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Functional Anatomy of the Sensory Organs

Department of anatomy and clinical anatomy

Dr. Angela Babuci

Plan of the lecture

1. General characteristics of the sensory organs.
2. Special types of senses.
3. Hearing.
4. Equilibrium (balance).
5. Vision.
6. Organ of smell (olfaction).
7. Organ of taste.
8. Developmental abnormalities of the organs of sense.

What an analyser is?

???

- ***Receptor ???***
- ***Conductor ???***
- ***Cortical end ???***

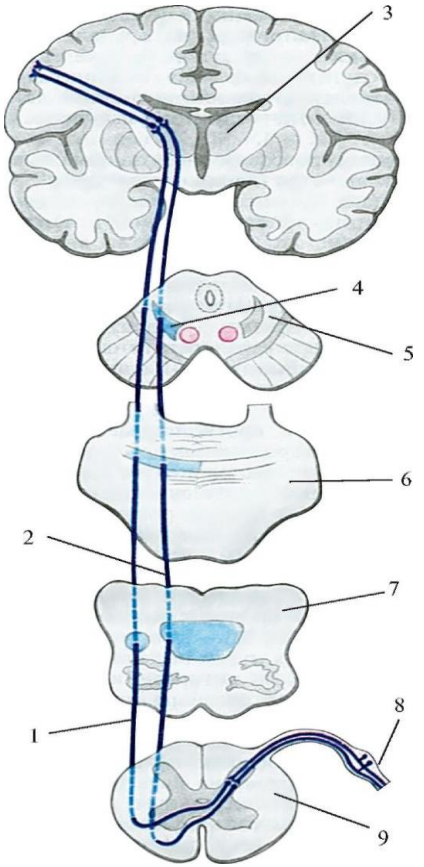
Analysers

- Each analyser consists of three links:

a) the ***receptor*** which transforms the energy of the stimulus into a nervous process;

b) the ***conductor*** which conveys the nerve excitation;

c) the ***cortical end*** of the analyser where the excitation is perceived as a sensation.



What the organs of sense are?

- The organs of sense include all the anatomical structures that receive energy of the external excitations and transform it into a nervous impulse, which is conducted to the brain.
- The sensory organs receive only specific excitations that are conducted as a nervous influx to the brain cortex, where after analyses are converted into sensations.
- The sense organs have been described as ***''windows for the brain''*** because through them we achieve awareness of the environment.
- The sense organs enable us to:
  - *hear warning sounds;*
  - *see dangers;*
  - *distinguish fragrances;*
  - *avoid ingesting toxic substances;*
  - *perceive sensations of pain, temperature, pressure and touch.*

All the organs are divided into two groups:

- Organs of **external sensibility** which receive nerve impulses from the exteroceptive field, the exteroceptors:

a) the organ of vision (or sight),
b) the organ of hearing,
c) the organ of taste,
d) the organ of smell,
e) the organs of cutaneous sense.

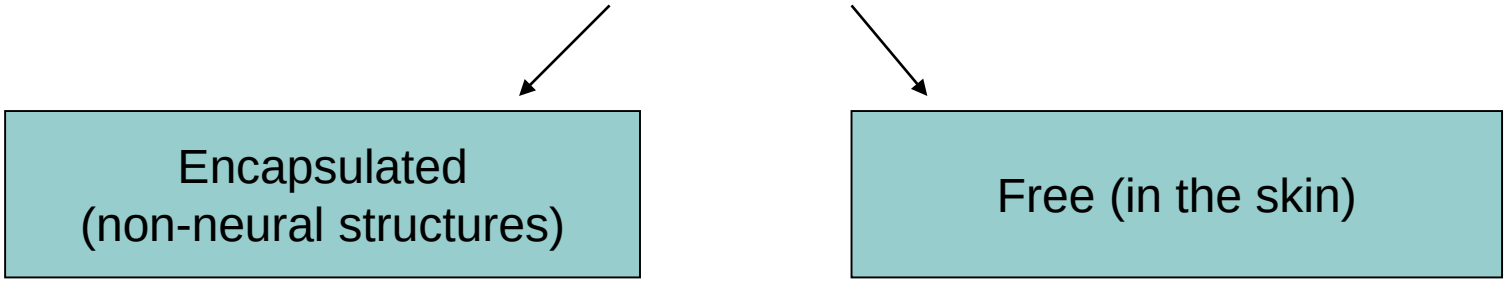
- **Organs of inner sensibility**:

a) organs that receive impulses from the proprioceptive field (the muscle-joint sensation), as well as from organ of balance (the inner ear);
b) organs receiving nerve impulse from the interoceptive field (internal organs and vessels).

