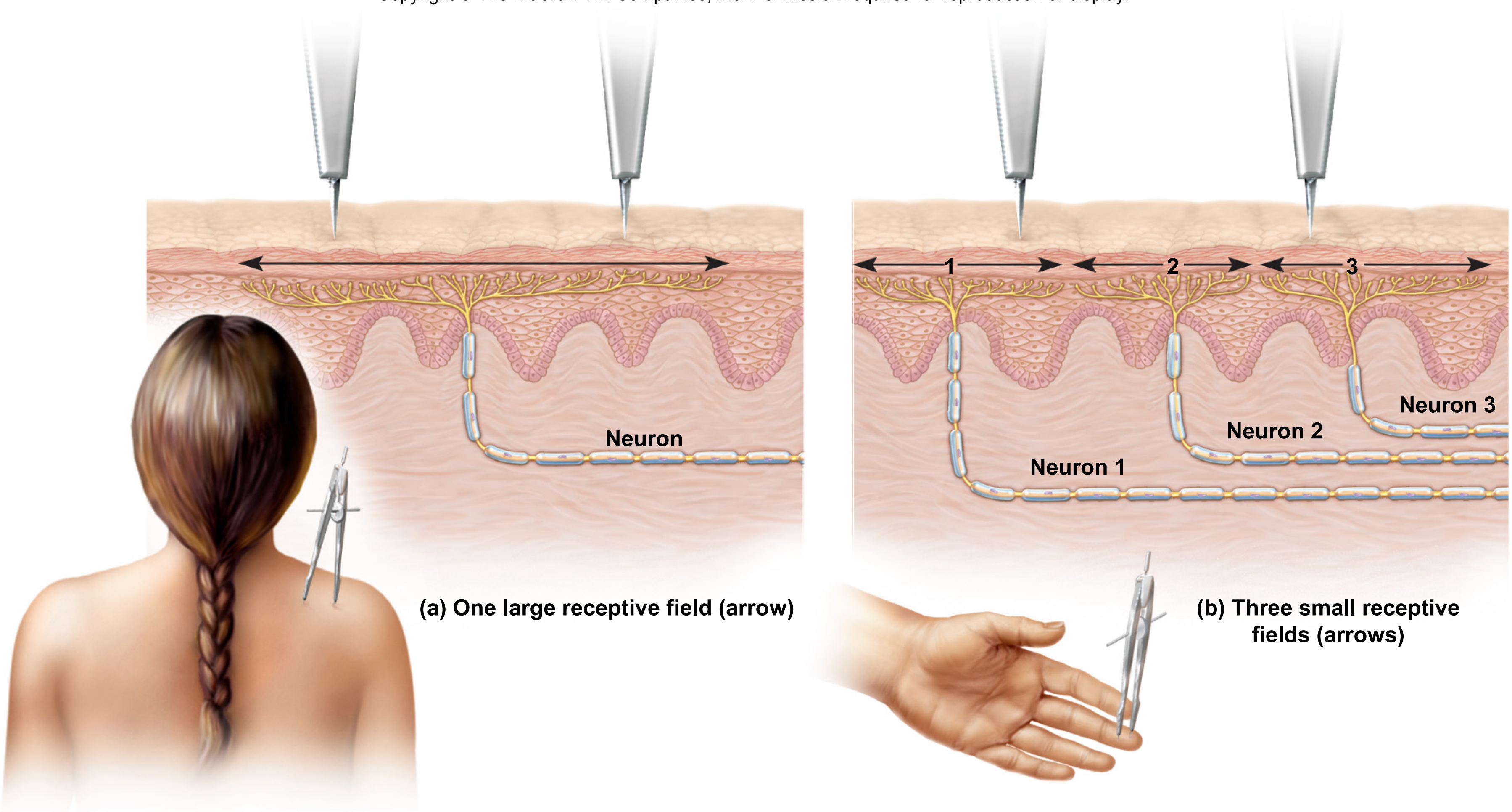
Receptive Fields



(a) One large receptive field (arrow)

(b) Three small receptive fields (arrows)

Figure 16.1

Hearing and Equilibrium

- **hearing –** a response to vibrating air molecules
- **equilibrium** – the sense of motion, body orientation, and balance
- both senses reside in the **inner ear**, a maze of fluid-filled passages and sensory cells
- fluid is set in motion and how the sensory cells convert this motion into an informative pattern of action potentials

