

Inquiry into Life

Eleventh Edition

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Chapter 18 Lecture Outline

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18.1 Sensory receptors and sensations

- **Sensory receptors**
 - Specialized to detect specific stimuli
 - **Exterioreceptors**-detect stimuli outside body
 - Includes receptors for light, sound, chemicals
 - Indirectly involved in homeostasis
 - Inform CNS about environmental conditions
 - **Interioreceptors**- detect stimuli inside body
 - Includes receptors for blood pressure, body temperature, water balance
 - Directly involved in homeostasis

Sensory receptors and sensations cont'd.

- Types of receptors
 - Chemoreceptors
 - Taste buds, olfactory receptors, receptors in aortic and carotid bodies monitoring blood pH, pain receptors
 - Photoreceptors
 - Rods (black and white vision) and cones (color vision)
 - Mechanoreceptors
 - Auditory receptors, touch receptors, receptors for equilibrium, pressoreceptors for blood pressure and stretch of lung tissue
 - Thermoreceptors
 - Receptors for body temperature

Exteroreceptors

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TABLE 18.1 EXTEROCEPTORS

Sensory Receptor	Stimulus	Category	Sense	Sensory Organ
Taste cells	Chemicals	Chemoreceptor	Taste	Taste buds
Olfactory cells	Chemicals	Chemoreceptor	Smell	Olfactory epithelium
Rod cells and cone cells in retina	Light rays	Photoreceptor	Vision	Eye
Hair cells in spiral organ	Sound waves	Mechanoreceptor	Hearing	Ear
Hair cells in semicircular canals	Motion	Mechanoreceptor	Rotational equilibrium	Ear
Hair cells in vestibule	Gravity	Mechanoreceptor	Gravitational equilibrium	Ear

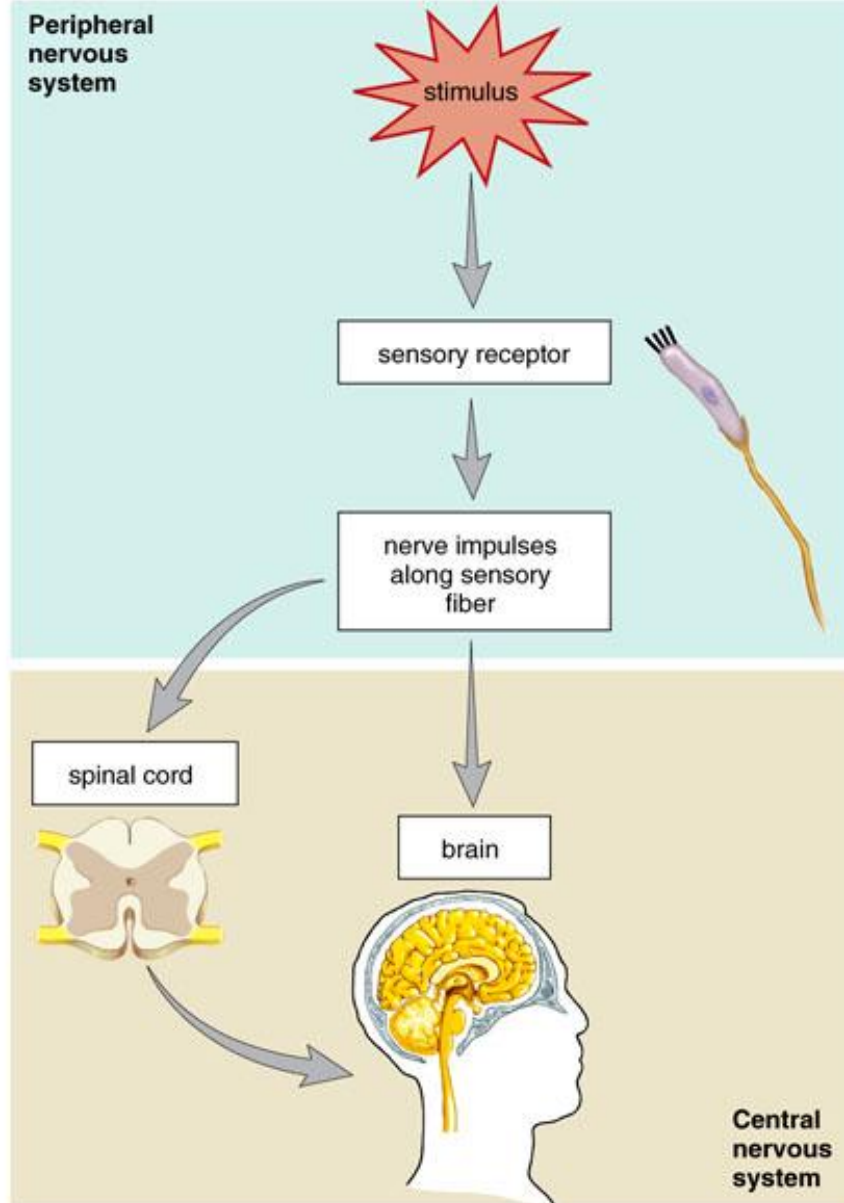
- Table 18.1

Sensory receptors and sensations cont'd.

- How sensation occurs
 - Sensation
 - Perception
 - Receptors
 - Integration (summing up of signals)
 - Sensory adaptation (decrease in response to stimulation)

