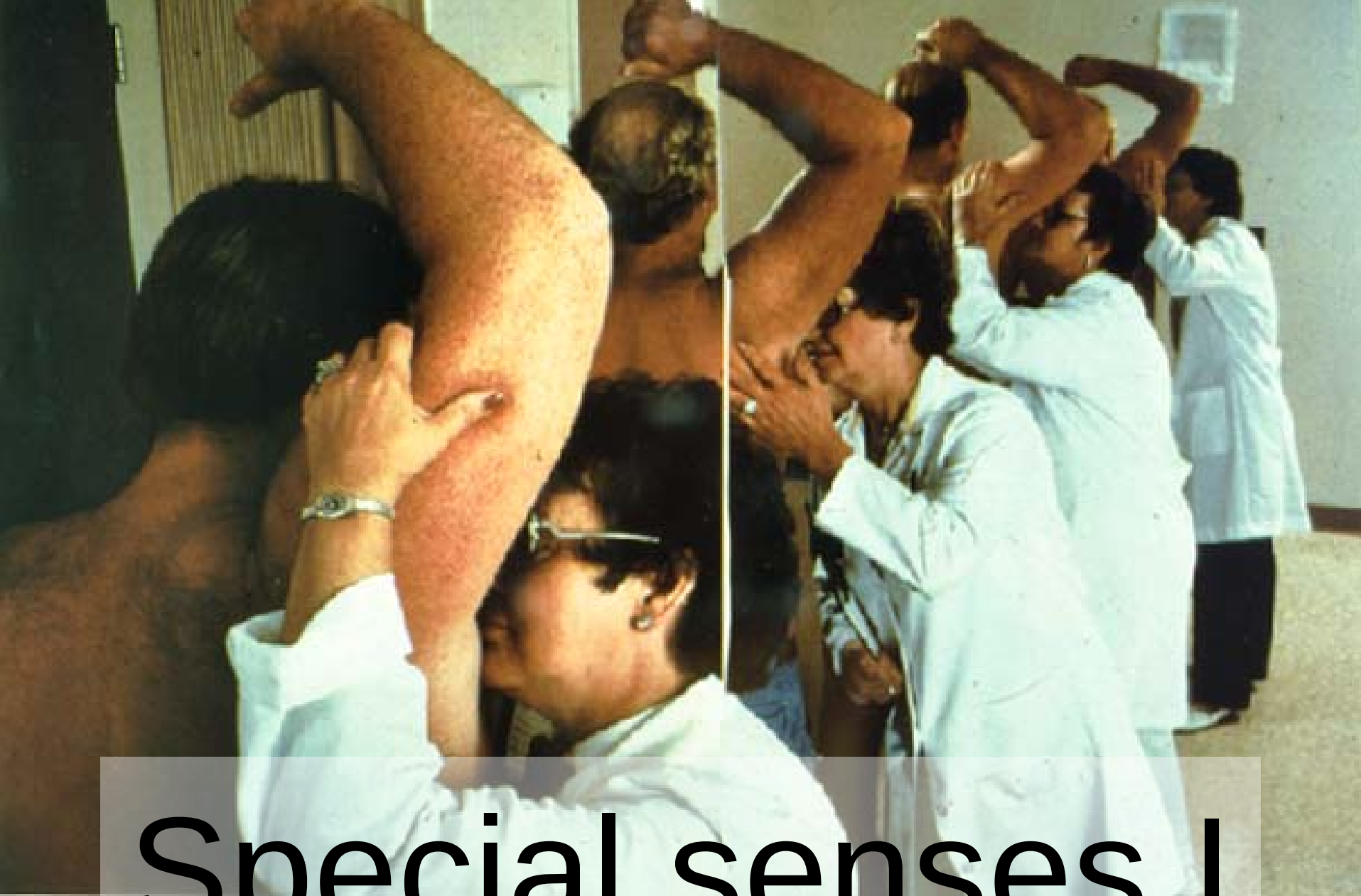


Special senses I

Receptors

- Detect stimulus in the body/external environment

General sense receptors-all over the body

The different types of receptors are:

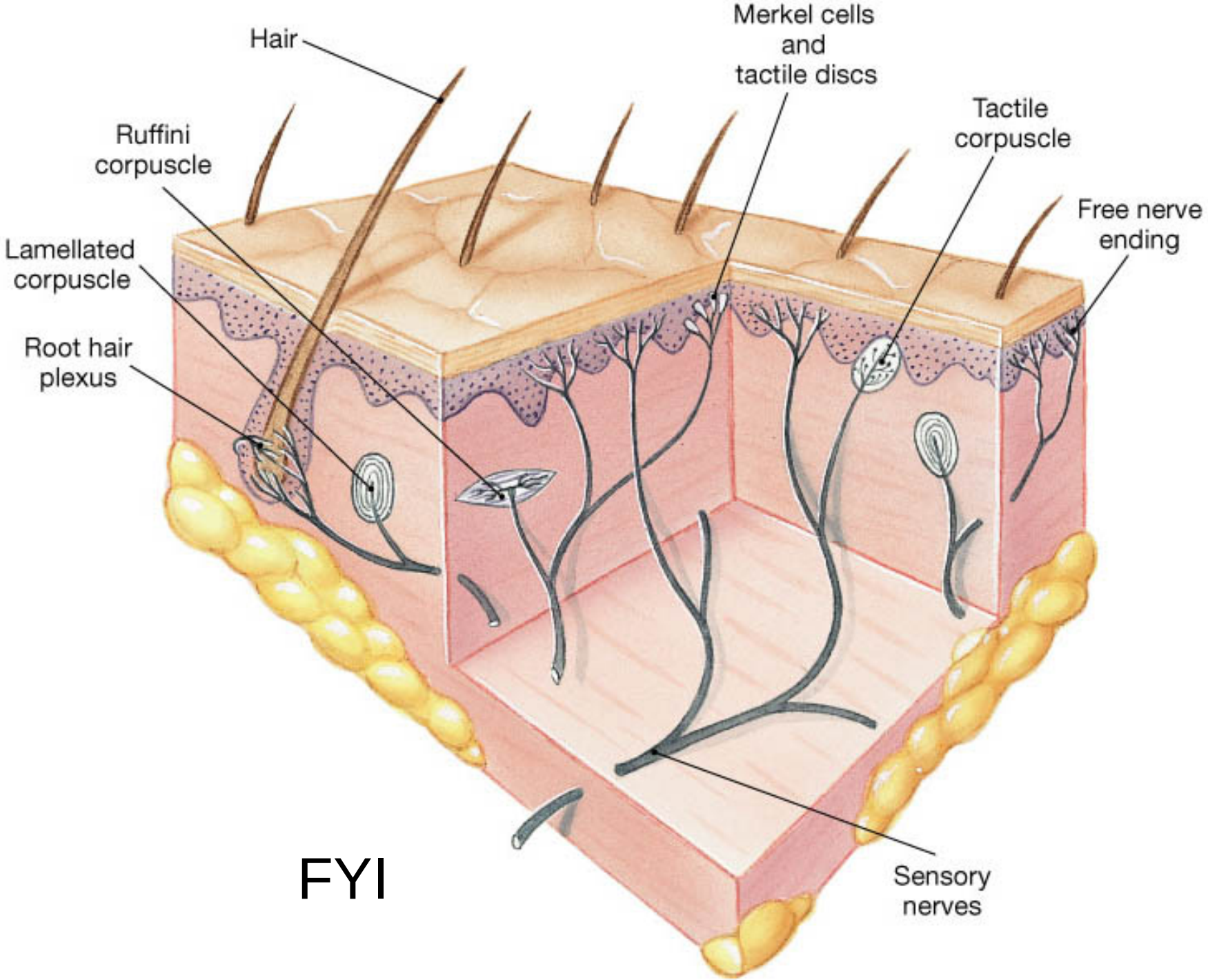
- Nociceptors-pain
- Thermoreceptors-temperature
- Mechanoreceptors-pressure (touch)
- Propioceptors-position of limbs
- Chemoreceptors: detect chemical change

- Vary in structure and functions
- Receptors show some “stimulus specific” quality
- If stimulus is sufficiently strong to make A.P.

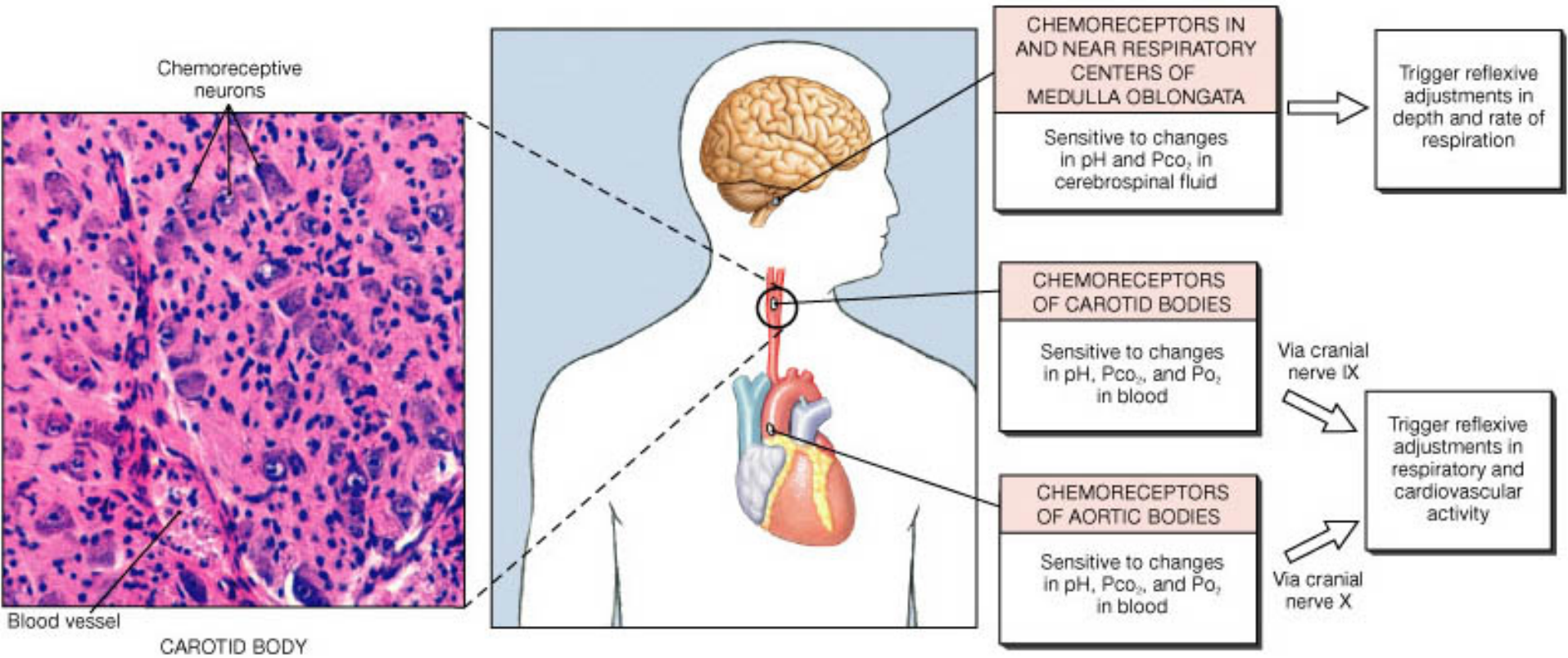
- **<u>Sensory Adaptation</u>**
- At first receptors easily stimulated
- Tolerance-greater stimulus is needed
- *General Receptors*: Receptors spread throughout body
- *Special Sense Receptors*: Receptors concentrated to an organ

Receptor > afferent neuron

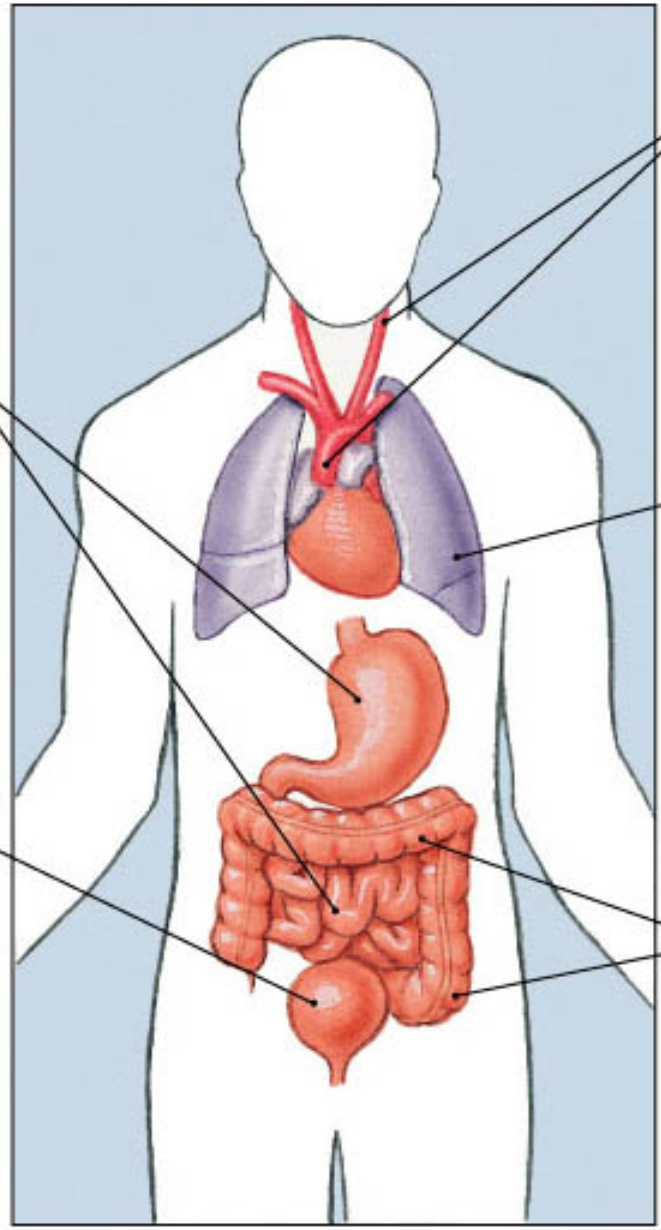
- Receptors stimulate sensory neurons
- Sensory neurons sends signal to the CNS


Hair
Merkel cells and tactile discs
Tactile corpuscle
Ruffini corpuscle
Free nerve ending
Lamellated corpuscle
Root hair plexus
Sensory nerves

FYI


Chemoreceptive neurons
Blood vessel
CAROTID BODY
CHEMORECEPTORS IN AND NEAR RESPIRATORY CENTERS OF MEDULLA OBLONGATA
Sensitive to changes in pH and Pco2 in cerebrospinal fluid
Trigger reflexive adjustments in depth and rate of respiration
CHEMORECEPTORS OF CAROTID BODIES
Sensitive to changes in pH, Pco2, and Po2 in blood
Via cranial nerve IX
CHEMORECEPTORS OF AORTIC BODIES
Sensitive to changes in pH, Pco2, and Po2 in blood
Via cranial nerve X
Trigger reflexive adjustments in respiratory and cardiovascular activity

FYI



BARORECEPTORS OF CAROTID SINUS AND AORTIC SINUS

Provide information on blood pressure to cardiovascular and respiratory control centers

BARORECEPTORS OF DIGESTIVE TRACT

Provide information on volume of tract segments, trigger reflex movement of materials along tract

BARORECEPTORS OF LUNG

Provide information on lung stretching to respiratory rhythmicity centers for control of respiratory rate

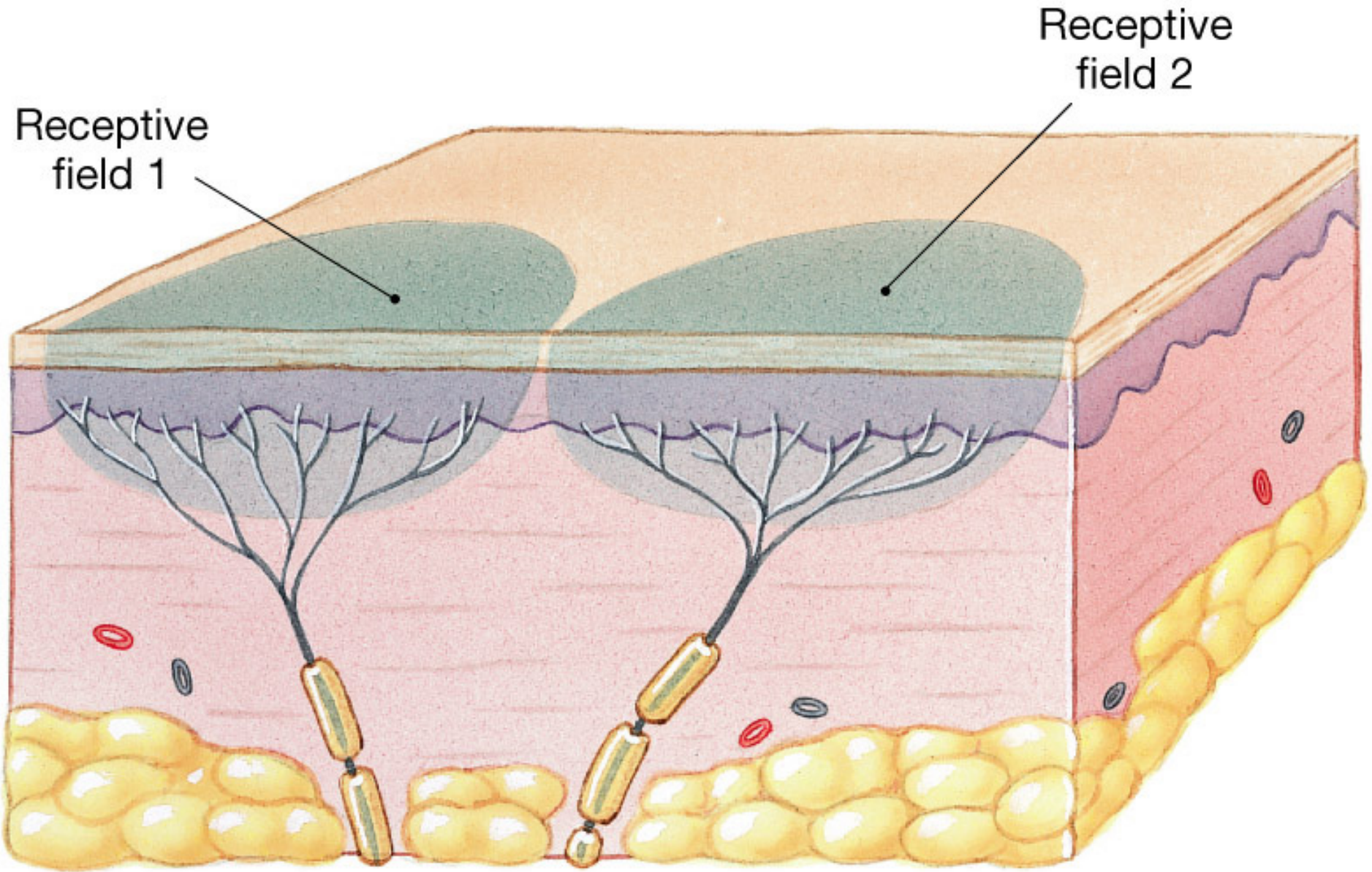
BARORECEPTORS OF BLADDER WALL

Provide information on volume of urinary bladder, trigger urinary reflex

BARORECEPTORS OF COLON

Provide information on volume of fecal material in colon, trigger defecation reflex

FYI

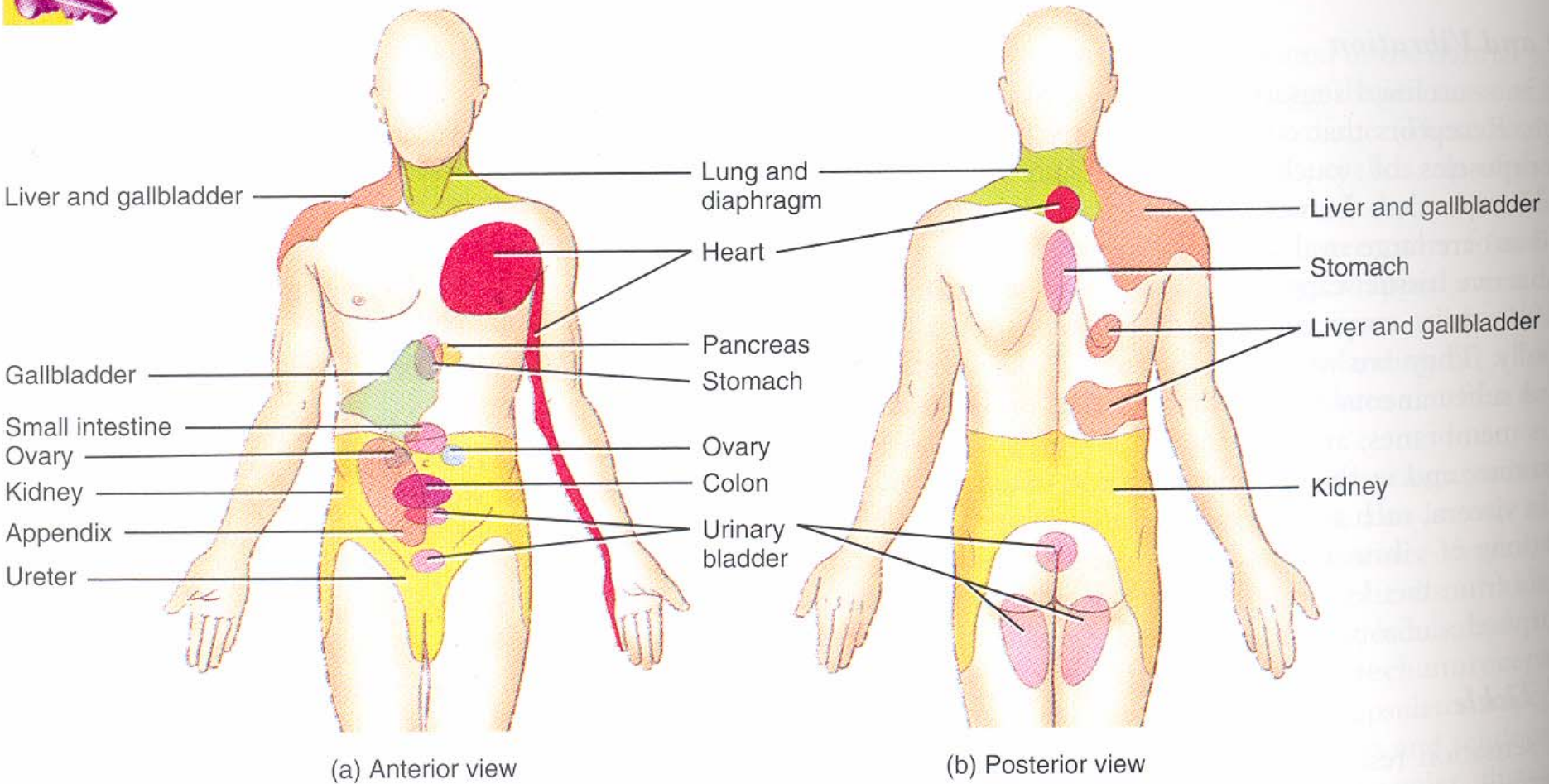


FYI

Receptive fields

Figure 19.2 / Distribution of referred pain. The colored portions of the diagrams indicate skin areas to which visceral pain is referred.