Categories of receptors

Sensory receptors can be categorized on basis of structure or function:

- Structurally - dendritic endings of sensory neurons



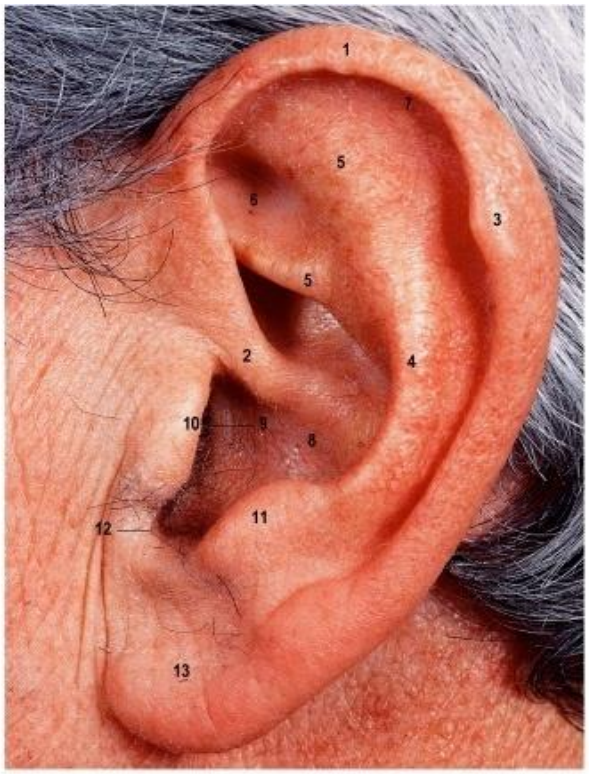
- The photoreceptors in the retina are highly specialized neurons.
- The taste buds on the tongue and hair cells in the inner ear are modified epithelial cells and they respond to environmental stimuli and activate sensory neurons.

Functional Categories

Sensory receptors can be grouped according to the type of stimulus energy they transduce

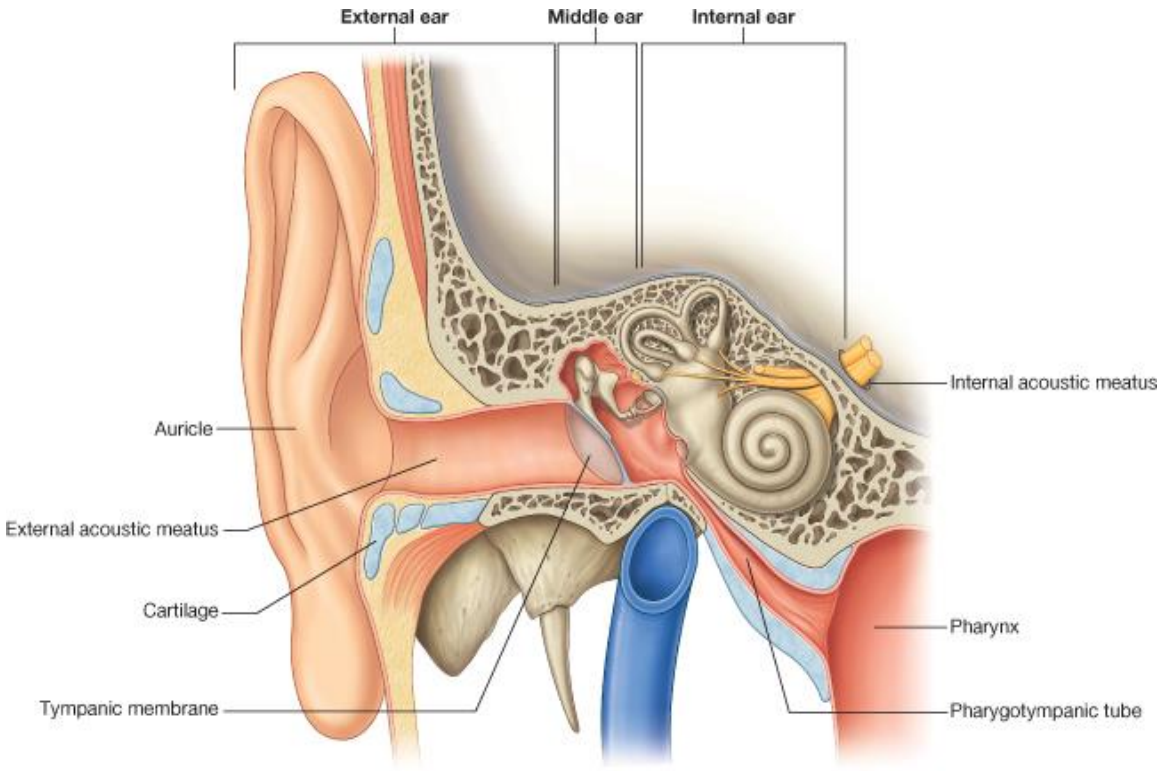
- **chemoreceptors**, such as the taste buds, olfactory epithelium, respond to chemical stimuli in the environment, or blood.
- **photoreceptors** – the rods and cones in the retina - respond to light.
- **termoreceptors** - respond to changes of temperature.
- **mechanoreceptors** such as the touch and pressure receptors in the skin and the hair cells within the inner ear – respond to mechanical stimuli.
- **nociceptors**, or **pain** receptors, are stimulated by chemical released from damaged tissue cells and thus are a type of chemoreceptors.