Sensation

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• Fig 18.1

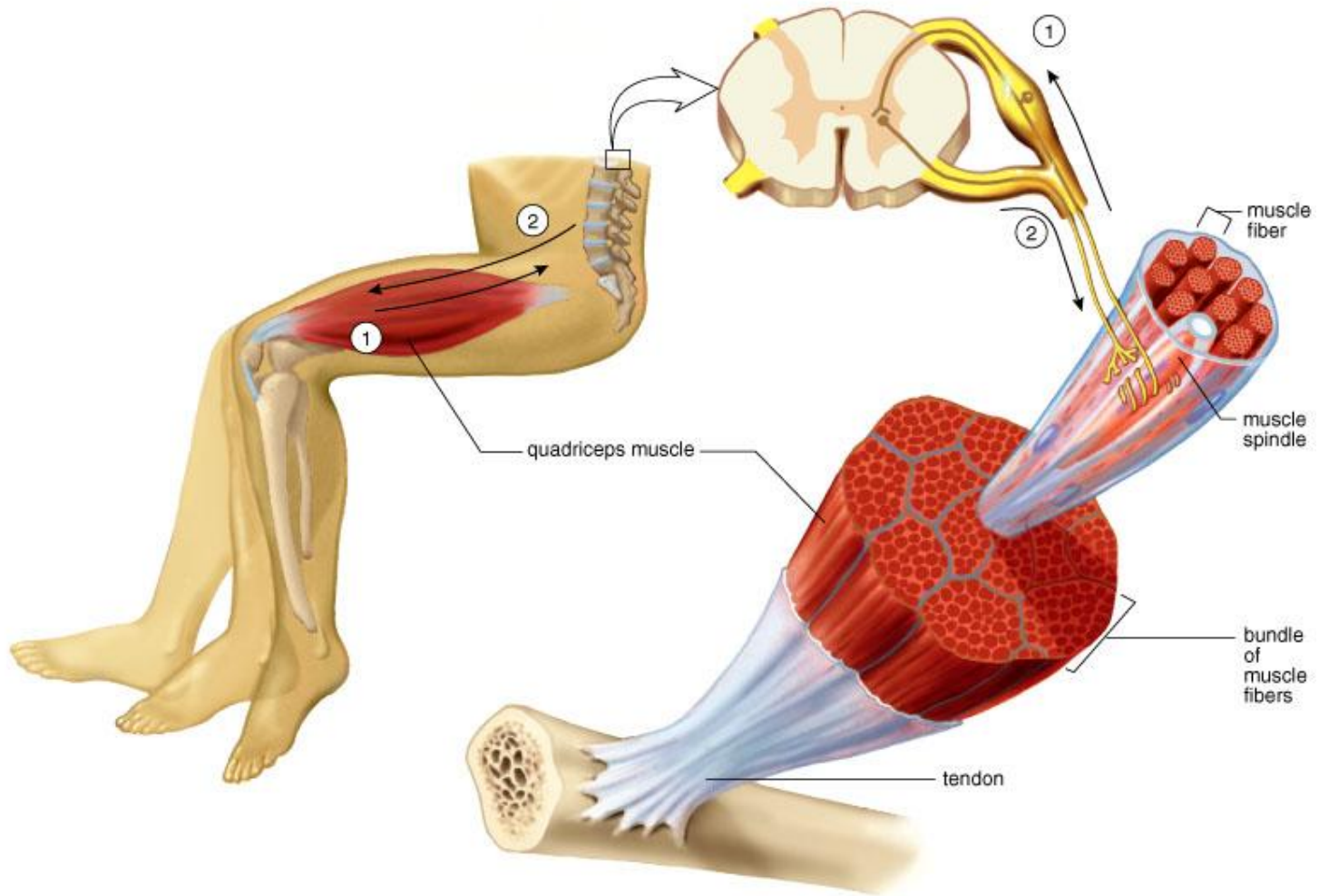
18.2 Proprioceptors and cutaneous receptors

- **Proprioceptors**

- Mechanoreceptors in muscles and tendons
- Gives us an unconscious “body sense”
 - Awareness of position of limbs
 - Degree of muscle and tendon stretch
 - Equilibrium and posture
- Muscle spindles are an example of a mechanoreceptor
 - Wrapped around muscle fibers
 - Monitor degree of stretch
 - Initiate reflexes to adjust
 - Example: knee jerk reflex

Muscle spindle

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• Fig 18.2

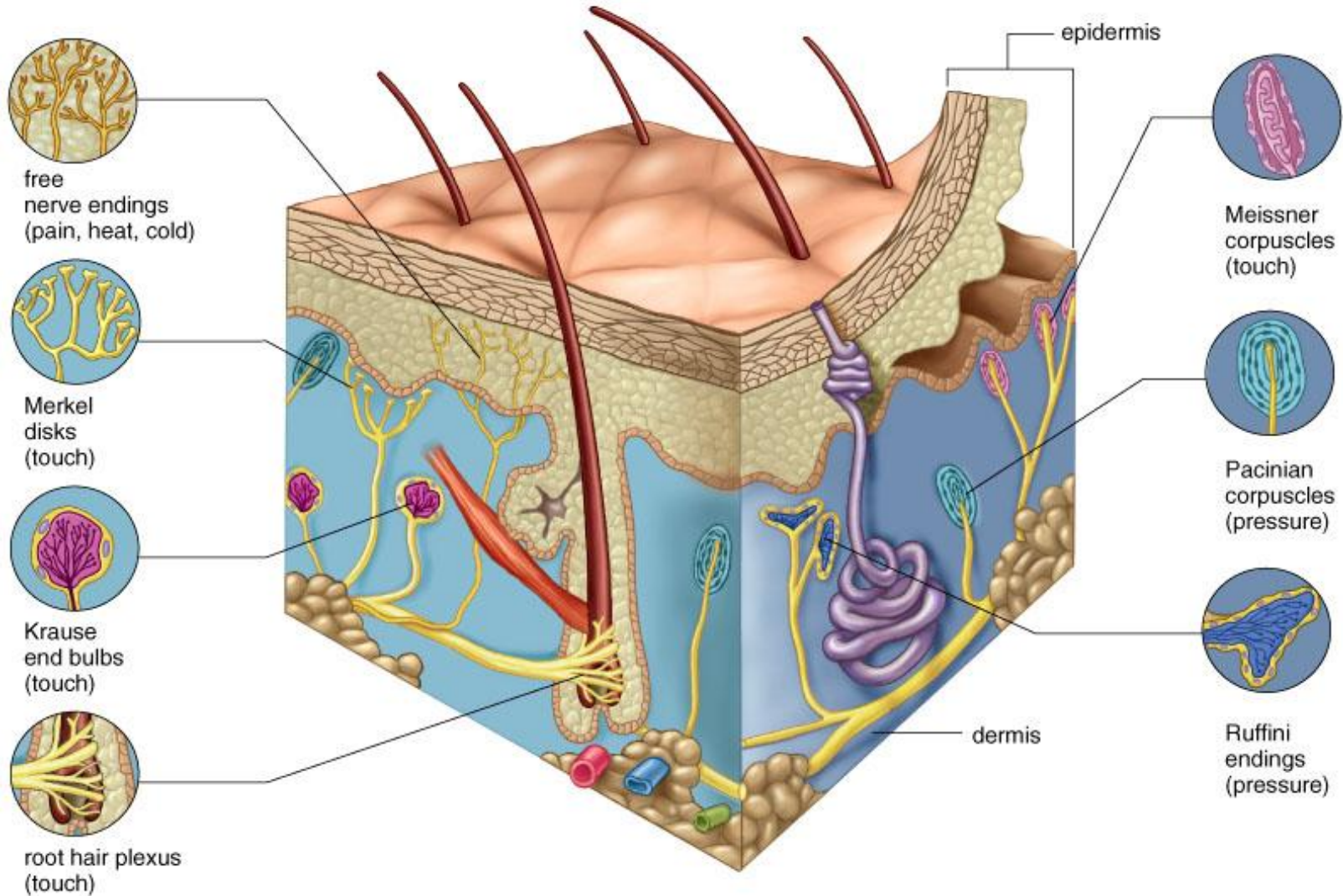
Proprioreceptors and cutaneous receptors cont'd.

- Cutaneous receptors

- In the dermis of the skin
- Allow skin to be sensitive to touch, pressure, and temperature
- Fine touch receptors
 - *Meissner corpuscles*-fingertips, lips, palms, penis, clitoris
 - *Merkel disks*- junction of epidermis and dermis
 - *Root hair plexus*- free nerve endings at base of follicles
 - Allows sensation when hair is touched
- Pressure receptors
 - *Pacinian corpuscles*-onion-shaped, deep in dermis
 - *Ruffini endings* and *Krause end bulbs*- encapsulated receptors with complex nerve networks

Sensory receptors in human skin

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• Fig 18.3

Proprioreceptors and cutaneous receptors cont'd.