Anatomy of Middle Ear

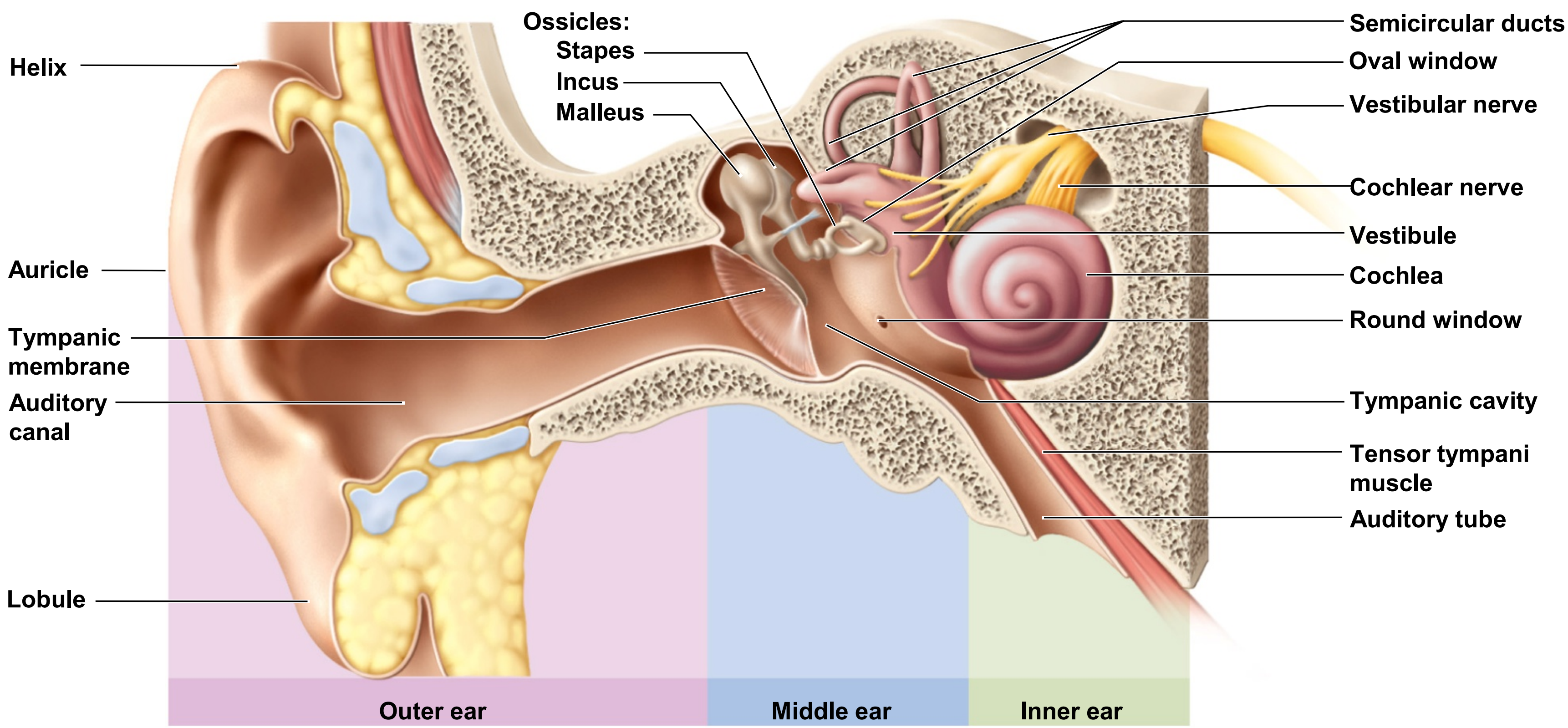


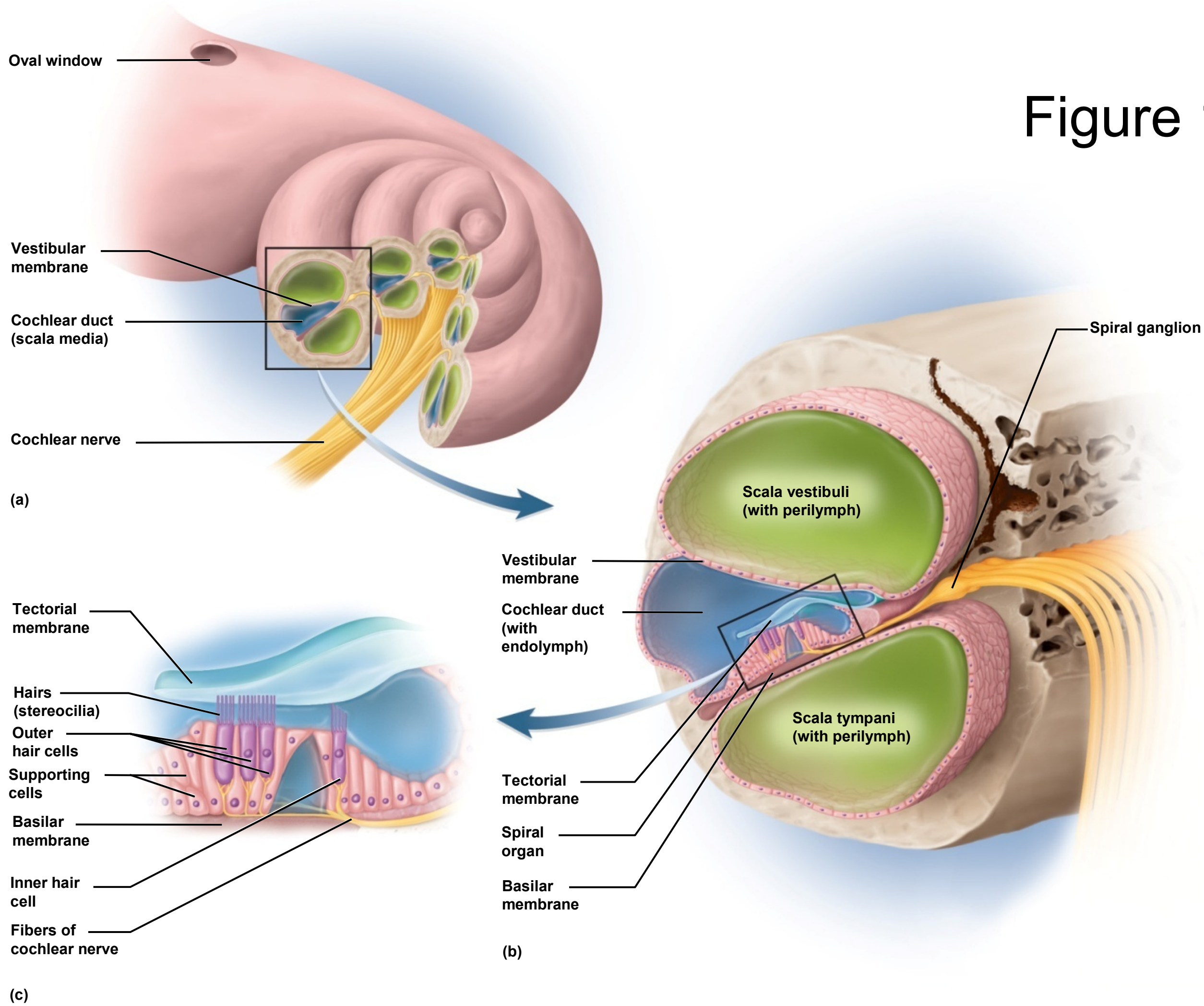
Figure 16.11

Middle-Ear Infection

- **Otitis media** (middle ear infection) is common in children
  - auditory tube is short and horizontal
  - infections easily spread from throat to tympanic cavity and mastoid air cells
- symptoms:
  - fluid accumulates in tympanic cavity producing pressure, pain, and impaired hearing
  - can spread leading to meningitis
  - can cause fusion of ear ossicles and hearing loss
- **tympanostomy** – lancing tympanic membrane and draining fluid from tympanic cavity
  - inserting a tube to relieve the pressure and allow infection to heal

Cochlea, Cochlear Duct and Spiral Organ

Figure 16.13



Spiral Organ (Organ of Corti)

- **spiral organ** has epithelium composed of **hair cells** and **supporting cells**
- hair cells have long, stiff microvilli called **stereocilia** on apical surface
    - gelatinous **tectorial membrane** rests on top of stereocilia

Stimulation of Cochlear Hair Cells

- vibration of ossicles causes vibration of basilar membrane under hair cells
  - as often as 20,000 times per second
  - hair cells move with basilar membrane