The external ear



1. Helix. **2.** Crus of helix. **3.** Auricular tubercle. **4.** Antihelix. **5.** Crura of antihelix. **6.** Triangular fossa. **7.** Scaphoid fossa. **8.** Concha of auricle. **9.** External acoustic meatus. **10.** Tragus. **11.** Antitragus. **12.** Intertragic notch. **13.** Lobule of auricle.

The middle ear



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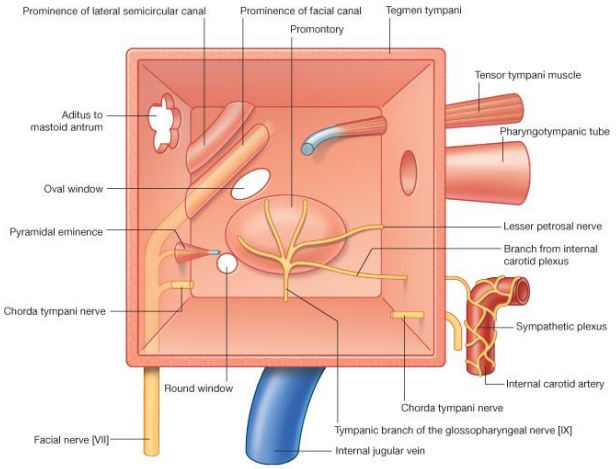

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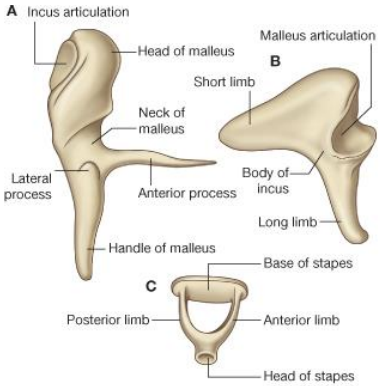

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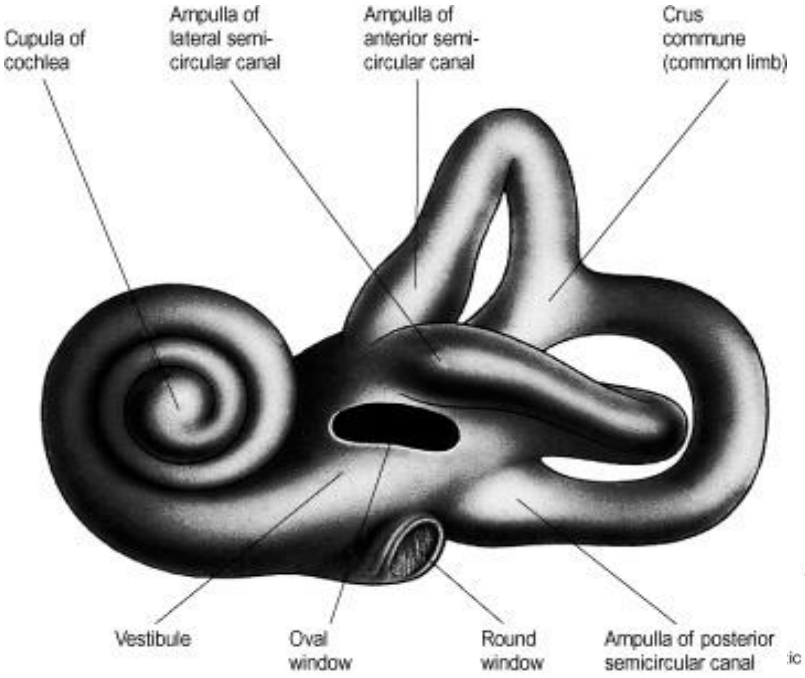
Internal ear – bony labyrinth



