Sensory System

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Sensory System

In this unit we will discuss:

- Receptors & Sensation
- What a sensation is
- General senses:
  - Pain—Touch—Pressure—Temperature
    Proprioception
- Special senses:
  - Smell—Taste—Sight—Hearing

Sensory System

- Our senses allow us to experience the world
- Our senses work both internally & externally giving our body messages about our environment

Sensory Receptors

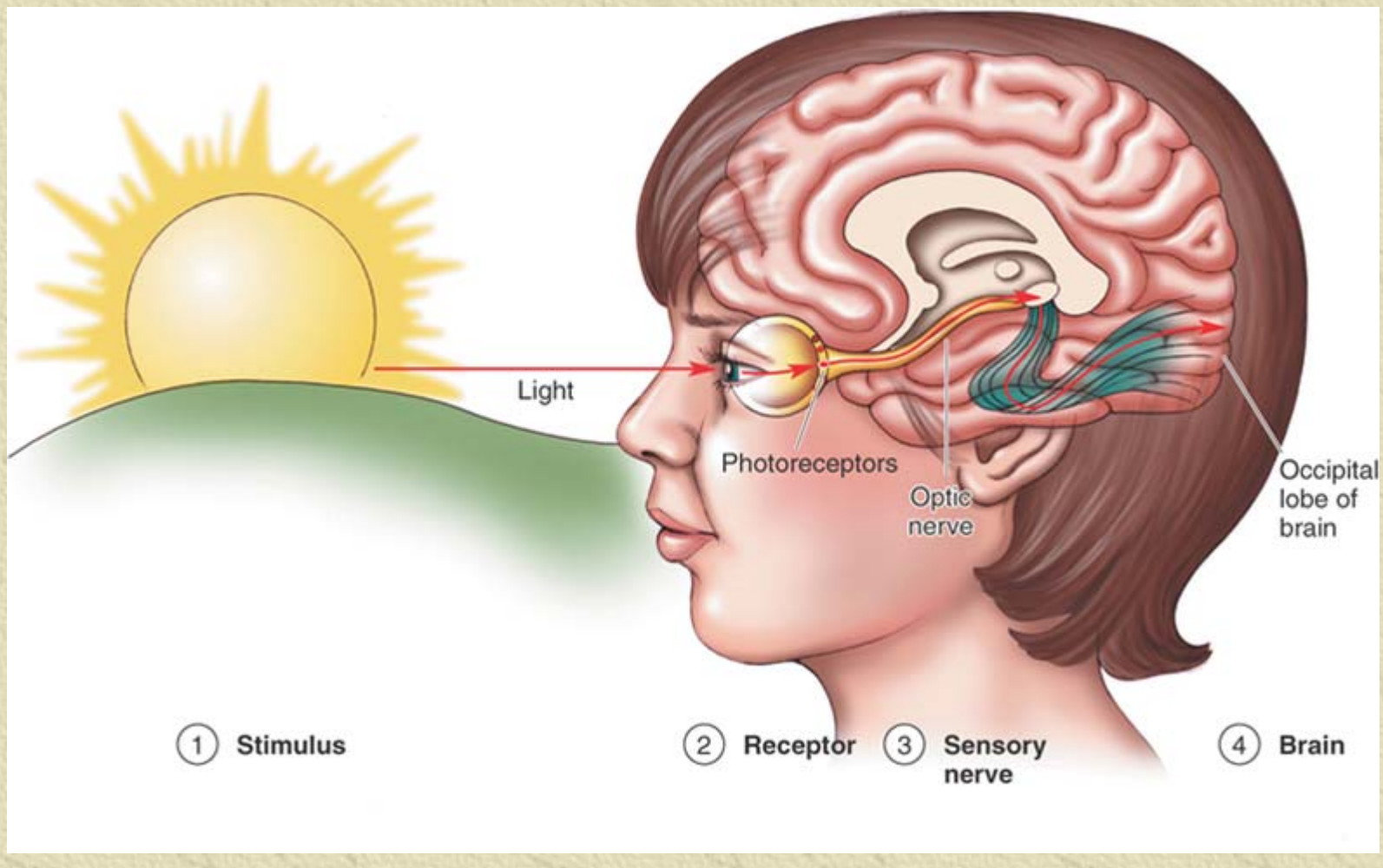
- Sensory neurons transmit messages to the CNS.
- A receptor is a specialized area of a sensory neuron that detects a specific stimulus
- 5 types of sensory receptors:
  - Chemoreceptors
  - Pain receptors
  - Thermoreceptors
  - Mechanoreceptors
  - Photoreceptors

Sensory Receptors

- Chemoreceptors: stimulated by changes in chemical concentration of substances
- Pain receptors: AKA nociceptors are stimulated by tissue damage
- Thermoreceptors: stimulated by temperature change
- Mechanoreceptors: stimulated by changes in pressure or movement of bodily fluids
- Photoreceptors: stimulated by light

Sensations

- A sensation is the conscious awareness of incoming information
- It is experienced by the brain
- Four components:
  - Stimulus
  - Receptor
  - Sensory nerve
  - Special area of the brain


Light
Photoreceptors
Optic nerve
Occipital lobe of brain
1 Stimulus
2 Receptor
3 Sensory nerve
4 Brain

Sensations

- Two important characteristics:
  - Projection: after brain receives the sensation it projects it back to the source

  Example: Phantom Pain
  - Adaptation: occurs when receptors are continuously stimulated, receptors send fewer & fewer signals to brain.

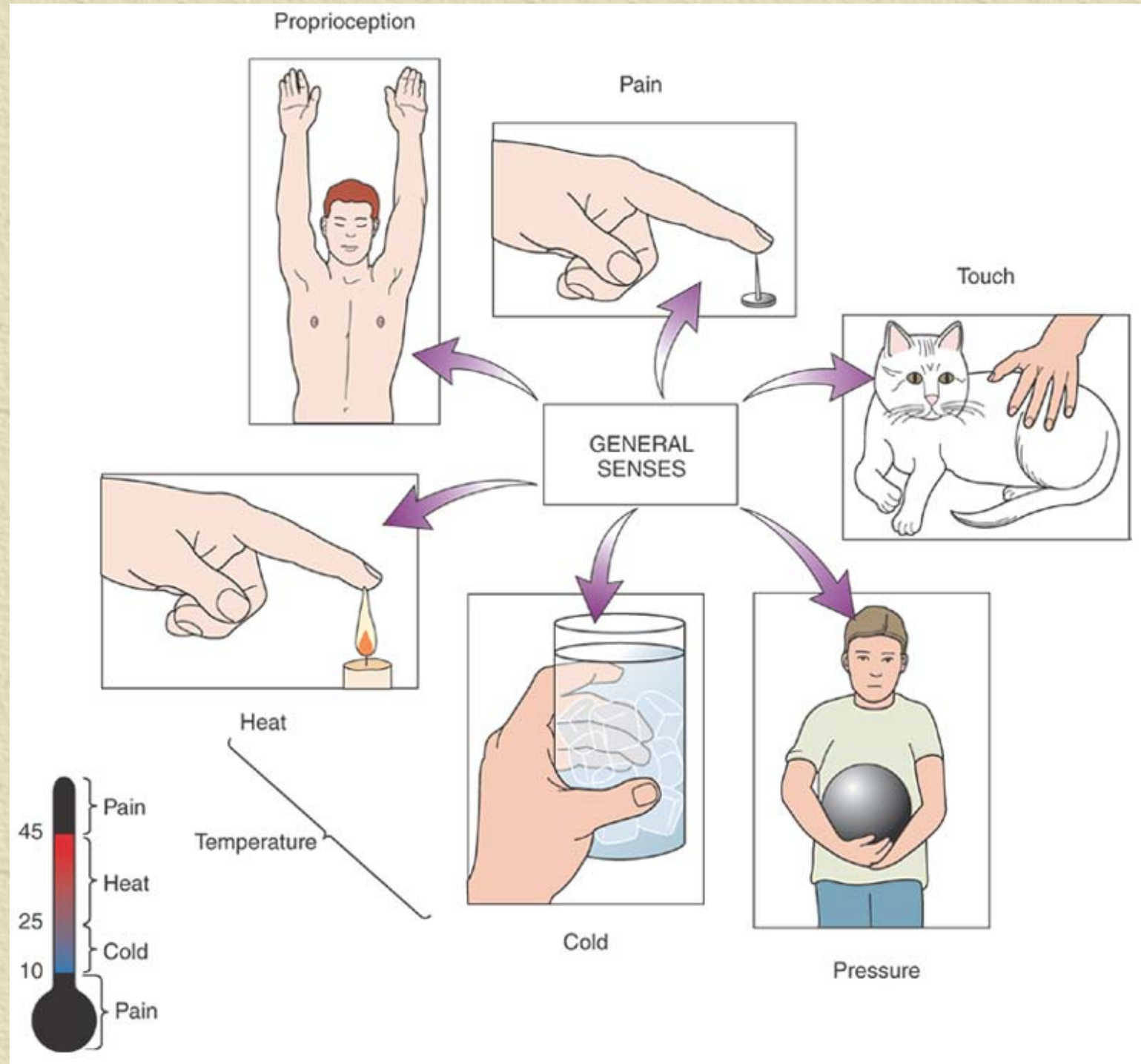
  Example: Strong odor

Sensations

- Two type of senses:
  - General senses
    - AKA somatic
    - Widely distributed throughout body
  - Specials senses
    - Localized within particular organ
    - Includes: sight, taste, smell, hearing, balance