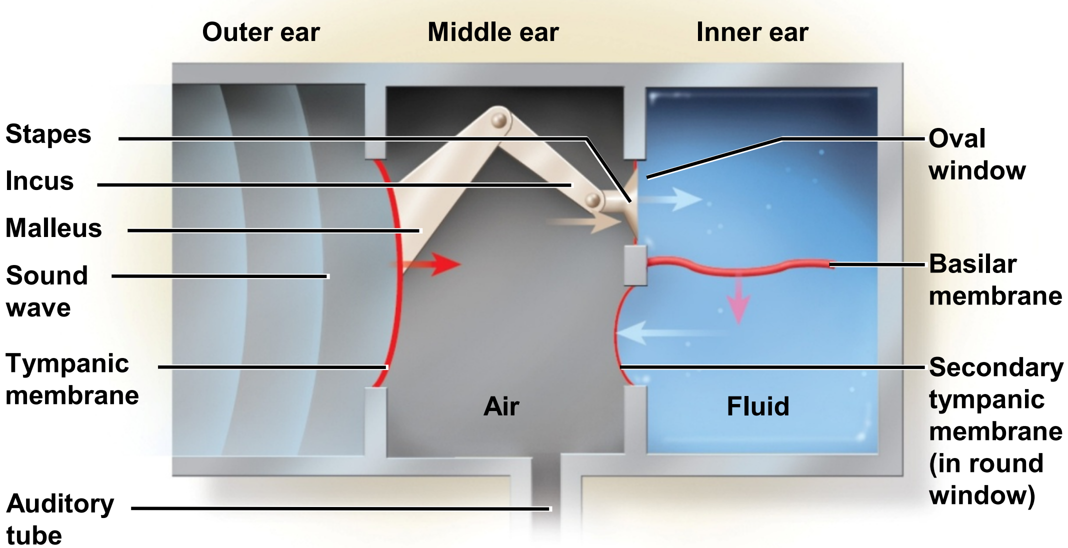


Figure 16.15

Basilar Membrane Frequency Response

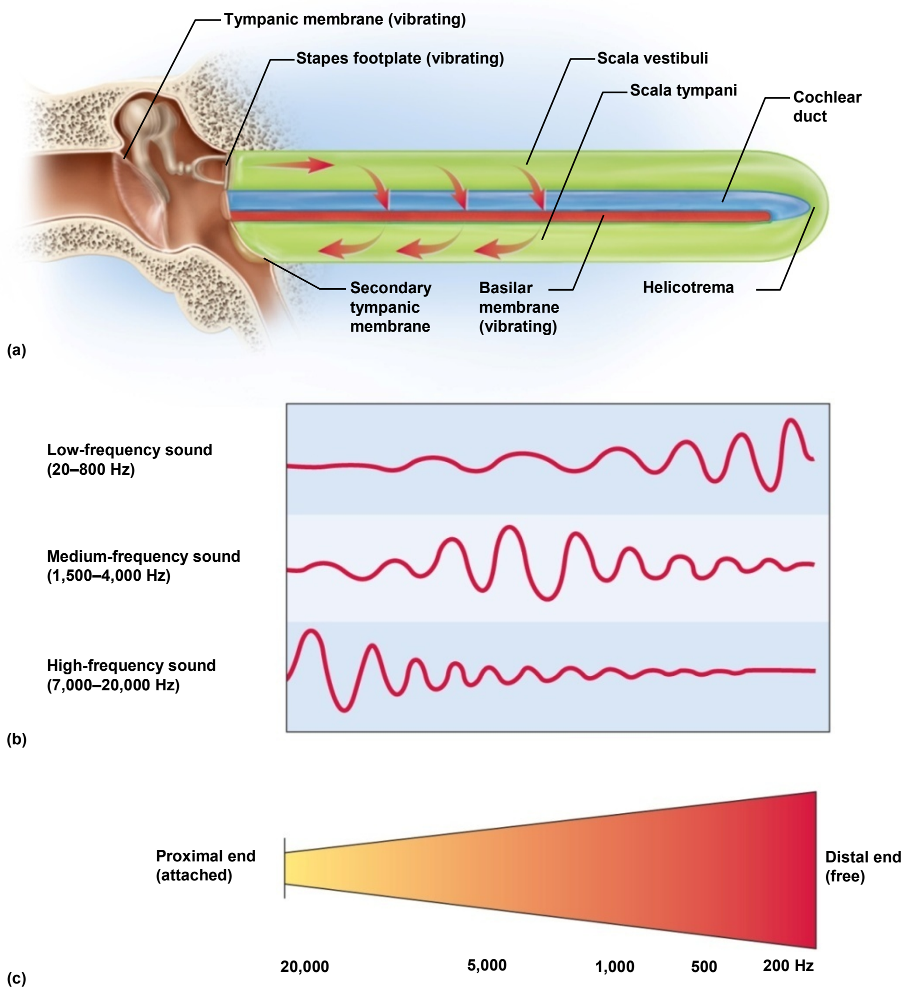


Figure 16.17

notice high and low frequency ends

Deafness

- **deafness** – hearing loss
  - **conductive deafness -** conditions interfere with transmission of vibrations to inner ear
    - damaged tympanic membrane, otitis media, blockage of auditory canal, and otosclerosis
      - **otosclerosis** - fusion of auditory ossicles that prevents their free vibration
  - **sensorineural (nerve) deafness** - death of hair cells or any nervous system elements concerned with hearing
    - factory workers, musicians and construction workers