Nociceptors are present in almost every tissue of the body.



(a) Anterior view

(b) Posterior view

Which visceral organ has the broadest area for referred pain?

FYI

- Special sense receptors-located inside of special sense organs
- Olfaction-nasal cavity
- Gustation-tongue
- Equilibrium & auditory-ears
- Vision-eyes

Olfaction (Smell)

10-20 million chemoreceptors in mucous membrane on roof of nasal cavity

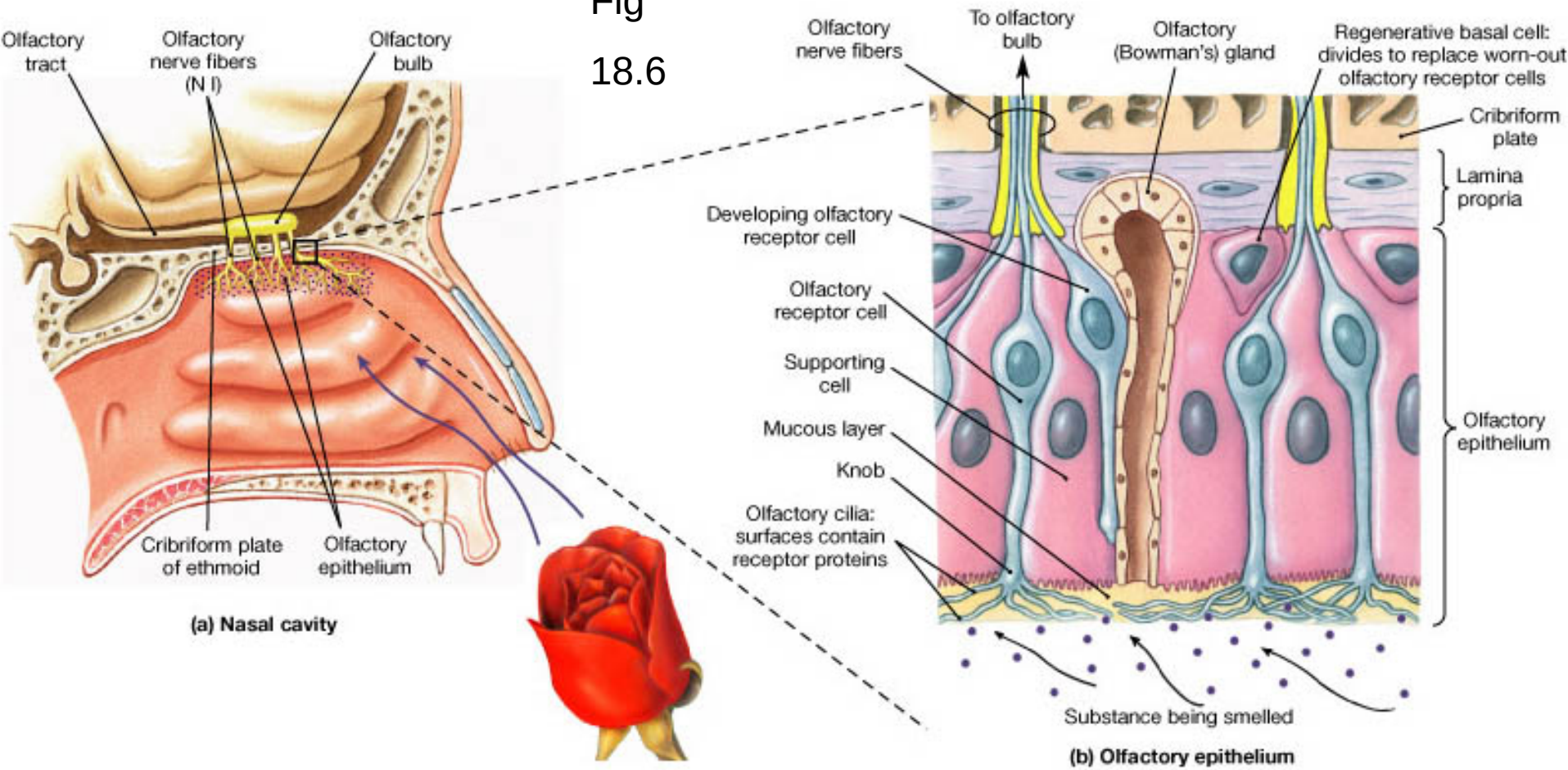
5 cm^2 patch

4 molecules of gas can cause an action potential

Sends sensory info to temporal Lobe

Sensory tract that bypass the thalamus to cerebrum

Fig 18.6


Olfactory tract
Olfactory nerve fibers (N I)
Olfactory bulb
Cribriform plate of ethmoid
Olfactory epithelium
(a) Nasal cavity
Olfactory nerve fibers
To olfactory bulb
Olfactory (Bowman's) gland
Regenerative basal cell: divides to replace worn-out olfactory receptor cells
Cribriform plate
Lamina propria
Developing olfactory receptor cell
Olfactory receptor cell
Supporting cell
Mucous layer
Knob
Olfactory cilia: surfaces contain receptor proteins
Olfactory epithelium
Substance being smelled
(b) Olfactory epithelium

tracing

- **Olfaction (smell)-CN 1- olfactory nerves**
- Olfactory receptors
- olfactory bulb
- olfactory nerve
- sensory cortex in temporal lobe

Gustation

- Sensory info about chemicals dissolved in saliva
- Gustatory receptors are in the:

  tongue

  throat (active in infancy)

Types of papillae

- Three types on the tongue:
- posterior
- Circumvallate papillae
- Fungiform papillae
- Filiform papillae
- anterior

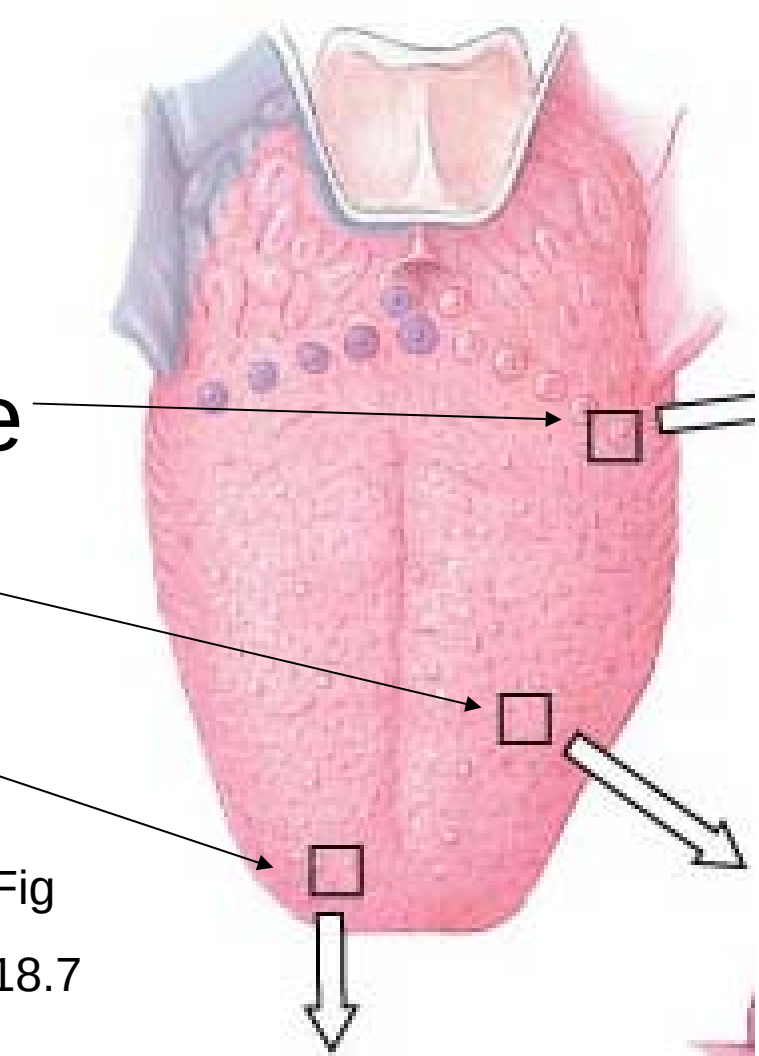
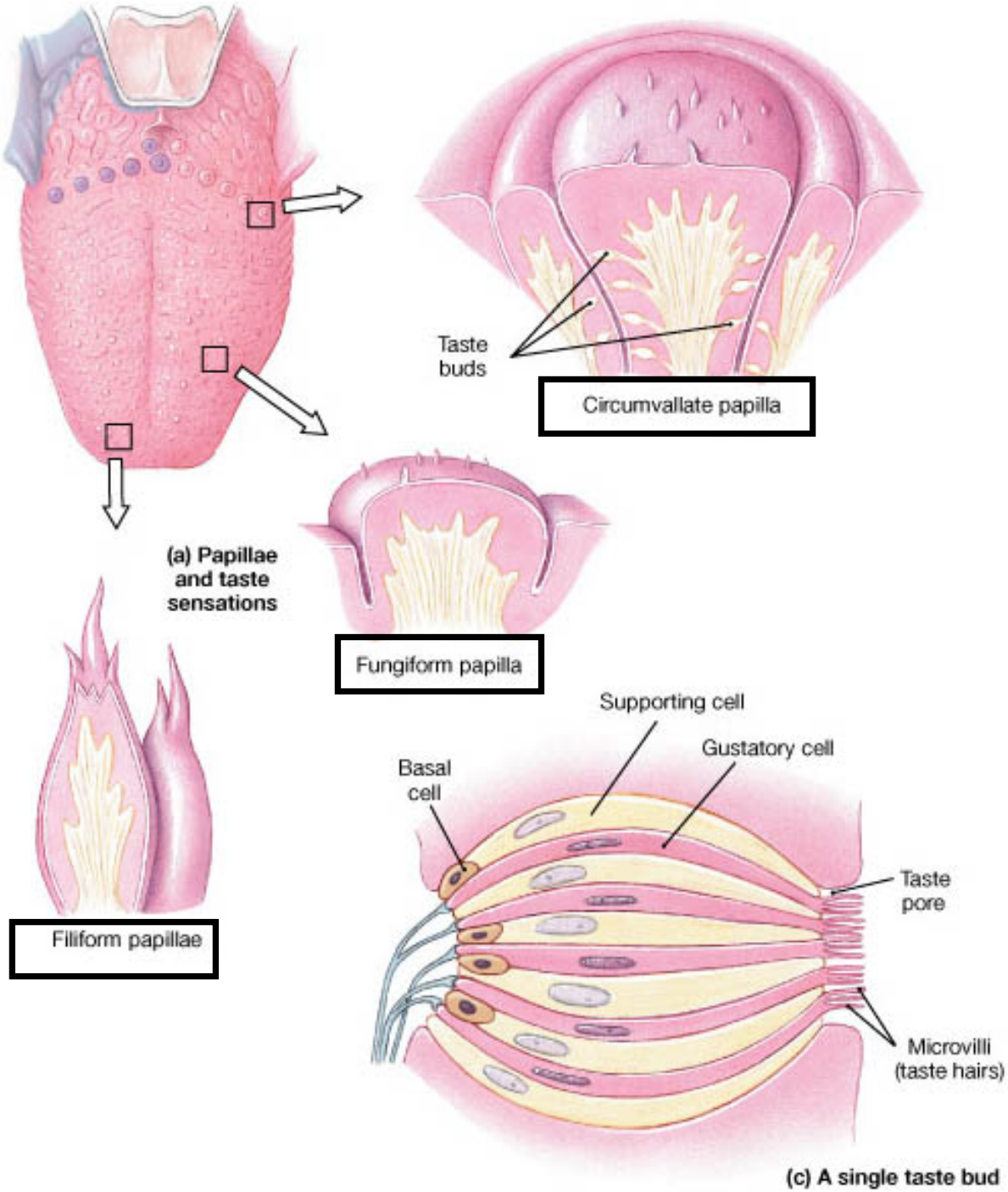


Fig 18.7

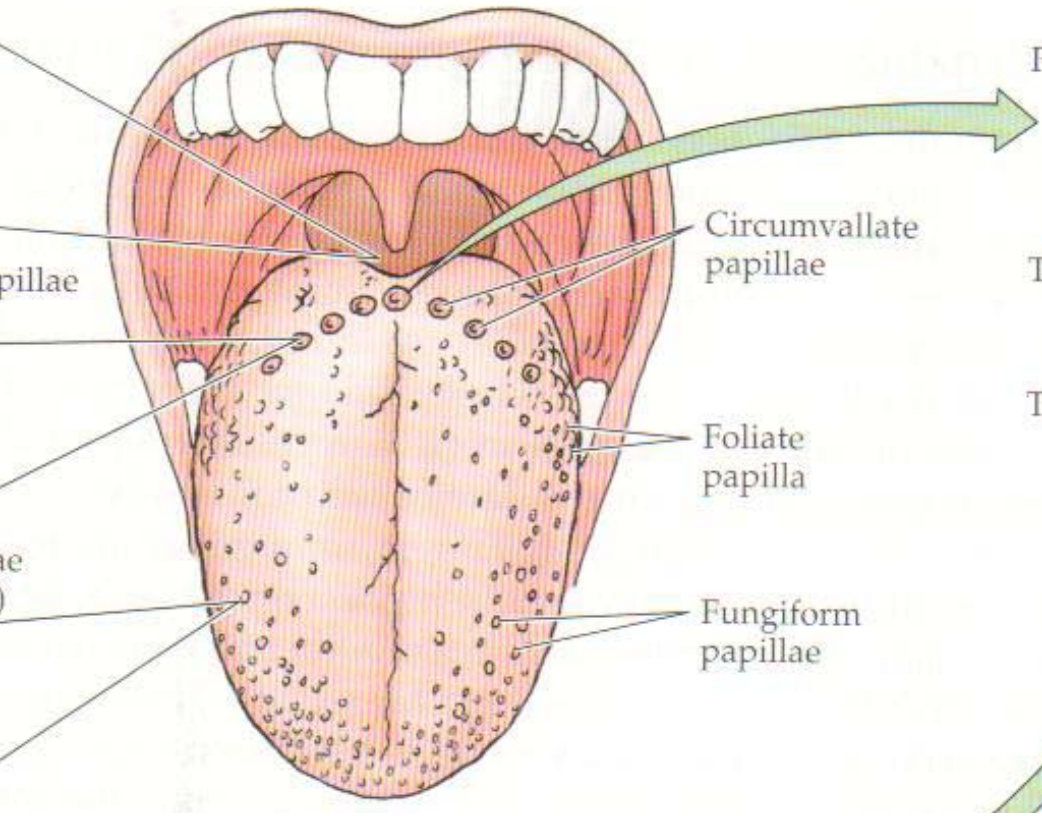
Fig 18.7


Taste buds
Circumvallate papilla
(a) Papillae and taste sensations
Fungiform papilla
Filiform papillae
Supporting cell
Gustatory cell
Basal cell
Taste pore
Microvilli (taste hairs)
(c) A single taste bud

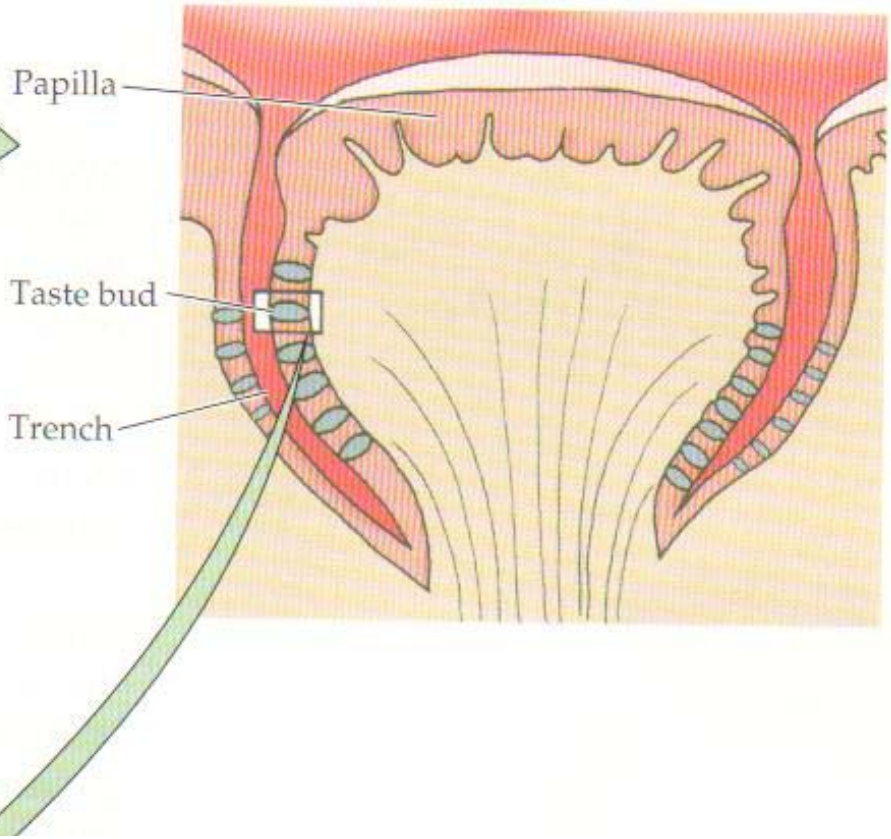
Gustatory receptors

- ~40 gustatory receptor cells are grouped in to a single taste bud
- Taste buds are located along the sides of the papillae 10,000

Kaye, 1995.)

