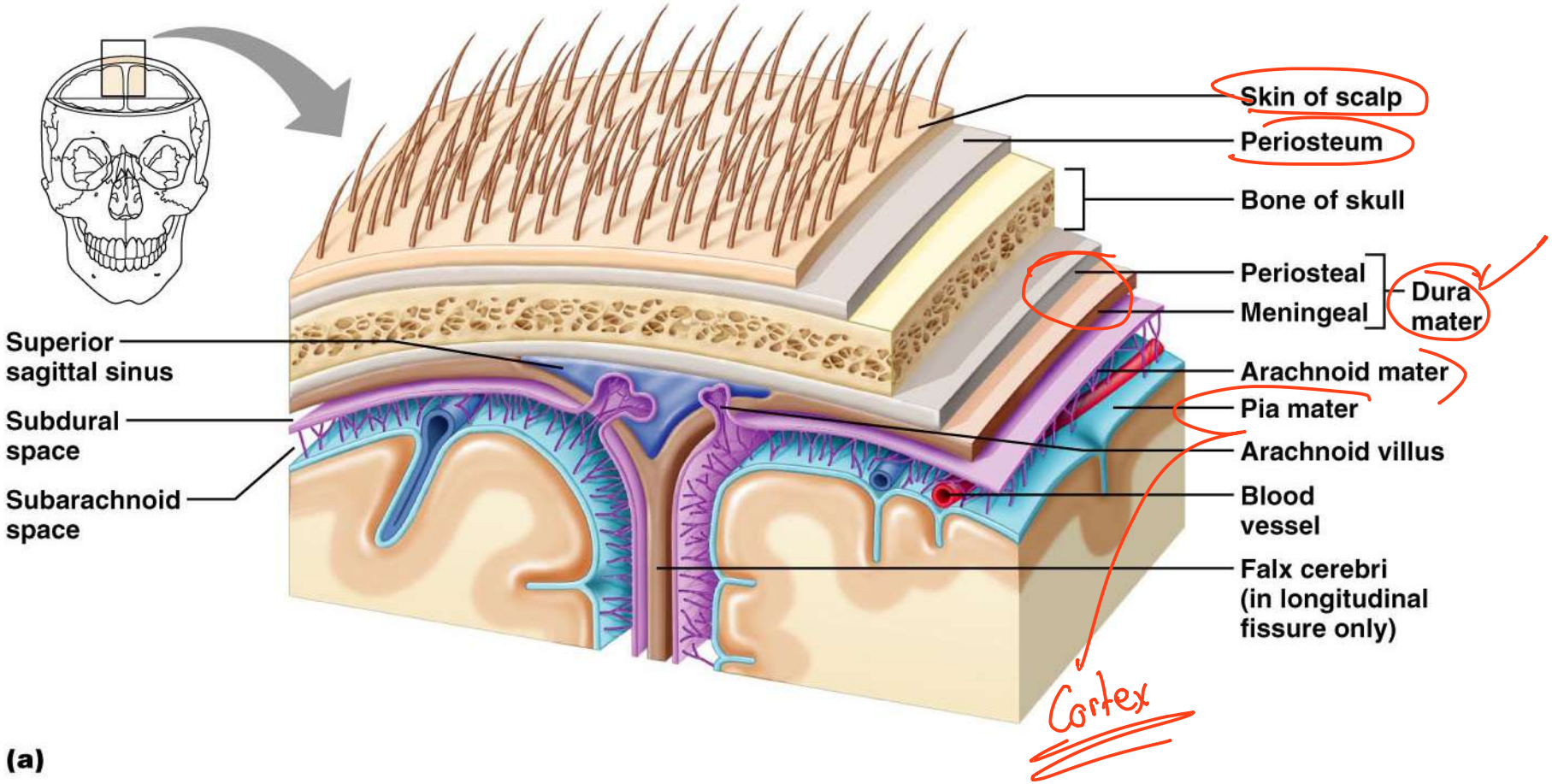


Figure 12.24a

Ventricles of the Brain

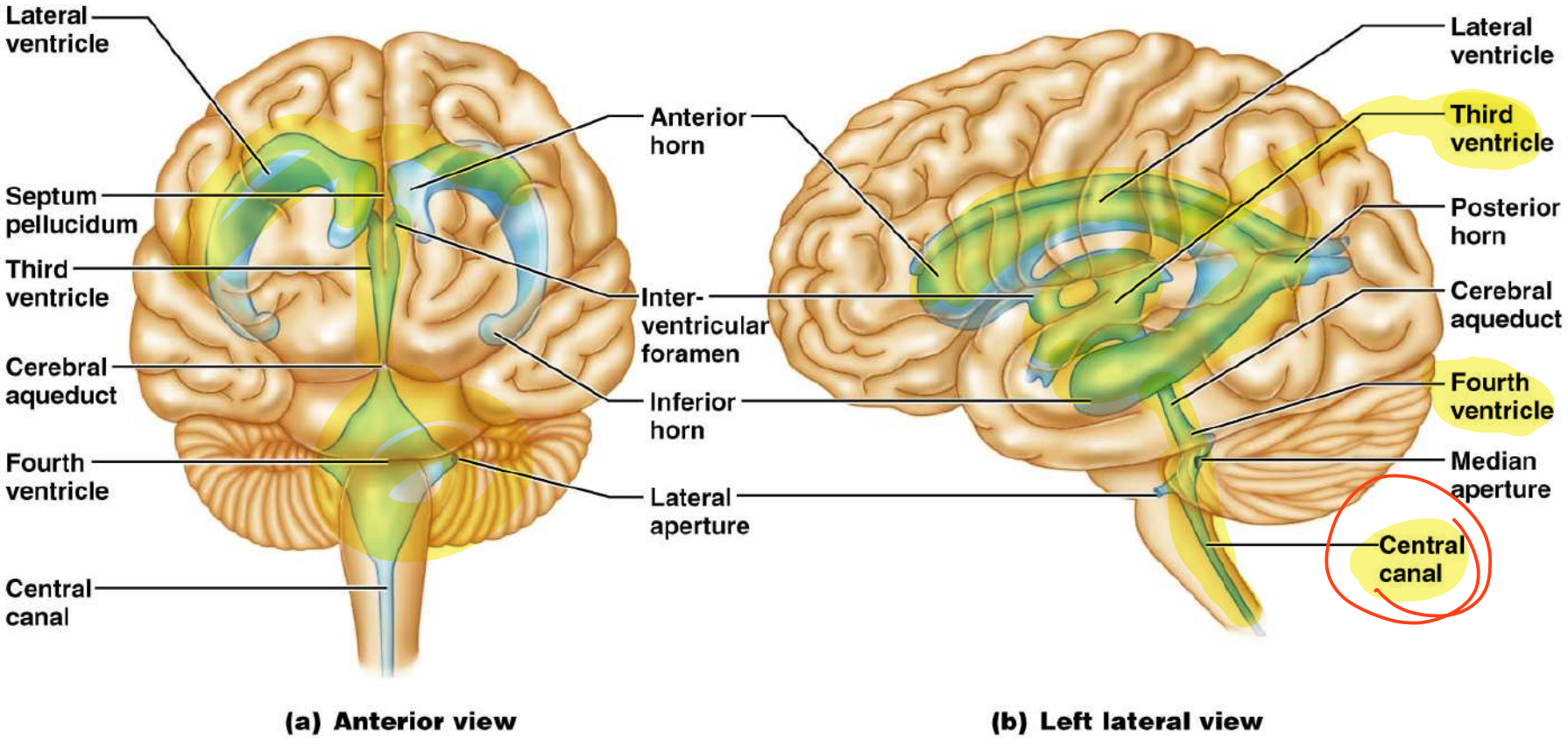


Figure 12.5

Cerebrospinal Fluid (CSF)

- Watery solution similar in composition to blood plasma
- Contains less protein and different ion concentrations than plasma
- Forms a liquid cushion that gives buoyancy to the CNS organs

Cerebrospinal Fluid (CSF)

- Prevents the brain from crushing under its own weight
- Protects the CNS from blows and other trauma
- Nourishes the brain and carries chemical signals throughout it