- Pain receptors

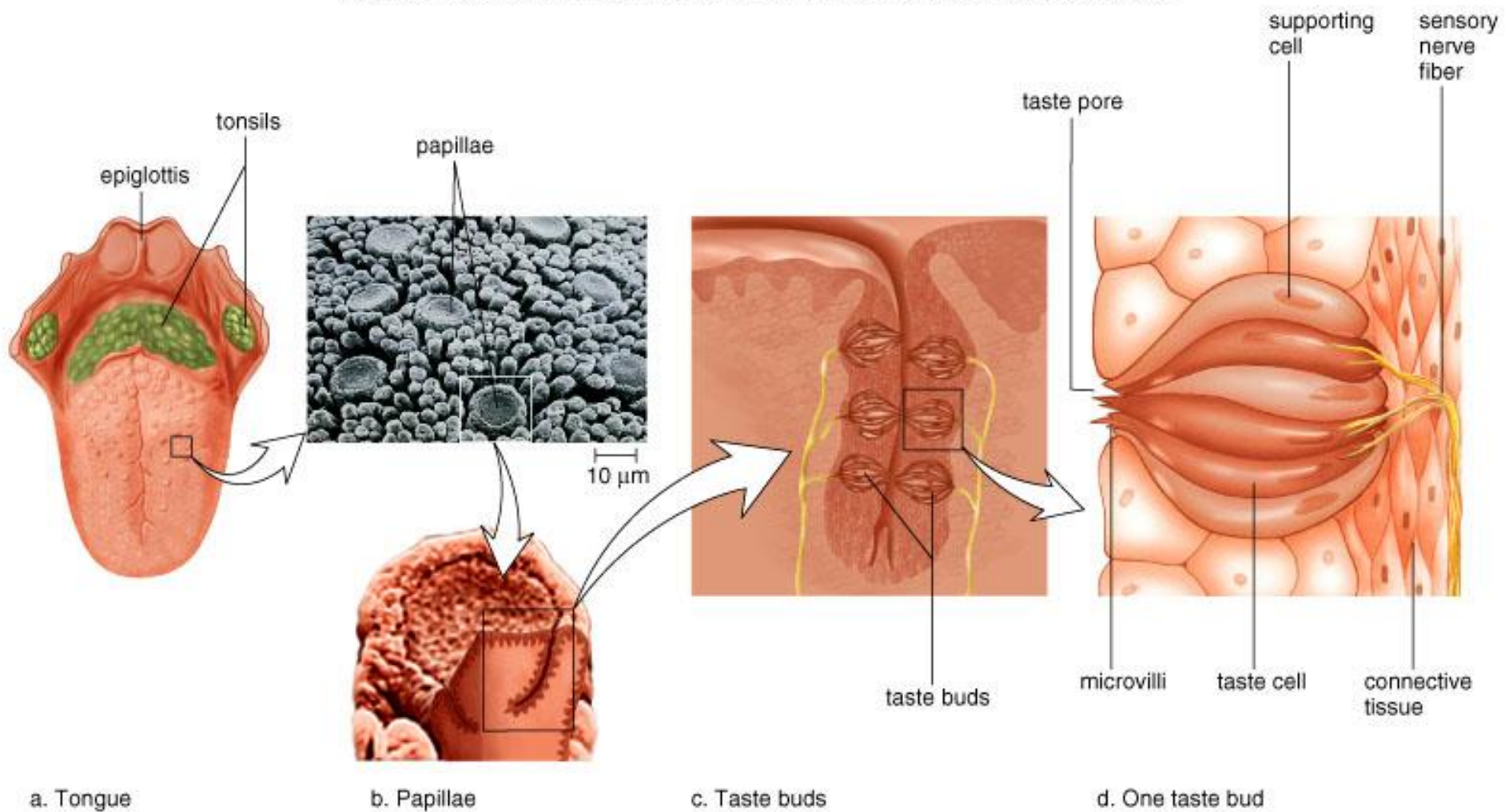
- Free nerve endings
- Damaged tissues release chemicals that stimulate pain receptors

- Referred pain

- In some areas stimulation of internal pain receptors is also perceived as pain from the skin
- Most likely explanation- impulses from internal pain receptors also synapse in cord with neurons receiving pain impulses from skin
 - Ex: pain originating in heart is also referred to left arm and shoulder

Taste buds

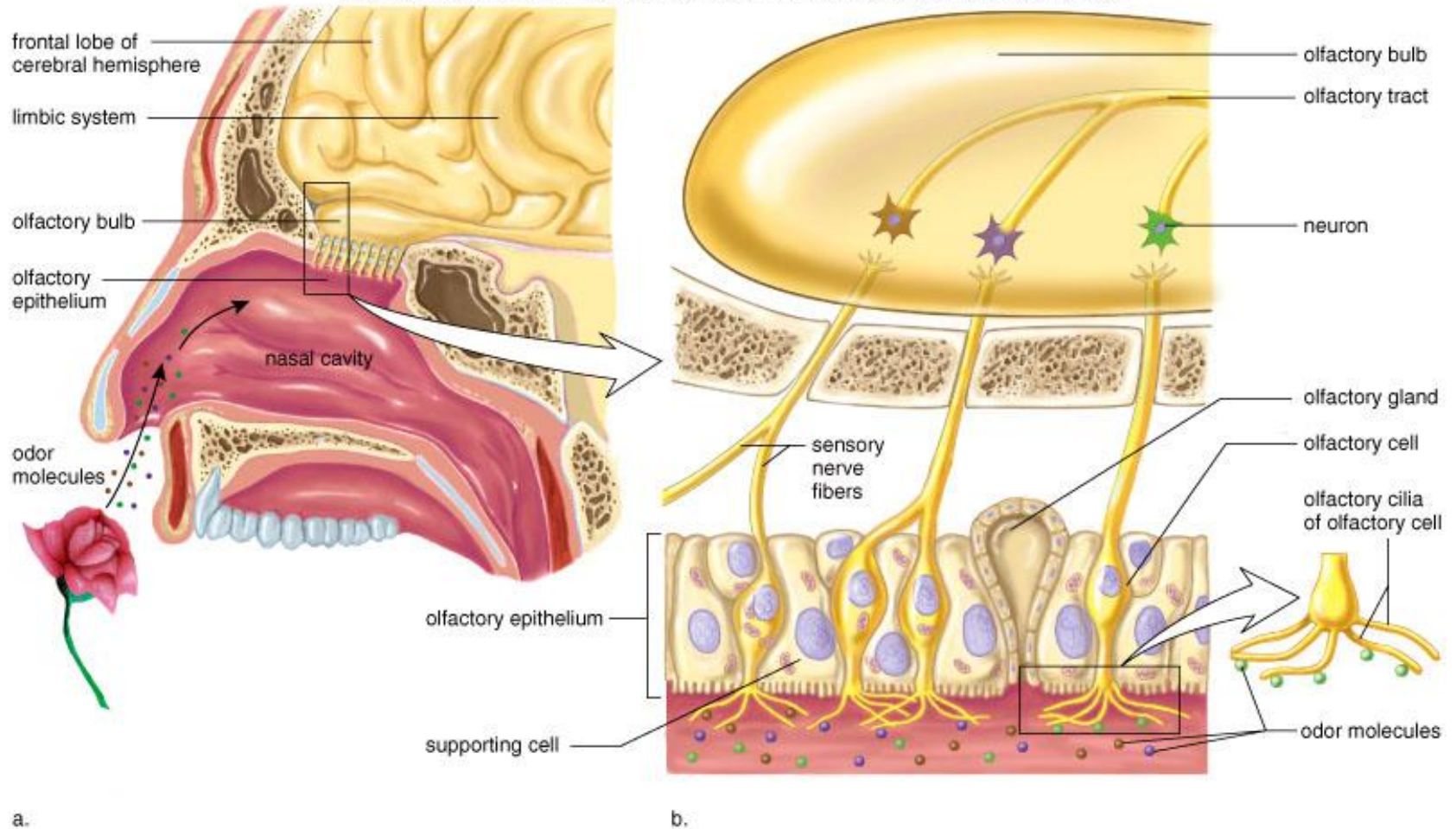
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• Fig 18.4