General Senses

- General Senses include:
  - Pain
  - Touch
  - Pressure
  - Temperature
  - Proprioception


Proprioception
Pain
Touch
GENERAL SENSES
Heat
Cold
Pressure
Temperature
45
25
10
Pain
Heat
Cold
Pain

General Sense: Pain

- Receptors for pain consists of free nerve endings
- Receptors do not adapt so continuously send signals even after the stimulus is removed
- Receptors are widely distributed throughout skin, visceral organs & internal tissues
- Serves as a protective function

General Sense: Pain

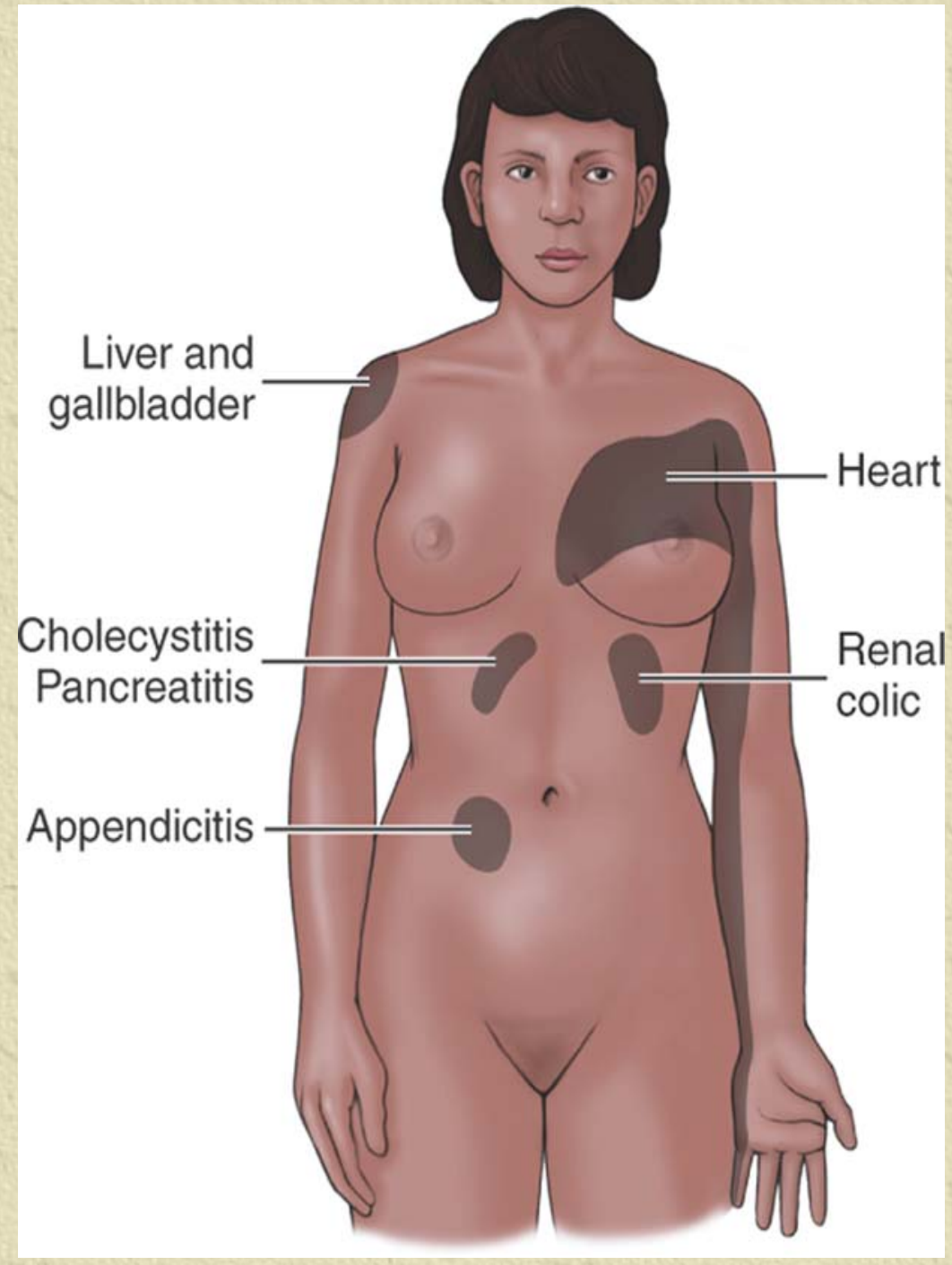
- Three pain triggers:
  1. Tissue injury promotes the release of certain chemicals that stimulate pain receptors
  2. Deficiency of oxygen stimulates pain receptors
  3. Mechanical stimulus such as stretching or distortion triggers pain receptors

General Sense: Pain

- Pain impulses travel up the spinal cord via a sensory nerve tract called spinothalamic tract
- Then the impulse is transmitted to the thalamus & person becomes aware of pain
- The impulse then travels to the cerebral cortex (in the parietal lobe) where the source is identified & intensity determined

General Sense: Pain

- Referred pain: pain is felt away from origin
- Thought to occur due to the sharing of sensory pathways; same nerves carry information back to more than one area
  - Example: gallbladder disease: pain felt in shoulder blade
  - Heart disease: pain felt in jaw or left arm


Liver and gallbladder
Heart
Cholecystitis Pancreatitis
Renal colic
Appendicitis

General Sense: Touch & Pressure

- Touch & pressure receptors are mechanoreceptors
- Respond to forces of pressure, movement or deforming of tissue
- Touch also called tactile receptors
- Receptors for heavy pressure are located in the skin, subcutaneous & deep tissue

General Sense: Temperature

- Two types of thermoreceptors:
  - Heat & Cold
- Found in free nerve endings & specialized sensory cells beneath skin & throughout body
- Cold receptors: stimulated 50 - 76 F
- Hot receptors: stimulated 76-112 F
- Beyond both temp scales pain receptors are stimulated producing freezing or burning sensation
- These receptors also adapt so sensations fade but pain does not if extreme temperature

General Sense: Proprioception

- Proprioception: the sense of orientation or position
- Allows us to locate body part without looking
- Helps with coordination & posture
- Proprioreceptors are located in muscles, tendons, joints & inner ear
- Sensory information is sent to the cerebellum & parietal lobe where it is interpreted

Special Senses

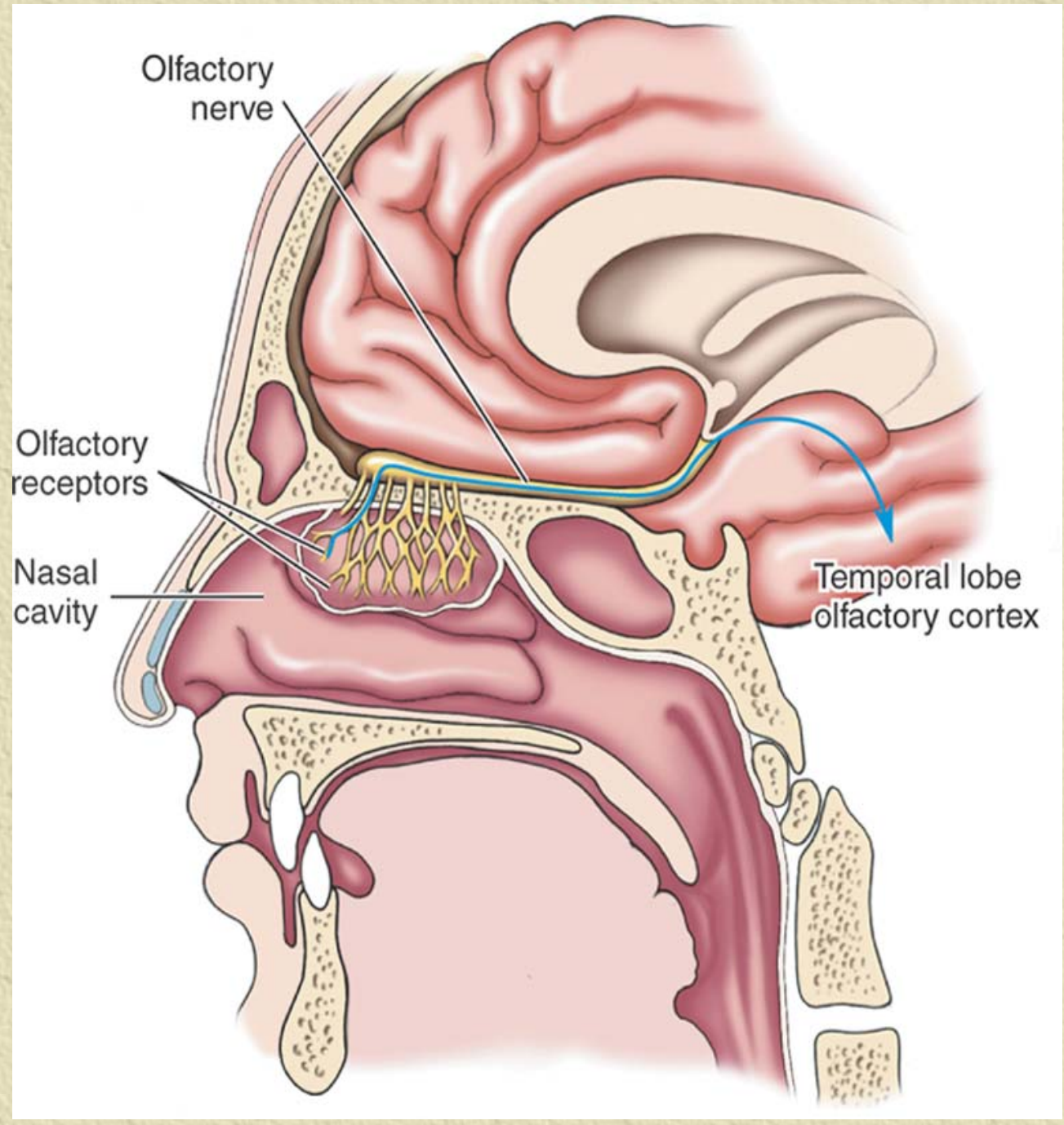
- Five special senses:
  - Smell
  - Taste
  - Sight
  - Hearing
  - Balance