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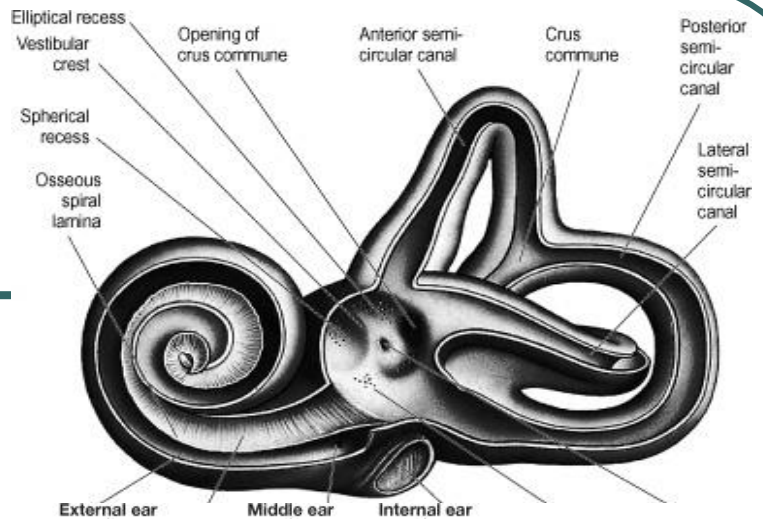