Circulation of CSF

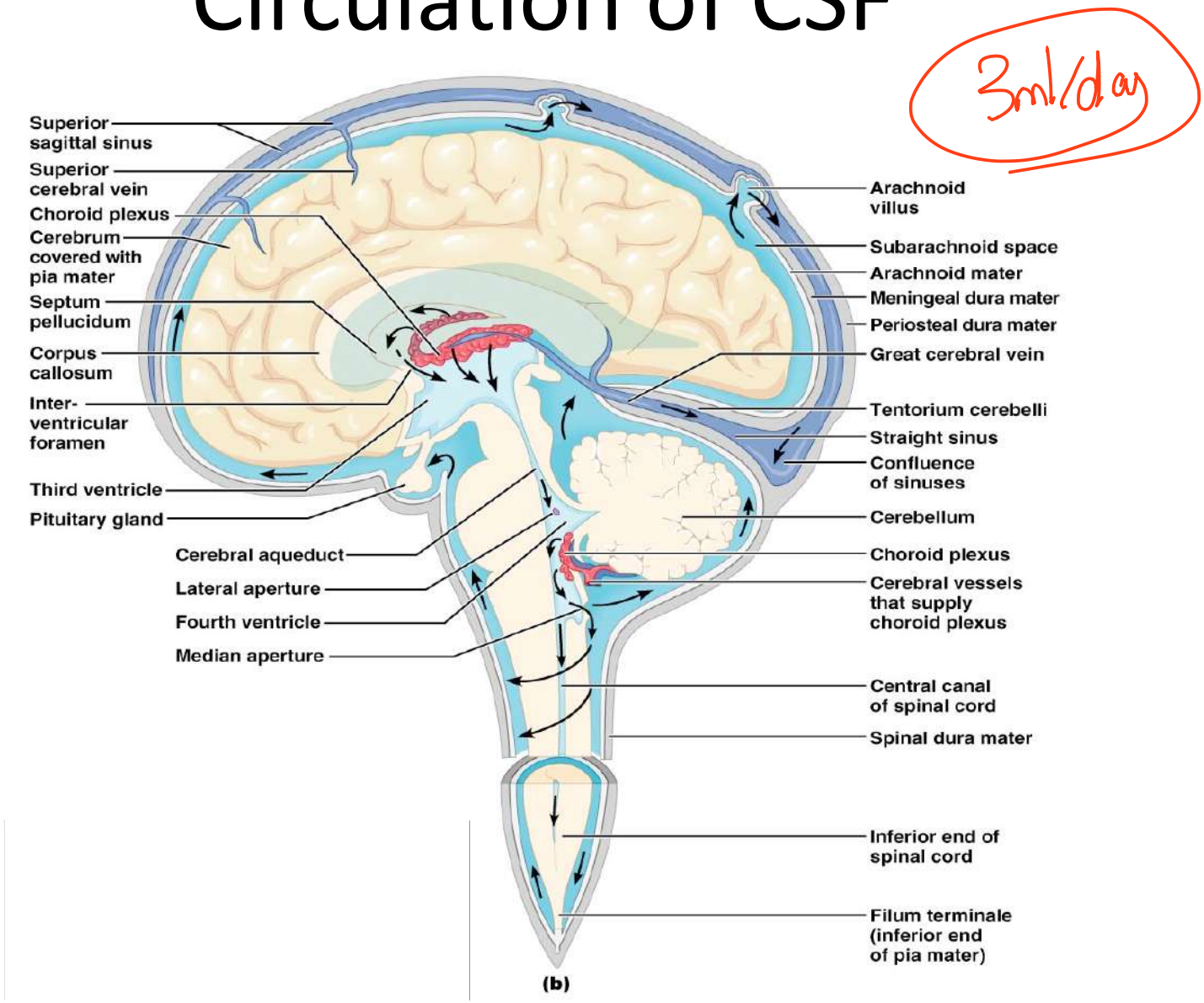


Figure 12.26b

PNS in the Nervous System

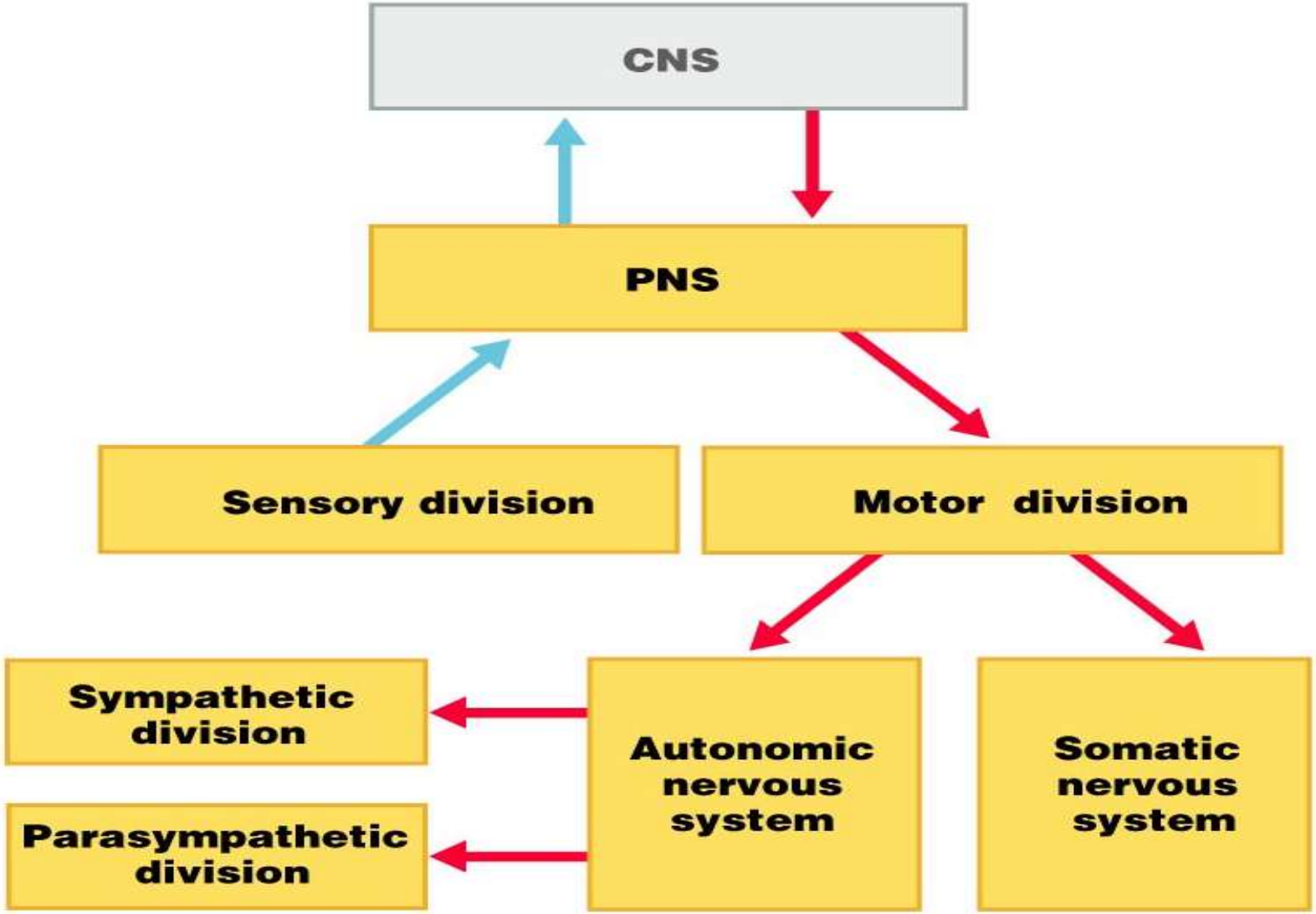


Figure 13.1

Structure of a Nerve

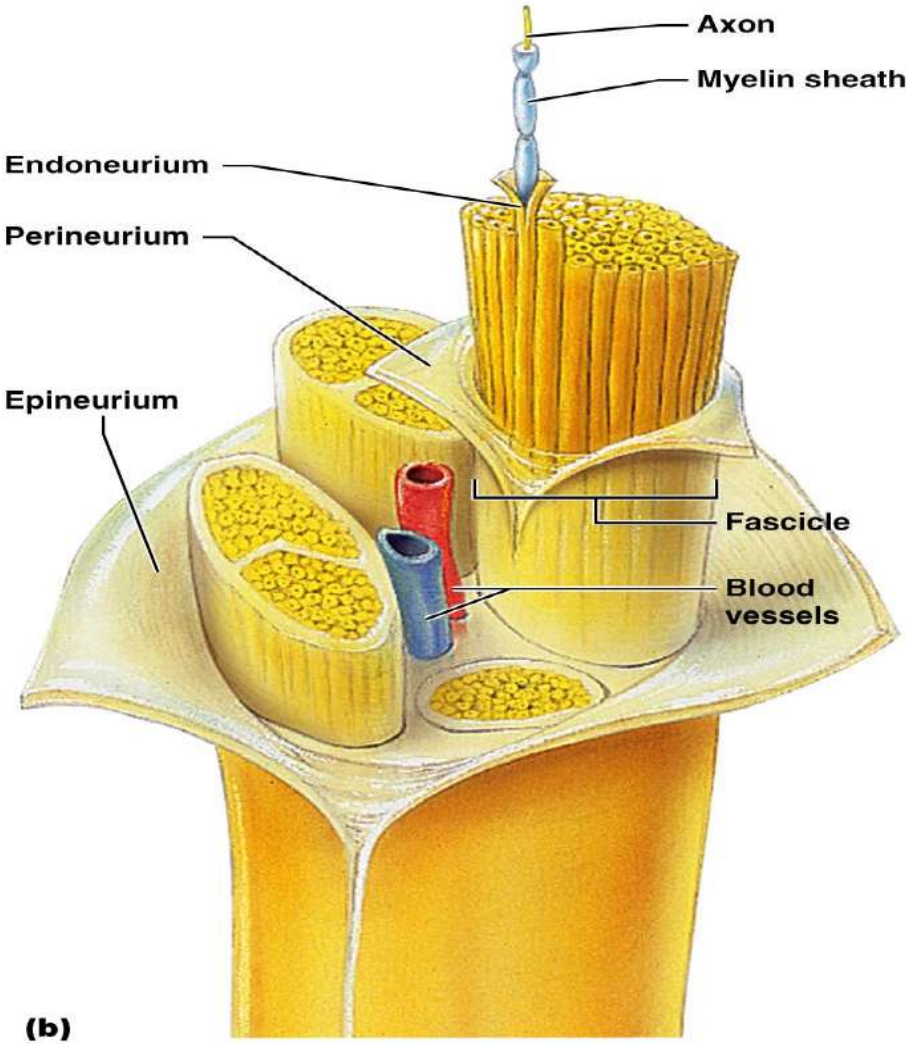


Figure 13.3b