Semicircular Ducts

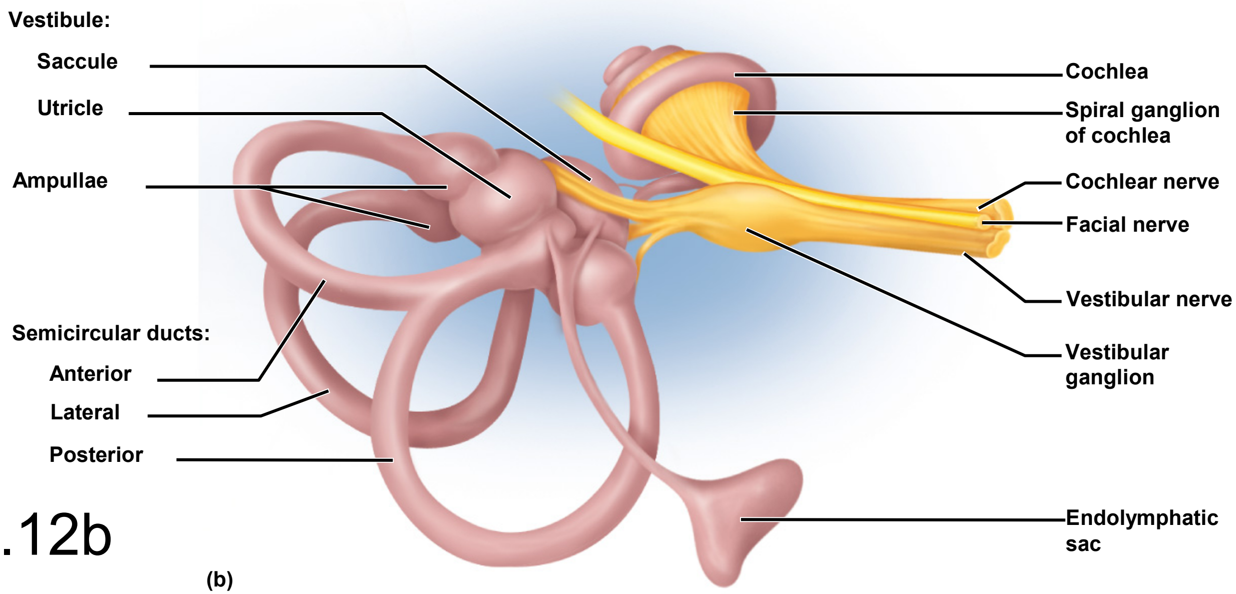
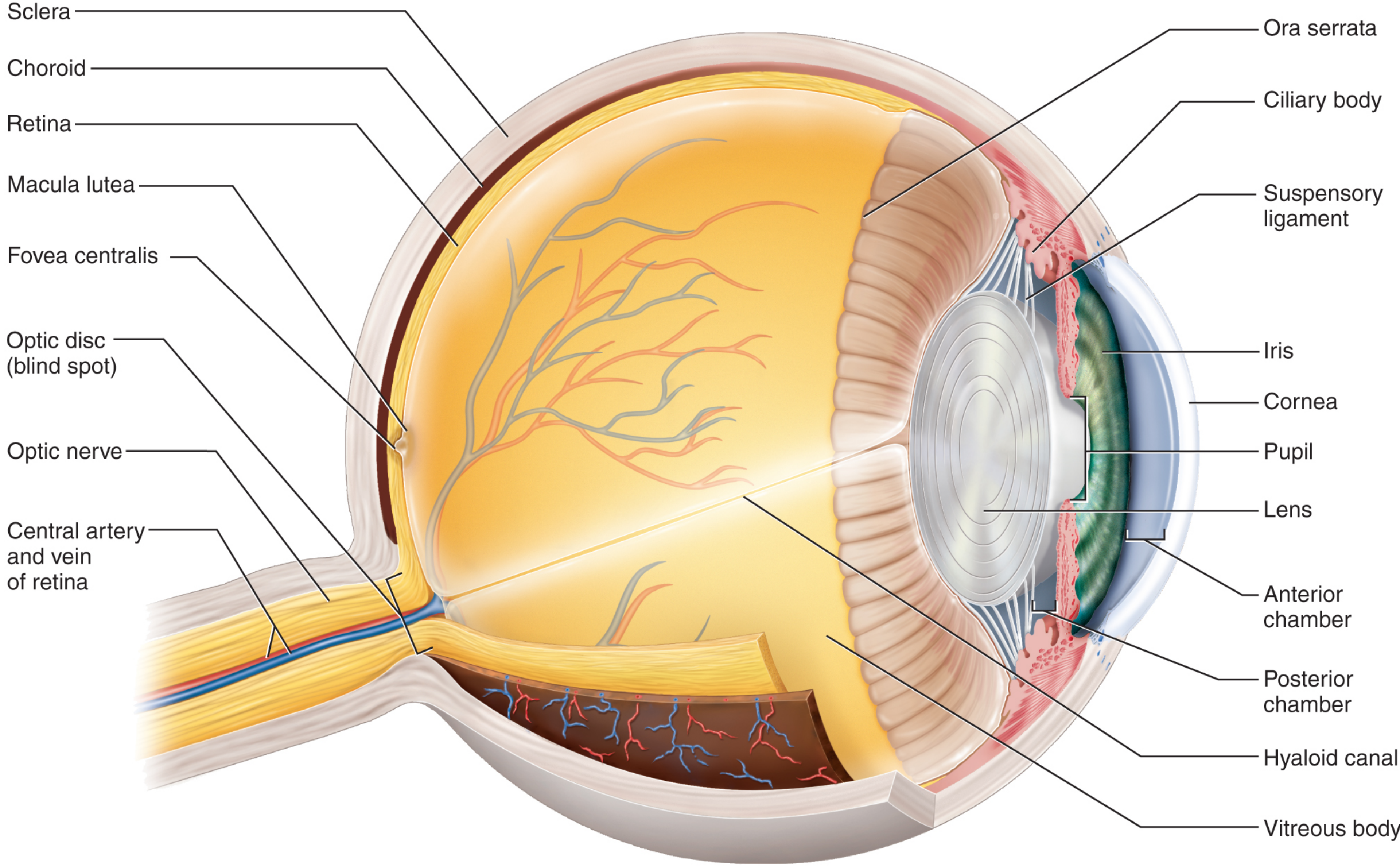


Figure 16.12b

- **rotary movements** detected by the three semicircular ducts


Sclera
Choroid
Retina
Macula lutea
Fovea centralis
Optic disc
(blind spot)
Optic nerve
Central artery
and vein
of retina
Ora serrata
Ciliary body
Suspensory
ligament
Iris
Cornea
Pupil
Lens
Anterior
chamber
Posterior
chamber
Hyaloid canal
Vitreous body

Optical Components

- transparent elements that admit light rays, refract (bend) them, and focus images on the retina
  - **cornea**
    - transparent cover on anterior surface of eyeball
  - **aqueous humor**
    - Between cornea and lens
  - **lens**
    - Flattened, tightly compressed, transparent cells form lens
    - suspended by suspensory ligaments from ciliary body
    - changes shape to help focus light
      - rounded with no tension or flattened with pull of suspensory ligaments
  - **vitreous body (humor)** fills vitreous chamber
    - jelly fills space between lens and retina

Neural Components

- includes retina and optic nerve
- **retina**
  - pressed against rear of eyeball by vitreous humor
  - detached retina causes blurry areas in field of vision and leads to blindness
  - **macula lutea** – patch of cells on visual axis of eye
  - **fovea centralis** – pit in center of macula lutea