Sense of Smell

- Known as the olfactory sense
- Associated with the sense structures located in the upper nose called **olfactory receptors**
- These olfactory receptors are also classified as **chemoreceptors** since they are stimulated by chemicals dissolved in the moisture of the nasal tissue

Sense of Smell

- Olfactory receptors are stimulated; sending a sensory impulse along the olfactory nerve (cranial nerve I)
- The information is interpreted as smell in the olfactory cortex of the temporal lobe
- Olfactory receptors readily adapt


Olfactory
nerve
Olfactory
receptors
Nasal
cavity
Temporal lobe
olfactory cortex

Sense of Taste

- AKA gustatory sense
- Taste buds are located on the tongue & are classified as chemoreceptors since they are sensitive to the chemicals in food
- 4 tastes sensations & location:

  salty—tip of tongue

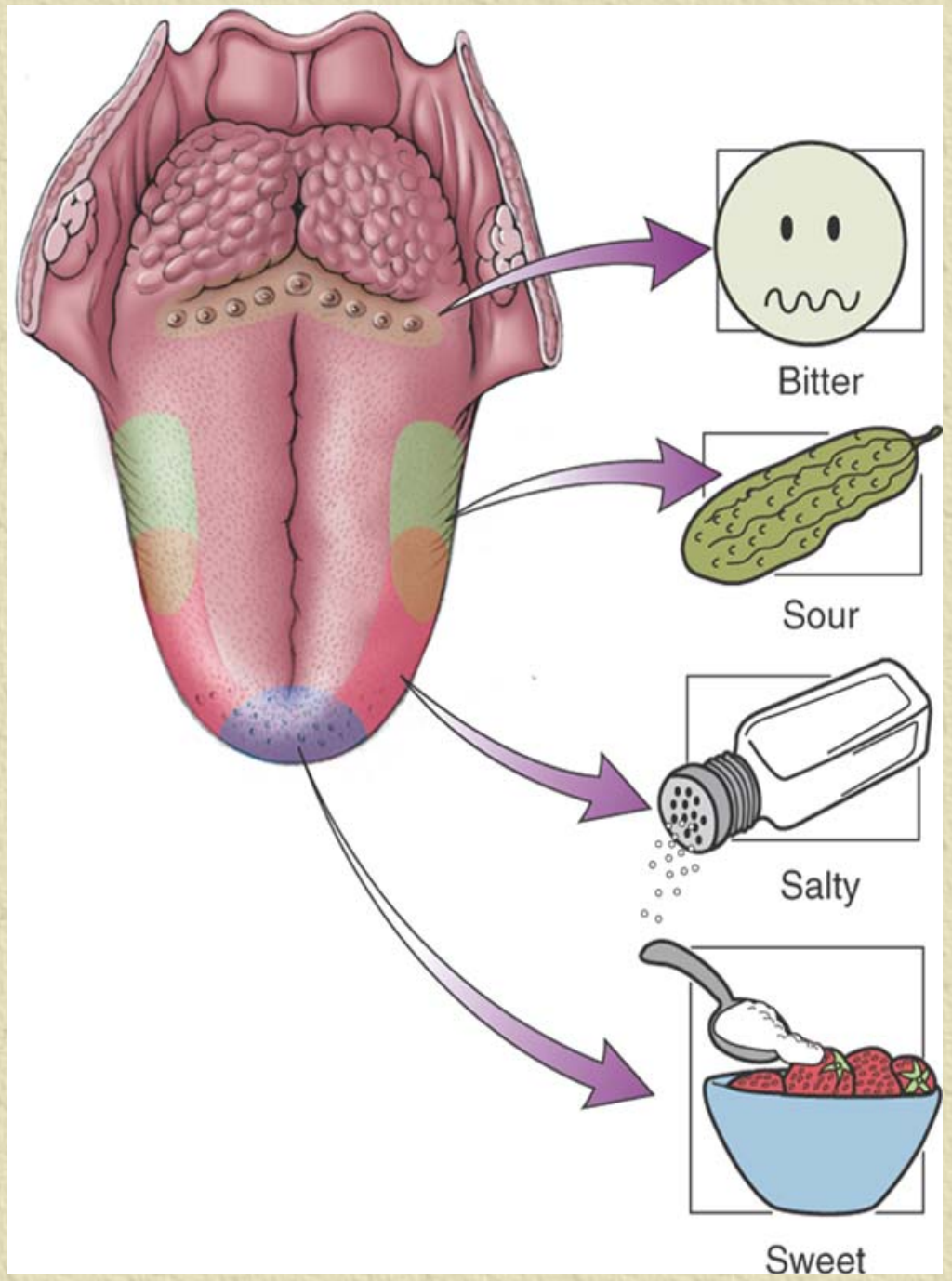
  sweet—tip of tongue

  bitter—back of tongue

  sour—sides of tongue

Sense of Taste

- Taste receptors are stimulated, the impulse travels along the facial(cranial nerve VII) & glossopharyngeal(cranial nerve IX)nerve to the parietal & temporal lobes of the cerebral cortex
- Taste receptors adapt
- Bitter sensation is especially sensitive & serves a protective role against poisonous substances which are generally bitter


Bitter
Sour
Salty
Sweet

Sense of Sight

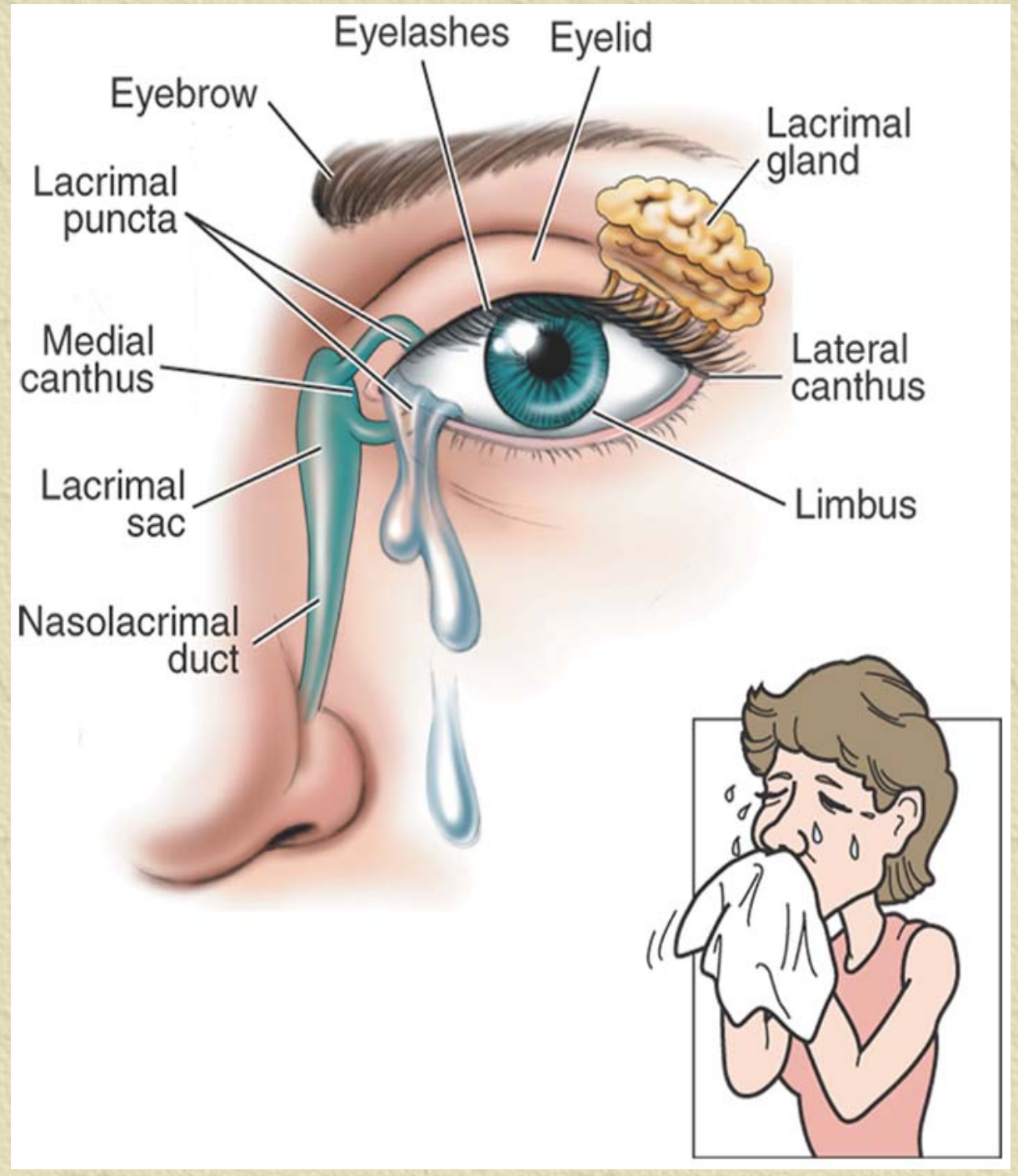
- Contain visual receptors
- Have visual accessory organs to assist & protect vision:
  - Eyebrows:
    - hair above eye
    - keeps perspiration out
    - shades sunlight