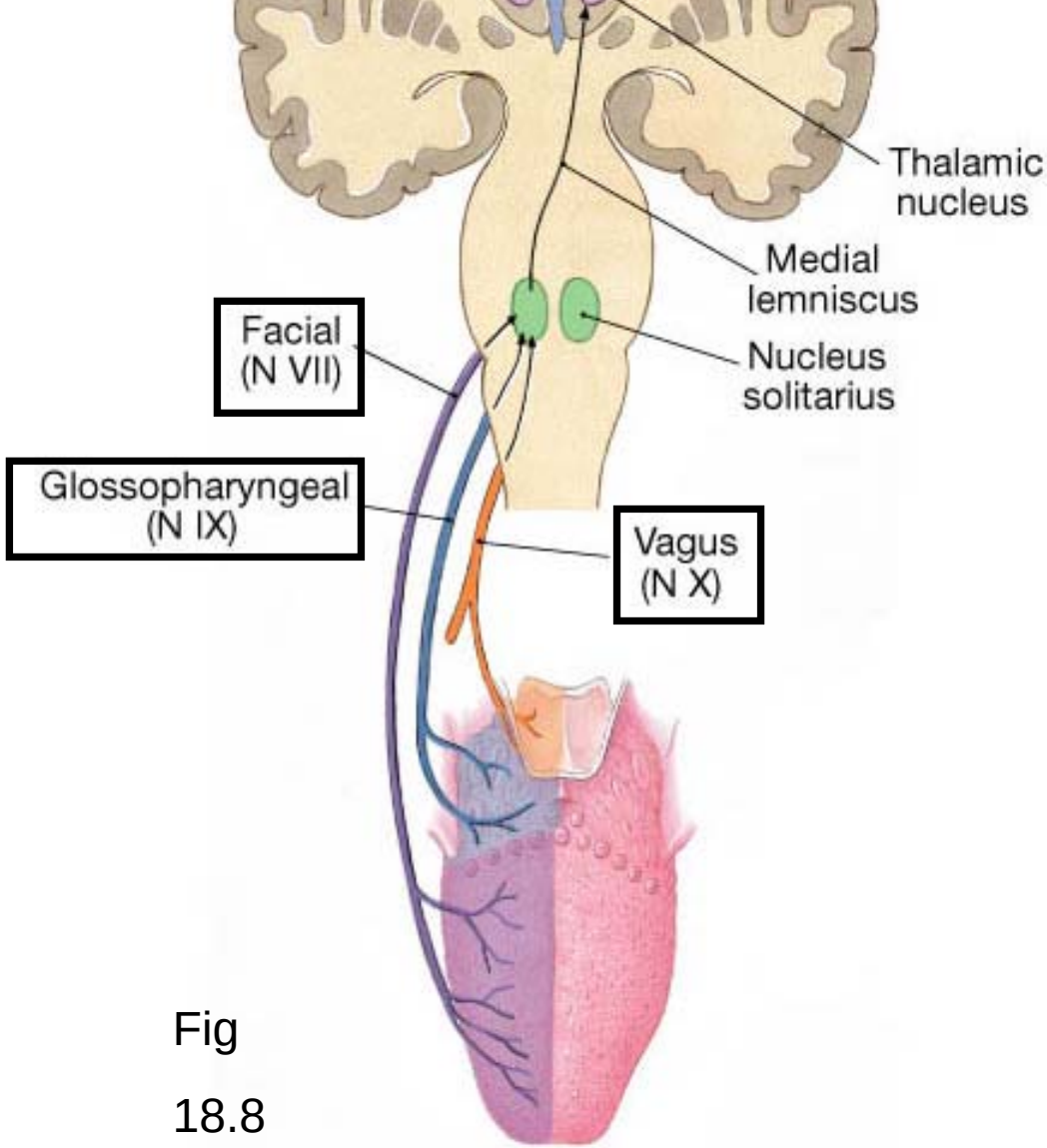

pillae
ae
Circumvallate papillae
Foliate papilla
Fungiform papillae

(B)


Papilla
Taste bud
Trench

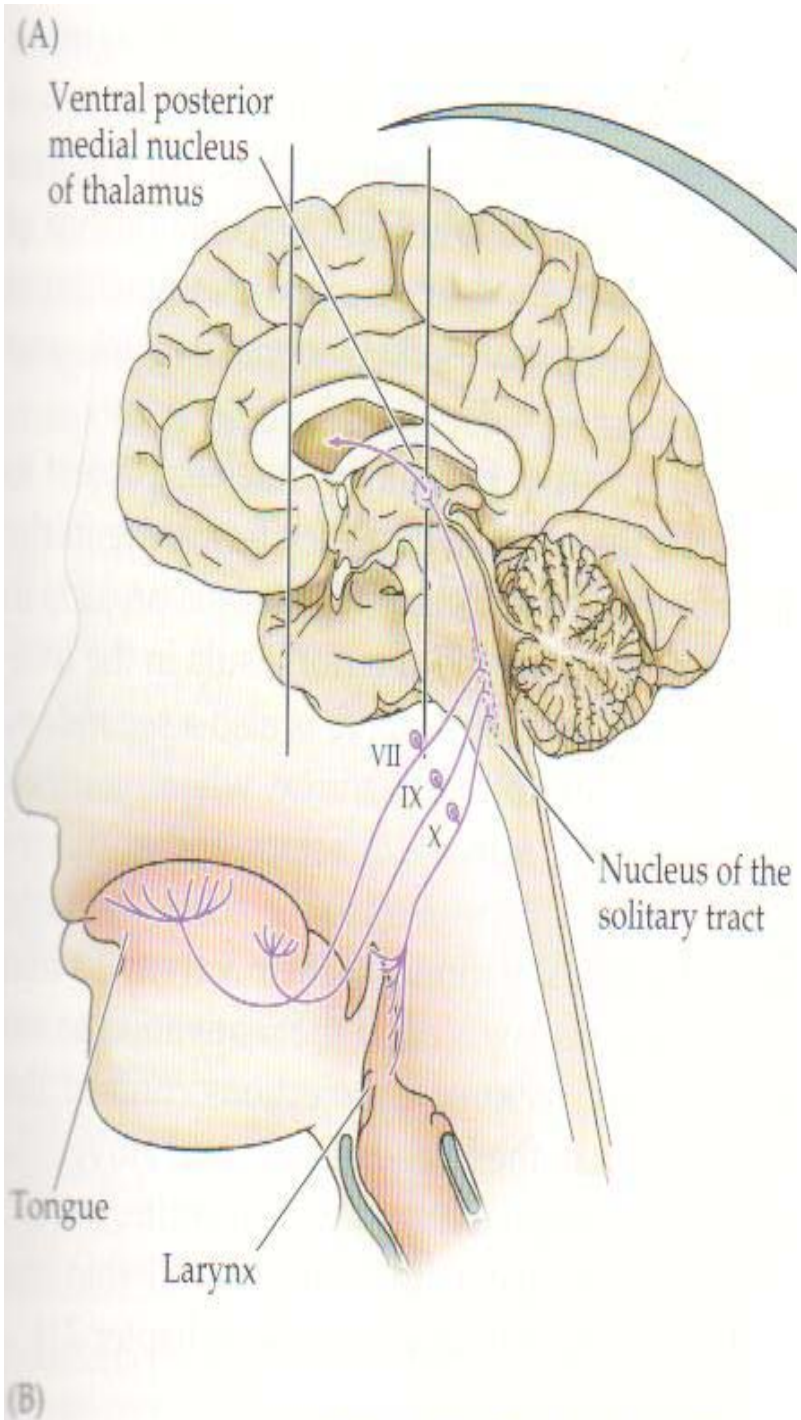
Innervation of the gustatory receptors

- Three nerves that innervate gustatory receptors:
- Anterior 2/3 of tongue
  - Facial nerve (Cranial Nerve 7)
- Posterior 1/3 of tongue
  - Glossopharyngeal nerve (CN 9)
- Throat
  - Vagus nerve (CN 10)


Thalamic nucleus
Medial lemniscus
Facial (N VII)
Nucleus solitarius
Glossopharyngeal (N IX)
Vagus (N X)

Fig

18.8


(A)
Ventral posterior
medial nucleus
of thalamus
VII
IX
X
Nucleus of the
solitary tract
Tongue
Larynx
(B)

Types of tastes

- In all of the taste buds there are:
- Sweet receptors simple carbohydrates
- Salt receptors Na^+
- Sour receptors H^+ acid
- Bitter receptors complex carbohydrates
- Water receptors H_20
- Umami receptors glutamate (MSG)

Gustation tracing

- Taste buds anterior 2/3 of tongue
- Facial nerve
- Medulla
- Thalamus
- Cerebral cortex in parietal/frontal lobe

- Taste buds posterior 1/3 of tongue
- Glossopharyngeal nerve
- Medulla
- Thalamus
- Cerebral cortex in parietal/frontal lobe

- Taste buds (pharynx)
- Vagus nerve
- Medulla
- Thalamus
- Cerebral cortex in parietal/frontal lobe

Auditory (hearing)

- Three regions of the used for auditory sense:
- External, middle, & internal ear

External ear

- Auricle directs sound waves toward tympanic memb.
- Auditory canal
  - lined with hair & Cerumious glands-release cerumen (ear wax)
- External auditory canal– tube that ends at tympanic membrane
  - Approx. 2.5 cm long.
- Tympanic membrane – thin, delicate CT sheet
- Vibrations of the tympanic membrane convert sound waves into mechanical movements.

External ear

- Funnels sound wave towards the tympanic membrane
- Sound makes the tympanic membrane vibrate
- Auricle = Pinna

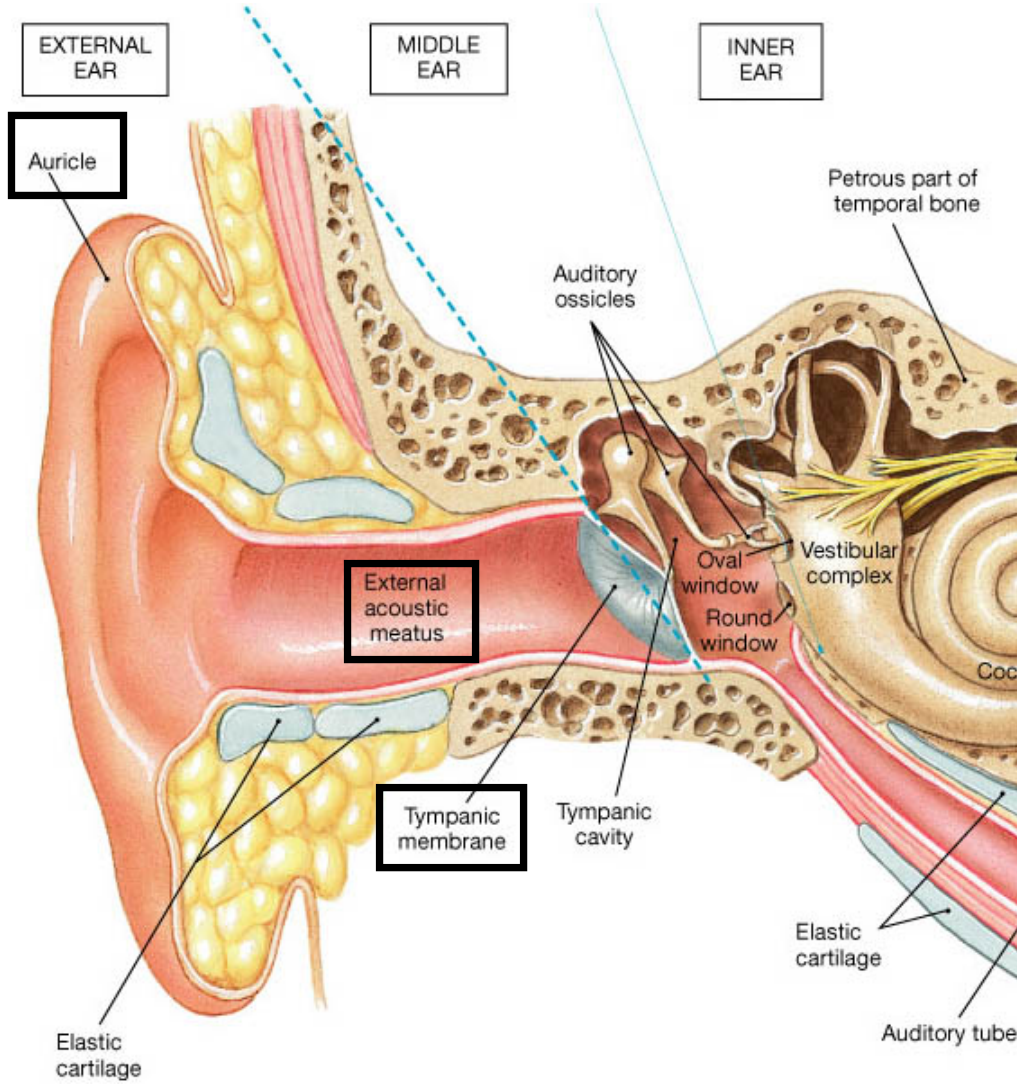


Fig 18.9

Middle Ear

- Ossicles located in air-filled space
- Malleus- attached to eardrum
  - Incus
  - Stapes-attached to oval window
- connect tympanic membrane with the receptor complex of the inner ear.
- They transfer vibrations from tympanum to fluid-filled chambers within the inner ear.
  - ossicles amplify & strengthen vibrations
  - skeletal muscles dampen vibration

- Auditory Tube- connects ear to nasopharynx and adjusts pressure in mid. ear
- Approx. 4cm long.
- Passes through temporal bone.
- Normally collapsed sealing off middle ear
- opens to allow middle ear pressure to equilibrate with atmospheric pressure during chewing, swallowing and yawning.

- Pressure must be equal on both sides of the tympanic membrane or there may be a partial distortion of the membrane.
- Short and horizontal in small children.
- common site of infections due to close proximity to the nasopharynx

Middle ear

- Transmits vibration from the tympanic membrane to the inner ear

- Auditory tube= Eustachian tube=
- Pharyngotympanic tube

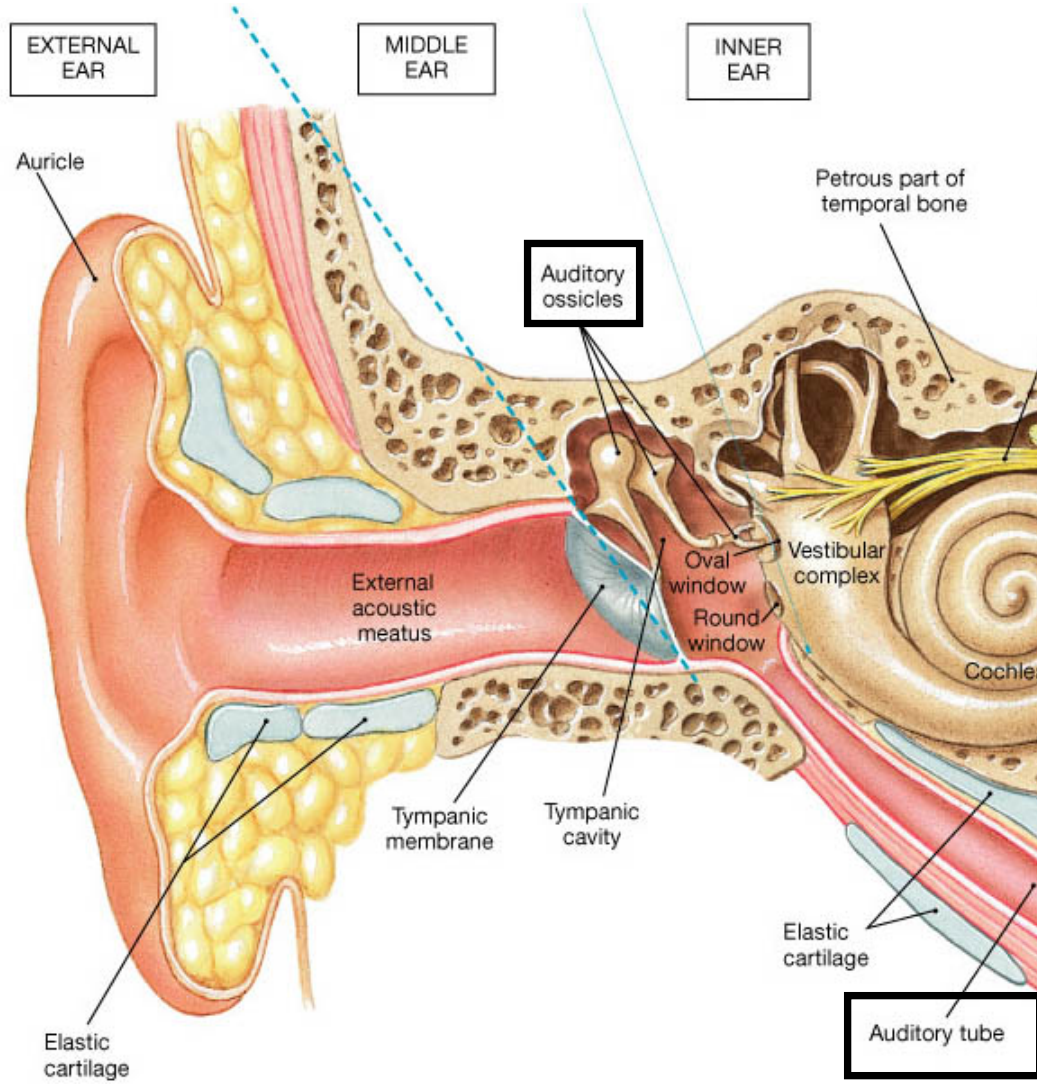
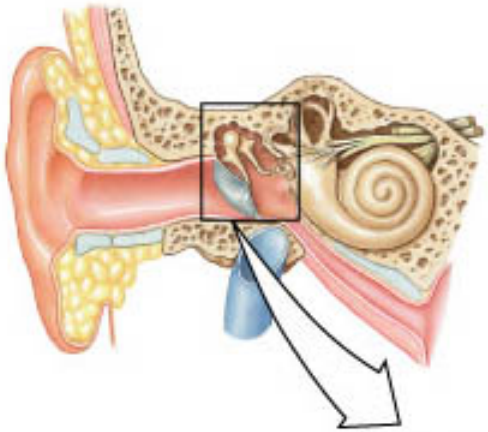
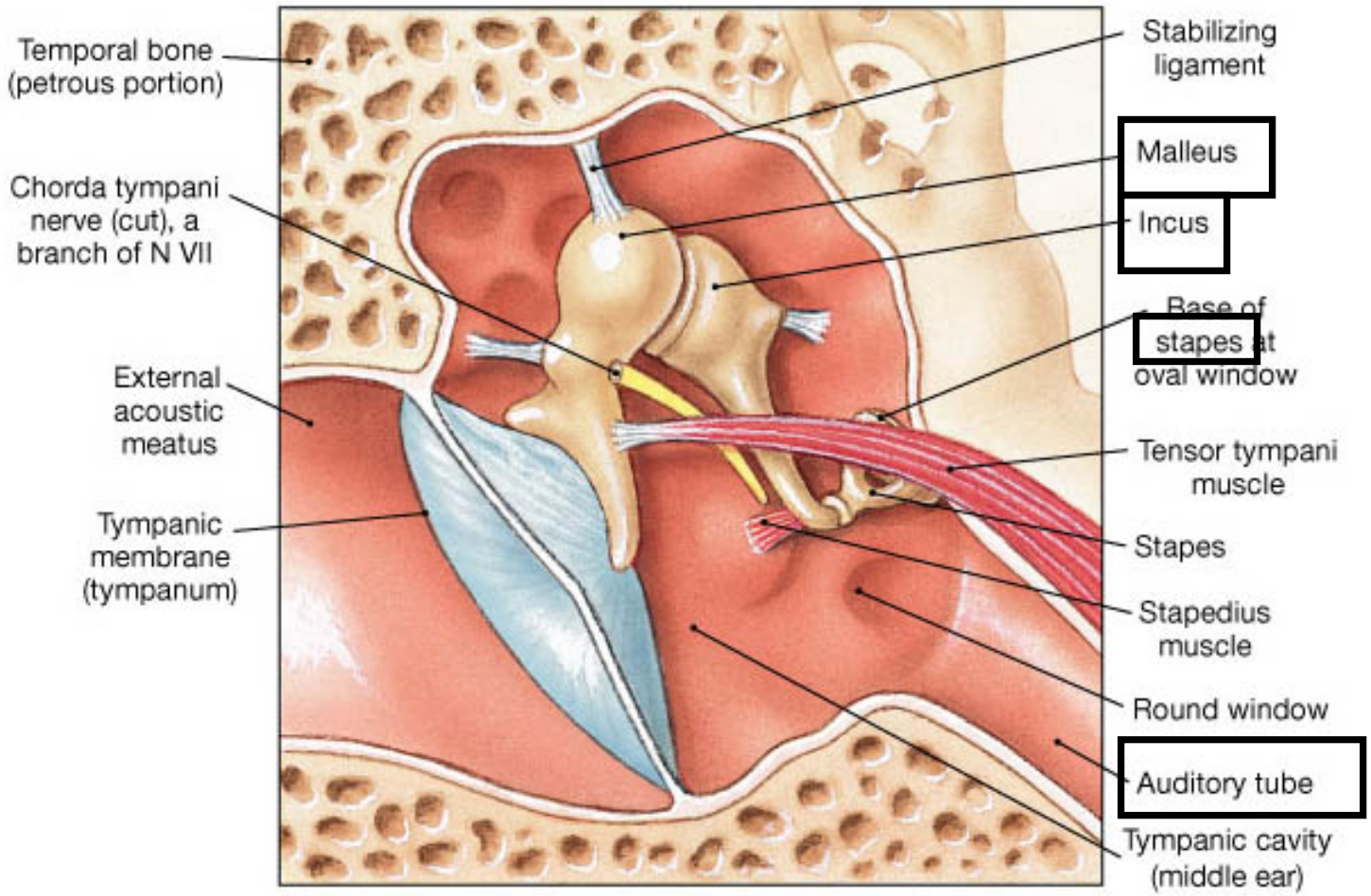