Olfactory cell location and anatomy

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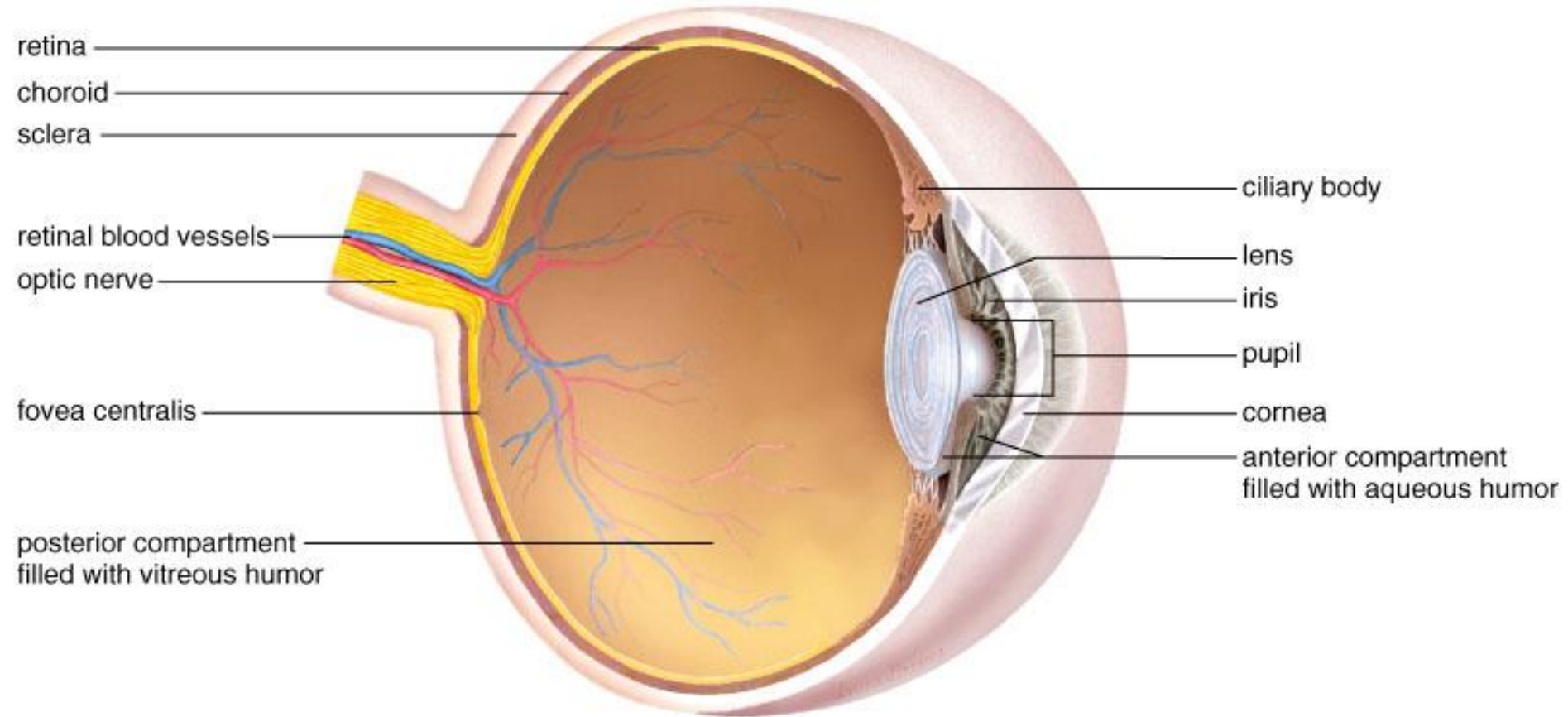
• Fig 18.5

18.4 Sense of vision

- Anatomy of the eye- 3 layers
 - *Sclera*- outer layer
 - White fibrous covering except for corneal region
 - Cornea- transparent collagen fibers
 - *Choroid*- middle layer
 - Thin, darkly pigmented
 - Vascular
 - Absorbs stray light rays
 - At front, it becomes the *iris*-controls *pupil* size
 - Iris is pigmented to give the eye it's color
 - Behind the iris the choroid thickens to form the *ciliary body*
 - Ciliary body controls curvature of the lens

Anatomy of the human eye

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- Fig 18.6

Sense of vision cont'd.

- Choroid layer cont'd.

- **Lens**-attached to the ciliary body by *suspensory ligaments*

- Lens divides the inner eyeball into chambers

- **Anterior chamber**- between the cornea and the lens

- » Filled with water *aqueous humor*

- » Small amount produced each day while same amount is drained through small ducts

- » **Glaucoma**- build up of fluid when ducts are blocked; can cause increased intraocular pressure and blindness

- **Posterior chamber**- between lens and back of eyeball

- » Filled with gelatinous *vitreous humor*

Sense of vision cont'd.

- **Retina**- innermost layer of eyeball
 - Lines the posterior compartment
 - Contains the photoreceptors
 - **Rods**- function in black and white dim-light vision
 - Evenly distributed throughout retina
 - **Cones**- function in bright-light color vision
 - Concentrated in *fovea centralis*
 - Sensory fibers leave the retina to form the optic nerve

Functions of the parts of the eye

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TABLE 18.2 FUNCTIONS OF THE PARTS
OF THE EYE

Part	Function
Sclera	Protects and supports eyeball
Cornea	Refracts light rays
Pupil	Admits light
Choroid	Absorbs stray light
Ciliary body	Holds lens in place, accommodation
Iris	Regulates light entrance
Retina	Contains sensory receptors for sight
Rods	Make black-and-white vision possible
Cones	Make color vision possible
Fovea centralis	Makes acute vision possible
Other	
Lens	Refracts and focuses light rays
Humors	Transmit light rays and support eyeball
Optic nerve	Transmits impulse to brain

- Table 18.2

Sense of vision cont'd.