Sense of Sight

- Eyelids:
  - protects eyes
  - meet at corners called medial canthus & lateral canthus
  - Composed of 4 layers:
    - skin
    - skeletal muscles: levator muscle opens eye; orbicularis oculi closes eye
    - connective tissue
    - Conjunctivia: thin mucous membrane lines inner surface of eyelid & anterior portion of eyeball (white of eye)

Sense of Sight

- Eyelashes:
  - Line the edges of eyelids; traps dust & foreign objects
- Lacrimal Apparatus:
  - Lacrimal gland:
    - upper lateral part of orbit
    - secretes tears which flow across surface of eye toward nose
  - Tears:
    - drain through lacrimal punta into lacrimal sac & nasolacrimal ducts which empty into the nasal cavity
    - moisten, lubricate & cleanse the surface of the eye
    - composed primarily water & contains enzymes **lysozymes** that destroy bacteria preventing infection


Eyelashes
Eyelid
Eyebrow
Lacrimal gland
Lacrimal puncta
Medial canthus
Lateral canthus
Lacrimal sac
Limbus
Nasolacrimal duct

Sense Of Sight

- Eyeball:
  - Spherical shape ¾ to 1 inch in diameter
  - Sits in orbital cavity
- Three layers:
  - Sclera:
    - outermost layer made of fibrous connective tissue
    - Shapes eye & is site of attachment for extrinsic eye muscles

Sense of Sight

- Cornea:
  - Anterior portion of the sclera
  - Avascular
  - Allows light to enter called window of the eye
  - Rich with sensory nerve fibers & sensitive to touch
  - Corneal reflex: blink when cornea touched; serves as protection to cornea

Sense of Sight

- Choroid:
  - Middle layer of eye
  - Highly vascular
  - Attached to retina (innermost layer)
  - Provides retina with blood supply
  - Contains dark pigment that absorbs excess light preventing glare

Sense of Sight

- Choroid
  - Extends toward front of eyeball forming ciliary body & iris
  - Ciliary body is located toward front of eye & has two functions:
    - Secretes aqueous humor
    - Contains ciliary muscles (intrinsic eye muscles)
  - Iris is colored portion of anterior eye & regulates the amount of light entering the eye
  - Pupil is opening in center of Iris

Sense of Sight

- Retina:
  - Innermost layer of the eyeball
  - Lines posterior 2/3 of the eyeball
  - Nervous layer containing visual receptors that are sensitive to light so are called photoreceptors
  - Two kinds of photoreceptors:
    - Rods:
      - scattered throughout retina but mostly in peripheral
      - Sensitive to dim light & give black & white vision
      - Image is fuzzy
      - Responsible for night vision

Sense of Sight

- Cones:
  - Most abundant in central portion of retina
  - Responsible for color vision
  - Three cones with different visual pigments: one cone produces green pigment, another blue & another red
  - Fovea centralis is the area of highest concentration of cones which is an area in the center of macula lutea
  - Macula lutea is the area of most acute vision
  - Sharp vision

Sense of Sight

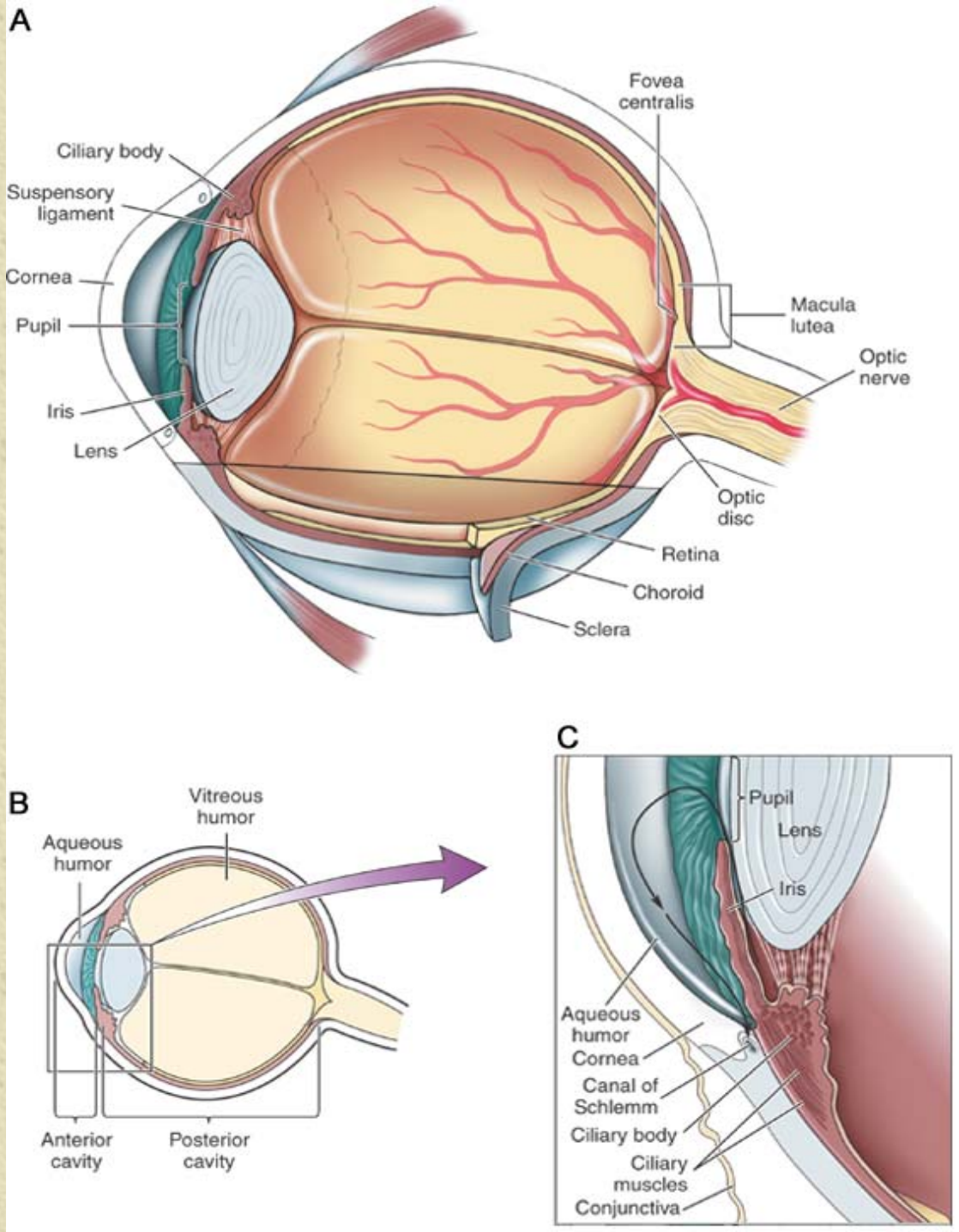
- Retina:
  - Optic disc is the small circular area located at the back of the eye where the neurons of the eye converge and form the optic nerve
  - Called the blind spot because it does not contain photoreceptors
  - With brain injury, increase in ICP cause a bulging of the optic disk called papilledema

Sense of Sight

- Cavities & Fluids:
  - Two cavities:
    - Posterior Cavity: larger & located between lens & retina; contains gel-like substance called **vitreous humor** which pushes retina against choroid layer ensuring good blood supply
    - Anterior Cavity: located between lens & cornea & is filled with watery fluid **aqueous humor**

Sense of Sight

- Aqueous humor:
  - Produced by ciliary body & circulates through pupil into space behind cornea
  - Maintains shape of anterior eye
  - Nourishes cornea
  - Exits anterior cavity via venous sinuses or canals of Schlemm located at the junction of the sclera & cornea