Eye diseases

- **cataract** - clouding of lens
- **glaucoma** - elevated pressure within the eye
  - death of retinal cells due to compression of blood vessels and lack of oxygen
    - illusory flashes of light are an early symptom
    - colored halos around lights are late symptom
    - lost vision can not be restored
- **Macular degeneration**
  - Caused by leaky capilaries under the macula – destroys retina in the center of visual field

Formation of an Image

- light passes through lens to form tiny inverted image on retina
- **iris diameter** controlled by two sets of contractile elements
  - **pupillary constrictor** - smooth muscle encircling the pupil
    - **parasympathetic** stimulation narrows pupil
  - **pupillary dilator** - spokelike myoepithelial cells
    - **sympathetic** stimulation widens pupil
- pupillary constriction and dilation occurs in two situations
  - when light intensity changes
  - when our gaze shifts between distant and nearby objects
- **photopupillary reflex** – pupillary constriction in response to light
  - **consensual light reflex** because both pupils constrict even if only one eye is illuminated

Sensory Transduction in the Retina

- conversion of light energy into action potentials occurs in the retina
- **structure of retina**
  - **pigment epithelium** – most posterior part of retina
    - absorbs stray light so visual image is not degraded
  - **neural components** of the retina from the rear of the eye forward
    - **photoreceptor cells** – absorb light and generate a chemical or electrical signal
      - rods, cones, and certain ganglion cells
      - only rods and cones produce visual images
    - **bipolar cells** – synapse with rods and cones and are first-order neurons of the visual pathway
    - **ganglion cells** – largest neurons in the retina and are the second-order neurons of the visual pathway

Photoreceptor Cells

- light absorbing cells

  - **rod cells** (night - vision or monochromatic vision)
    - stack of 1,000 membranous discs studded with globular proteins, the visual pigment, **rhodopsin**

  - **cone cells** (color and day vision)
    - similar except outer segment tapers

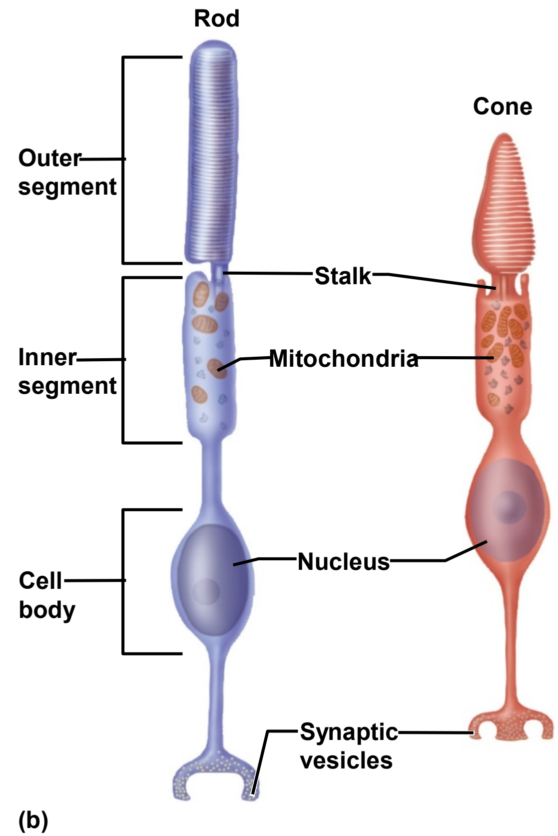
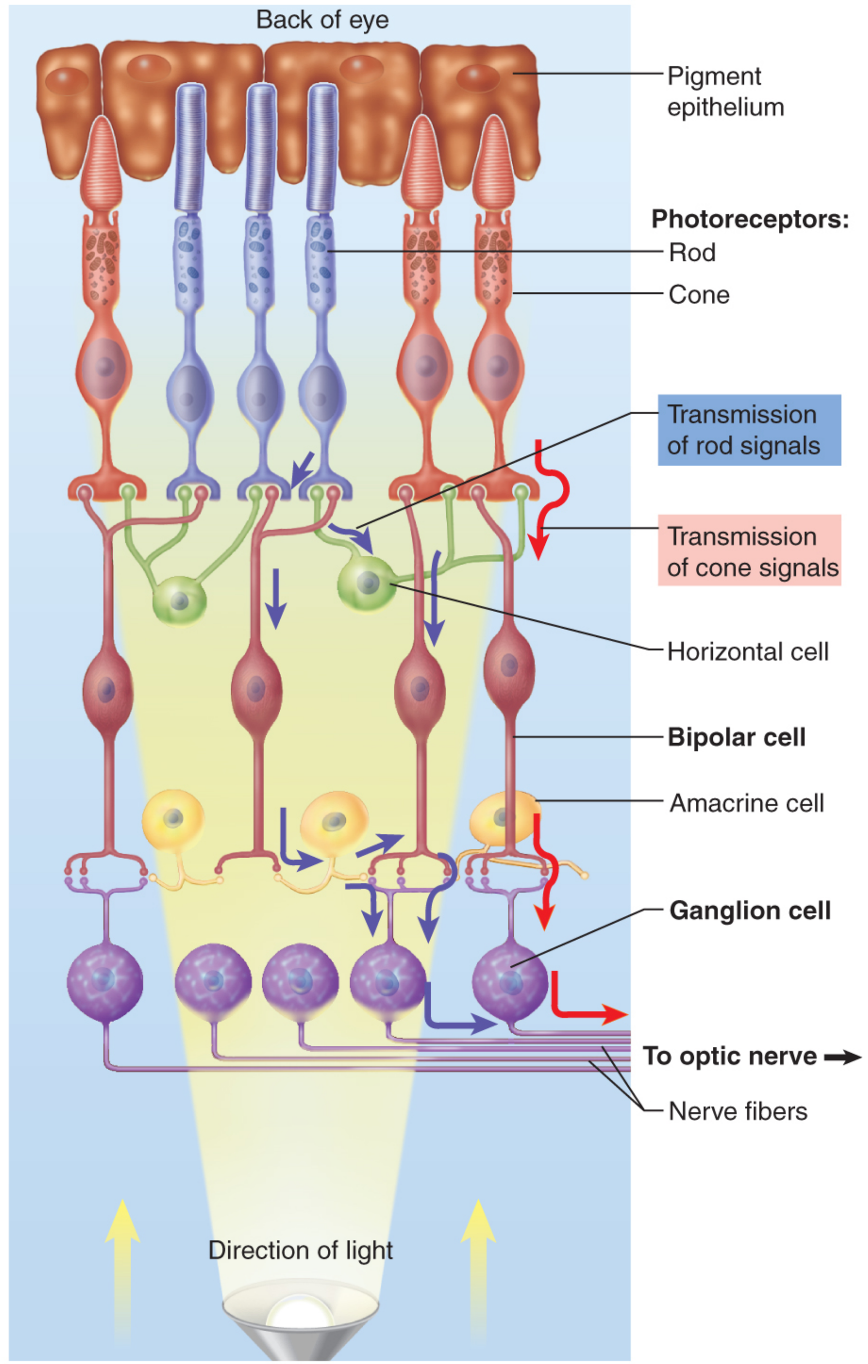