Fig 18.9



Fig

18.10



(b) The middle ear

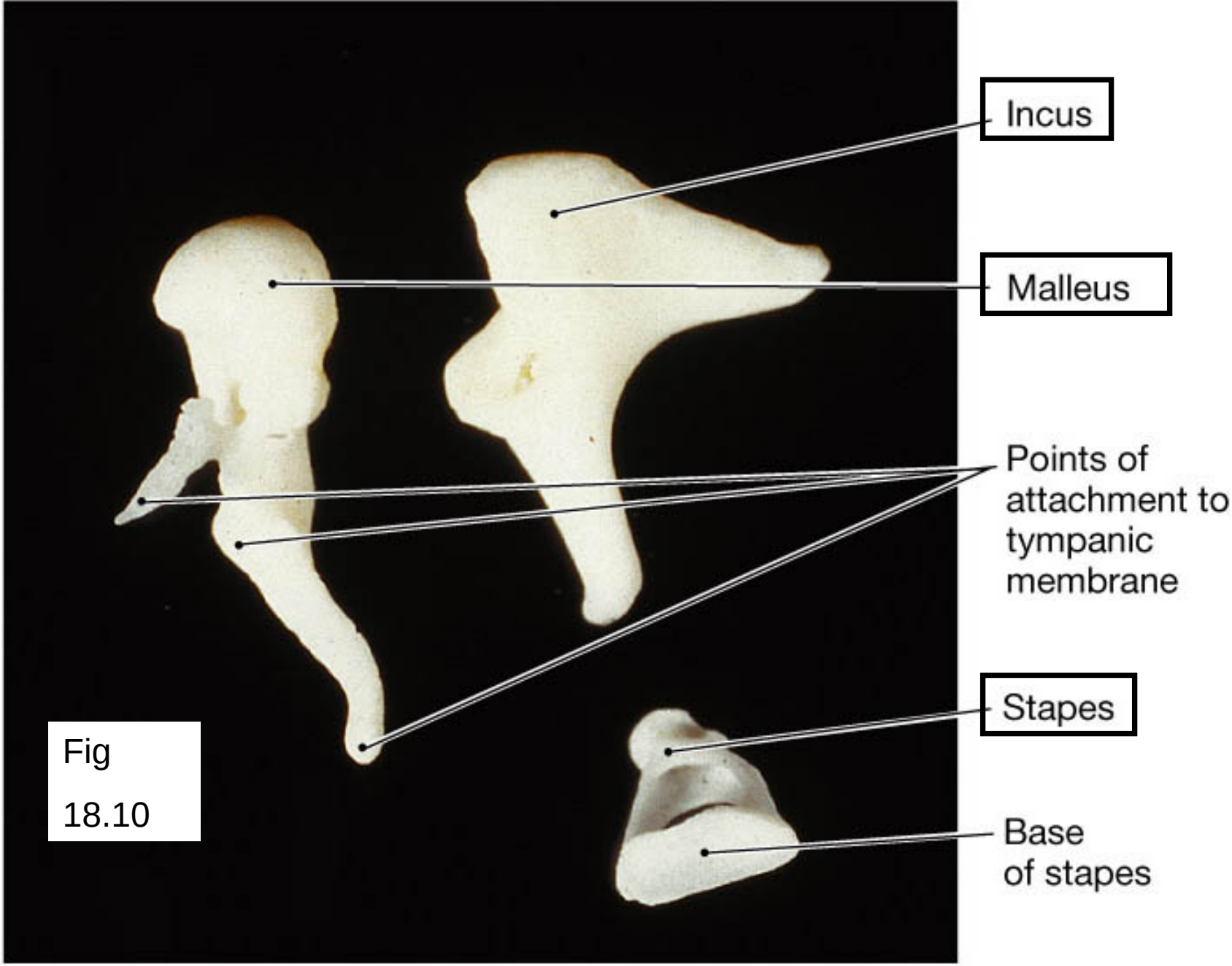


Fig 18.10

(c) Auditory ossicles

Inner Ear

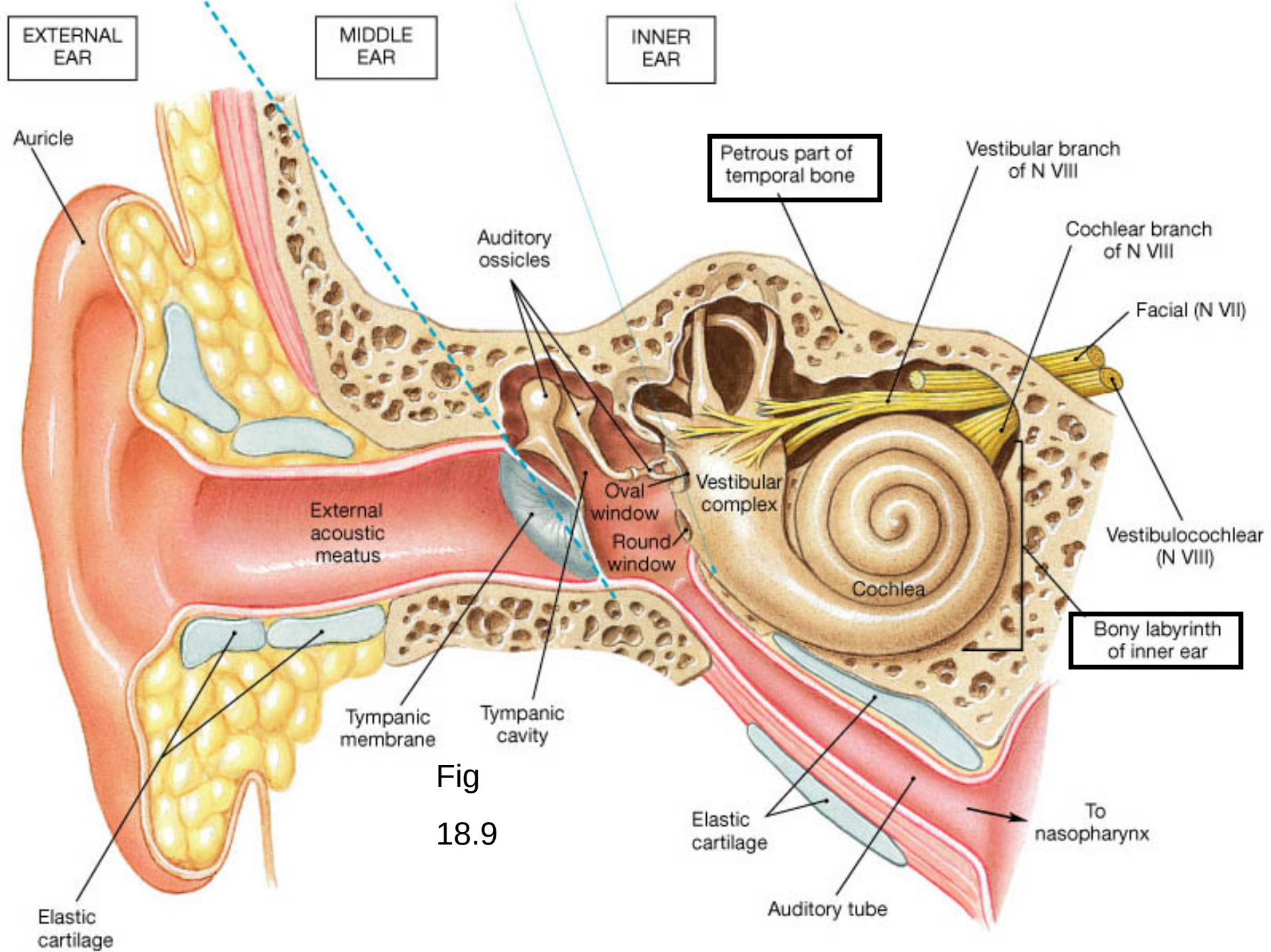
- Bony Labyrinth (canals within temporal bone)
- Membranous Labyrinth (connect. tissue in bony lab.)
- Contains Cochlea (hearing)

- Contains semicircular canals/ vestibule (equilibrium)
- **Hearing**
- mechanoreceptors found in cochlea
- stapes vibrates against oval window (moves fluid)
- Hair cells bend as sound waves move fluid (endolymph) and membranes in cochlear duct.

Inner ear

- Contain mechanoreceptors for vibration (auditory) and mechanoreceptors for motion of the head (equilibrium)

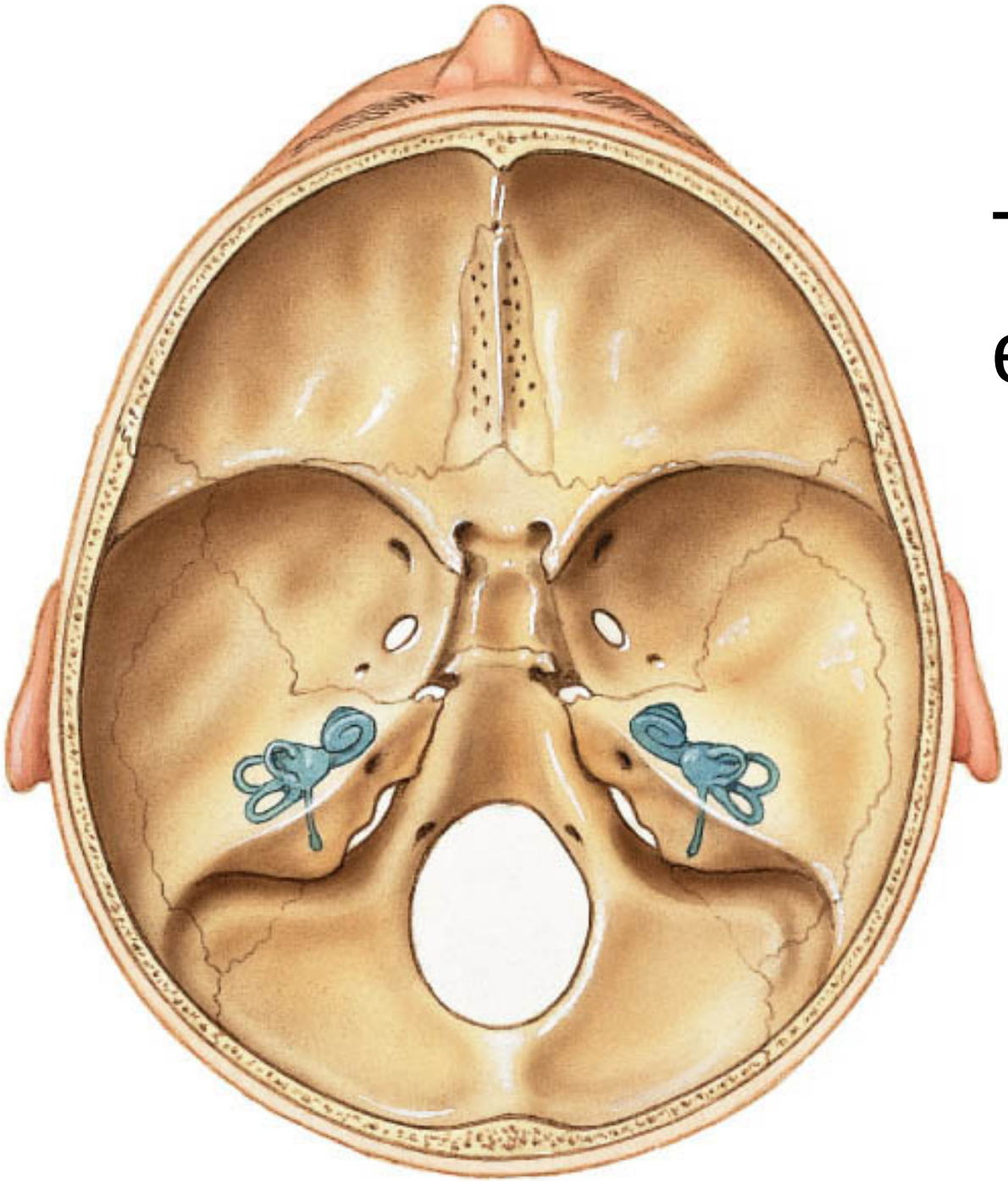
- Bony/Osseous labyrinth is a sinus in the temporal bone
- Membranous labyrinth is inside of the bony labyrinth


EXTERNAL EAR
MIDDLE EAR
INNER EAR
Auricle
Petrous part of temporal bone
Vestibular branch of N VIII
Auditory ossicles
Cochlear branch of N VIII
Facial (N VII)
Oval window
Vestibular complex
External acoustic meatus
Round window
Vestibulocochlear (N VIII)
Cochlea
Bony labyrinth of inner ear
Tympanic membrane
Tympanic cavity
Elastic cartilage
To nasopharynx
Auditory tube
Elastic cartilage

Fig

18.9

The inner ear



Fig

18.12

(a) Floor of cranial cavity (superior view)

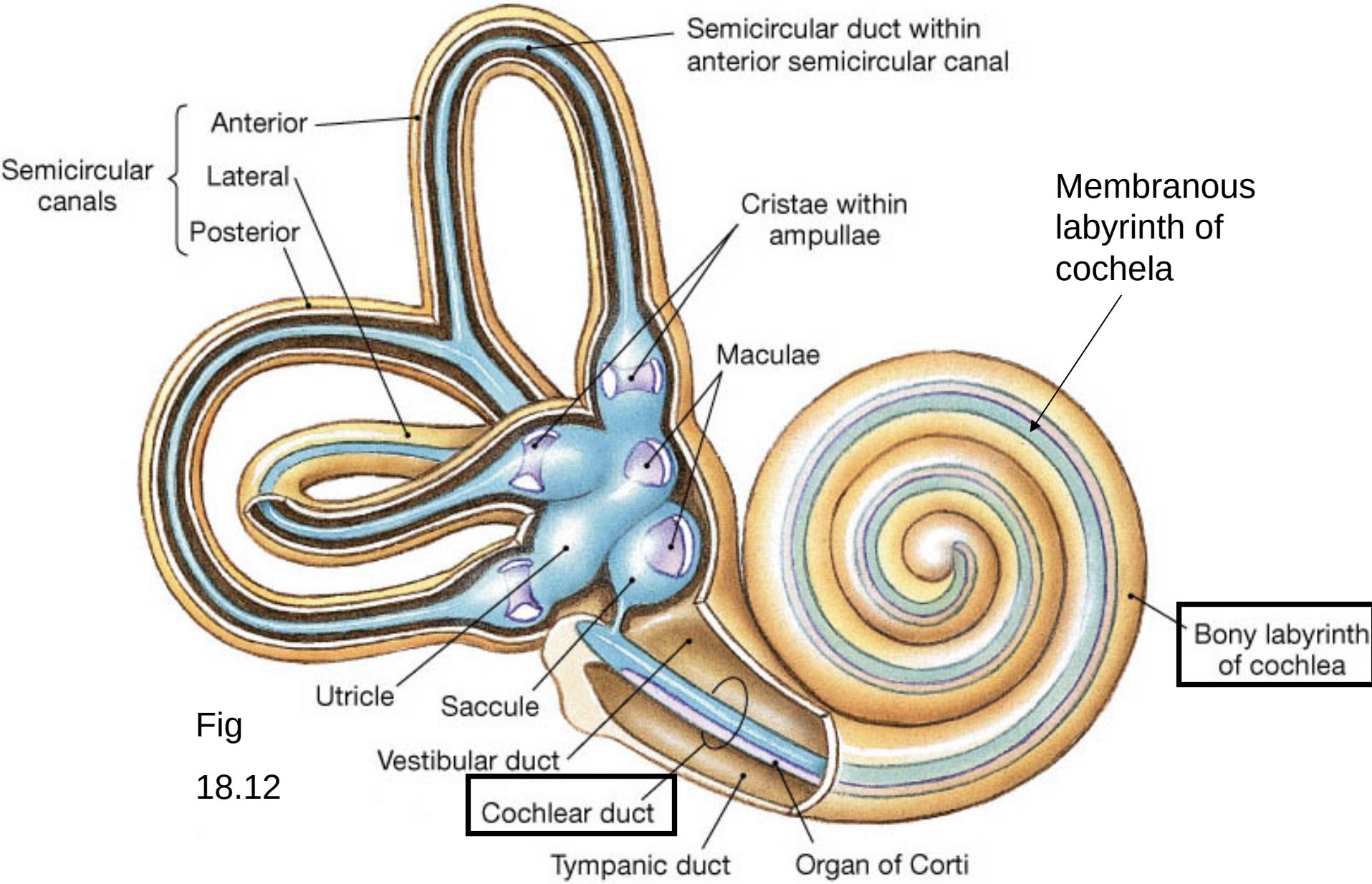
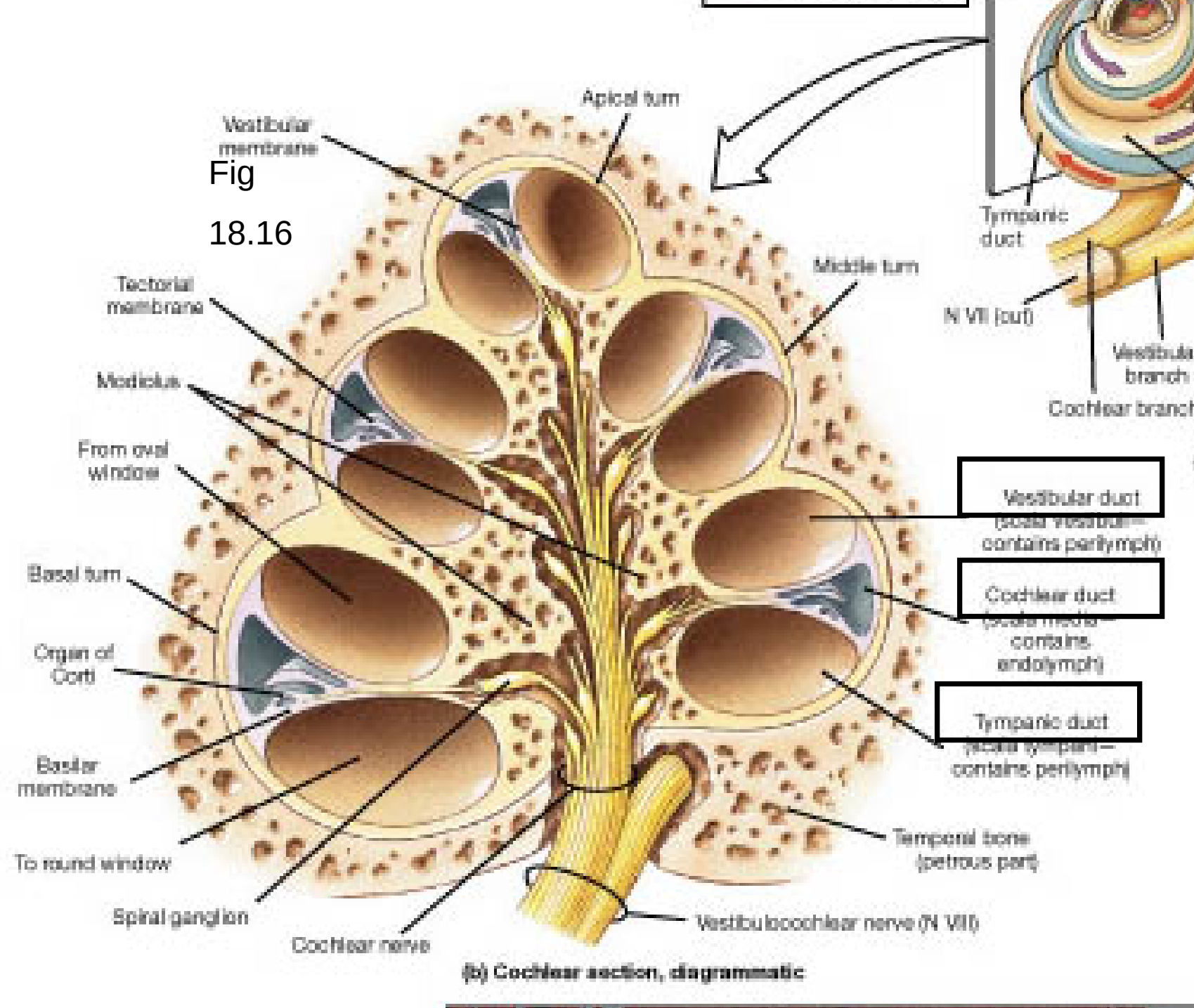


Fig 18.12

(b) Semicircular canals and ducts (anterior view)