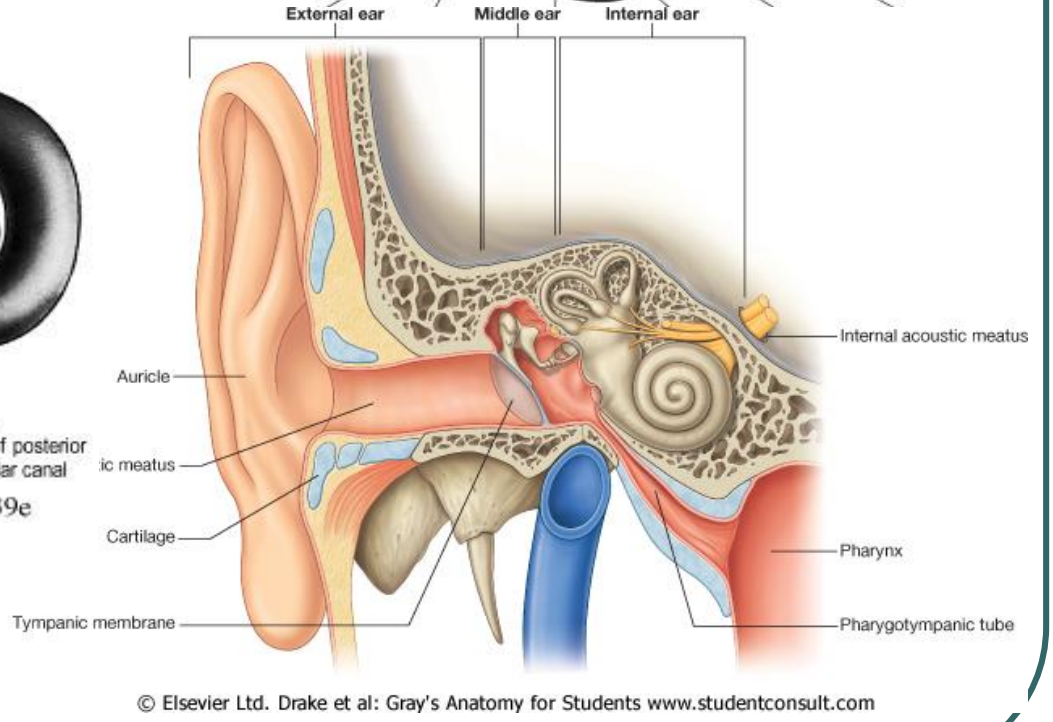

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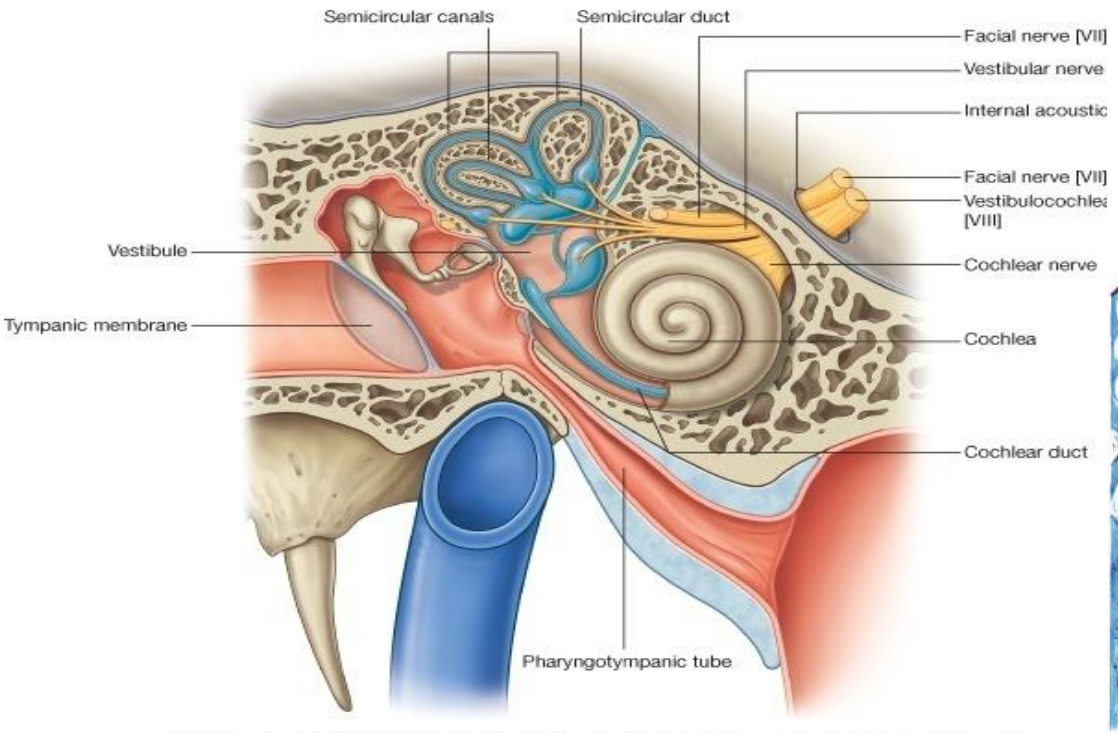
Internal ear – membranous labyrinth



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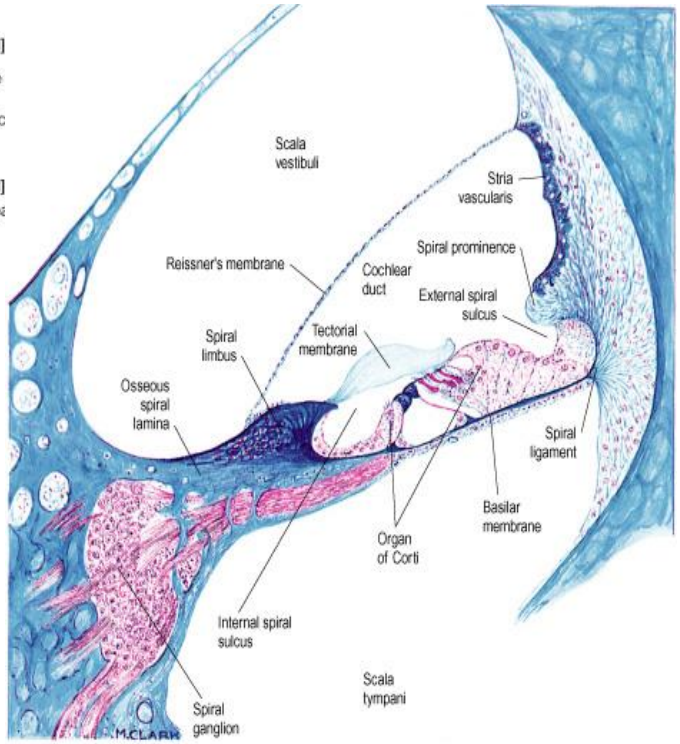