A
Fovea centralis
Ciliary body
Suspensory ligament
Cornea
Pupil
Iris
Lens
Macula lutea
Optic nerve
Optic disc
Retina
Choroid
Sclera
B
Vitreous humor
Aqueous humor
Anterior cavity
Posterior cavity
C
Pupil
Lens
Iris
Aqueous humor
Cornea
Canal of Schlemm
Ciliary body
Ciliary muscles
Conjunctiva

Sense of Sight

- Intrinsic Eye Muscles:
  - 3 Smooth muscles in iris & ciliary body
  - First muscle is **ciliary** muscles which arise from ciliary process, attach to lens & helps focus the light waves on the retina
  - Iris contains 2, the **radial** & **circular** muscles, that control the size of the pupil therefore the amount of light entering the eye

Sense of Sight

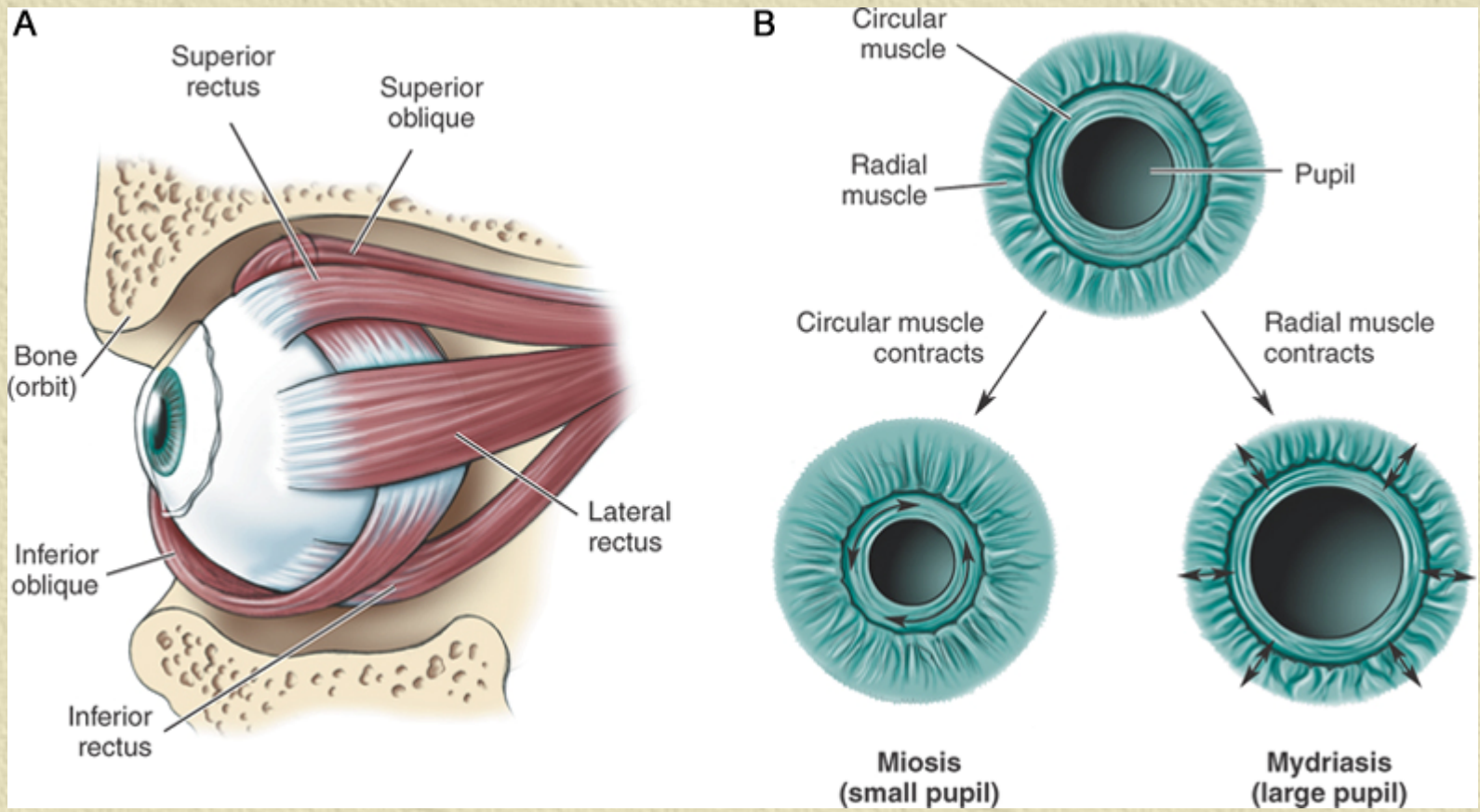
- Intrinsic Muscles:
  - Radial:
    - Arranged like spokes of a wheel
    - Contraction cause light to dilate increasing the amount of light into the eye
    - Supplied by sympathetic nerves so with sympathetic nerve stimulation dilation occurs called ***mydriasis***

Sense of Sight

- Intrinsic Muscle:
  - Circular muscle:
    - Arranged circularly
    - Contraction of muscles causes constriction of the pupil decreasing the amount of light into the eye
    - Supplied by the parasympathetic nervous system more specifically Cranial Nerve III (oculomotor)
    - Stimulation of the parasympathetic nerve causes pupillary constriction or ***miosis***

Sense of Sight

- Extrinsic eye muscles:
  - Skeletal muscles located outside of eye attaching bone to eyeball
  - 6 extrinsic muscles attach to the bone of eye orbit & sclera:
    - 4 rectus: moves up, down & sidways
    - 2 oblique: allow us to roll eyes
  - Innervated by three cranial nerves; most importantly Cranial nerve III- occulomotor
  - Allows the various movements of the eyes

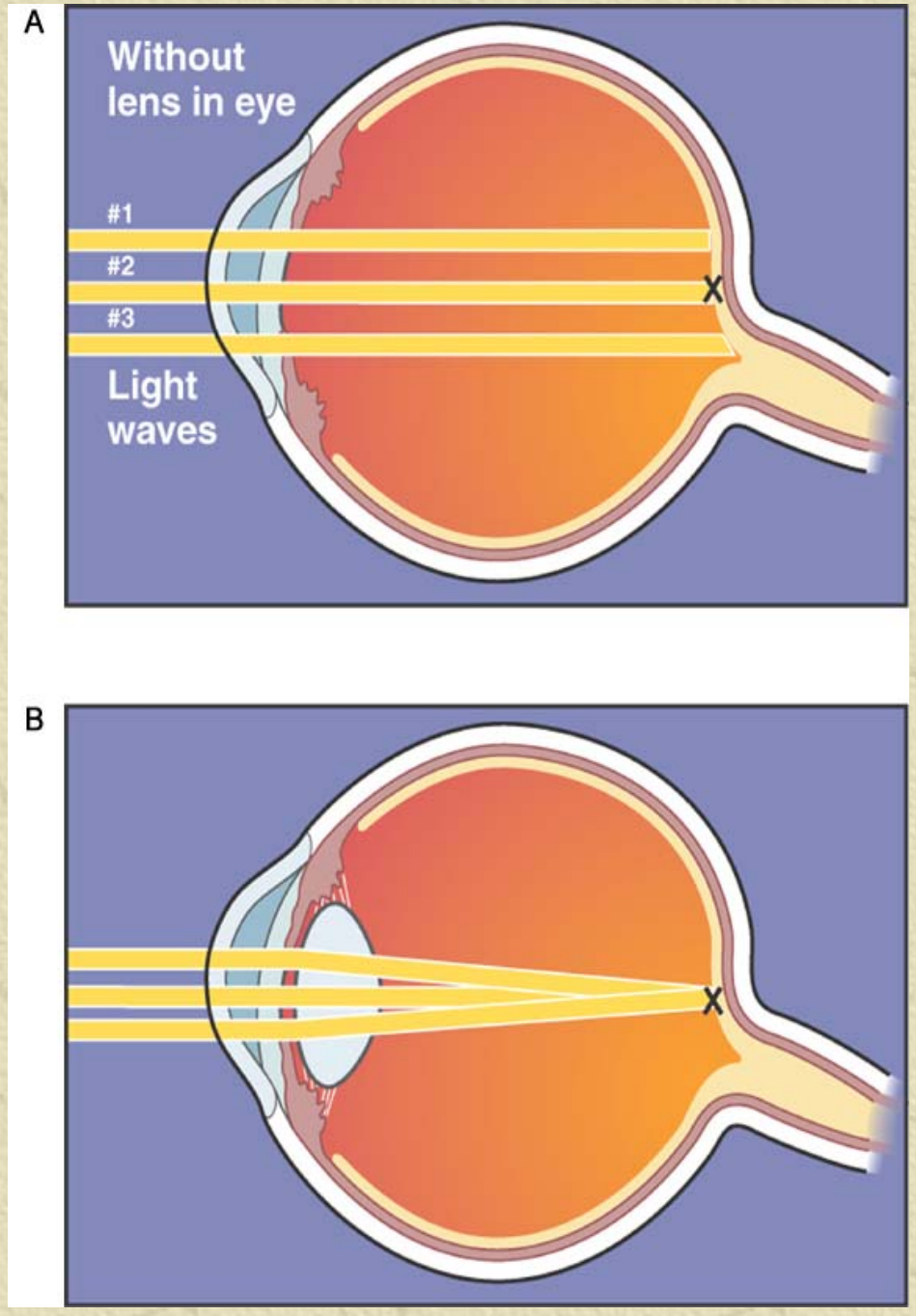

A
Superior rectus
Superior oblique
Bone (orbit)
Lateral rectus
Inferior oblique
Inferior rectus
B
Circular muscle
Radial muscle
Pupil
Circular muscle contracts
Radial muscle contracts
Miosis (small pupil)
Mydriasis (large pupil)