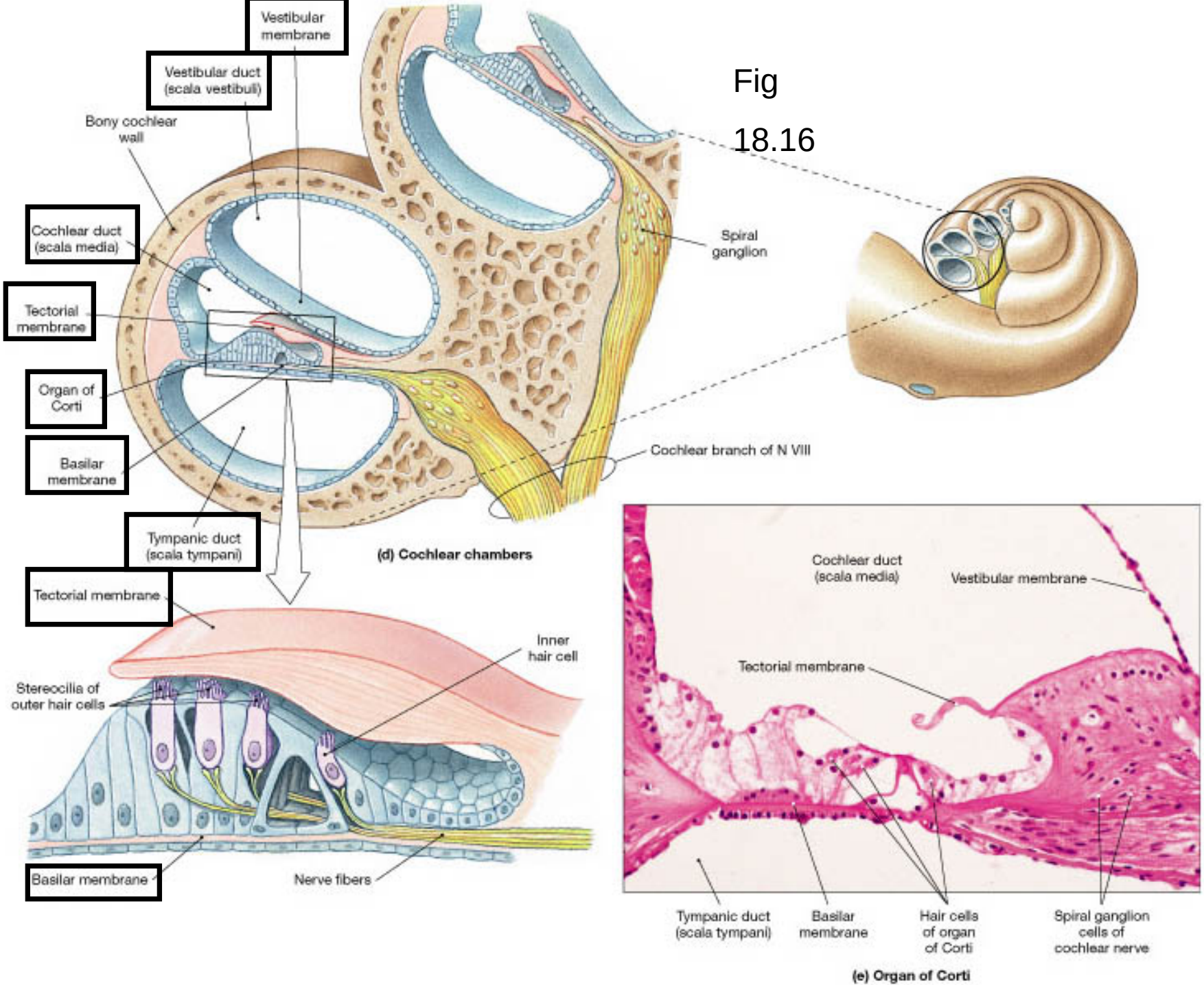
Fig

18.16



(b) Cochlear section, diagrammatic

Fig 18.16


Vestibular membrane
Vestibular duct (scala vestibuli)
Bony cochlear wall
Cochlear duct (scala media)
Tectorial membrane
Organ of Corti
Basilar membrane
Tympanic duct (scala tympani)
Spiral ganglion
Cochlear branch of N VIII
(d) Cochlear chambers
Tectorial membrane
Inner hair cell
Stereocilia of outer hair cells
Basilar membrane
Nerve fibers
Cochlear duct (scala media)
Vestibular membrane
Tectorial membrane
Tympanic duct (scala tympani)
Basilar membrane
Hair cells of organ of Corti
Spiral ganglion cells of cochlear nerve
(e) Organ of Corti

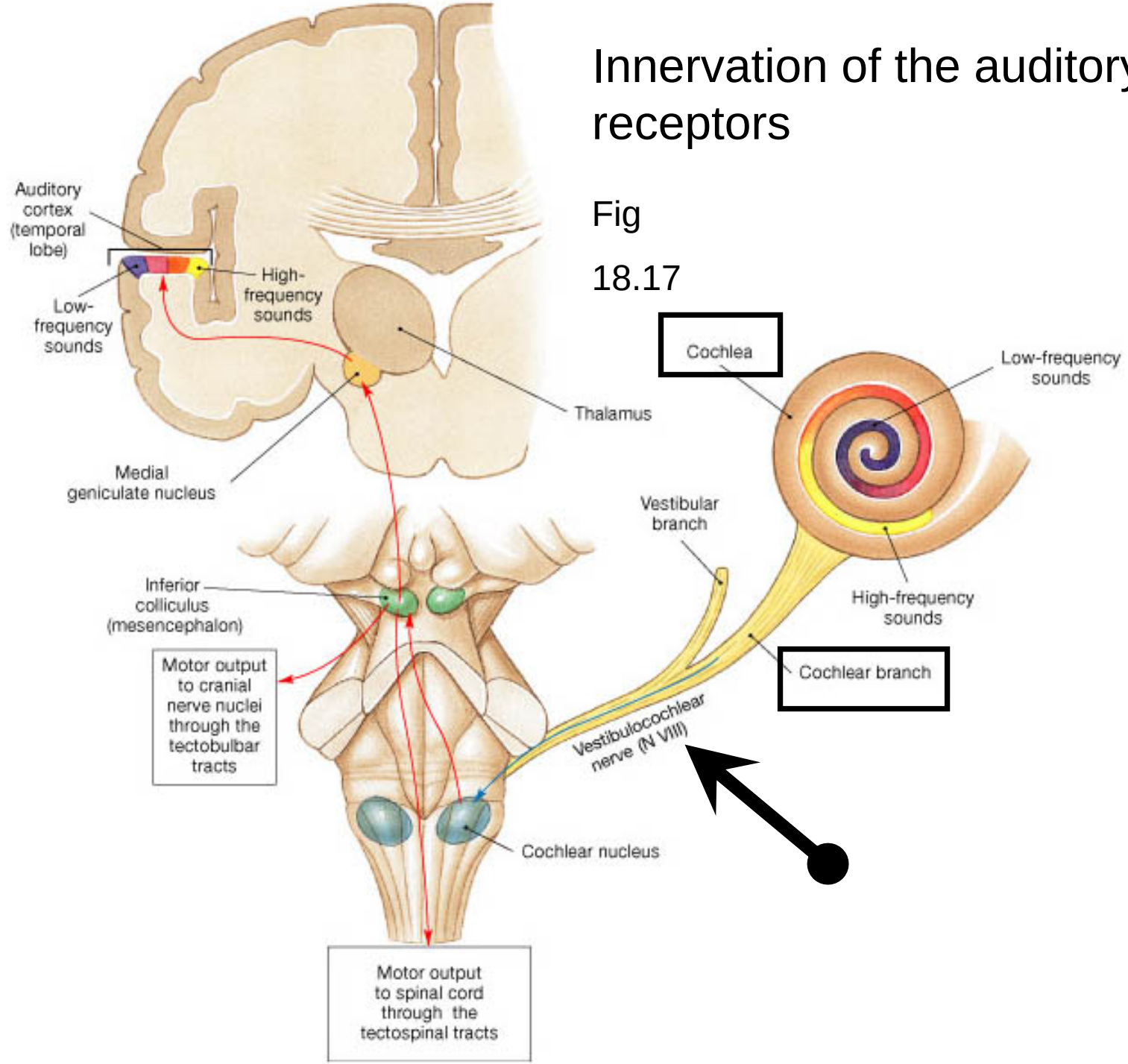
- The vestibular & tympanic ducts are filled with perilymph

- Cochlear duct is filled with endolymph

Innervation of the auditory receptors

Fig

18.17



Types of sound

- Intensity-
  - louder sound->stronger vibration>more stimulation of receptors
- Frequency-(pitch)
  - Location of the specific auditory receptor
  - humans sounds range of 20-20,000 Hz
  - most acute hearing between 1000-3000 Hz.
  - range decrease with age.
- Phase-
  - which ear the sound is closer to
- Timbre-
  - Integration of sensory info in the brain

Auditory tracing

- Sound
- External ear
- Tympanic membrane
- Middle ear bones
- Oval window
- Motion of perilymph in vestibular & tympanic ducts
- Vibration of vestibular & basilar membranes
- Vibration of organ of corti
- Tectorial membrane pulls on hair cells
- cochlear nerve
- vestibulocochlear nerve (cranial nerve 8)
- Thalamus
- Cerebral cortex in temporal lobe

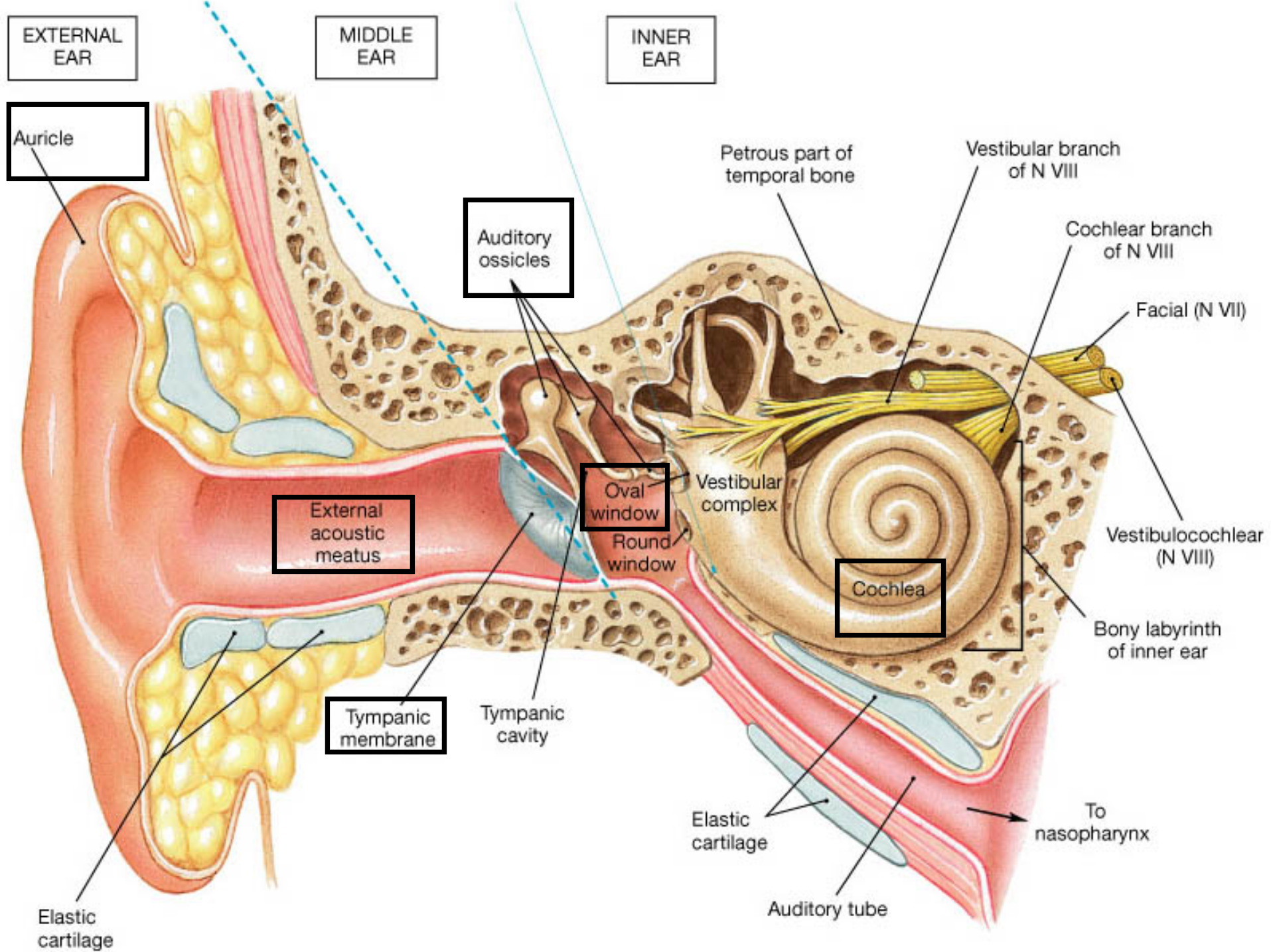
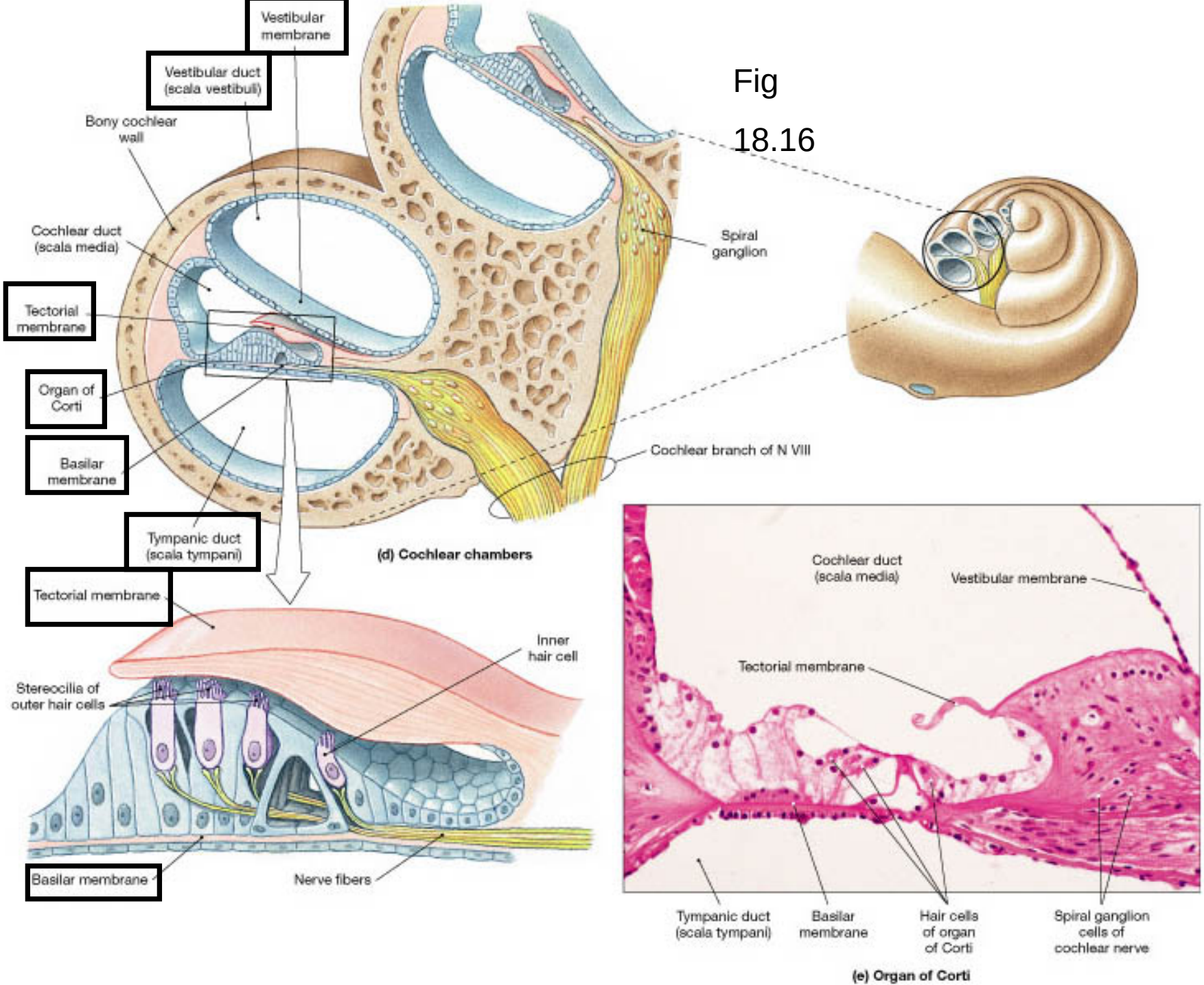

EXTERNAL EAR
MIDDLE EAR
INNER EAR
Auricle
Auditory ossicles
Petrous part of temporal bone
Vestibular branch of N VIII
Cochlear branch of N VIII
Facial (N VII)
Vestibulocochlear (N VIII)
External acoustic meatus
Oval window
Round window
Vestibular complex
Cochlea
Bony labyrinth of inner ear
Tympanic membrane
Tympanic cavity
Elastic cartilage
Elastic cartilage
To nasopharynx
Auditory tube

Fig 18.16


Vestibular membrane
Vestibular duct (scala vestibuli)
Bony cochlear wall
Cochlear duct (scala media)
Tectorial membrane
Organ of Corti
Basilar membrane
Tympanic duct (scala tympani)
Spiral ganglion
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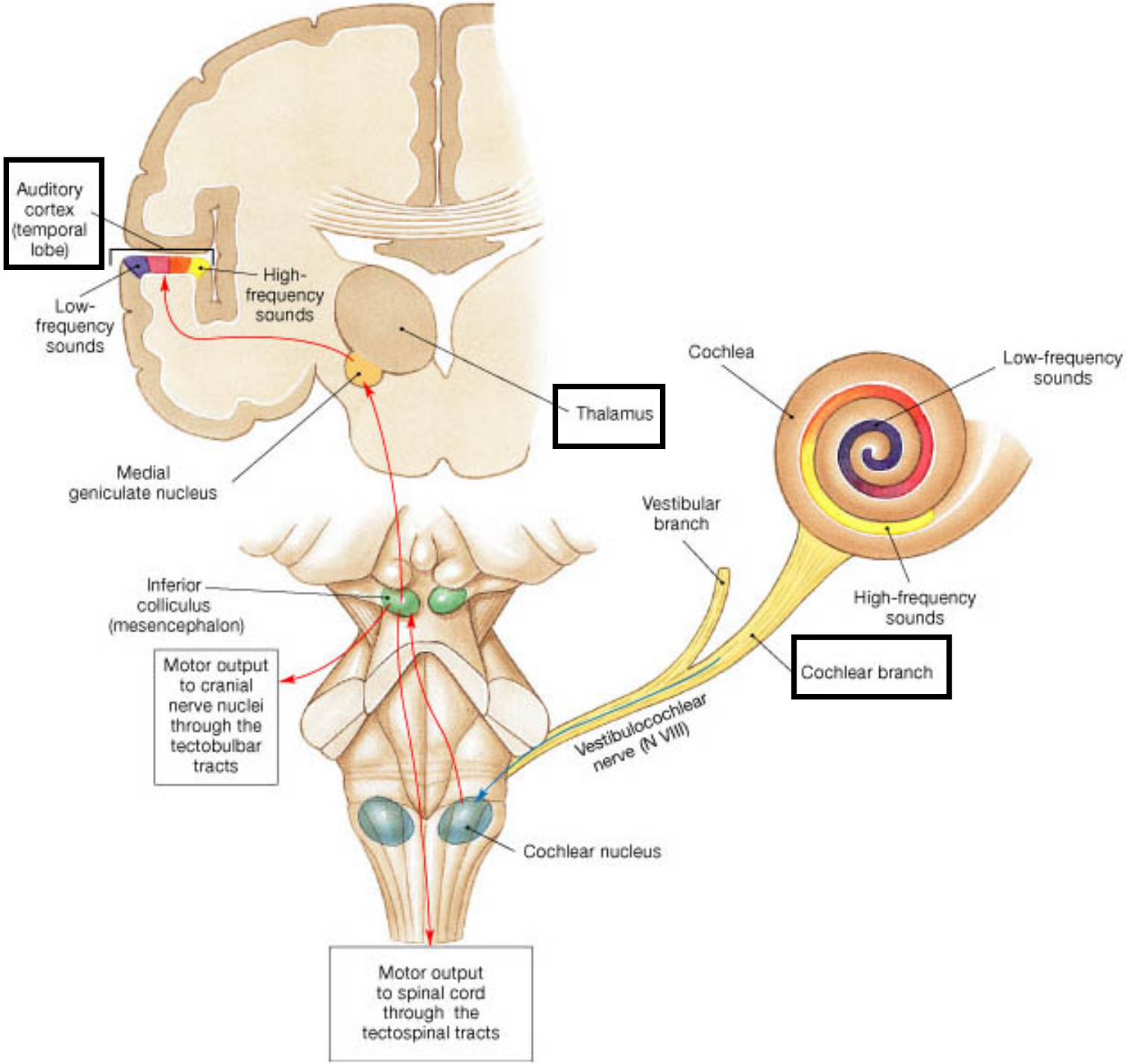
Tectorial membrane
Tympanic duct (scala tympani)
Basilar membrane
Hair cells of organ of Corti
Spiral ganglion cells of cochlear nerve
(e) Organ of Corti


Auditory cortex (temporal lobe)
Low-frequency sounds
High-frequency sounds
Thalamus
Medial geniculate nucleus
Cochlea
Low-frequency sounds
Vestibular branch
High-frequency sounds
Inferior colliculus (mesencephalon)
Cochlear branch
Motor output to cranial nerve nuclei through the tectobulbar tracts
Vestibulocochlear nerve (N VIII)
Cochlear nucleus
Motor output to spinal cord through the tectospinal tracts

Equilibrium

- Mechanoreceptors in semicircular ducts/ampulla sense dynamic equilibrium
  - movement of head/body
- Mechanoreceptors in vestibule sense static equilibrium
  - position of head/direction of gravity
    - utricle and saccule
    - Semi. Canal/vestibule send info to cerebellum