Figure 16.35b

Schematic Layers of the Retina

- 130 million rods and 6.5 million cones in retina
- only 1.2 million nerve fibers in optic nerve
- **neuronal convergence** and information processing in retina before signals reach brain
  - multiple rod or cone cells synapse on one bipolar cell
  - multiple bipolar cells synapse on one ganglion cell


Back of eye
Pigment epithelium
Photoreceptors:
Rod
Cone
Transmission of rod signals
Transmission of cone signals
Horizontal cell
Bipolar cell
Amacrine cell
Ganglion cell
To optic nerve
Nerve fibers
Direction of light

(b)

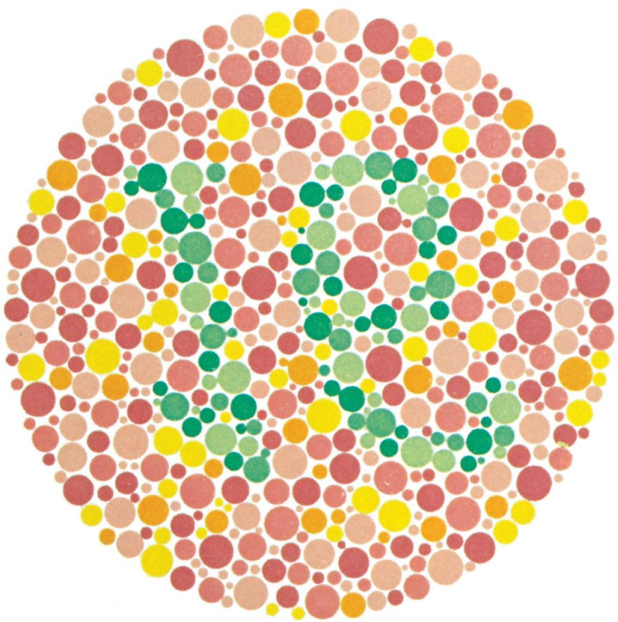
Light and Dark Adaptation

- **light adaptation** (walk out into sunlight)
  - pupil constriction and pain from over stimulated retinas
  - pupils constrict to reduce pain & intensity
  - color vision and acuity below normal for 5 to 10 minutes
  - time needed for pigment bleaching to adjust retinal sensitivity to high light intensity
  - rod vision nonfunctional
- **dark adaptation** (turn lights off)
  - dilation of pupils occurs
  - rod pigment was bleached by lights
  - in dark, rhodopsin regenerates faster than it bleaches
  - in a minute or two night vision begins to function
  - after 20 to 30 minutes the amount of regenerated rhodopsin is sufficient for your eyes to reach maximum sensitivity

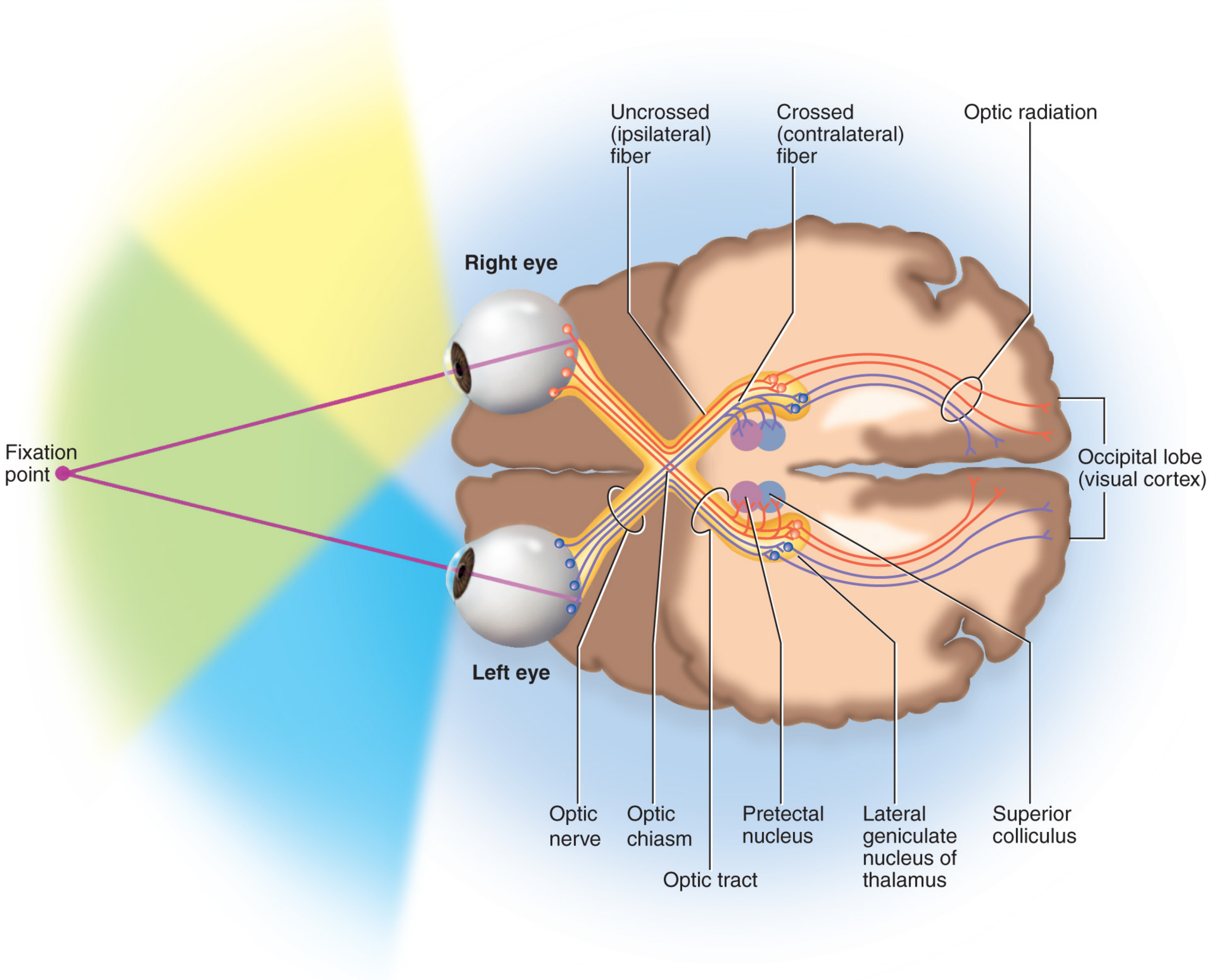
Color Blindness

- **color blindness** – have a hereditary atteration or lack of one photopsin or another
- most common is red-green color blindness
  - results from **lack of either L or M cones**
  - causes difficulty distinguishing these related shades from each other
  - occurs in 8% of males, and 0.5% in females (sex-linkage)

Figure 16.41



Kanahara Trading Ltd.