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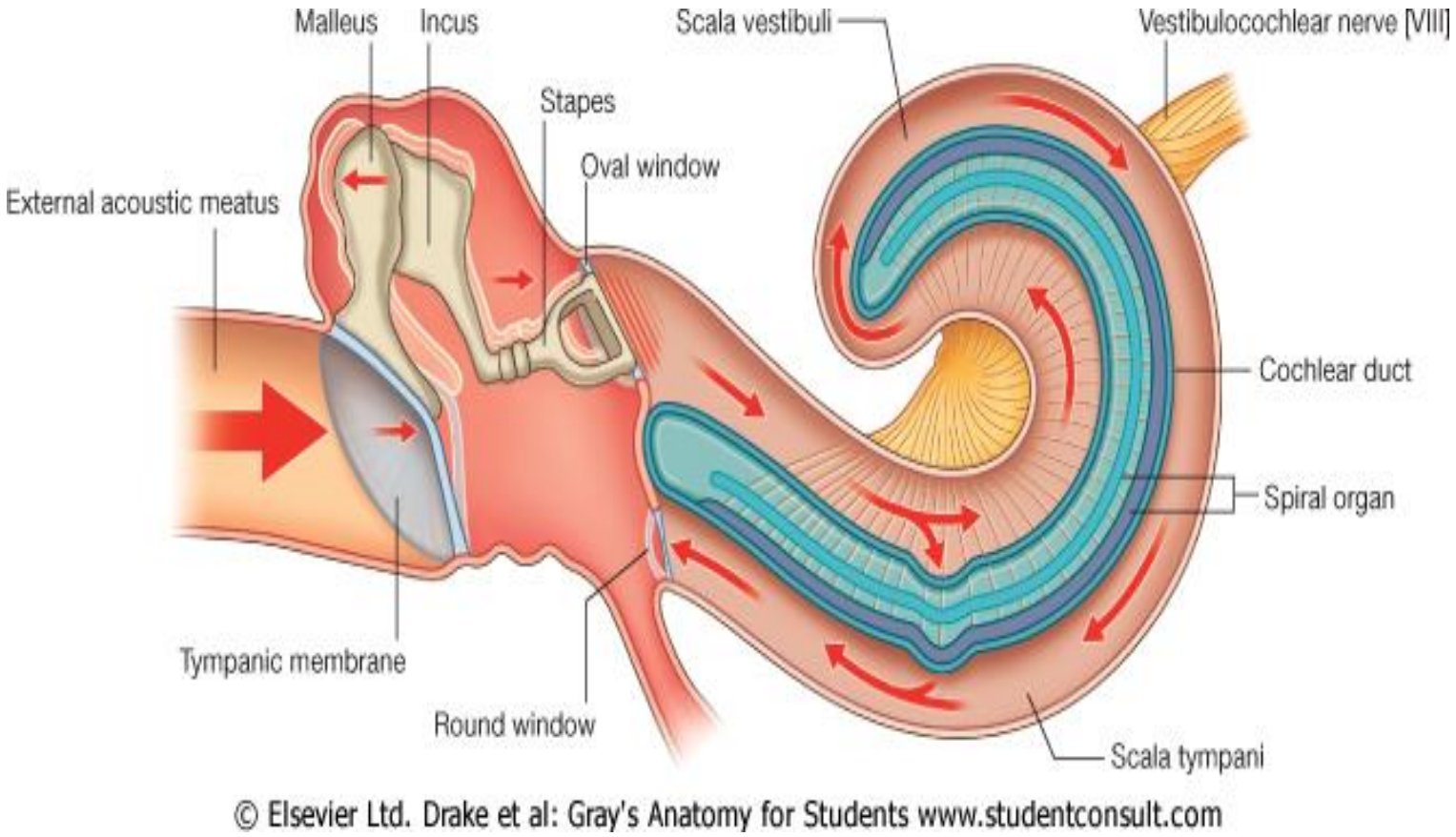
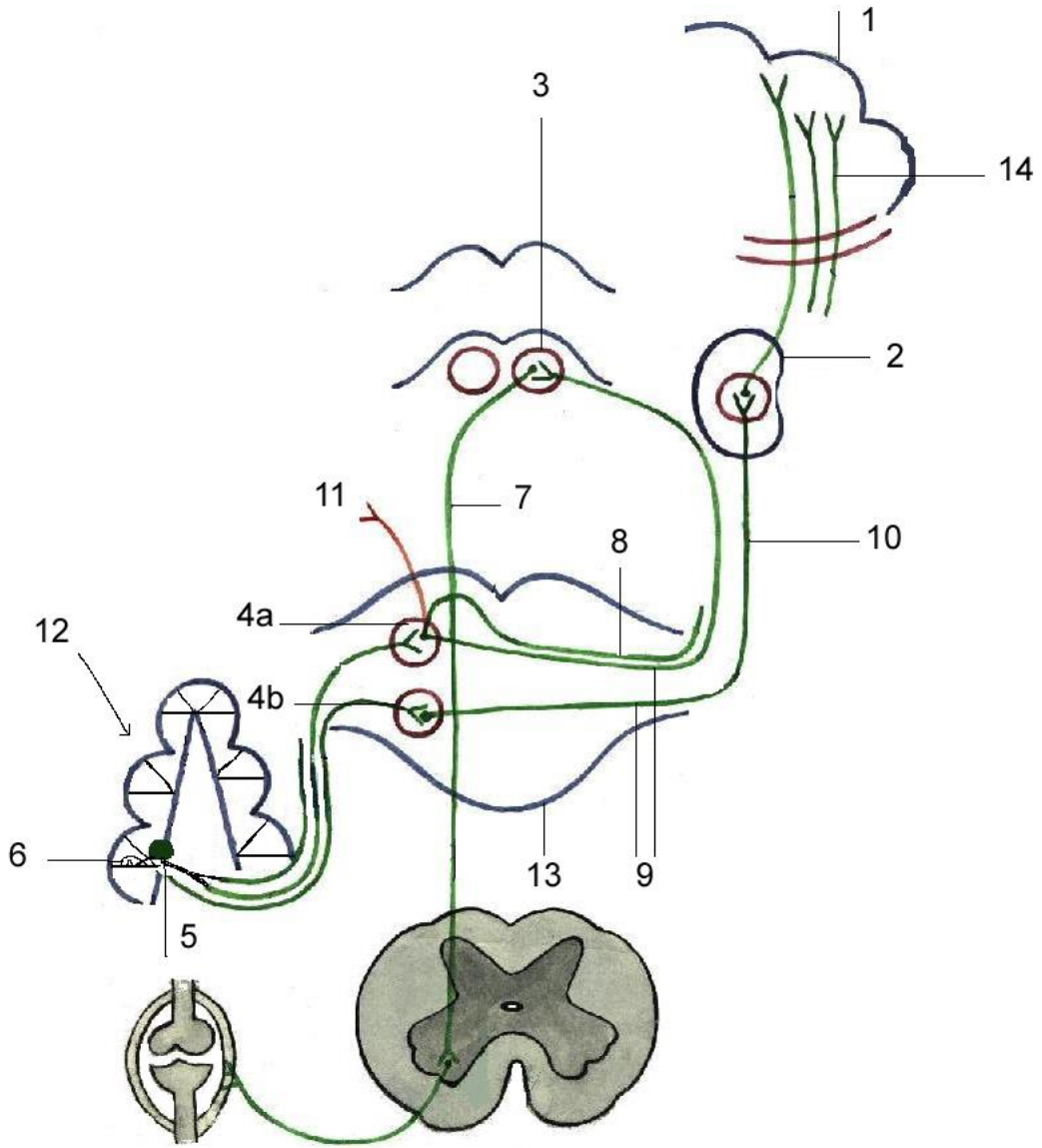
Transmission of sounds