- *The remainder of the ear is used for hearing

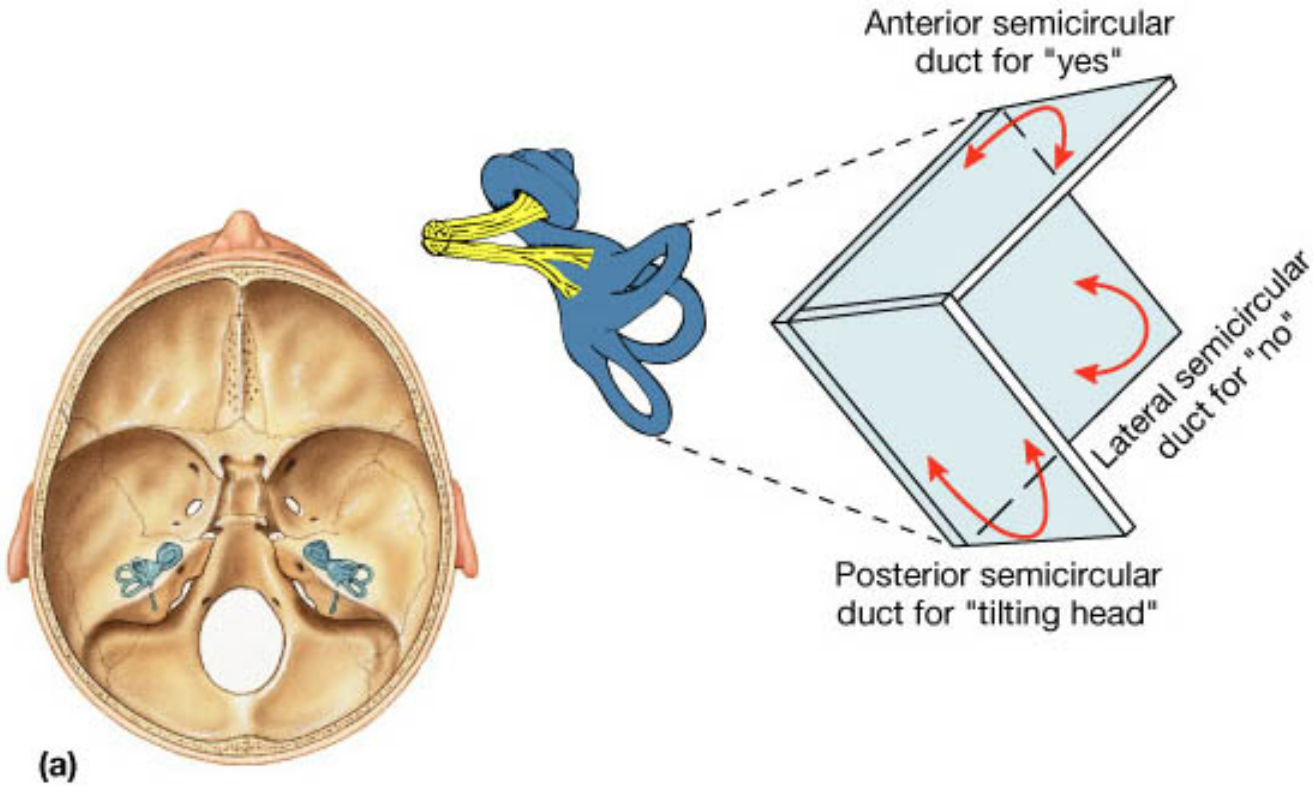
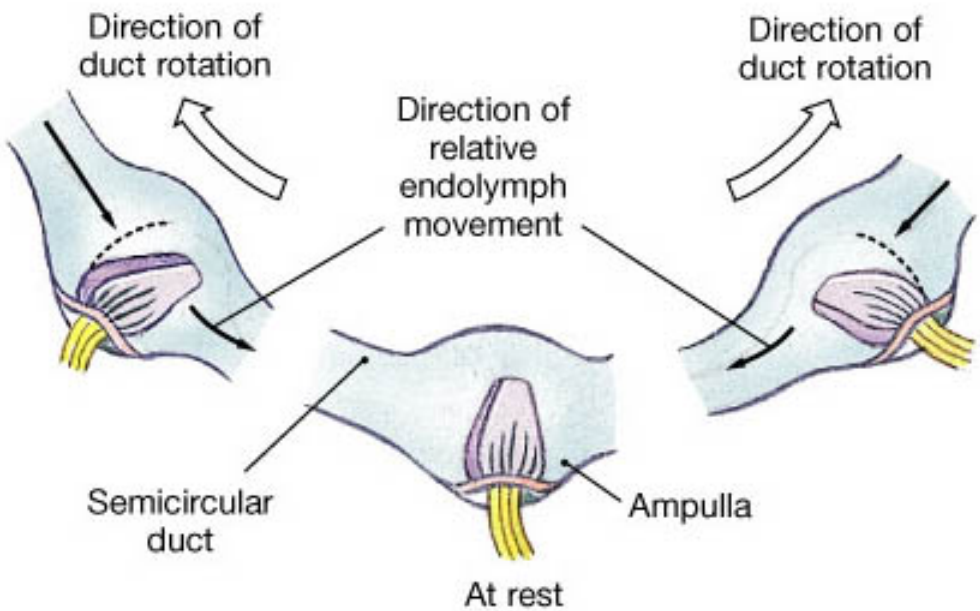
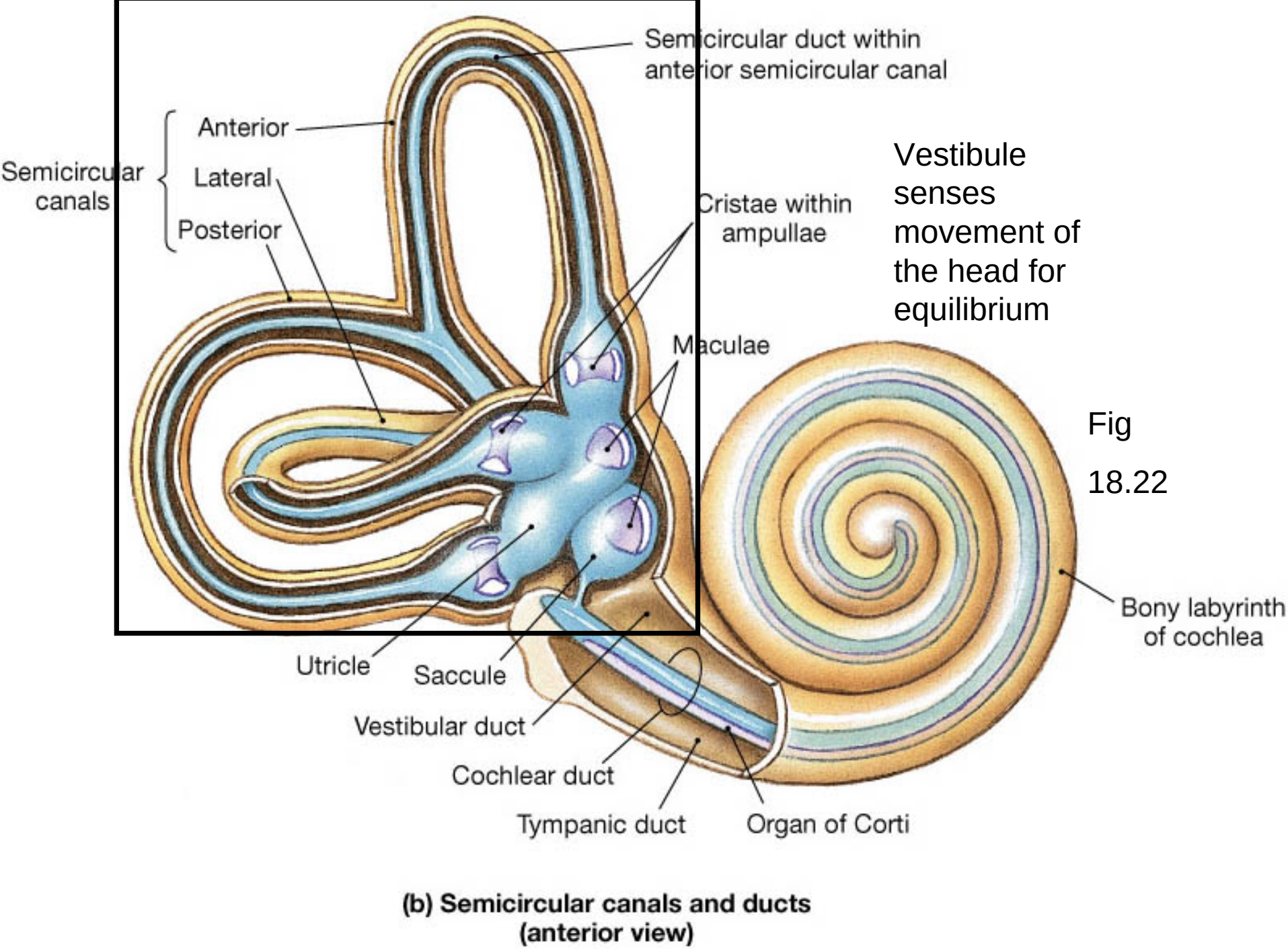

Anterior semicircular duct for "yes"
Lateral semicircular duct for "no"
Posterior semicircular duct for "tilting head"
(a)

Fig 18.13


Direction of duct rotation
Direction of relative endolymph movement
Direction of duct rotation
Semicircular duct
Ampulla
At rest
(b)



Vestibule senses movement of the head for equilibrium

Fig 18.22

(b) Semicircular canals and ducts (anterior view)

Equilibrium-vestibular nerves

- Hair cells in utricle, saccule, and ampullae
- vestibular nerve
- vestibulocochlear nerve
- medulla
- cerebellum

Vision

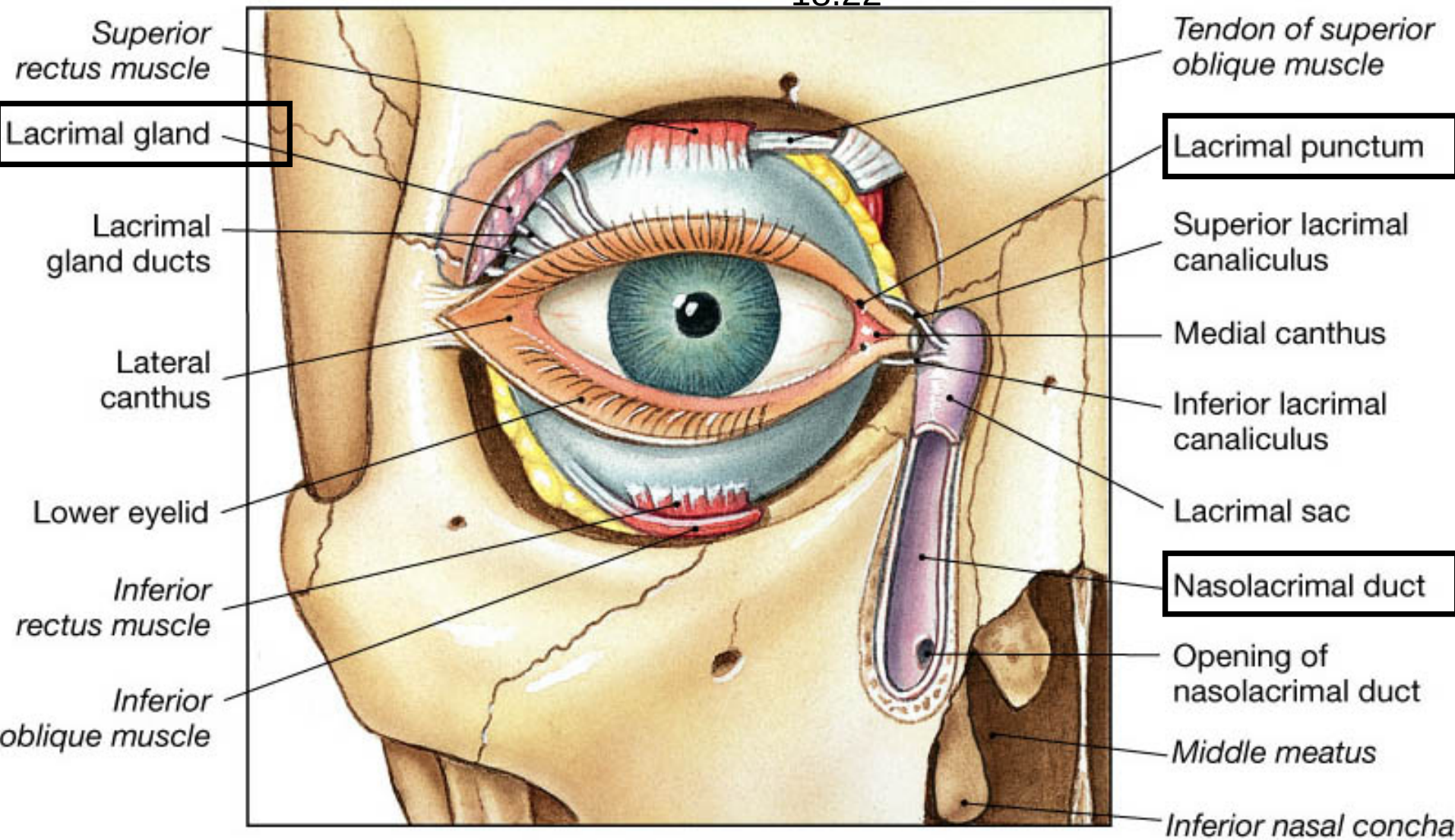
- 70% of ALL body receptors are found in the eye
- Use Photoreceptors
  - cones- detect color (3 types) visual acuity
  - rods- detect light / dark
- Three tunics:
- Fibrous tunic
- Vascular tunic
- Nervous tunic

- Fibrous Tunic
- **Sclera**- “the whites of their eyes”
- **Cornea**- focus light (no blood vessels)

Vascular Tunic

- **Choroid**-contains blood vessels
- **Cillary Body**- muscle that suspends / moves lens
- **Iris**- muscular diaphragm used to amount of light adjust entering eye (pigmented)
- **Lens**- clear / flexible
- Nervous Tunic
- -made of nervous tissue
- -contains photoreceptors (light receptors)
- **Fovea**- concentration of cones at back of eye
- **Optic Disc**- “blind spot” where optic nerve exits no photoreceptors

Fig 18.22



(c) Dissection of right orbit

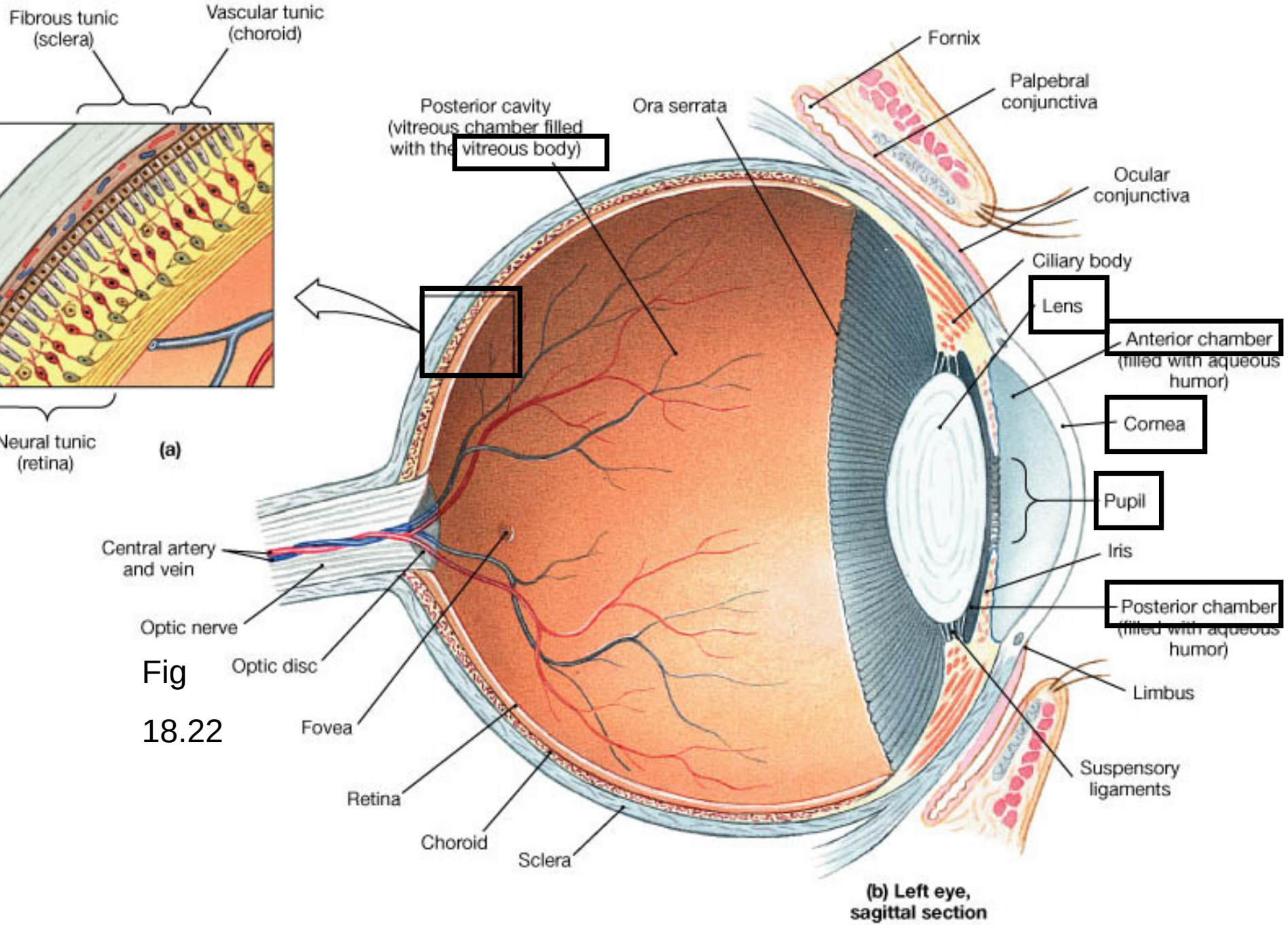

Fibrous tunic (sclera)
Vascular tunic (choroid)
Neural tunic (retina)
(a)
Posterior cavity (vitreous chamber filled with the vitreous body)
Ora serrata
Fornix
Palpebral conjunctiva
Ocular conjunctiva
Ciliary body
Lens
Anterior chamber (filled with aqueous humor)
Cornea
Pupil
Iris
Posterior chamber (filled with aqueous humor)
Limbus
Suspensory ligaments
Central artery and vein
Optic nerve
Optic disc
Fovea
Retina
Choroid
Sclera
(b) Left eye, sagittal section