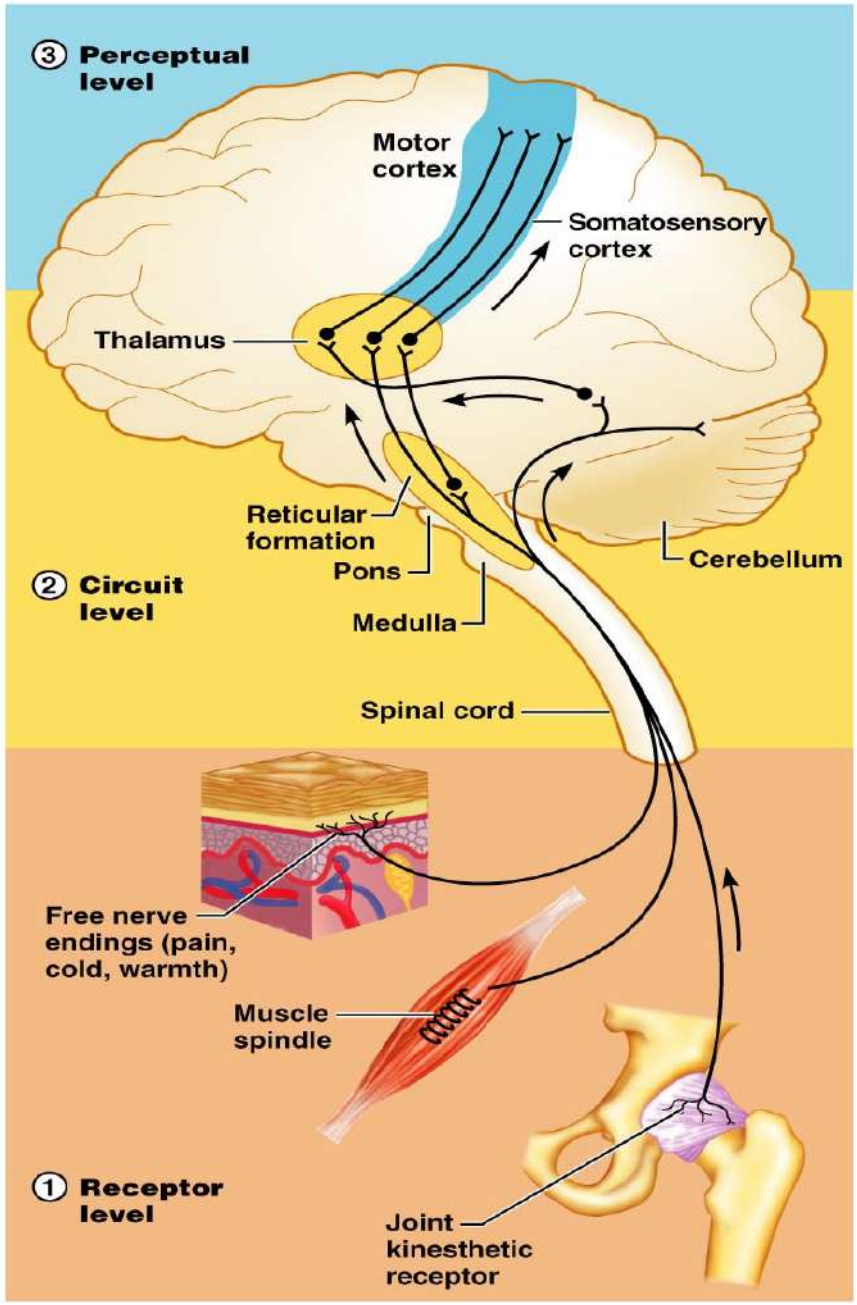

③ Perceptual level
Motor cortex
Somatosensory cortex
Thalamus
Reticular formation
Pons
Medulla
Cerebellum
② Circuit level
Spinal cord
Free nerve endings (pain, cold, warmth)
Muscle spindle
① Receptor level
Joint kinesthetic receptor