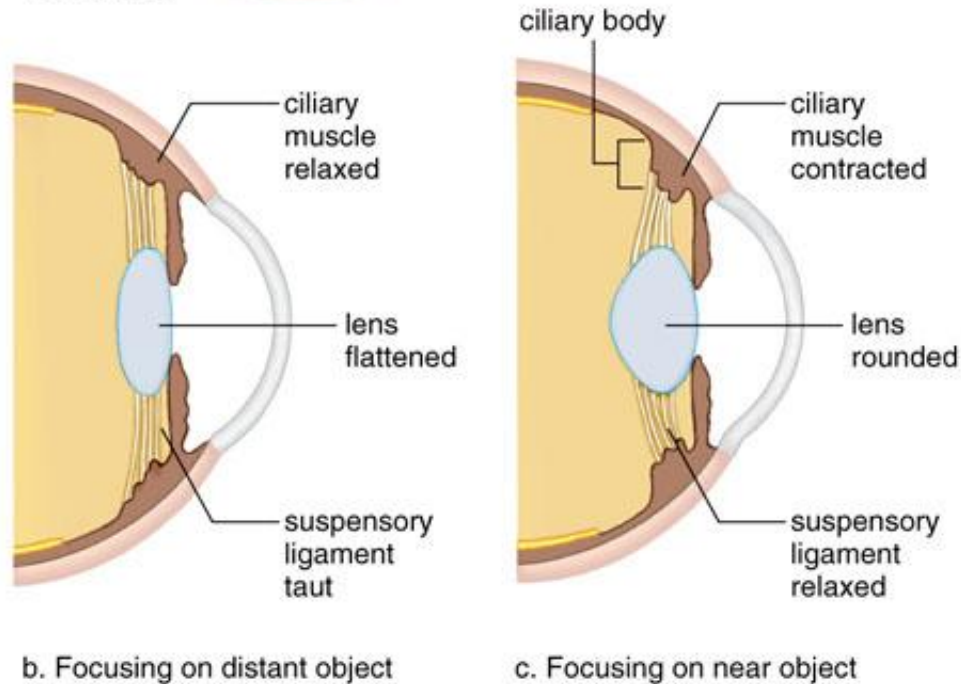
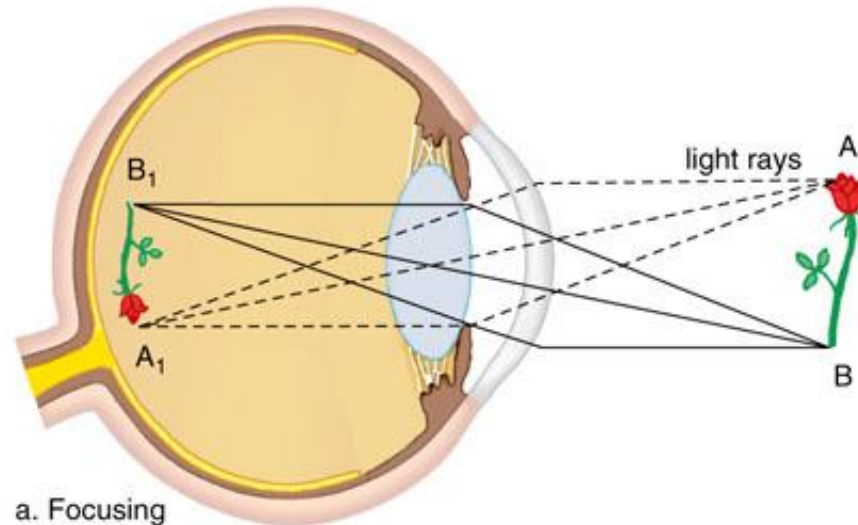
- Function of the lens
 - Focuses light rays onto the retina
 - Image is inverted and upside down on the retina
 - If eyeball is too long or too short corrective lenses are needed to bring image into focus on the retina
 - Visual accommodation
 - For viewing close objects
 - Ciliary muscle contracts which releases tension on suspensory ligaments
 - Lens rounds up due to natural elasticity
 - Increases refraction (bending) of light rays to bring them into focus on the lens
 - Presbyopia-age changes decrease elasticity of lens

Sense of vision cont'd.

- Visual accommodation con'td.
 - Accommodation for distance vision
 - Ciliary muscle relaxes
 - Increases tension on the suspensory ligaments
 - Causes lens to flatten out
 - This brings light rays from distant objects into focus on the retina

Focusing

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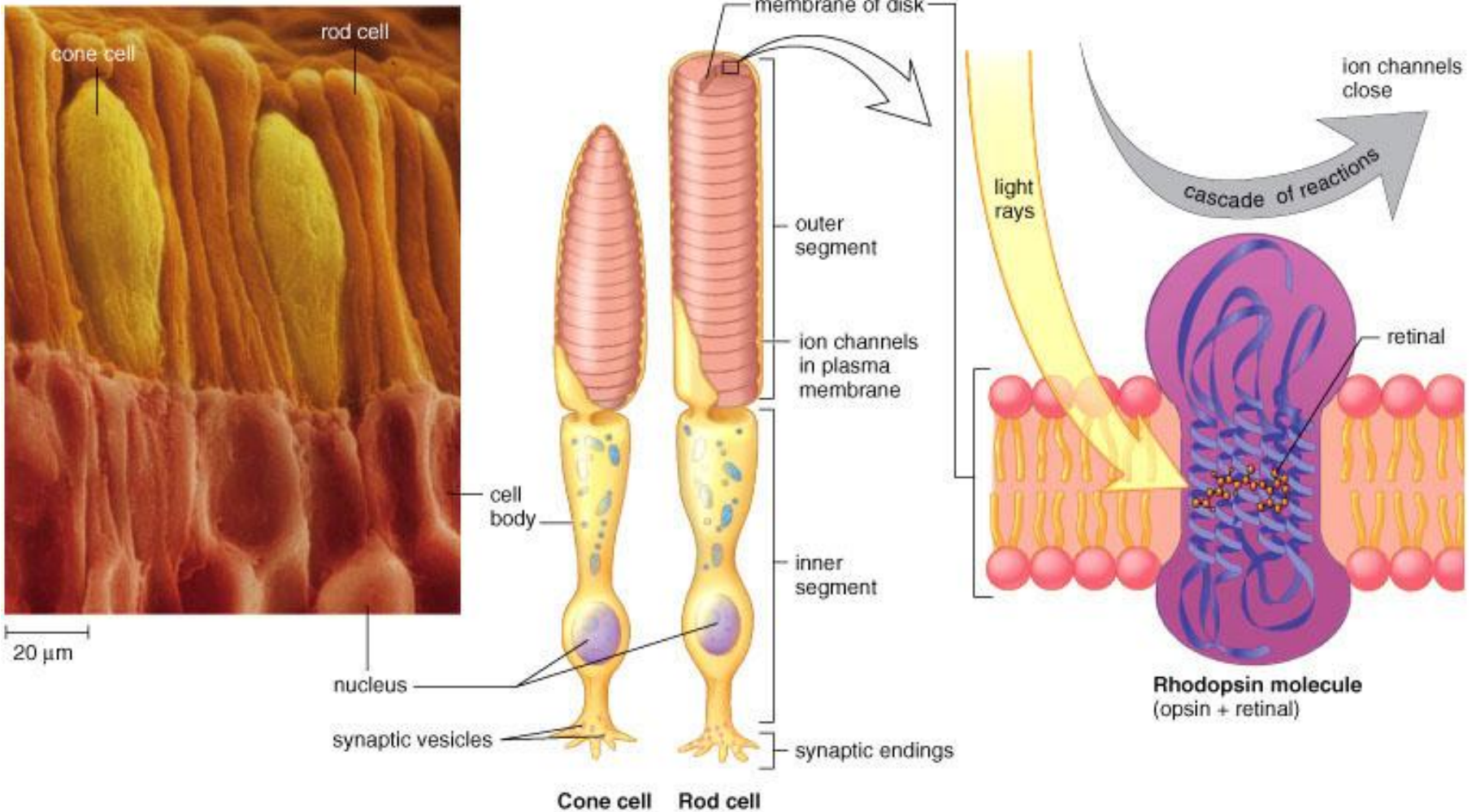
- Fig 18.7

Sense of vision cont'd.