Fig 18.22

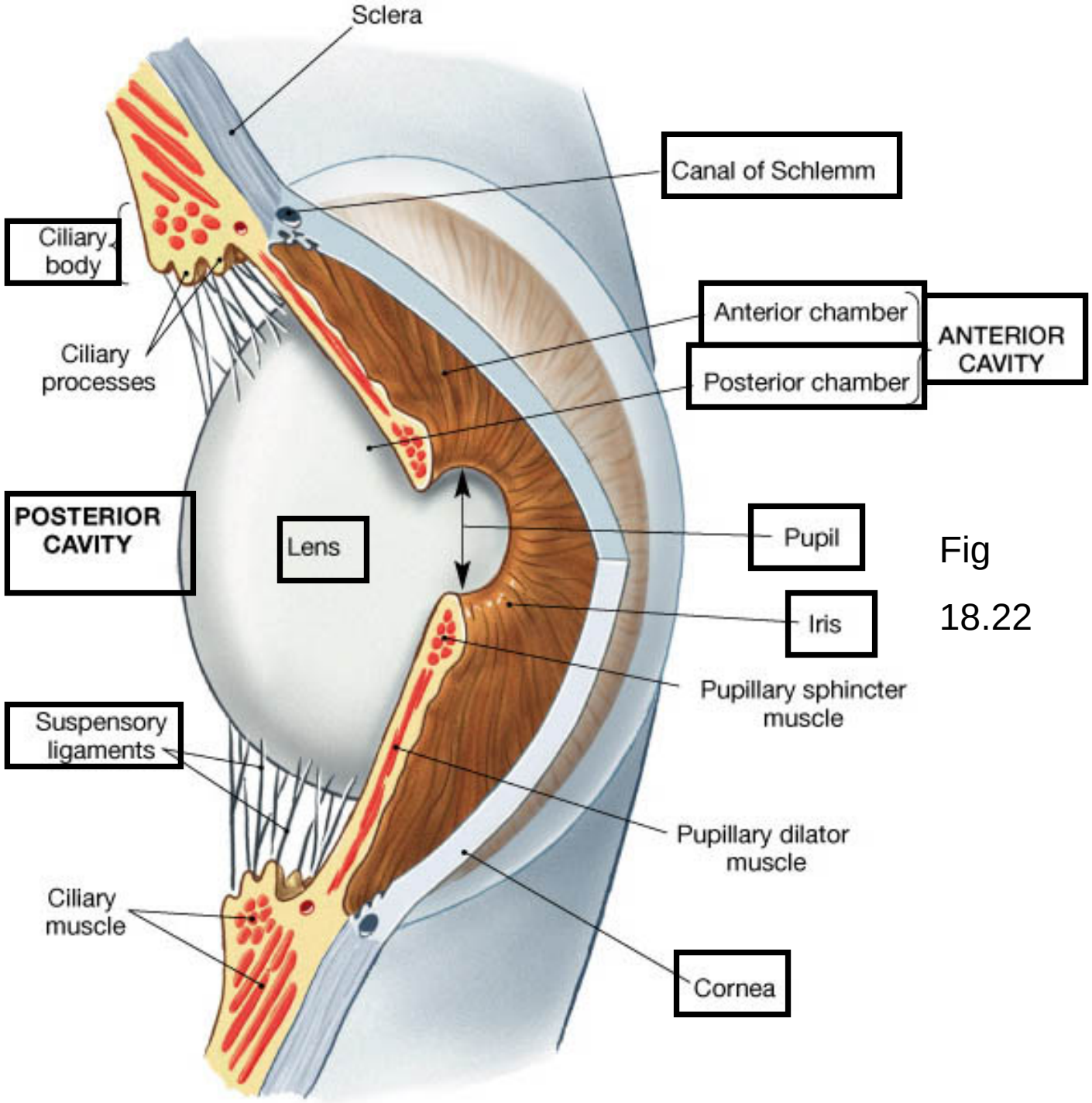
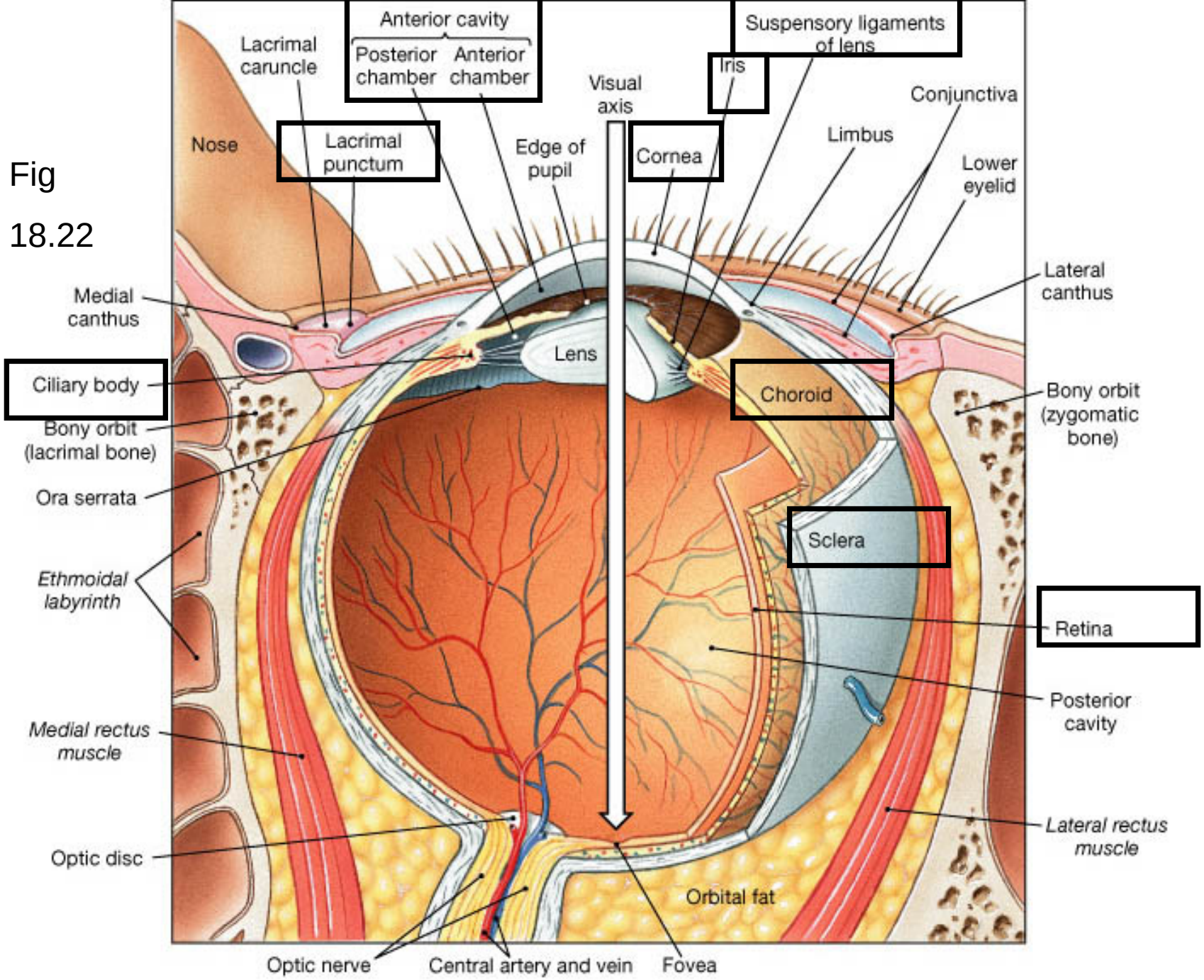

Sclera
Canal of Schlemm
Ciliary body
Ciliary processes
Anterior chamber
Posterior chamber
ANTERIOR CAVITY
POSTERIOR CAVITY
Lens
Pupil
Iris
Pupillary sphincter muscle
Suspensory ligaments
Pupillary dilator muscle
Ciliary muscle
Cornea

Fig 18.22

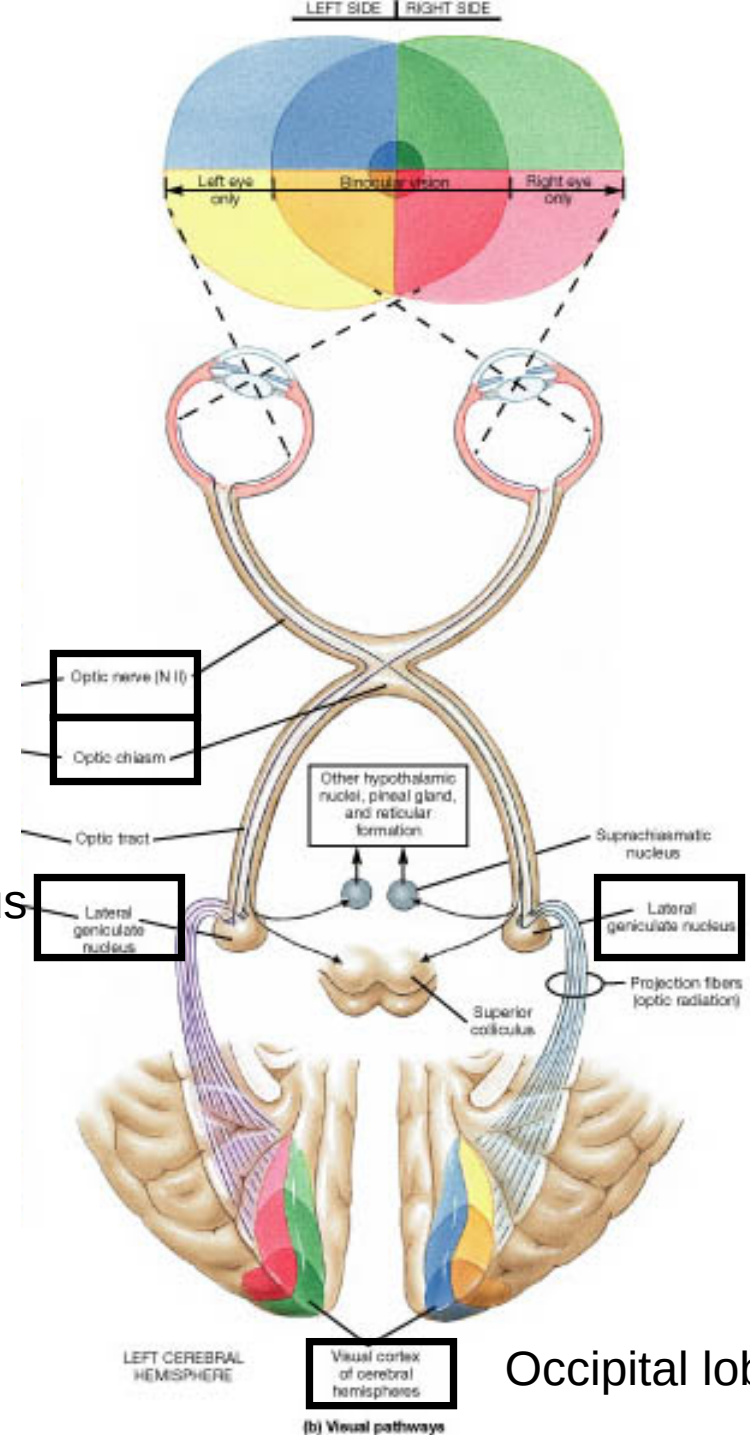
Fig

18.22



(e) Horizontal section, superior view

Fig 18.22



thalamus

thalamus

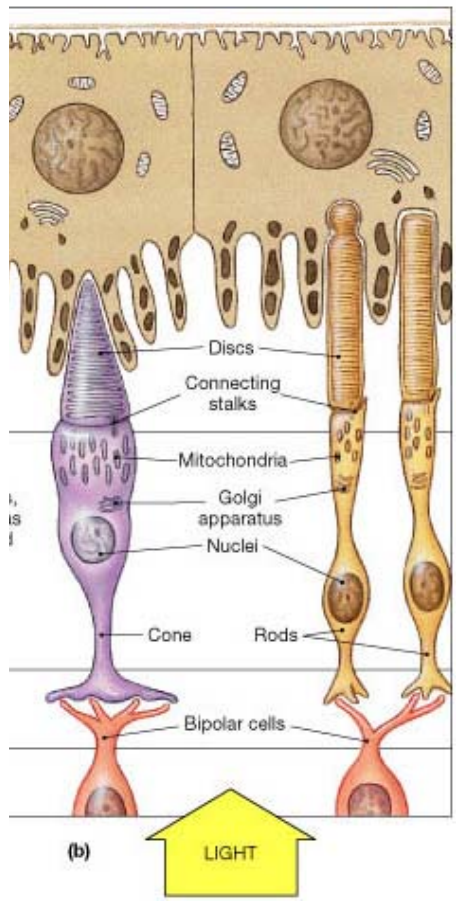
Occipital lobe

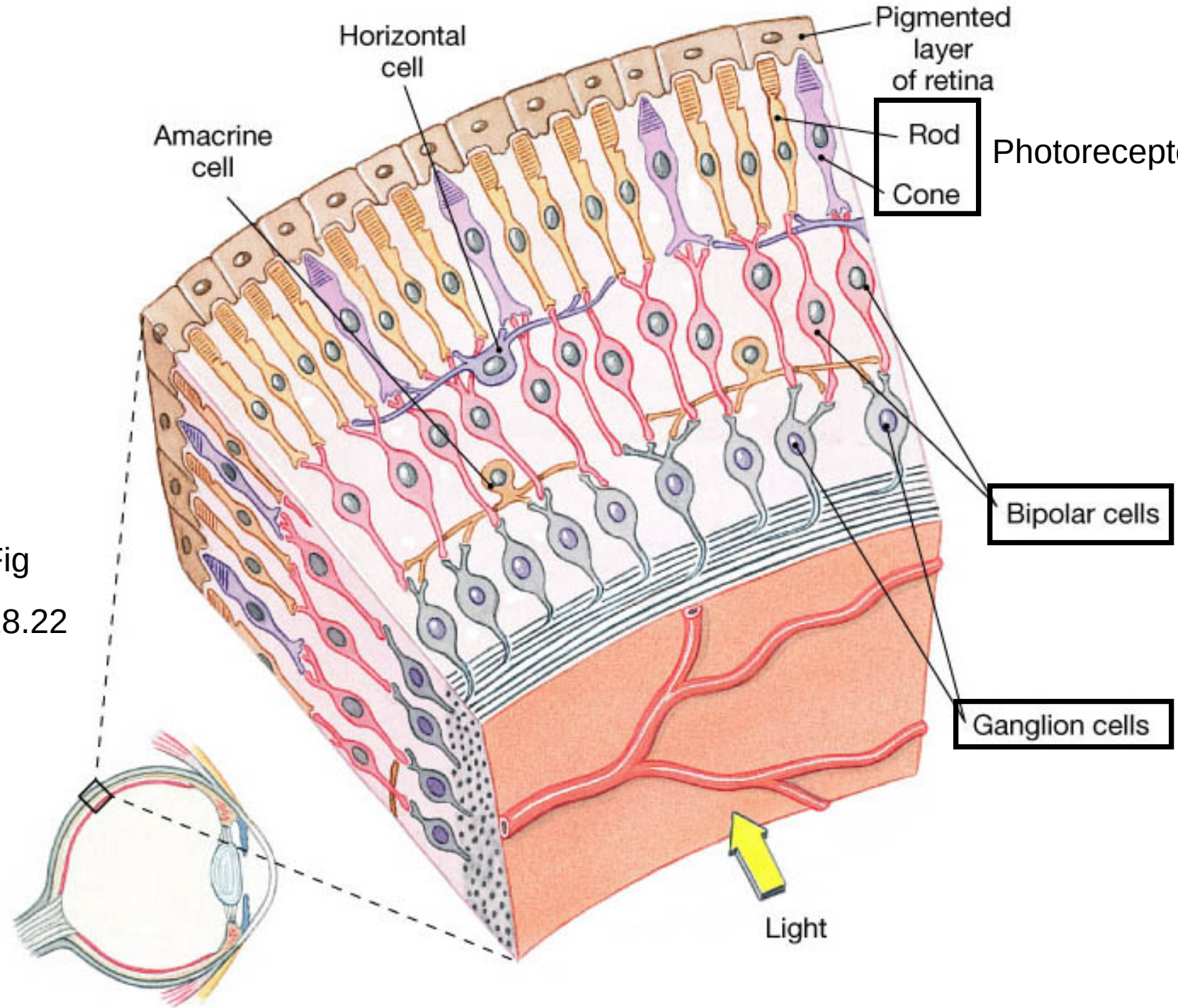
Photoreceptors in retina

- Rods & Cones
- Cones: 6 mil in posterior region of retina
- Three colors-red, blue, green
- High acuity
- Function in bright light

- Rods-125 mil at periphery of retina
- Black & white vision
- Low acuity
- Function at low light levels

Fig 18.22



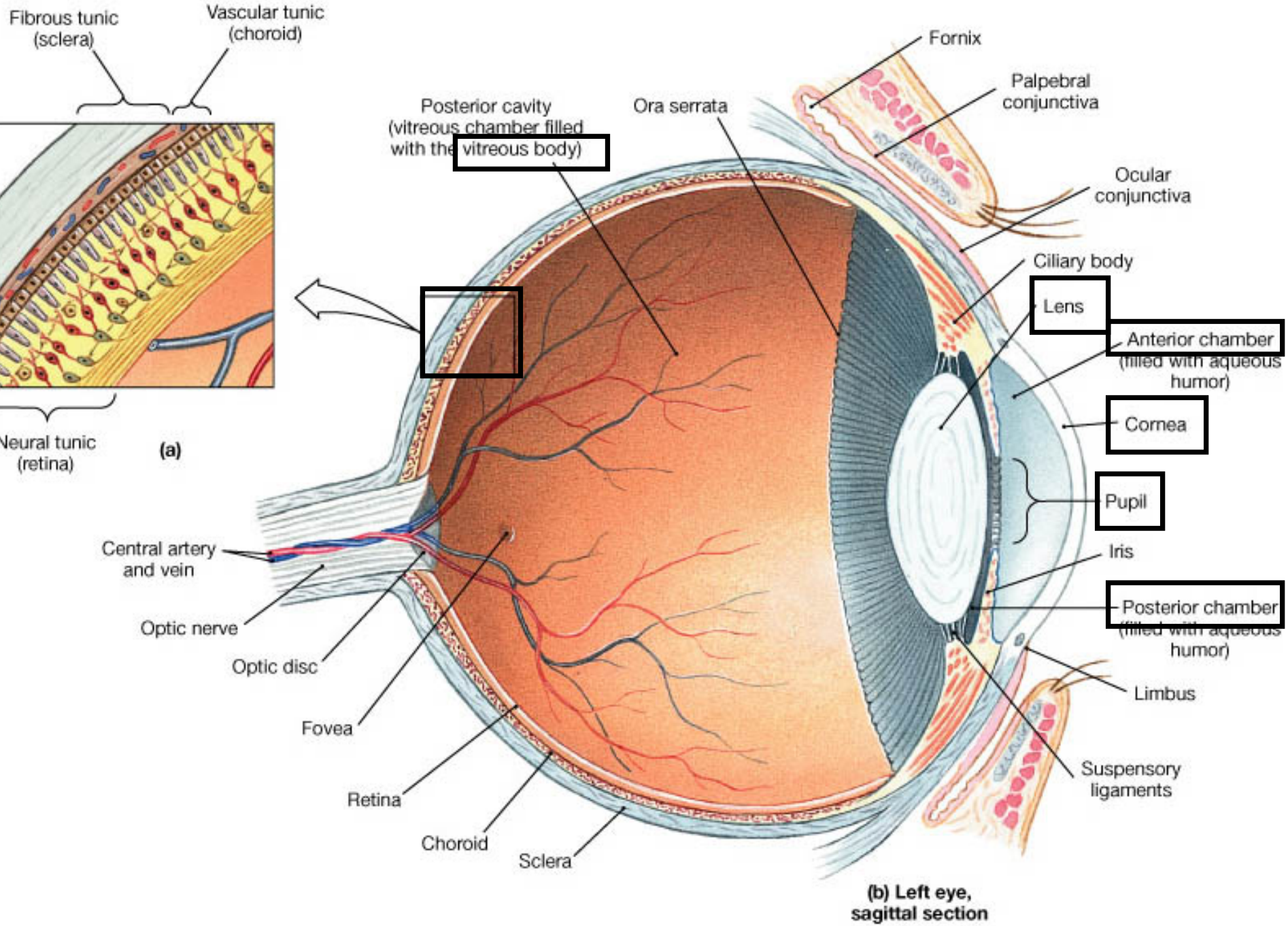

Horizontal cell
Pigmented layer of retina
Amacrine cell
Rod
Cone
Photoreceptors
Bipolar cells
Ganglion cells
Light