Figure 13.2

Comparison of Somatic and Autonomic Systems

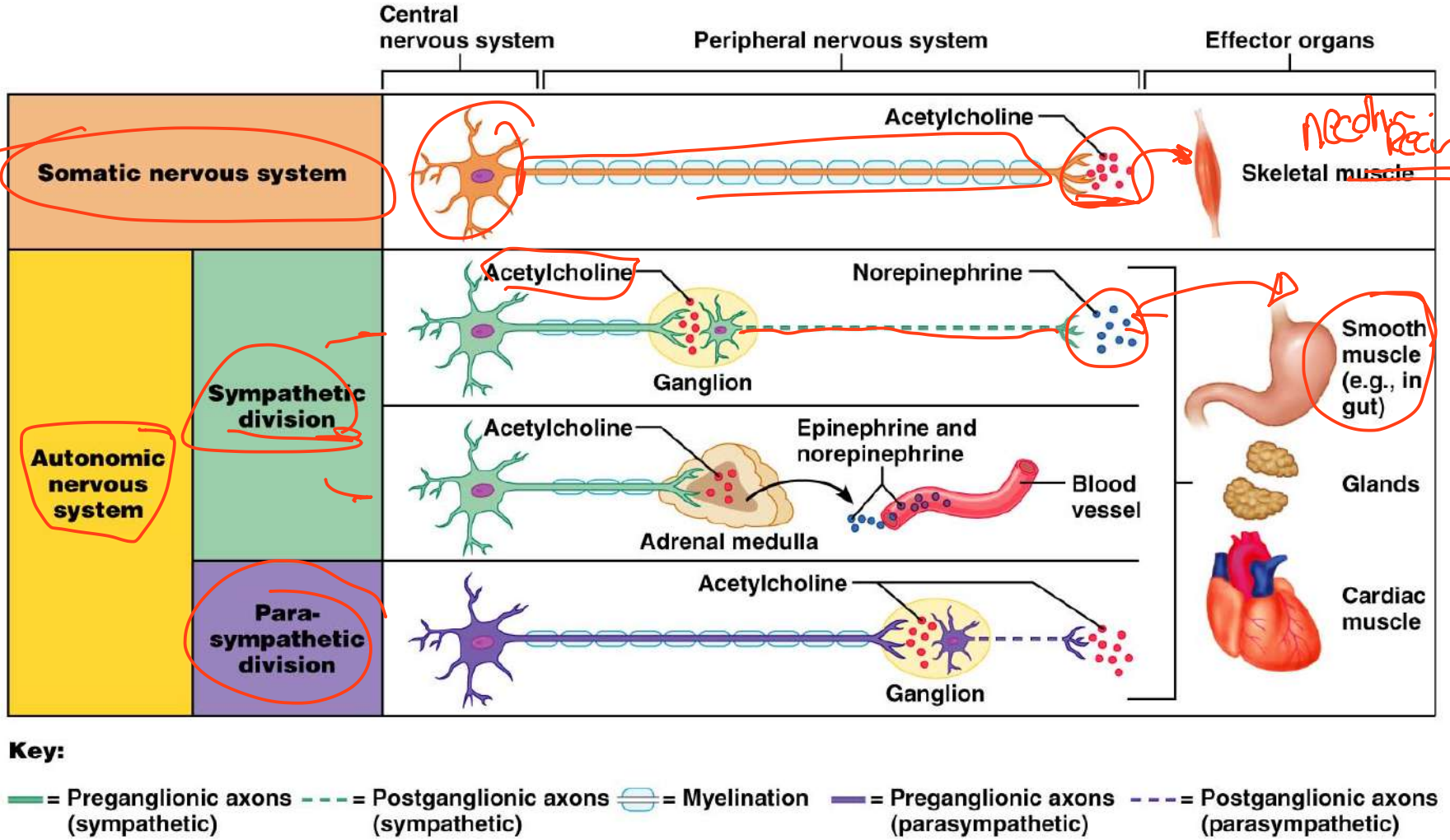


Figure 14.2

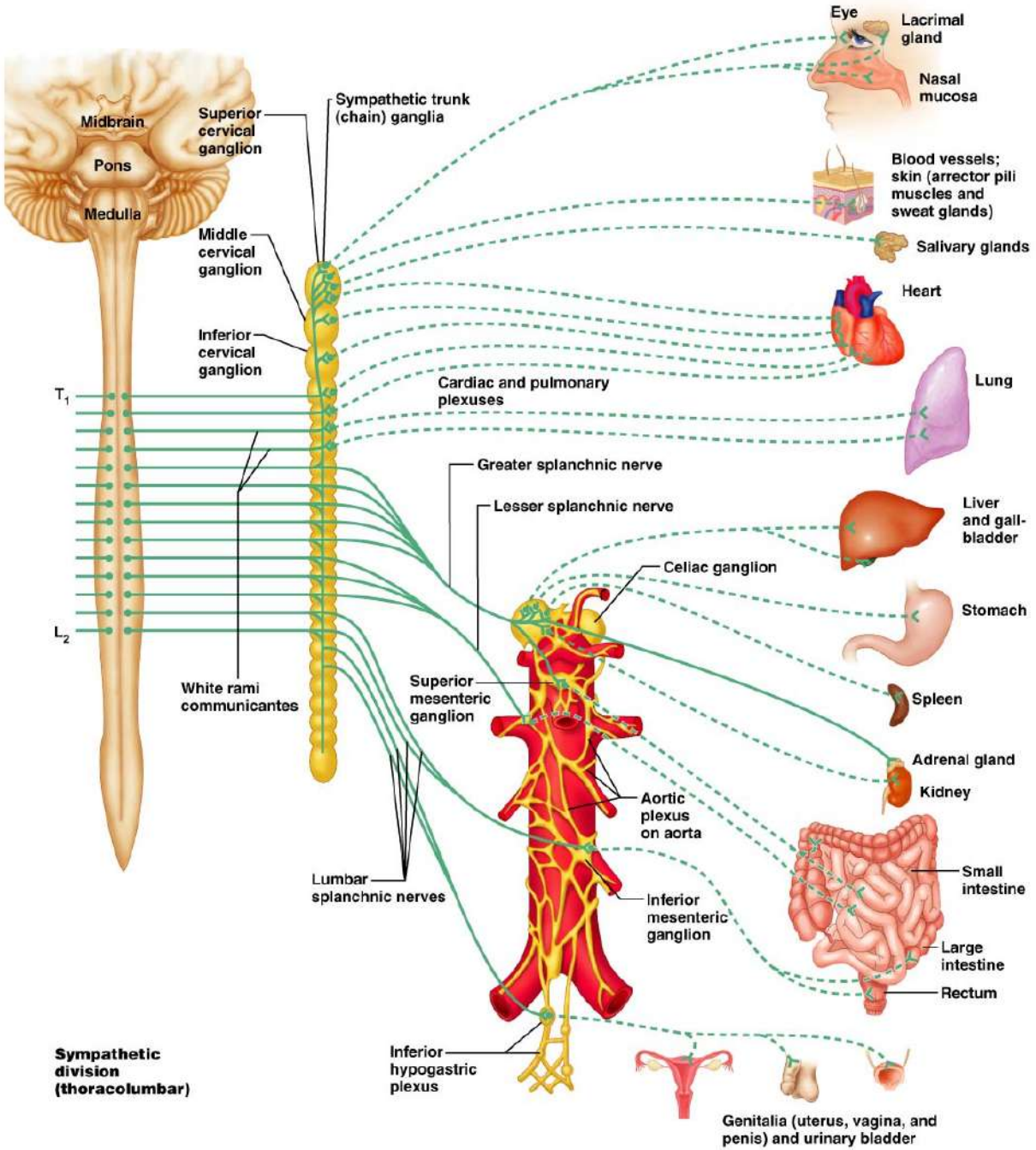

Midbrain
Pons
Medulla
Superior cervical ganglion
Sympathetic trunk (chain) ganglia
Middle cervical ganglion
Inferior cervical ganglion
T1
L2
White rami communicantes
Eye
Lacrimal gland
Nasal mucosa
Blood vessels; skin (arrector pili muscles and sweat glands)
Salivary glands
Heart
Lung
Cardiac and pulmonary plexuses
Greater splanchnic nerve
Lesser splanchnic nerve
Liver and gall-bladder
Celiac ganglion
Stomach
Spleen
Superior mesenteric ganglion
Adrenal gland
Kidney
Aortic plexus on aorta
Small intestine
Lumbar splanchnic nerves
Inferior mesenteric ganglion
Large intestine
Rectum
Inferior hypogastric plexus
Genitalia (uterus, vagina, and penis) and urinary bladder
Sympathetic division (thoracolumbar)

Figure 14.5

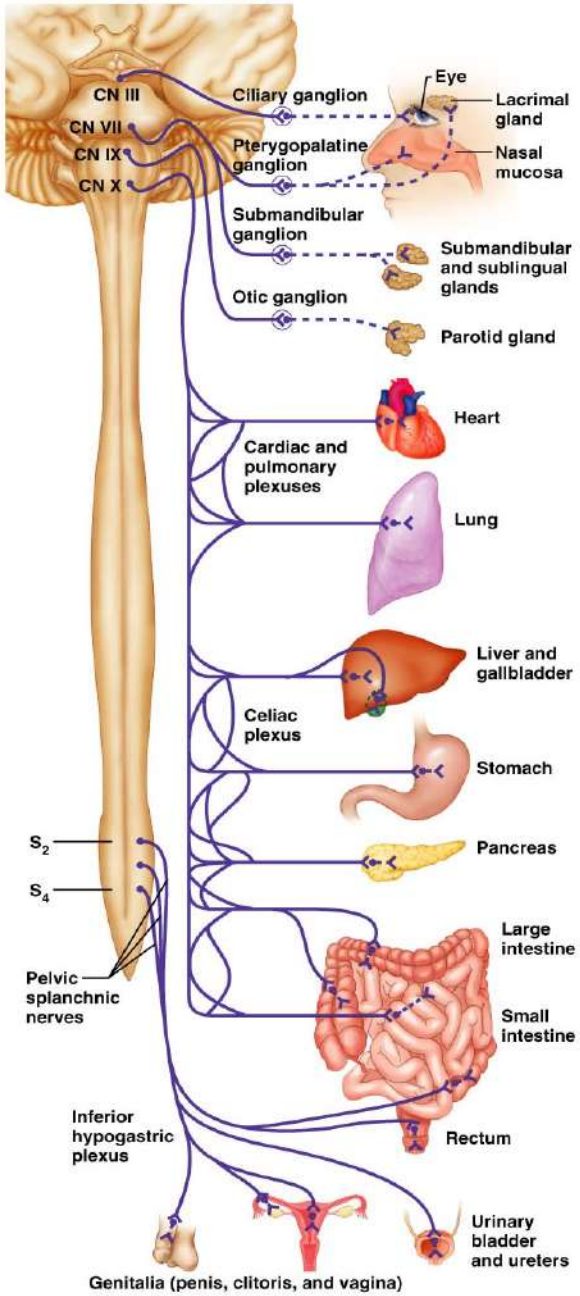

CN III
CN VII
CN IX
CN X
Ciliary ganglion
Eye
Lacrimal gland
Pterygopalatine ganglion
Nasal mucosa
Submandibular ganglion
Submandibular and sublingual glands
Otic ganglion
Parotid gland
Heart
Cardiac and pulmonary plexuses
Lung
Liver and gallbladder
Celiac plexus
Stomach
S_2
S_4
Pancreas
Large intestine
Pelvic splanchnic nerves
Small intestine
Inferior hypogastric plexus
Rectum
Urinary bladder and ureters
Genitalia (penis, clitoris, and vagina)