Uncrossed (ipsilateral) fiber
Crossed (contralateral) fiber
Optic radiation
Right eye
Fixation point
Occipital lobe (visual cortex)
Left eye
Optic nerve
Optic chiasm
Optic tract
Pretectal nucleus
Lateral geniculate nucleus of thalamus
Superior colliculus

Autonomic Nervous System and Visceral Reflexes

Autonomic Nervous System (ANS)

general properties

anatomy

Autonomic Effects on Target Organs

Central Control of Autonomic Function

General Properties of ANS

autonomic nervous system (ANS) – a motor nervous system that controls glands, cardiac muscle, and smooth muscle

also called **visceral motor system**

carries out actions **involuntarily** – without our conscious intent or awareness

visceral effectors do not depend on the ANS to function

- only to adjust their activity to the body's changing needs

denervation hypersensitivity – exaggerated response of cardiac and smooth muscle if autonomic nerves are severed

Visceral Reflexes

- **visceral reflexes -** unconscious, automatic, stereotyped responses to stimulation involving visceral receptors and effectors and somewhat slower responses

- **visceral reflex arc**
  - **receptors** – nerve endings that detect stretch, tissue damage, blood chemicals, body temperature, and other internal stimuli
  - **afferent neurons** – leading to the CNS
  - **interneurons** – in the CNS
  - **efferent neurons** – carry motor signals away from the CNS
  - **effectors** – that make adjustments

- ANS modifies effector activity

Visceral Reflex to High BP

high blood pressure detected by arterial stretch receptors (1), afferent neuron (2) carries signal to CNS, efferent (3) signals travel to the heart (4), heart slows reducing blood pressure

example of homeostatic negative feedback loop

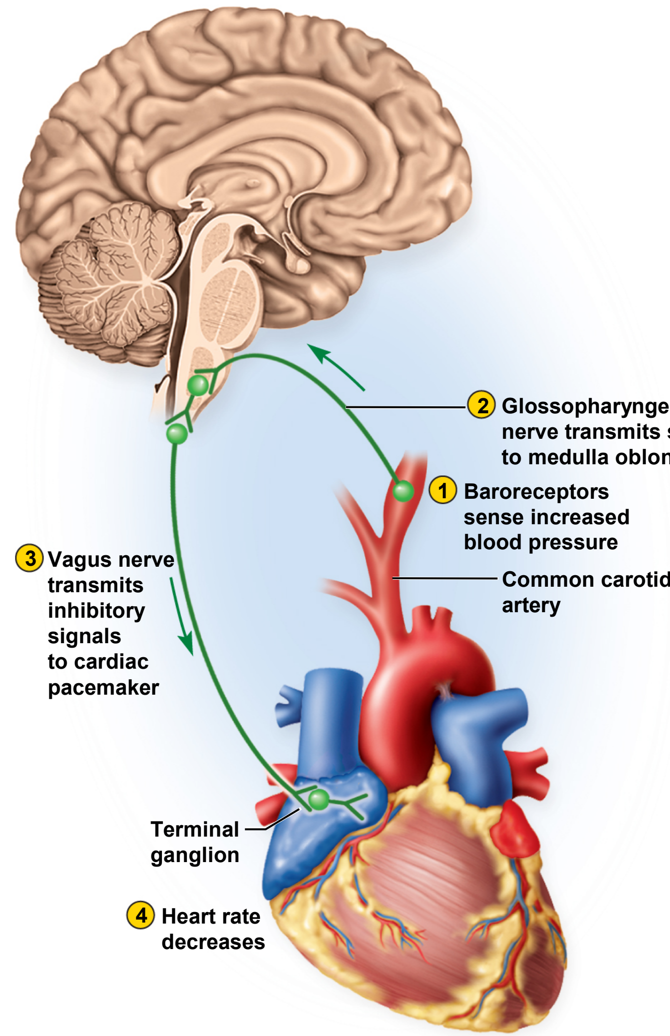


Figure 15.1

Divisions of ANS

- two divisions innervate same target organs
  - may have cooperative or contrasting effects

sympathetic division

- prepares body for physical activity – exercise, trauma, arousal, competition, anger, or fear
  - increases heart rate, BP, airflow, blood glucose levels, etc
  - reduces blood flow to the skin and digestive tract

parasympathetic division

- calms many body functions reducing energy expenditure and assists in bodily maintenance
  - digestion and waste elimination
  - "resting and digesting" state

Dual Innervation

dual innervation - most viscera receive nerve fibers from both parasympathetic and sympathetic divisions

antagonistic effect – oppose each other

cooperative effects – two divisions act on different effectors to produce a unified overall effect

both divisions do not normally innervate an organ equally

- digestion, heart rate

Dual Innervation

antagonistic effects - oppose each other

exerted through dual innervation of same effector cells

- heart rate decreases (parasympathetic)
- heart rate increases (sympathetic)

exerted because each division innervates different cells

- pupillary dilator muscle (sympathetic) dilates pupil
- constrictor pupillae (parasympathetic) constricts pupil