Pathways of the organ of hearing

a) The body of the first neuron – spiral ganglion.
b) The body of the second neuron – ventral and dorsal cochlear nuclei in the pons.
c) The body of the third neuron – medial geniculate body and inferior colliculi of the tectal lamina (midbrain).



Pathways of the organ of balance (equilibrium)

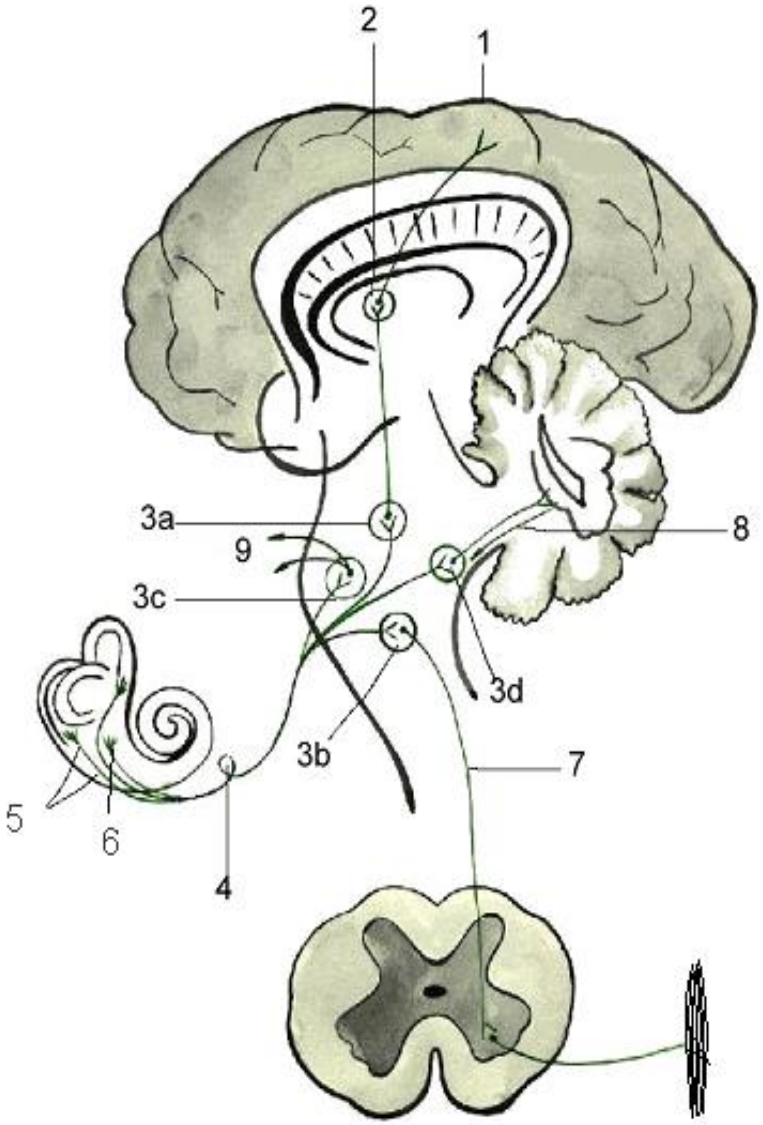
a) The body of the first neuron – vestibular ganglion (Scarpa).

b) The body of the second neuron – superior, inferior, medial and lateral vestibular nuclei in the pons.