Figure 14.4

Cranial Nerves

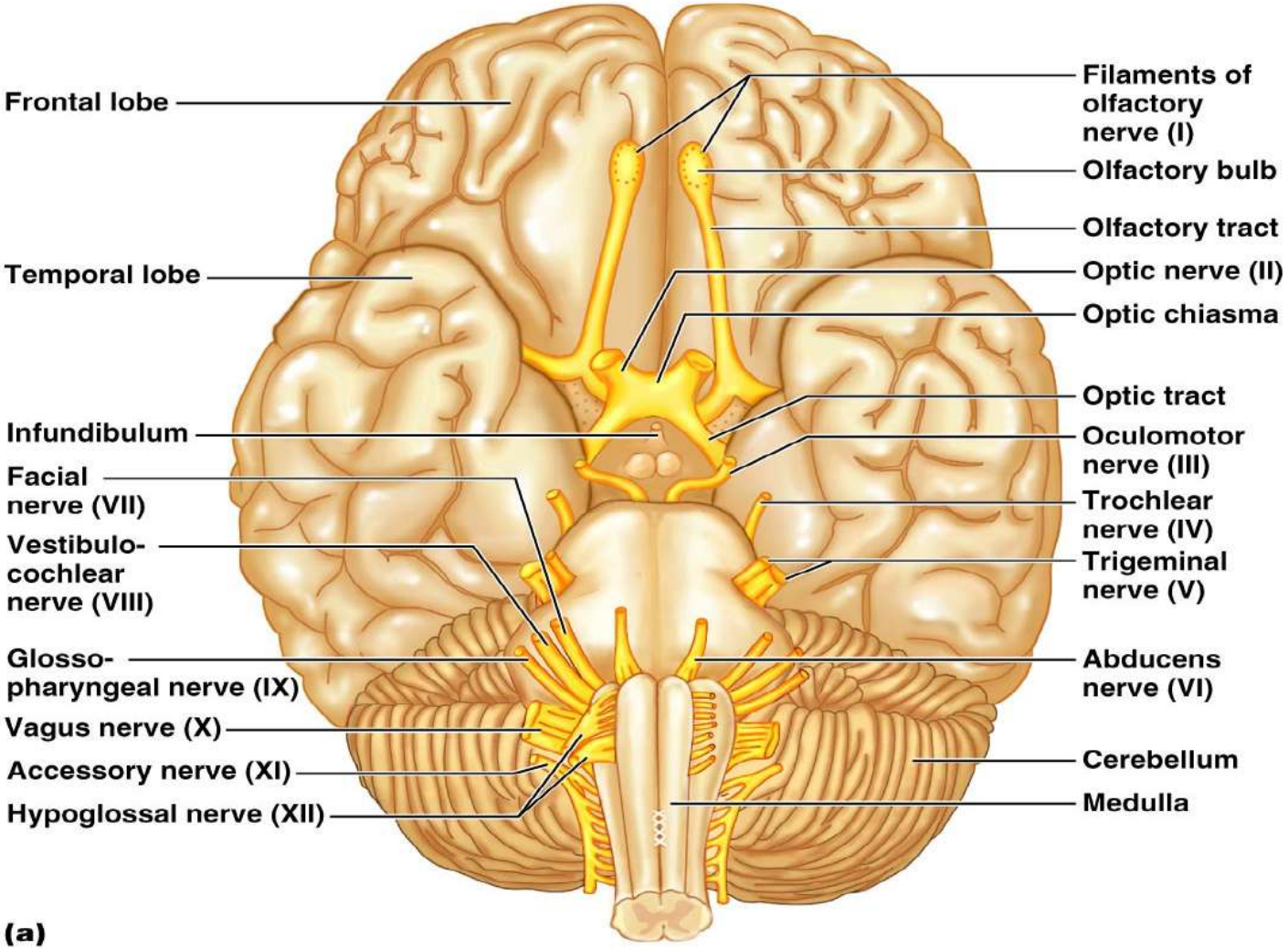


Figure 13.5a

Summary of Function of Cranial

Cranial nerves I – VI	Sensory function	Motor function	PS* fibers
I Olfactory	Yes (smell)	No	No
II Optic	Yes (vision)	No	No
III Oculomotor	No	Yes	Yes
IV Trochlear	No	Yes	No
V Trigeminal	Yes (general sensation)	Yes	No
VI Abducens	No	Yes	No

Cranial nerves VII – XII	Sensory function	Motor function	PS* fibers
VII Facial	Yes (taste)	Yes	Yes
VIII Vestibulocochlear	Yes (hearing and balance)	Some	No
IX Glossopharyngeal	Yes (taste)	Yes	Yes
X Vagus	Yes (taste)	Yes	Yes
XI Accessory	No	Yes	No
XII Hypoglossal	No	Yes	No