- Function of photoreceptors
 - General structure
 - Outer segment joined to inner segment by a stalk
 - Pigment located in disks within outer segments
 - Synaptic vesicles located at synaptic endings of inner segments
 - Rods
 - Visual pigment is **rhodopsin**
 - Complex molecule made up of the protein **opsin** and **retinal** which is a derivative of vitamin A
 - When rod absorbs light rhodopsin is split to opsin + retinal
 - Closes ion channels in rod cell membrane
 - Stops release of inhibitory transmitter signals
 - Signals sent to other neurons in retina and on to optic nerve

Photoreceptors in the eye

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- Fig 18.8

Sense of vision cont'd.

- Cones
 - 3 kinds of cones each with a specific pigment
 - B (blue), G (green), and R (red) pigments
 - Each is an **iodopsin** composed of retinal and an opsin
 - Opsin is slightly different in each
 - Combinations of cones are simulated by in-between colors
 - Mechanics of light absorption and stimulus generation is the same as in rods
 - Cones allow color vision which is of higher acuity than the rods

Sense of vision cont'd.

- Function of the retina

- 3 layers of cells

- Layer closest to choroid contains rods and cones
 - Middle layer composed of bipolar cells
 - Inner layer composed of ganglion cells

- Rod and cone cells synapse with bipolar cells which synapse with ganglion cells- axons of these cells become the optic nerve

- Many more photoreceptors than ganglion cells

- 150 rods stimulate a single ganglion cells
 - 1 cone stimulates 1 ganglion cell
 - Explains why color vision is higher acuity

Sense of vision cont'd.

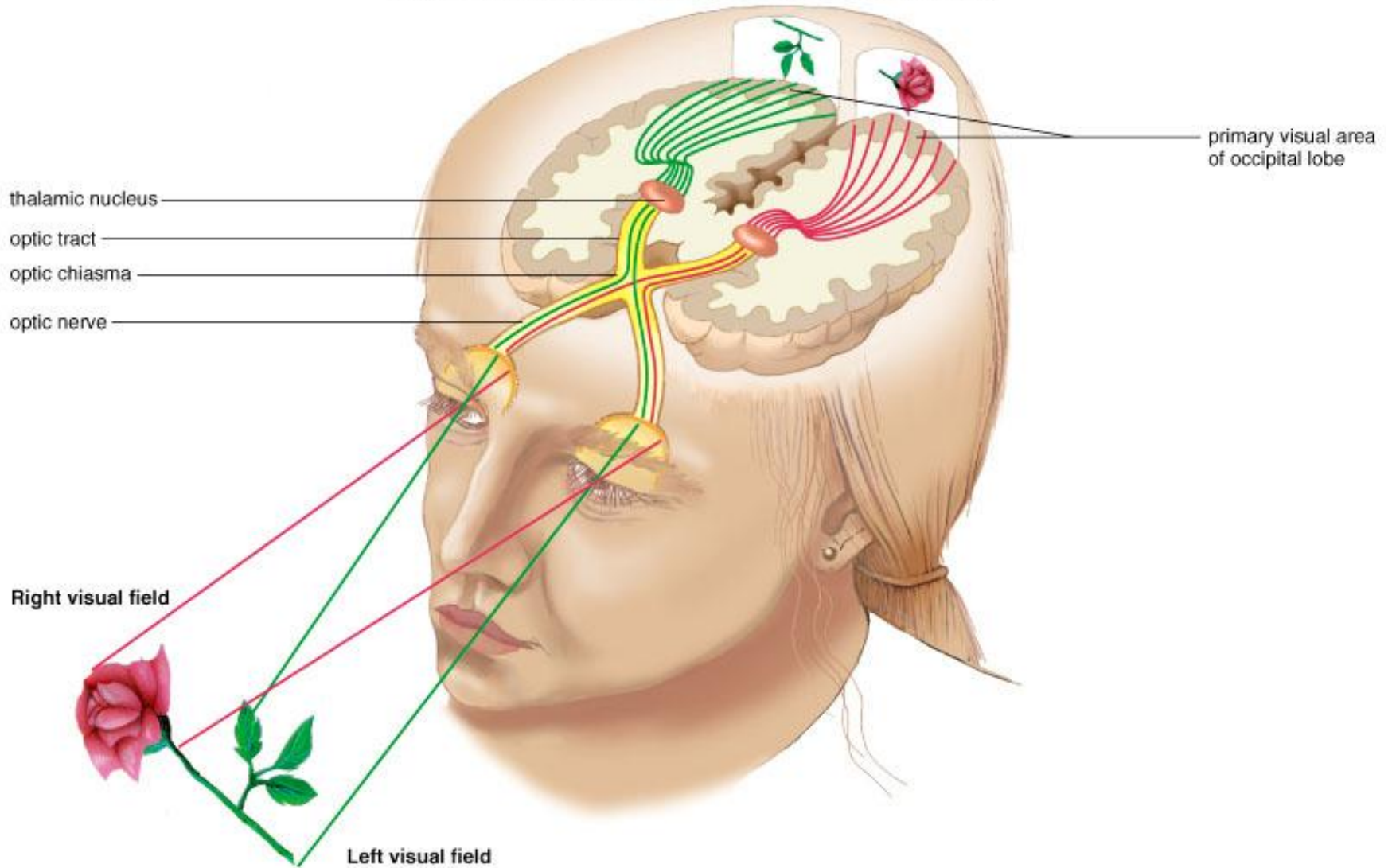
- **Blind spot**
 - Area on retina where optic neurons leave to form the optic nerve
 - There are no photoreceptors here
 - You can find your blind spot by placing a dot on the right side of a piece of paper
 - Use your right hand to slowly bring the paper closer to your face while you look straight ahead
 - Note that the dot disappears at a certain point- this is your blind spot

Sense of vision cont'd.

- From the retina to the visual cortex
 - Optic nerves from each eye travel to the optic chiasma
 - Some of the axons cross over at the optic chiasma
 - Optic tracts travel around the hypothalamus and most fibers synapse with nuclei in the thalamus

Optic chiasma

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• Fig 18.10

Sense of vision cont'd.