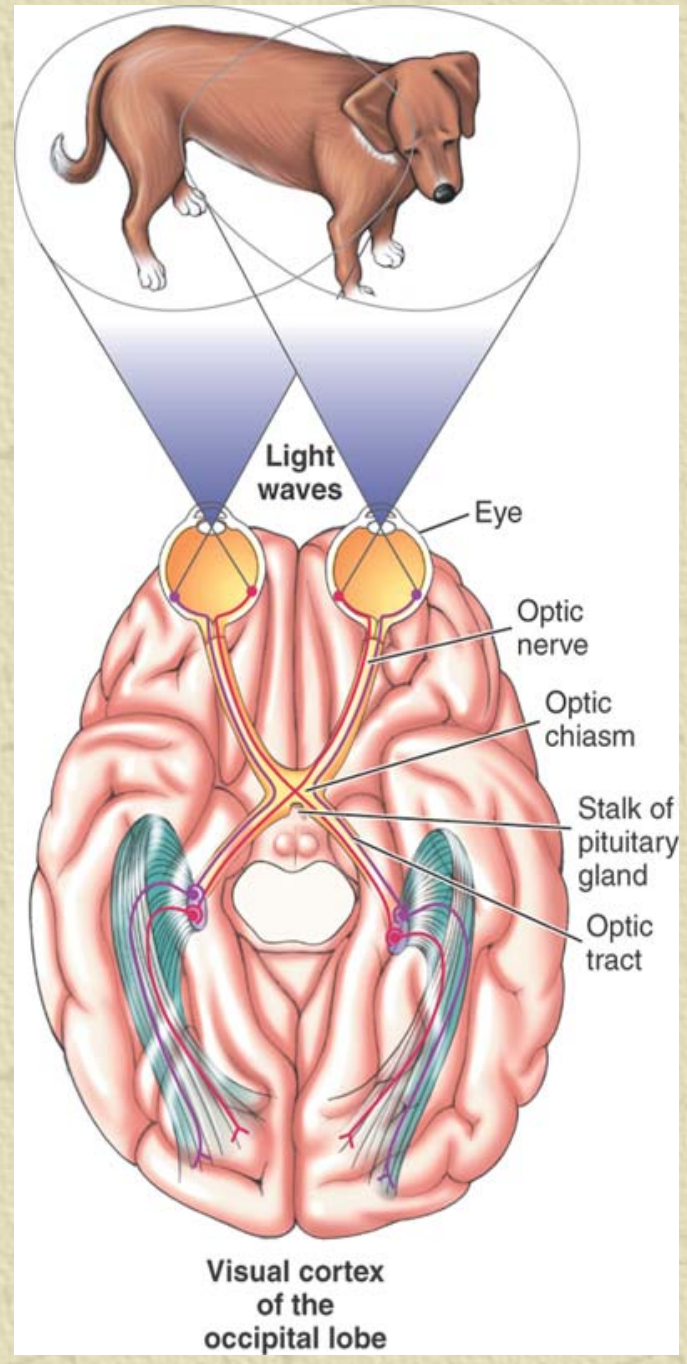
Sense of Sight

- How we see:
- Light waves enter the eye & are refracted (bent) & focus on the photoreceptors of the retina.
- Photoreceptors translate the light signal into a nerve impulse which is transmitted from the retina along the optic nerve (along visual pathway) to the occipital lobe of the brain where we experience vision
- Crossover of fibers from left & right eye at the optic chiasm (located directly in front of the pituitary gland) allow for only one image

Sense of Sight

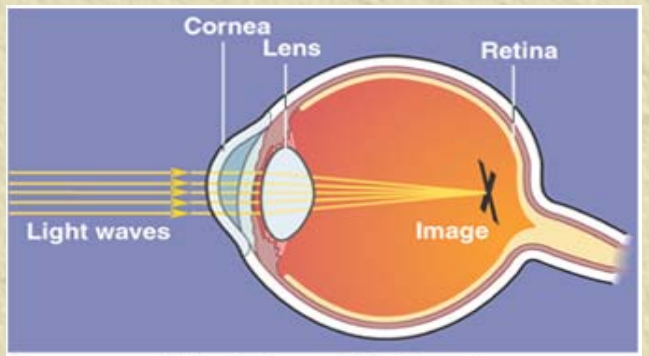
- For sharp image light waves must be bent or refracted on a particular spot on the retina; the lens, cornea & aqueous humor do this
- The lens adjusts the amount of refraction by changing shape (flattens & rounds)
- The lens is held in place by suspensory ligaments attached to the ciliary muscles
- Ciliary muscles contract & relax causing change in the shape of the lens
- The ability of the lens to change shape allows the eye to focus on objects close up(accommodation) or at a distance


A
Without lens in eye
#1
#2
#3
Light waves
X
B
X

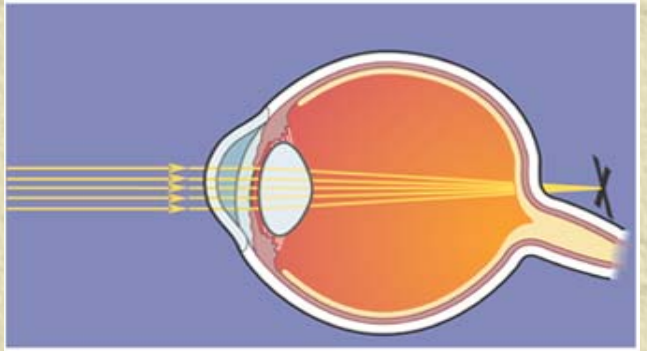

Light waves
Eye
Optic nerve
Optic chiasm
Stalk of pituitary gland
Optic tract
Visual cortex of the occipital lobe

Sense of Sight

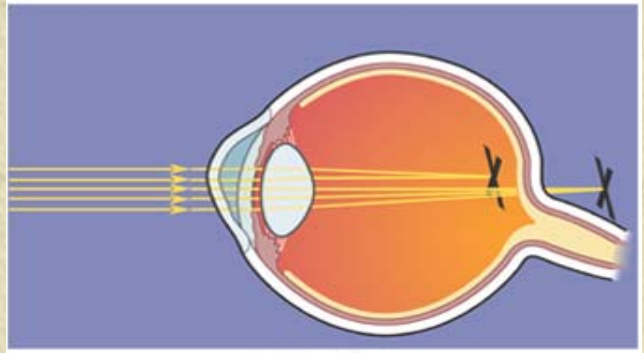
- Errors with refraction:
  - Myopia: nearsightedness; light is in front of retina; can only see close objects clearly
  - Hyperopia: farsightedness; light behind retina; can only see far objects clearly
  - Astigmatism: uneven refraction of light waves so image not properly focused on retina



Myopia (nearsightedness)



Hyperopia (farsightedness)



Astigmatism

Sense of Hearing

- Structure of the ear:
  - Three parts: External ear—middle ear—inner ear
  - External ear:
    - Visible to us
    - Composed of:
      - auricle: AKA pinna; composed of cartilage covered with loose-fitting skin
      - external auditory canal: hollow canal provides passage way for sound; 1” long & 1/2” wide; extends to tympanic membrane
      - tympanic membrane: AKA ear drum; separates the external & middle ear
    - The external auditory canal is lined with tiny hairs & glands that secrete cerumen which is protective mechanism

Sense of Hearing

- Middle Ear:
  - Small air-filled chamber located between the tympanic membrane & a bony wall
  - Contains: tympanic membrane—malleus—incus—stapes—eustachian tube
  - Tympanic membrane:
    - is composed of connective tissue
    - has rich blood & nerve supply
    - Vibrates in response to sound waves