(b) *PS = parasympathetic

Figure 13.5b

Cranial Nerve I: Olfactory

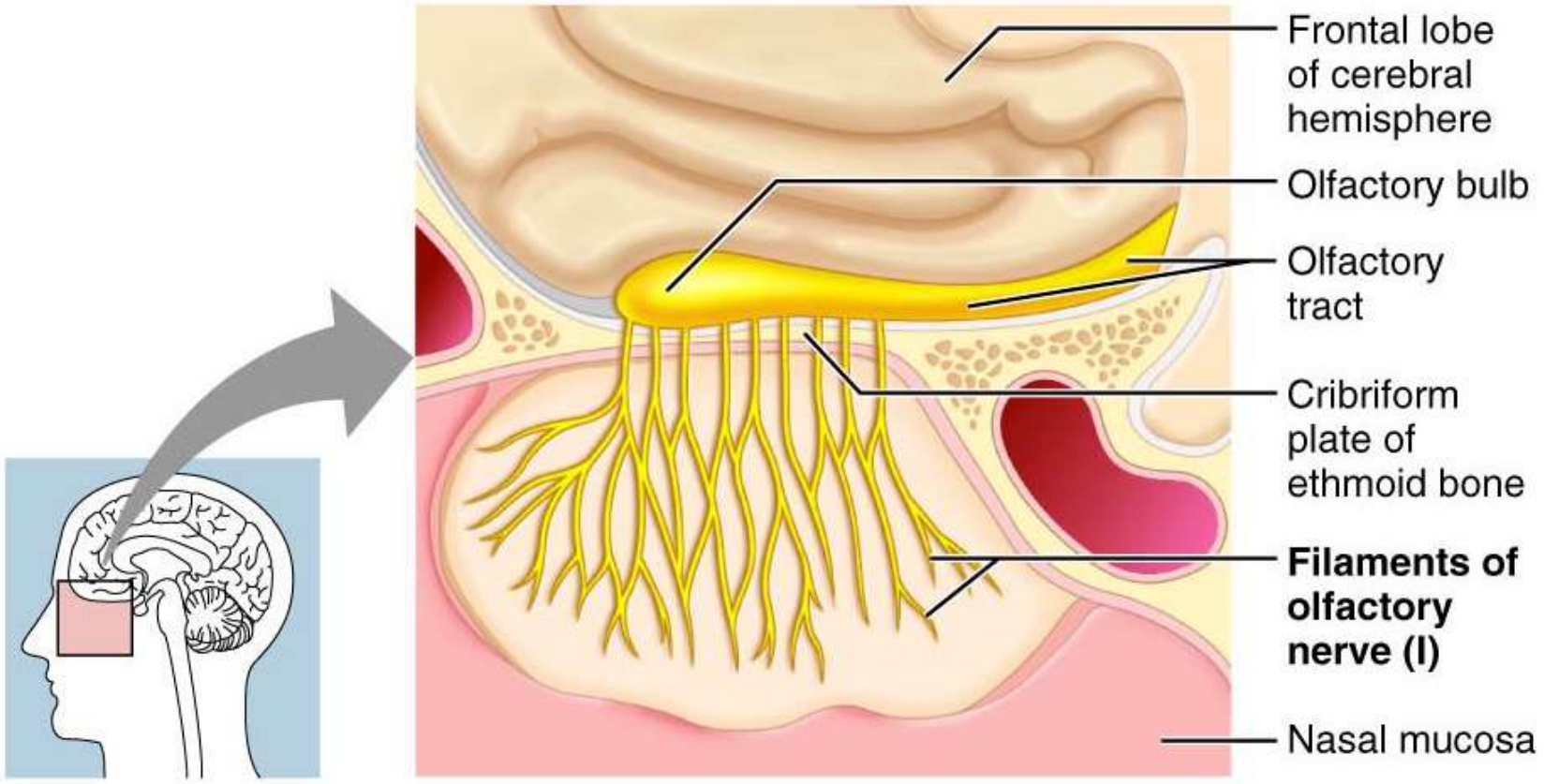


Figure I from Table 13.2

Cranial Nerve II: Optic

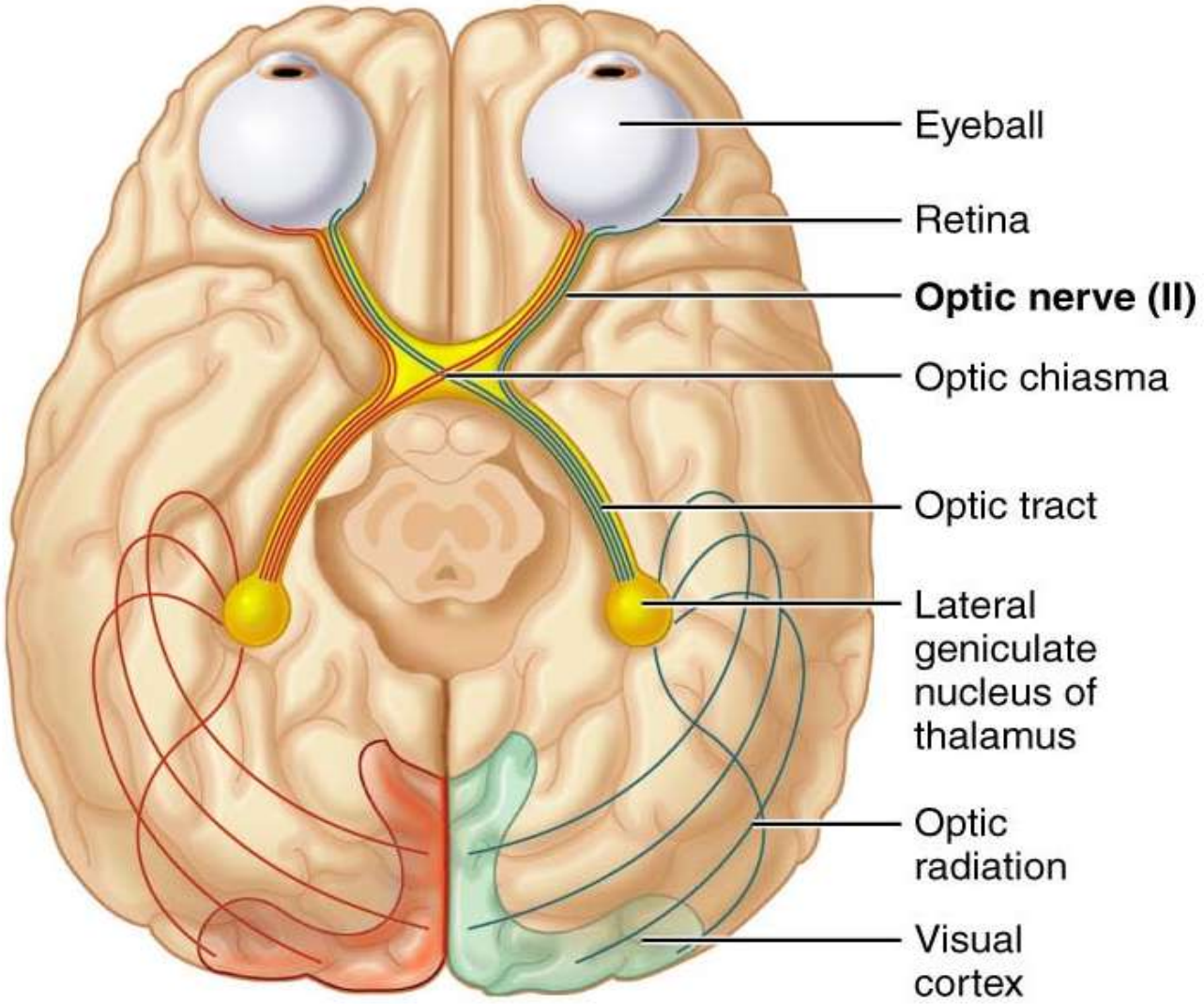