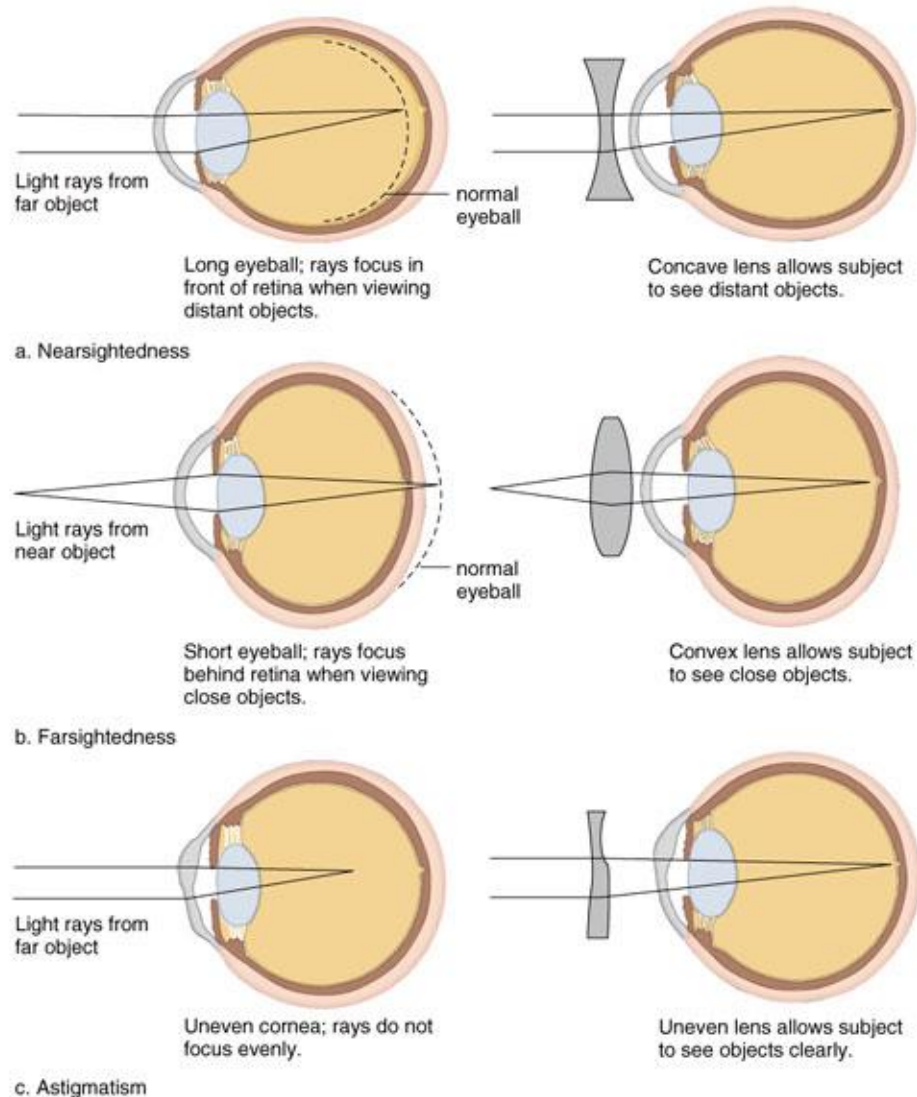
- Abnormalities of the eye
 - Color blindness
 - Complete colorblindness is rare
 - Most common types involve deficiency in one type of cone
 - Red-green colorblindness
 - Most common type
 - X-linked recessive trait
 - 5-8% of the male population

Sense of vision cont'd.

- Abnormalities of vision con't.
 - Distance vision
 - Nearsighted
 - Can see close objects better than distant ones
 - Eyeball is elongated so image is brought to point focus in front of the retina
 - Corrected by concave lenses which diverge light rays so point focus is farther back
 - Farsighted
 - Can see distant objects better than close ones
 - Eyeball is shortened so image is brought to point focus behind the lens
 - Corrected by convex lenses to increase bending of light rays so point focus is farther forward

Common abnormalities of the eye, with possible corrective lenses

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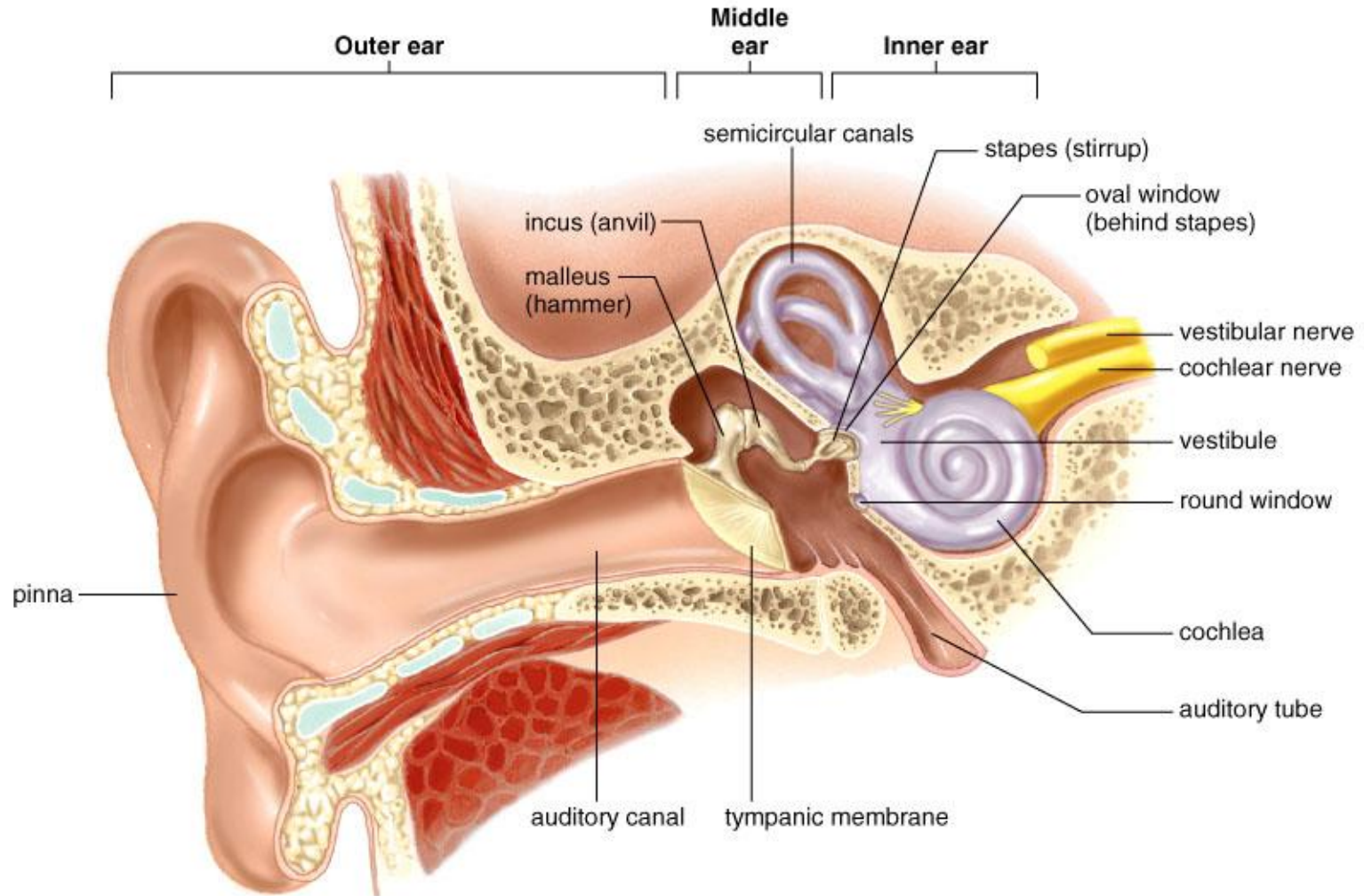
• Fig 18.11

18.5 Sense of hearing

- Anatomy of ear
 - Outer ear
 - Pinna
 - Auditory canal
 - Middle ear
 - Tympanic membrane-beginning of the middle ear
 - Auditory ossicles-malleus, incus, stapes
 - Forms a “bridge” across the middle ear
 - Auditory tube-extends from middle ear to nasopharynx
 - Helps equalize pressure across the tympanic membrane
 - Oval window and round window- membranous connections with inner ear
 - Inner ear
 - Semicircular canals, vestibule, and cochlea

Anatomy of the human ear

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- Fig 18.12

Sense of hearing cont'd.