Sense of Hearing

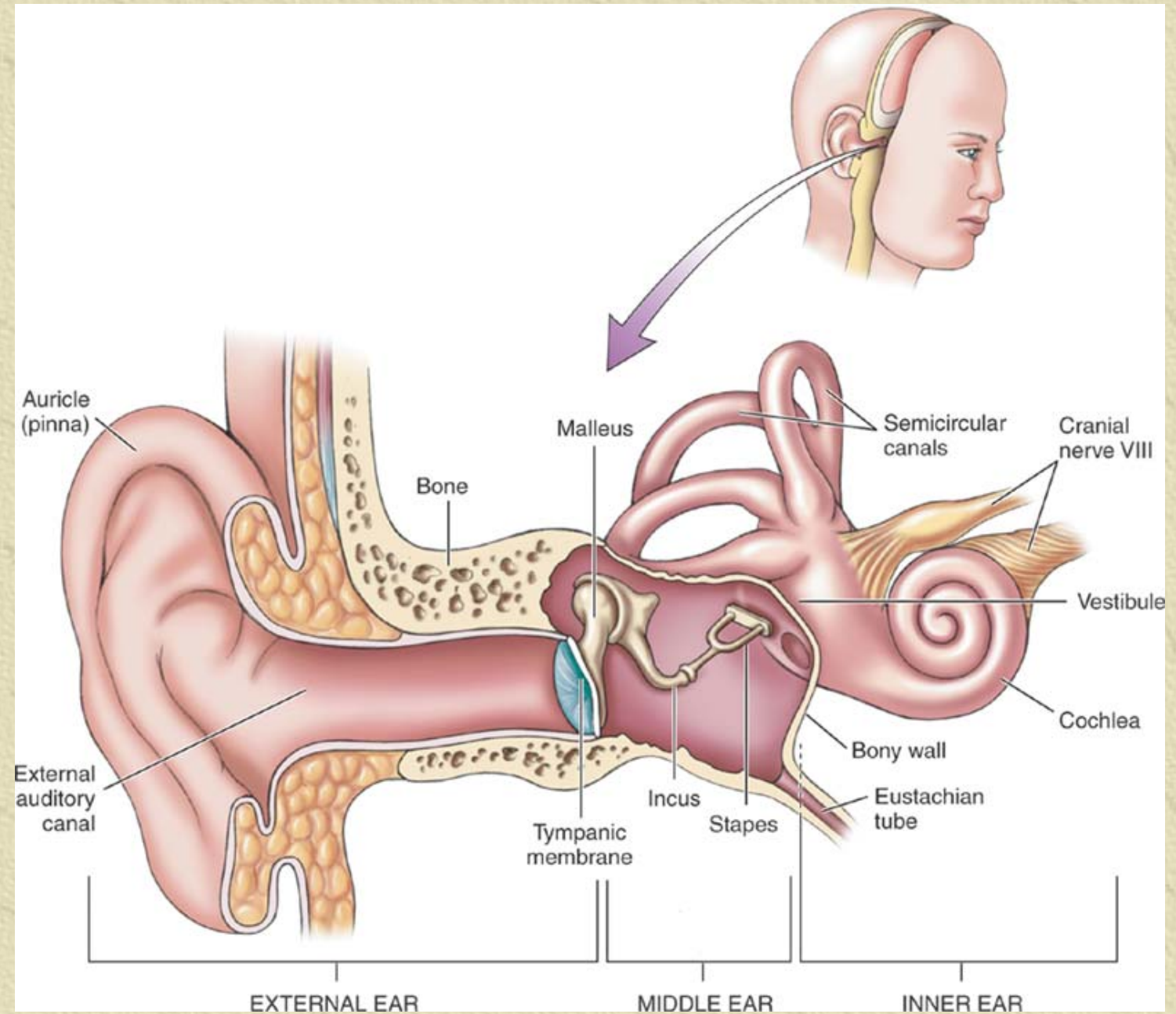
- Middle Ear:
  - Ossicles: AKA three tiny bones
    - Extend from the tympanic membrane to the oval window which is a membranous structure in the bony wall that separates the middle ear from the inner ear
    - Bones are the mallus(hammer), incus(anvil) & stapes (stirrup)
    - They transmit vibration from the tympanic membrane to the oval window
  - Eustachain tube:
    - passageway connecting the middle ear to the pharynx (throat)
    - Function: equalize pressure on both sides of the tympanic membrane by permitting air to pass from throat to middle ear

Sense of Hearing

- Inner Ear:
  - Intricate system of tubes hollowed out of temporal bone called bony labyrinth
  - Inside of bony labyrinth is membraneous labyrinth
  - Perilymph is a fluid that fills the bony labyrinth & surrounds the membraneous labyrinth
  - Endolymph is thick fluid within the membraneous labyrinth
  - Three parts: the vestibule—semicircular canals—cochlea