Figure II from Table 13.2

Cranial Nerve III: Oculomotor

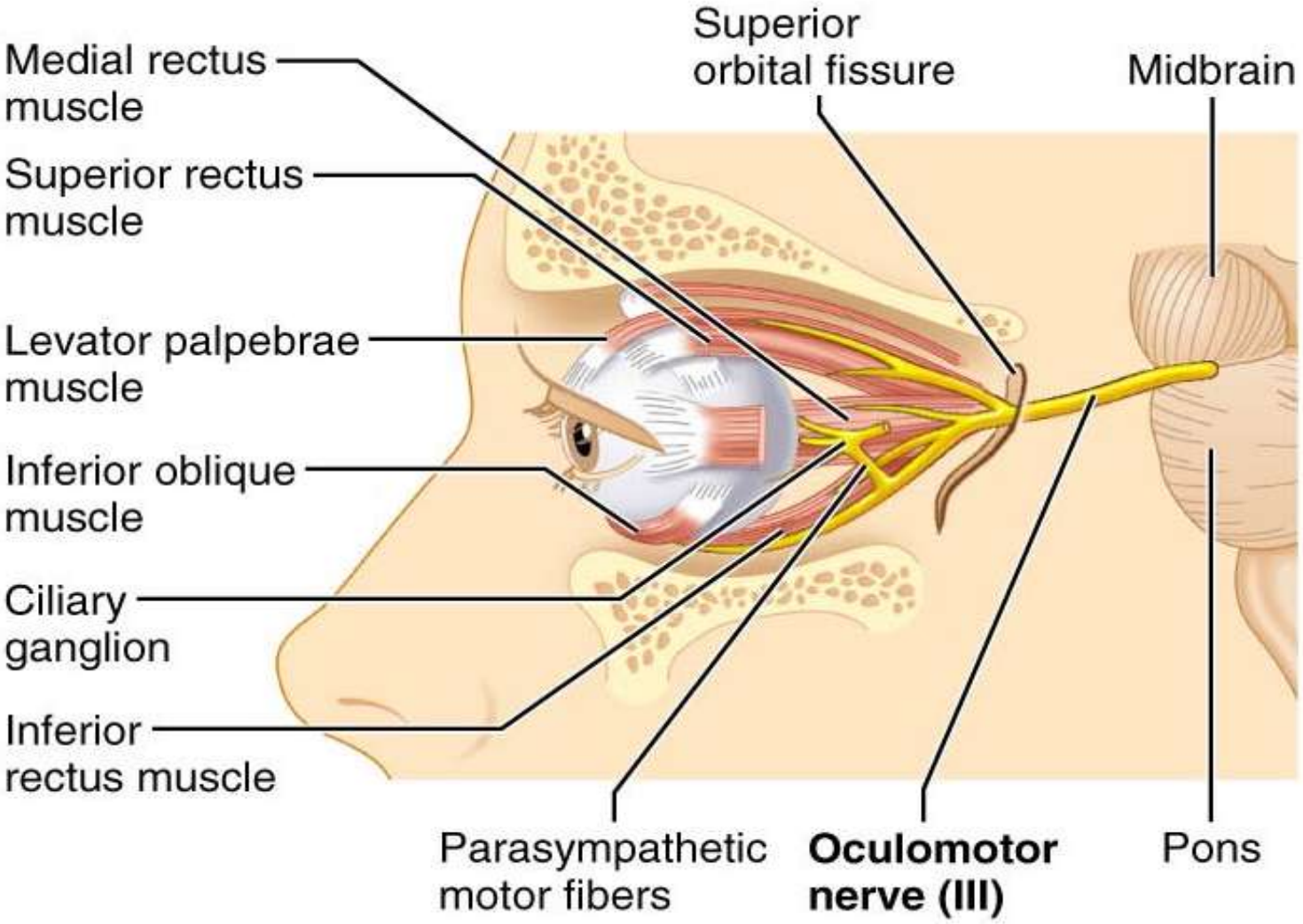
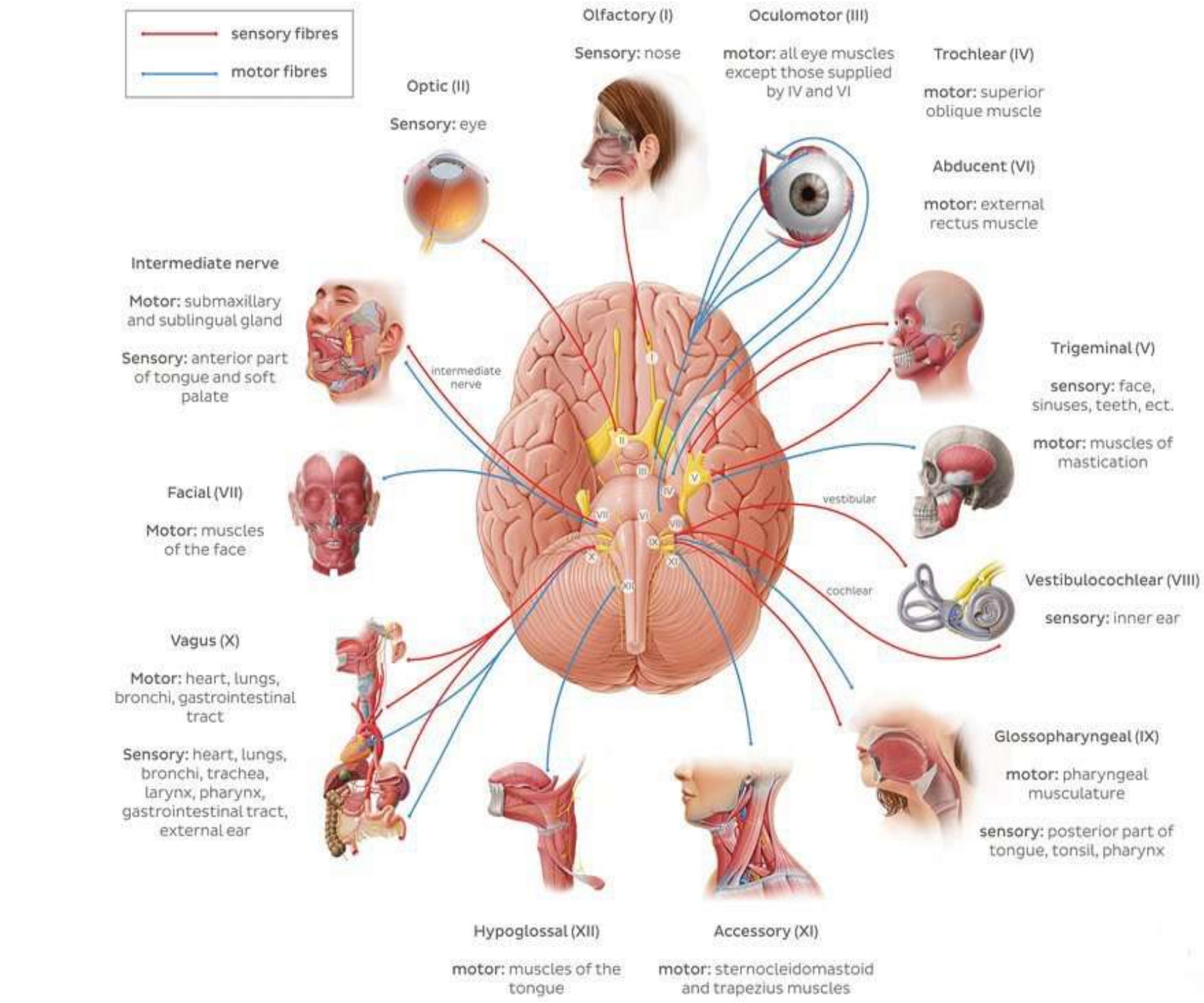
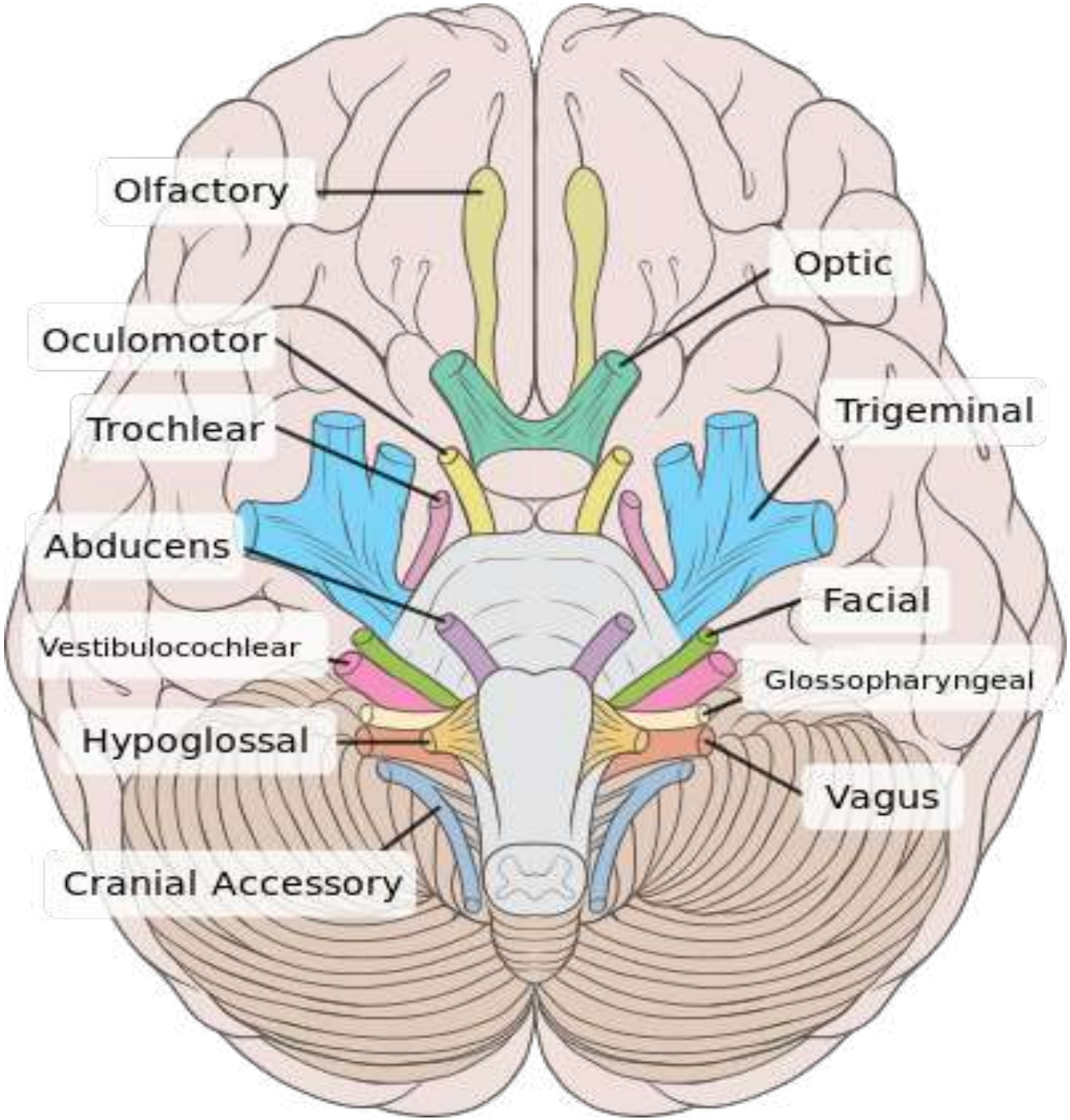
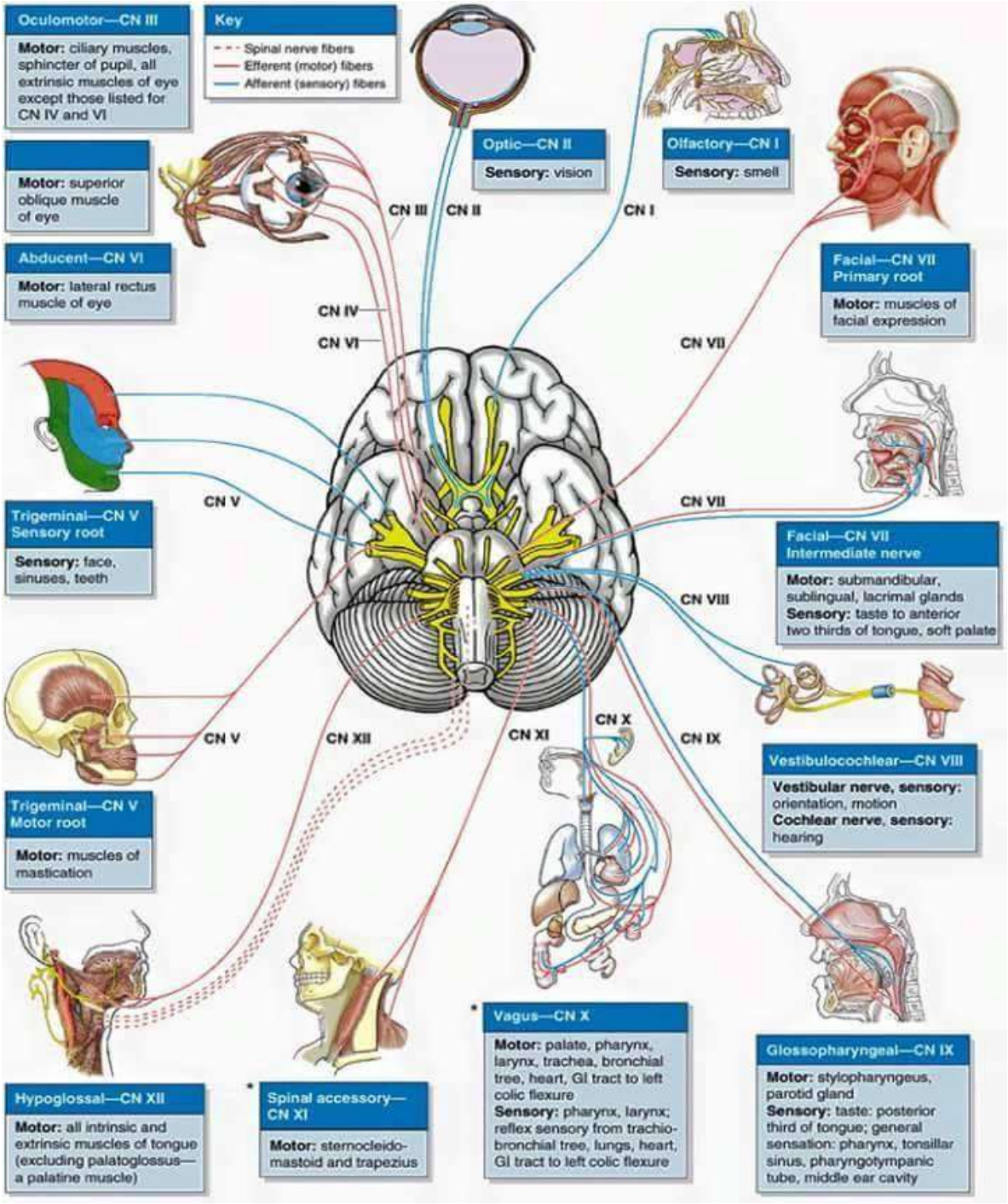