Dual Innervation

cooperative effects - when two divisions act on different effectors to produce a unified effect

parasympathetics increase salivary serous cell secretion

sympathetics increase salivary mucous cell secretion

Dual Innervation of the Iris

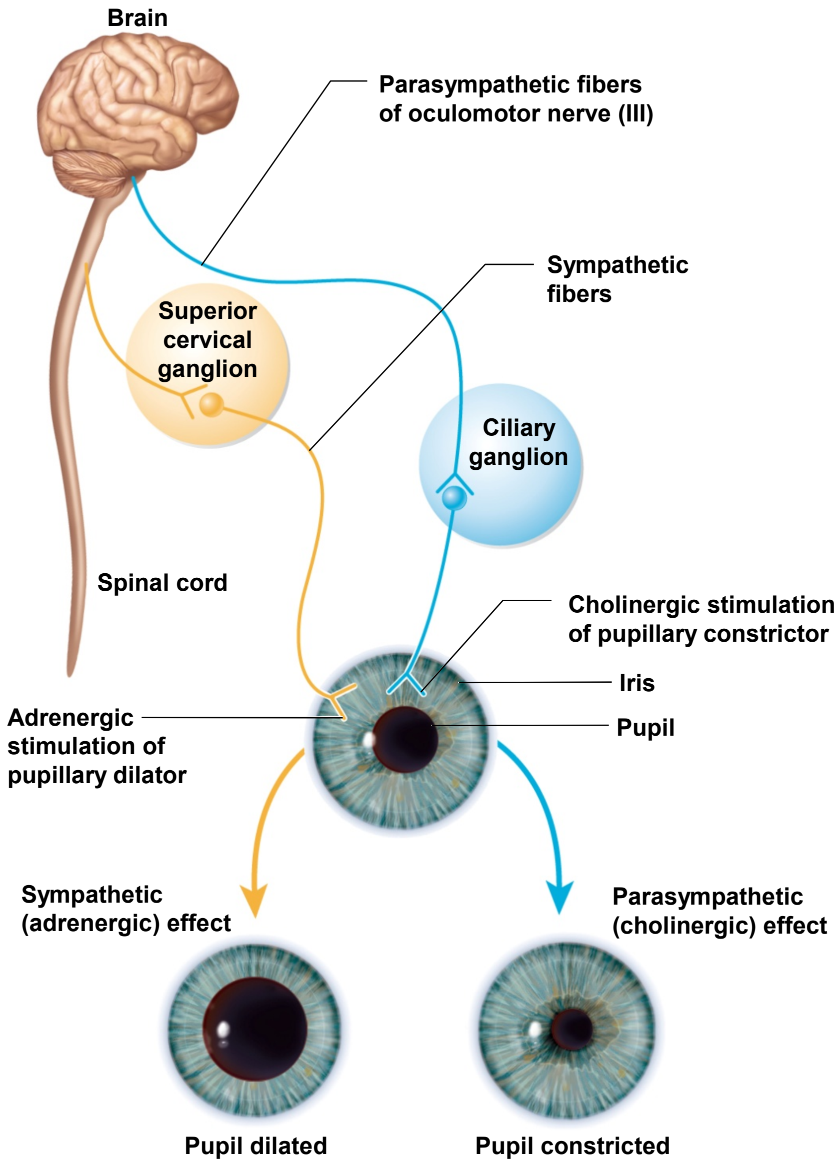


Figure 15.9

Without Dual Innervation

some effectors receive **only sympathetic fibers**

adrenal medulla, arrector pili muscles, sweat glands and many blood vessels

control of blood pressure and routes of blood flow

sympathetic **vasomotor tone** - a baseline firing frequency of sympathetics

- keeps vessels in state of partial constriction
- increase in firing frequency - **vasoconstriction**
- decrease in firing frequency - **vasodilation**
- can shift blood flow from one organ to another as needed

sympathetic division acting alone can exert opposite effects on the target organ through control of blood vessels

during stress

- blood vessels to muscles and heart dilate
- blood vessels to skin constrict

Sympathetic and Vasomotor Tone

sympathetic division prioritizes blood vessels to skeletal muscles and heart in times of emergency

blood vessels to skin vasoconstrict to minimize bleeding if injury occurs during stress or exercise

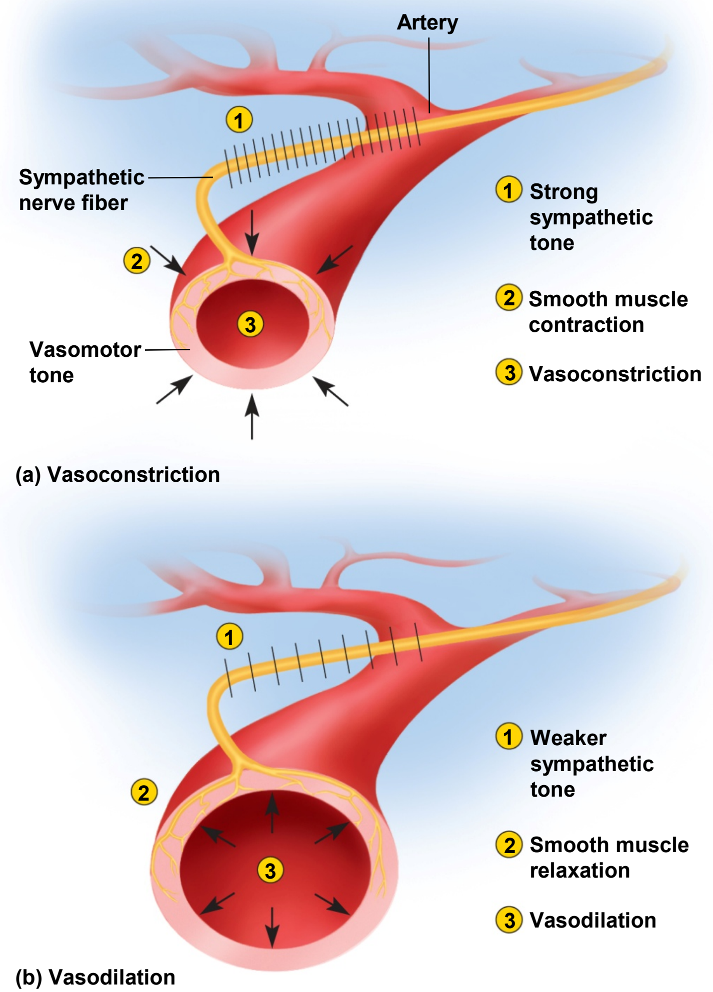


Figure 15.10

Control of Autonomic Function

ANS regulated by several levels of CNS

cerebral cortex has an influence – anger, fear, anxiety

- powerful emotions influence the ANS because of the connections between our limbic system and the hypothalamus

hypothalamus - major visceral motor control center

- nuclei for primitive functions – hunger, thirst, sex

midbrain, **pons**, and **medulla oblongata** contain:

- nuclei for cardiac and vasomotor control, salivation, swallowing, sweating, bladder control, and pupillary changes

spinal cord reflexes

- defecation
- we control these functions because of our control over skeletal muscle sphincters…if the spinal cord is damaged, the smooth muscle of bowel and bladder is controlled by autonomic reflexes built into the spinal cord