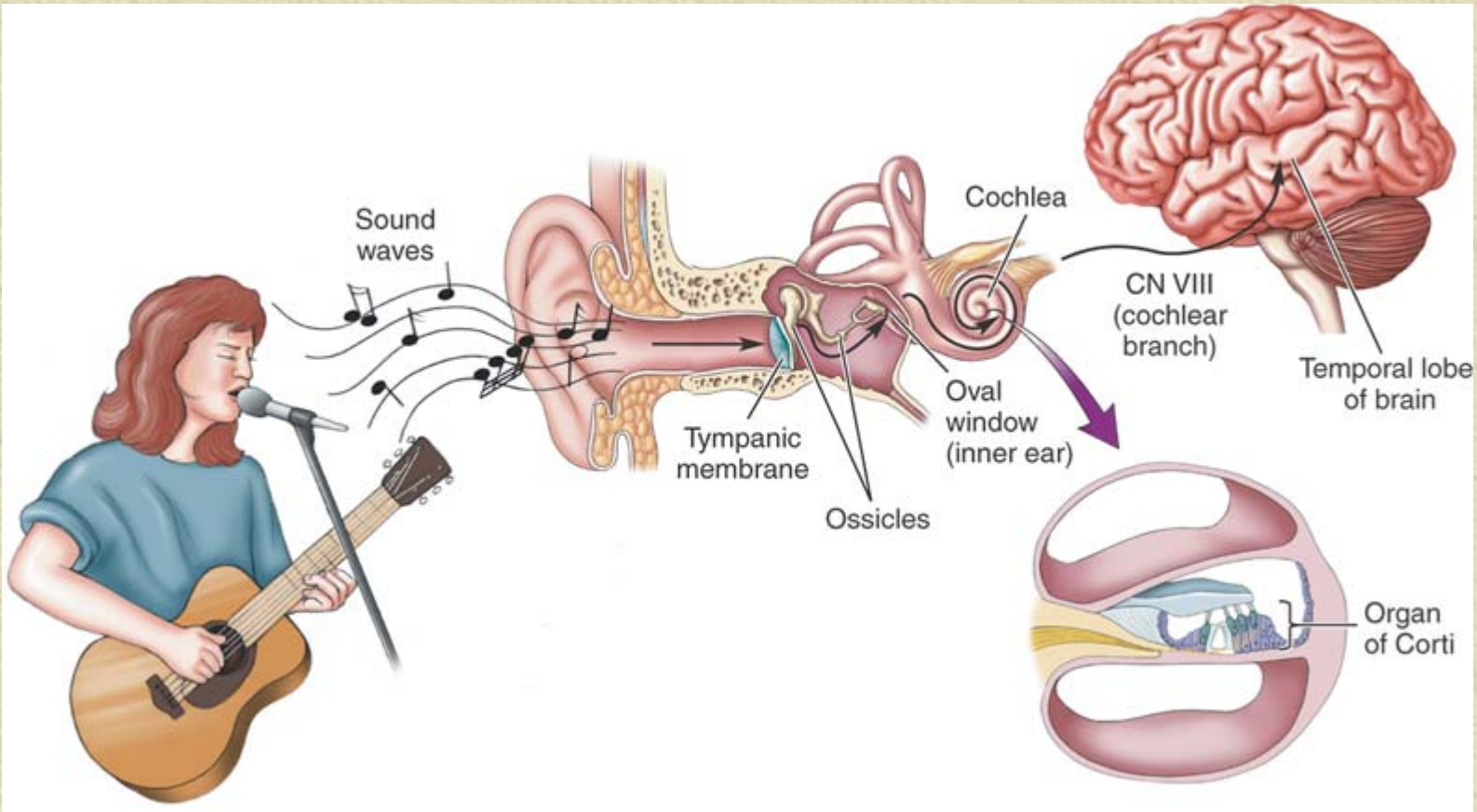
Sense of Hearing

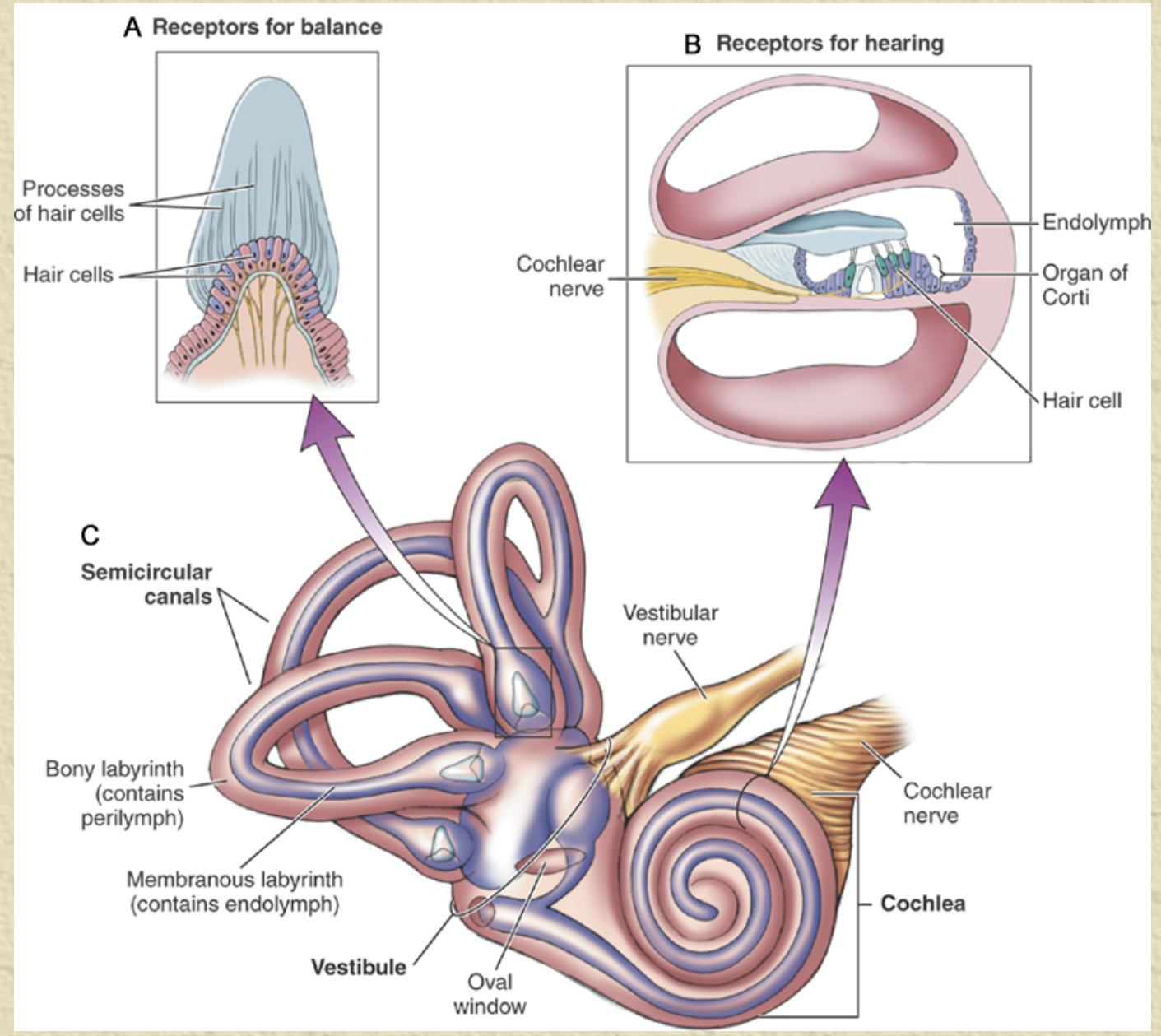
- Inner Ear:
  - vestibule & semicircular canals are concerned with balance
  - Cochlea:
    - snail-shaped part of bony labyrinth that contains hearing receptors
    - organ of Corti: cells that contain tiny hairs; hearing receptors
    - When the hairs on the receptor cells are bent, a nerve impulse is sent by the cochlear branch of the vestibulocochlear nerve to the temporal lobe where the sensation is interpreted as hearing


Auricle (pinna)
Bone
Malleus
Semicircular canals
Cranial nerve VIII
Vestibule
Cochlea
Bony wall
Eustachian tube
External auditory canal
Incus
Stapes
Tympanic membrane
EXTERNAL EAR
MIDDLE EAR
INNER EAR

Sense of Hearing

- Physiology of Hearing:
  - Sound waves travel through the external auditory canal & hit the tympanic membrane causing it to vibrate.
  - That vibration causes the middle ear bones (malleus, incus & stapes) to vibrate.
  - The stapes sitting in the oval window causes the fluid in the inner ear to move.
  - This causes the hairs (organ of Corti) sitting within the fluid to bend.
  - The bending of the hair triggers a nerve impulse (via the cochlear nerve branch of the vestibulocochlear nerve) to the temporal lobe where it is interpreted as sound


Sound
waves
Cochlea
CN VIII
(cochlear
branch)
Temporal lobe
of brain
Oval
window
(inner ear)
Tympanic
membrane
Ossicles
Organ
of Corti

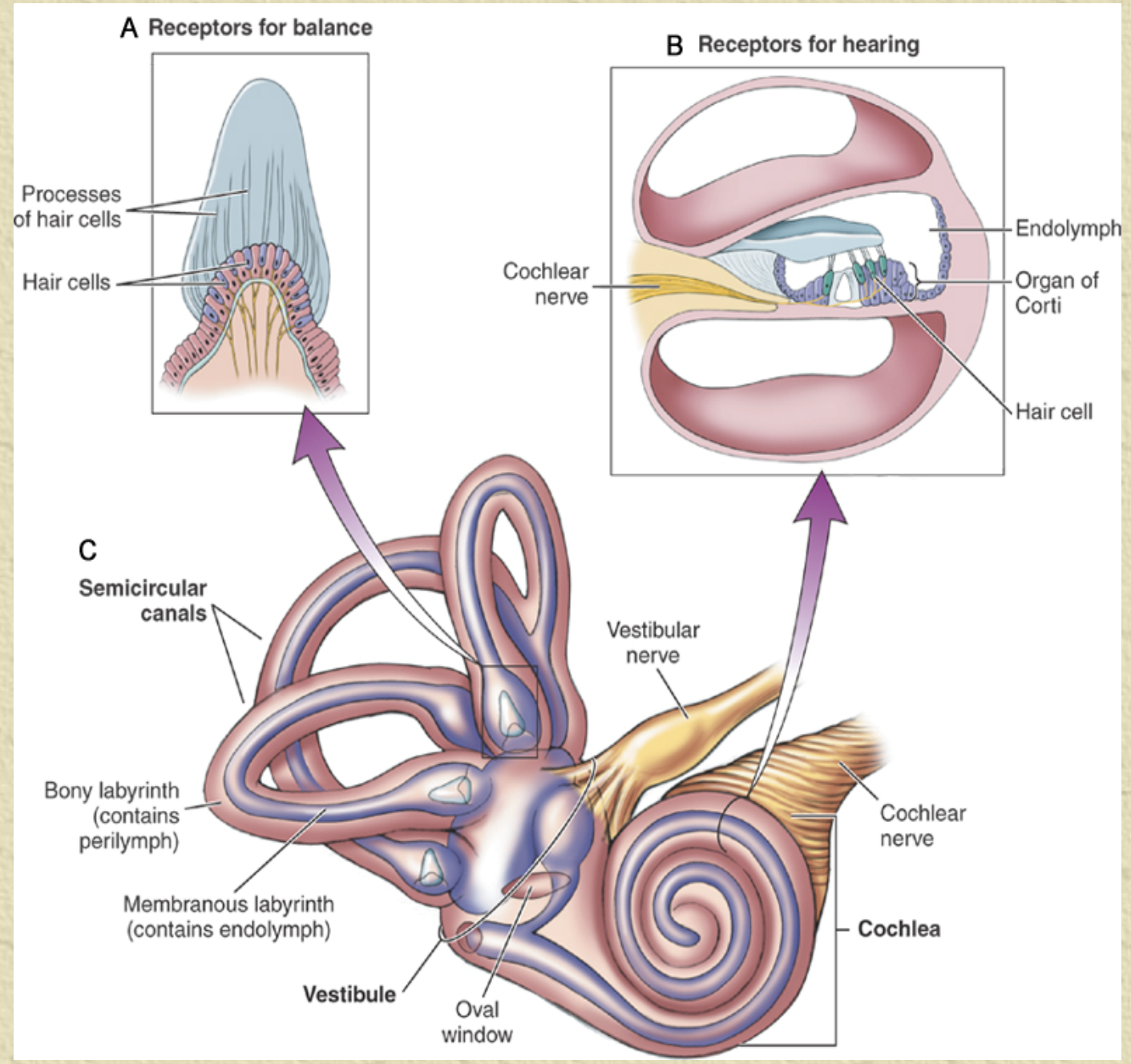

A Receptors for balance
Processes of hair cells
Hair cells
B Receptors for hearing
Endolymph
Cochlear nerve
Organ of Corti
Hair cell
C
Semicircular canals
Vestibular nerve
Bony labyrinth (contains perilymph)
Membranous labyrinth (contains endolymph)
Cochlear nerve
Cochlea
Vestibule
Oval window

Sense of Hearing

- Hearing can become impaired at various points along the way
  - Ear wax build up can affect the vibration of the tympanic membrane affecting transmission
  - Ossicles can become fused diminishing the ability to transmit vibration to the oval window
  - Stapes may become fixed to window diminishing the transmission to inner ear
  - Cranial nerve may be damaged impairing nerve impulse to the temporal lobe for interpretation

Sense of Balance

- The ear play a role in equilibrium
- The vestibule contains receptors for position of the head at rest
- The semicircular canals contains receptors in relation to the body as it moves
- When the position of the head changes, the hairs are bent triggering receptor cells to send a nerve impulse via the vestibular branch of the vestibulocochlear nerve(cranial nerve VIII) to the cerebellum, midbrain & temporal lobe.


A Receptors for balance
Processes of hair cells
Hair cells
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Semicircular canals
Vestibular nerve
Bony labyrinth (contains perilymph)
Membranous labyrinth (contains endolymph)
Cochlear nerve
Cochlea
Vestibule
Oval window