Figure III from Table 13.2


sensory fibres
motor fibres
Olfactory (I)
Sensory: nose
Oculomotor (III)
motor: all eye muscles except those supplied by IV and VI
Trochlear (IV)
motor: superior oblique muscle
Optic (II)
Sensory: eye
Abducent (VI)
motor: external rectus muscle
Intermediate nerve
Motor: submaxillary and sublingual gland
Sensory: anterior part of tongue and soft palate
intermediate nerve
Trigeminal (V)
sensory: face, sinuses, teeth, ect.
motor: muscles of mastication
Facial (VII)
Motor: muscles of the face
vestibular
cochlear
Vestibulocochlear (VIII)
sensory: inner ear
Vagus (X)
Motor: heart, lungs, bronchi, gastrointestinal tract
Sensory: heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear
Glossopharyngeal (IX)
motor: pharyngeal musculature
sensory: posterior part of tongue, tonsil, pharynx
Hypoglossal (XII)
motor: muscles of the tongue
Accessory (XI)
motor: sternocleidomastoid and trapezius muscles


Olfactory
Optic
Oculomotor
Trochlear
Trigeminal
Abducens
Facial
Vestibulocochlear
Glossopharyngeal
Hypoglossal
Vagus
Cranial Accessory


Oculomotor—CN III
Motor: ciliary muscles, sphincter of pupil, all extrinsic muscles of eye except those listed for CN IV and VI
Key
Spinal nerve fibers
Efferent (motor) fibers
Afferent (sensory) fibers
Motor: superior oblique muscle of eye
Optic—CN II
Sensory: vision
Olfactory—CN I
Sensory: smell
CN III
CN II
CN I
Abducent—CN VI
Motor: lateral rectus muscle of eye
Facial—CN VII Primary root
Motor: muscles of facial expression
CN IV
CN VI
CN VII
CN V
Trigeminal—CN V Sensory root
Sensory: face, sinuses, teeth
CN VII
Facial—CN VII Intermediate nerve
Motor: submandibular, sublingual, lacrimal glands
Sensory: taste to anterior two thirds of tongue, soft palate
CN VIII
CN V
CN XII
CN XI
CN X
CN IX
Vestibulocochlear—CN VIII
Vestibular nerve, sensory: orientation, motion
Cochlear nerve, sensory: hearing
Trigeminal—CN V Motor root
Motor: muscles of mastication
Hypoglossal—CN XII
Motor: all intrinsic and extrinsic muscles of tongue (excluding palatoglossus—a palatine muscle)
* Spinal accessory—CN XI
Motor: sternocleido-mastoid and trapezius
* Vagus—CN X
Motor: palate, pharynx, larynx, trachea, bronchial tree, heart, GI tract to left colic flexure
Sensory: pharynx, larynx; reflex sensory from trachio-bronchial tree, lungs, heart, GI tract to left colic flexure
Glossopharyngeal—CN IX
Motor: stylopharyngeus, parotid gland
Sensory: taste: posterior third of tongue; general sensation: pharynx, tonsillar sinus, pharyngotympanic tube, middle ear cavity

Referred Pain

- Pain stimuli arising from the viscera are perceived as somatic in origin
- This may be due to the fact that visceral pain afferents travel along the same pathways as somatic pain fibers

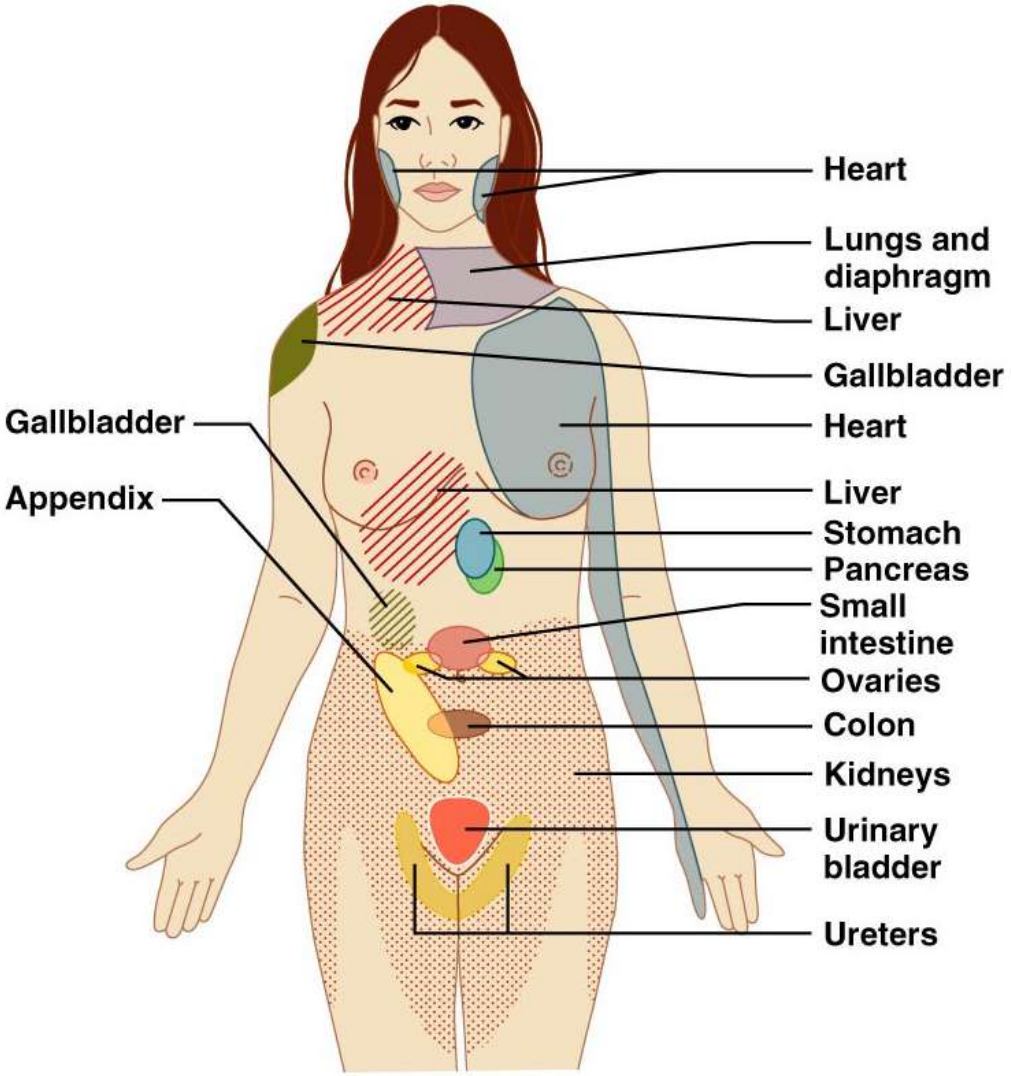


Figure 14.8