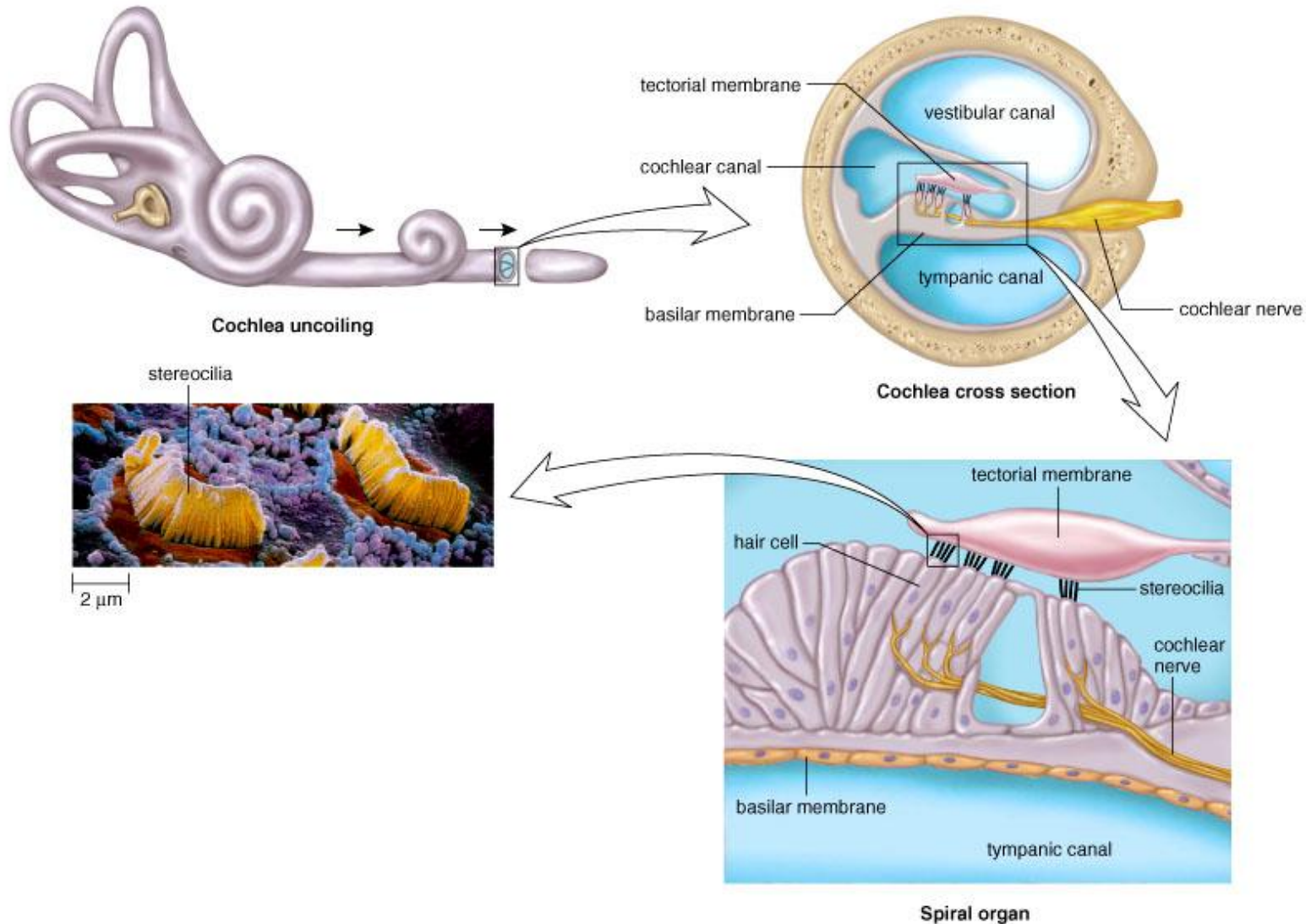
- Auditory pathway to the brain
 - Sound waves channeled into the auditory canal by the pinna
 - Strike the tympanic membrane and it begins to vibrate
 - Vibrations are amplified across the ossicles
 - Amplified about 20 times
 - Stapes is attached to oval window-
 - Oval window vibrates and transmits vibrations to fluid inside the cochlea

Sense of hearing cont'd.

- From the cochlea to the auditory cortex
 - Cochlear structure
 - 3 canals
 - Vestibular canal
 - Cochlear canal
 - Tympanic canal
 - Spiral organ (organ of Corti) is located in the cochlear canal
 - Consists of hair cells and a gelatinous tectorial membrane
 - Hair cells sit on the basilar membrane and have stereocilia embedded in the tectorial membrane

Mechanoreceptors for hearing

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- Fig 18.13

Sense of hearing cont'd.

- From the cochlea to the auditory cortex cont'd.
 - Stapes causes oval window to vibrate
 - Vibrations move from vestibular canal to tympanic canal across the basilar membrane
 - Basilar membrane moves up and down and the stereocilia of the hair cells bend
 - Generates nerve impulses in the cochlear nerve
 - Travel to the brain
 - Auditory cortex interprets them as sound

Sense of hearing cont'd.

- From the cochlea to the auditory cortex cont'd.
 - Each part of the spiral organ is sensitive to different wave frequencies or pitch of sound
 - Near tip- responds to low pitches
 - Near base- responds to high pitches
 - Nerve fibers along the length of spiral organ lead to slightly different areas of auditory cortex
 - Pitch we hear depends on which region of the basilar membrane is vibrating and which area of the auditory cortex is stimulated
 - Volume is a function of amplitude of sound waves
 - Loud sounds cause greater vibrations of basilar membrane
 - Increased stimulation is interpreted as volume
 - Brain interprets tone based on distribution of hair cells stimulated

Functions of the parts of the ear

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TABLE 18.3 FUNCTIONS OF THE PARTS OF THE EAR

Part	Medium	Function	Mechanoreceptor
<i>Outer Ear</i>			
Pinna	Air	Collects sound waves	—
Auditory canal		Filters air	—
<i>Middle Ear</i>			
Tympanic membrane and ossicles	Air	Amplify sound waves	—
Auditory tube		Equalizes air pressure	—
<i>Inner Ear</i>			
Semicircular canals	Fluid	Rotational equilibrium	Stereocilia embedded in cupula
Vestibule (contains utricle and saccule)		Gravitational equilibrium	Stereocilia embedded in otolithic membrane
Cochlea (spiral organ)		Hearing	Stereocilia embedded in tectorial membrane

- Table 18.3