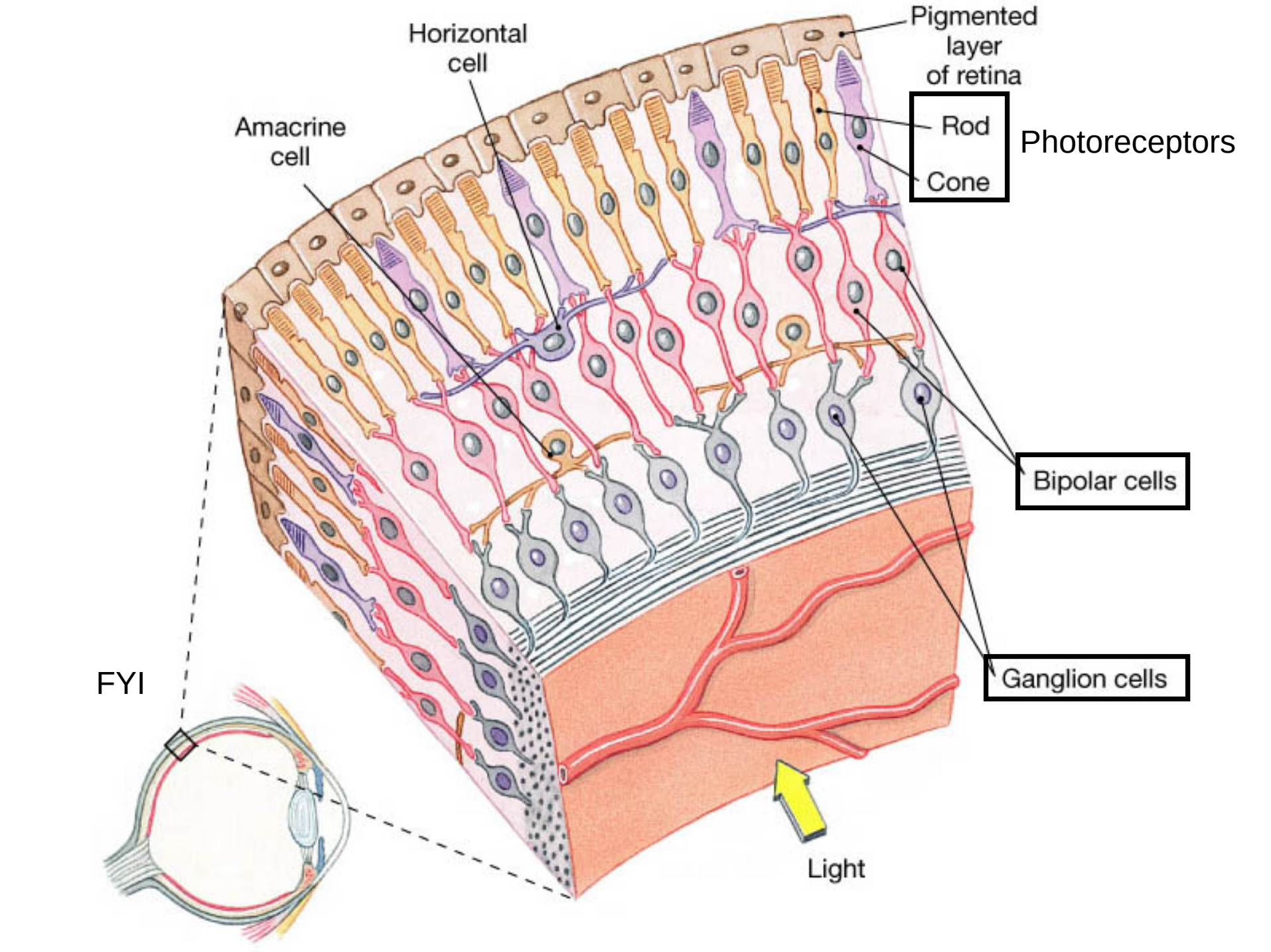
Fig

18.22

Vision tracing

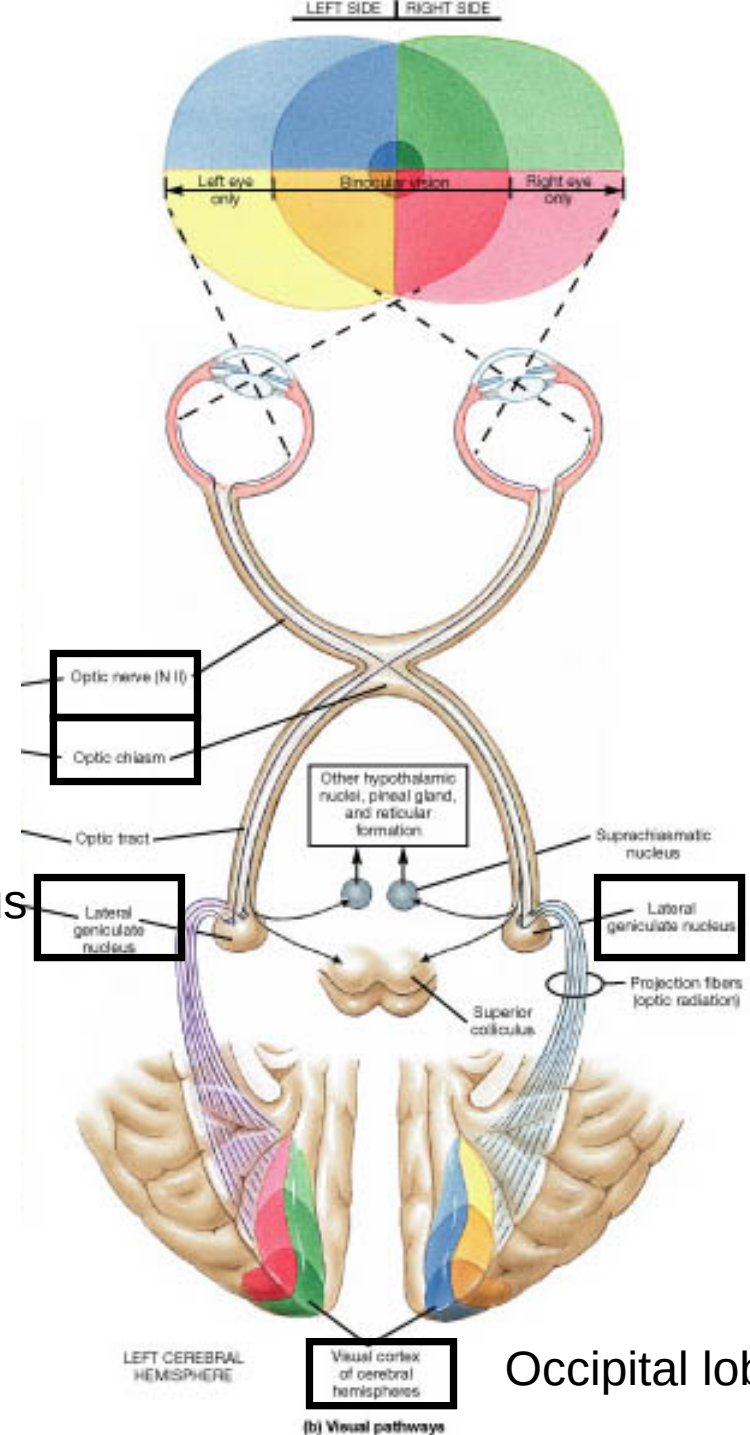
- Light rays
- Cornea
- Anterior chamber
- Pupil
- Posterior chamber
- Lens
- Vitreous body
- Rods & cones
- Bipolar cells
- Ganglion cells
- Optic nerve (cranial nerve 2)
- Optic chiasm
- Thalamus
- Cerebral cortex in occipital lobe


Fibrous tunic (sclera)
Vascular tunic (choroid)
Neural tunic (retina)
(a)
Fornix
Palpebral conjunctiva
Ocular conjunctiva
Ciliary body
Lens
Anterior chamber (filled with aqueous humor)
Cornea
Pupil
Iris
Posterior chamber (filled with aqueous humor)
Limbus
Suspensory ligaments
Posterior cavity (vitreous chamber filled with the vitreous body)
Ora serrata
Central artery and vein
Optic nerve
Optic disc
Fovea
Retina
Choroid
Sclera
(b) Left eye, sagittal section


Horizontal cell
Pigmented layer of retina
Amacrine cell
Rod
Cone
Photoreceptors
Bipolar cells
Ganglion cells
FYI
Light

FYI

thalamus



thalamus

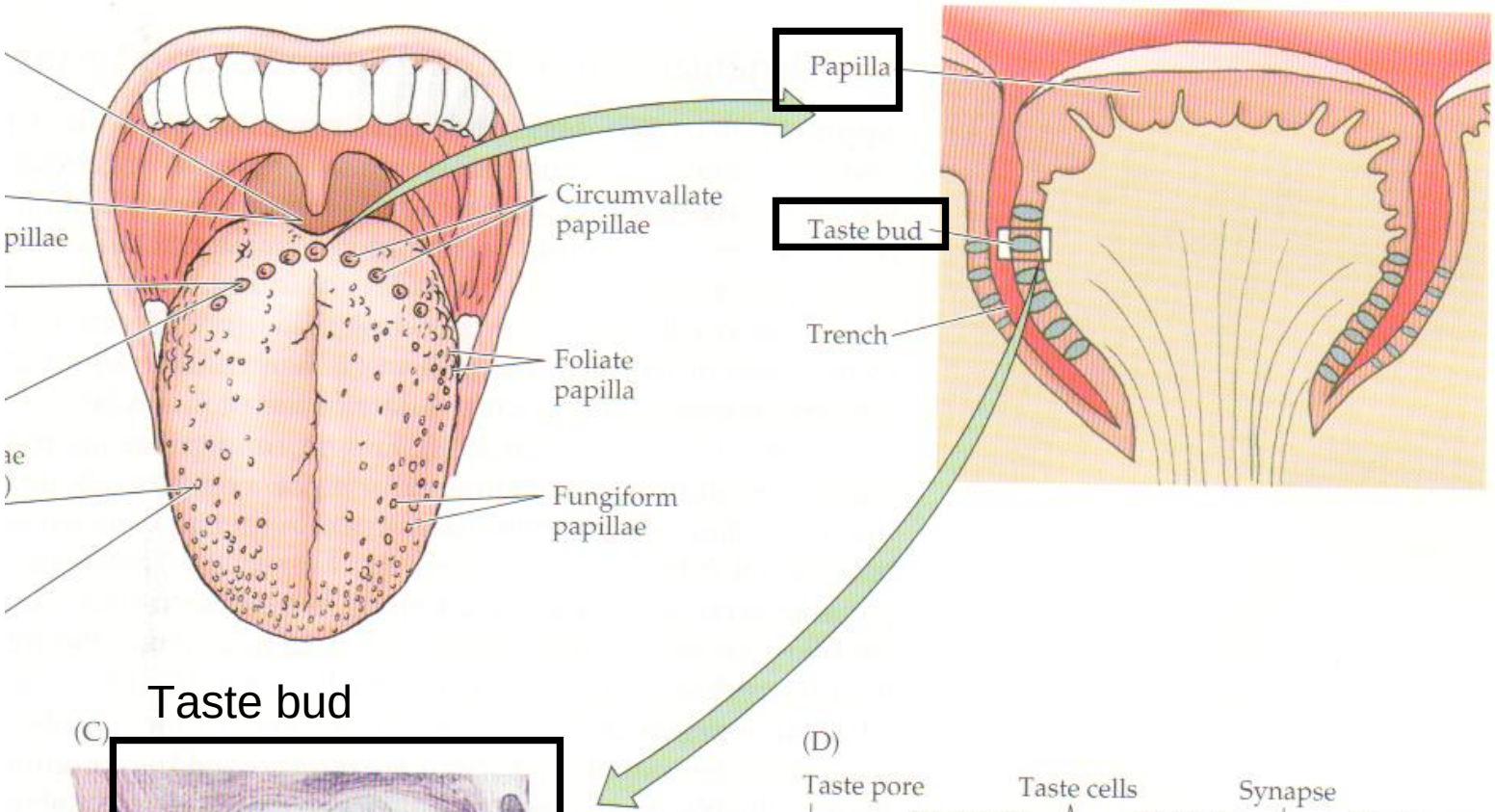
Occipital lobe

Temporal lobe	Frontal lobe	Parietal lobe	Occipital lobe
Auditory	Motor	General sensory	visual
olfactory	gustatory	gustatory	

break

(B)

Kaye, 1995.)

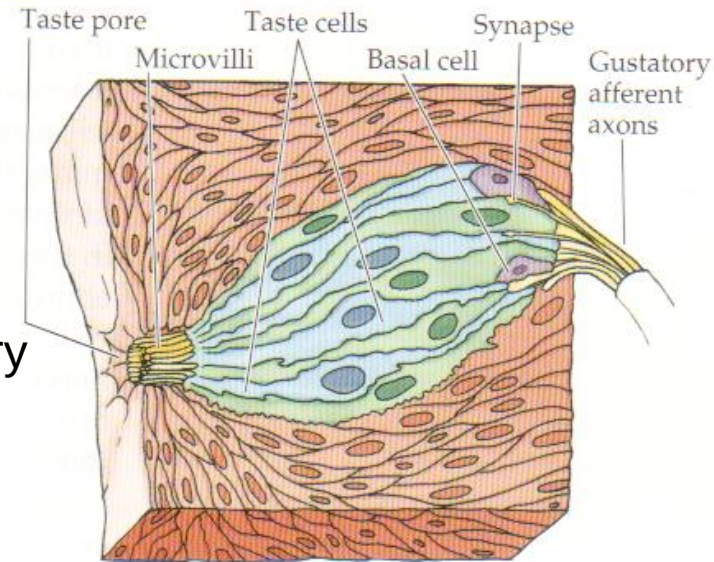


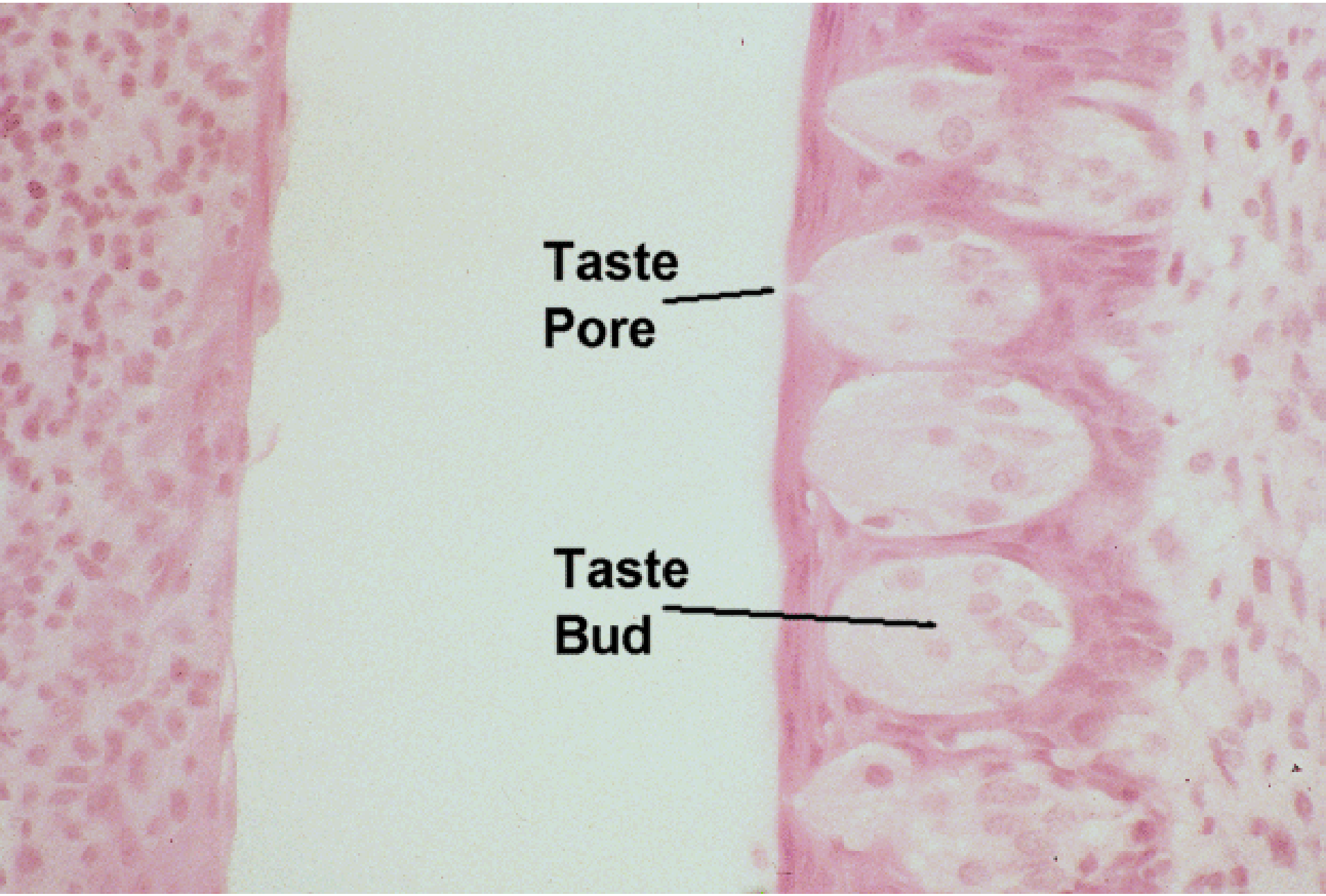
Taste bud

(C)

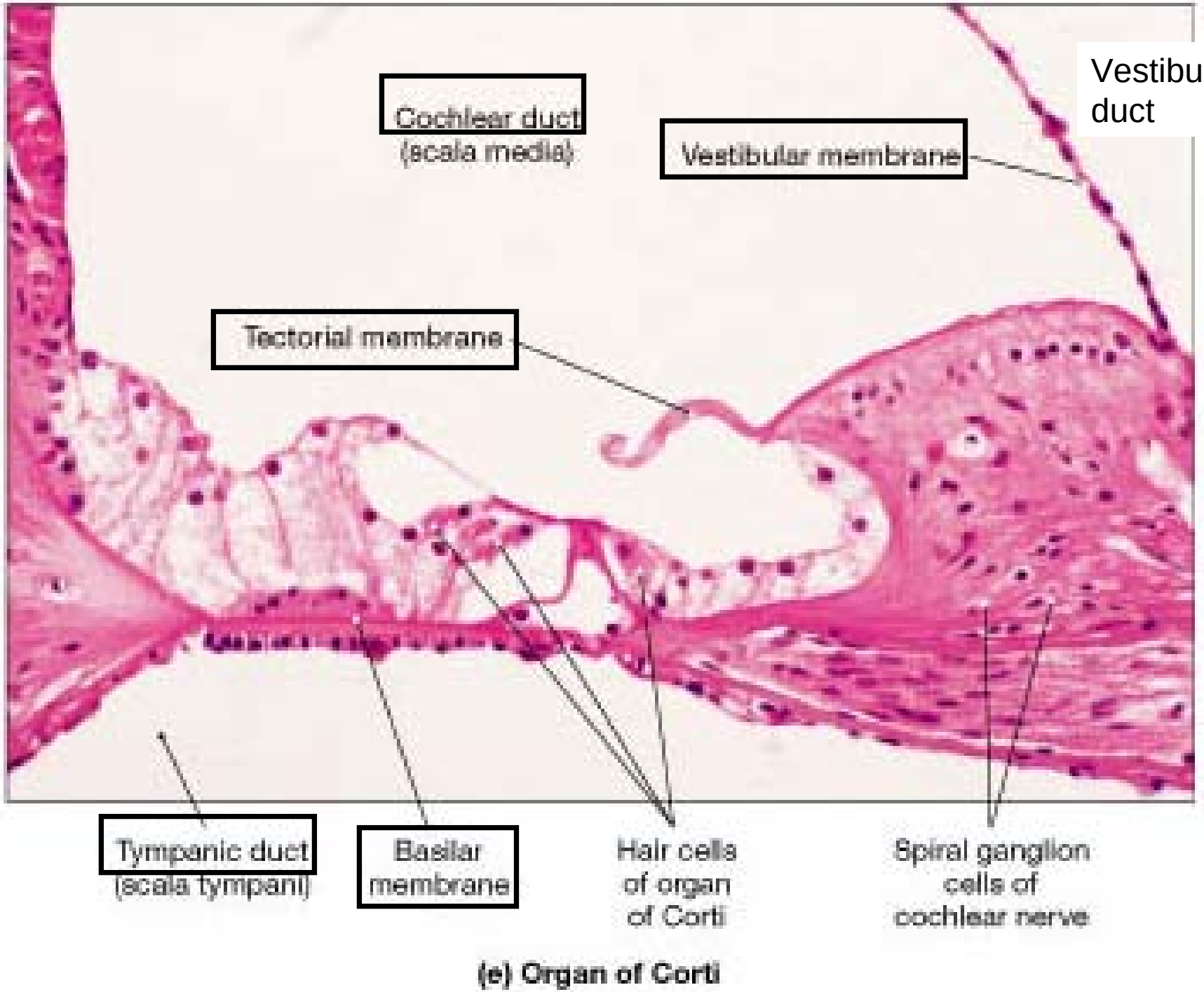
Gustatory receptor cells

(D)

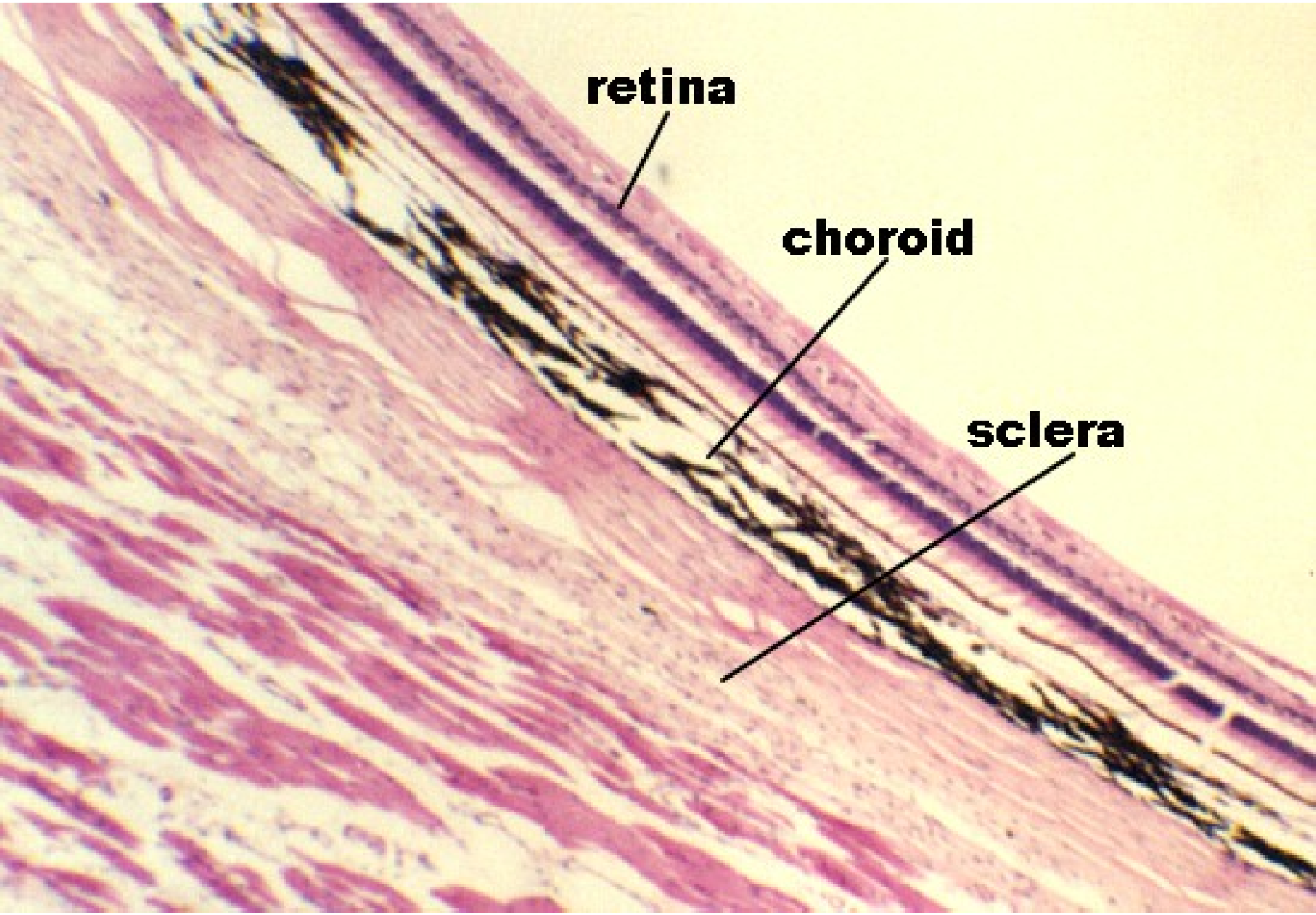



Taste
Pore
Taste
Bud

Cochlea (100x)



(e) Organ of Corti


retina
choroid
sclera

Ganglion cells

Bipolar cells

Photoreceptors