Connections of the vestibular nuclei:

- with spinal cord by means of vestibulo-spinal tract;
- with cerebellum through the cerebello-vestibular and vestibulo-cerebellar fibres (tracts);
- connections through the medial longitudinal fascicle with the IIIrd, IVth, VIth, IXth and Xth pairs of cranial neves.

a) The body of the third neuron – is in the thalamus and it ends in the ***parietoinsular vestibular cortex (PIVC),*** in humans it is called lateral cortical temporoparietal area or "***temporo-peri-sylvian vestibular cortex***" (Khan_2013).

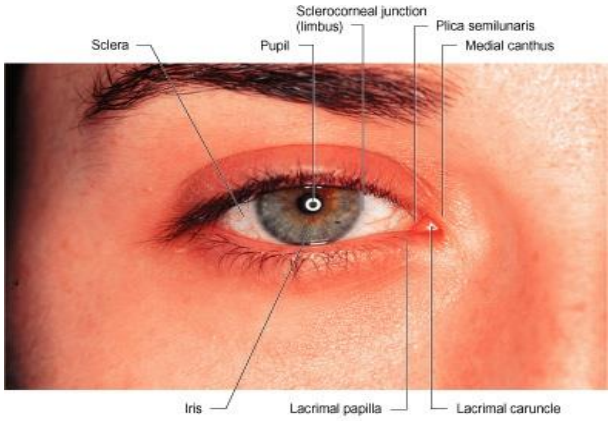


Khan S, Chang R. Anatomy of the vestibular system: a review. NeuroRehabilitation. 2013;32(3):437-43. doi: 10.3233/NRE-130866. PMID: 23648598.

Organ of vision

- Eye and auxiliary apparatus

  The eye consists of 3 coats:
- The outer or fibrous coat: cornea and sclera
- The middle or vascular coat: the choroidea, the ciliary body and the iris.
- The innermost one – retina.



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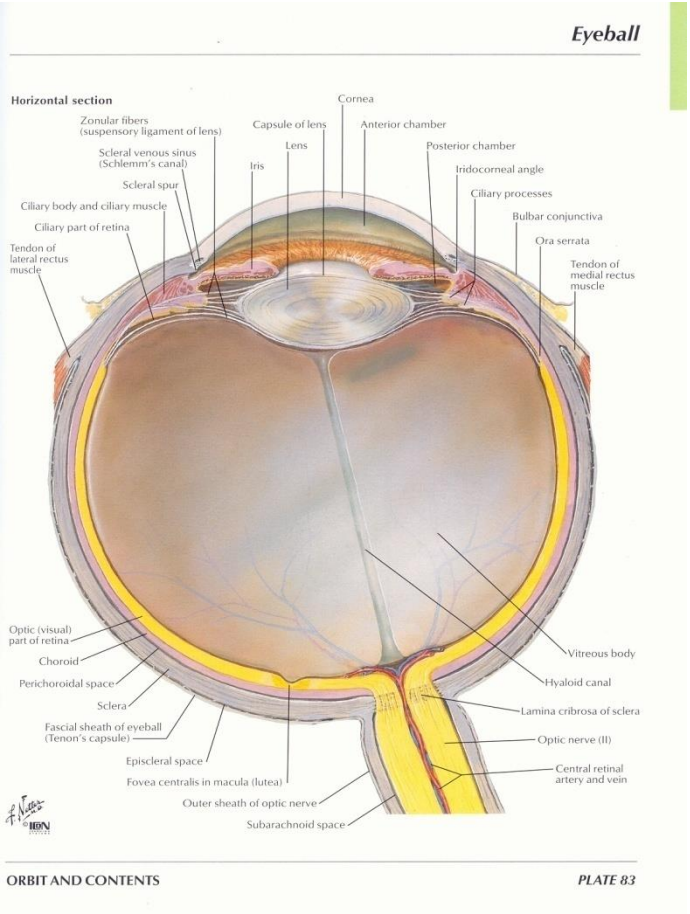
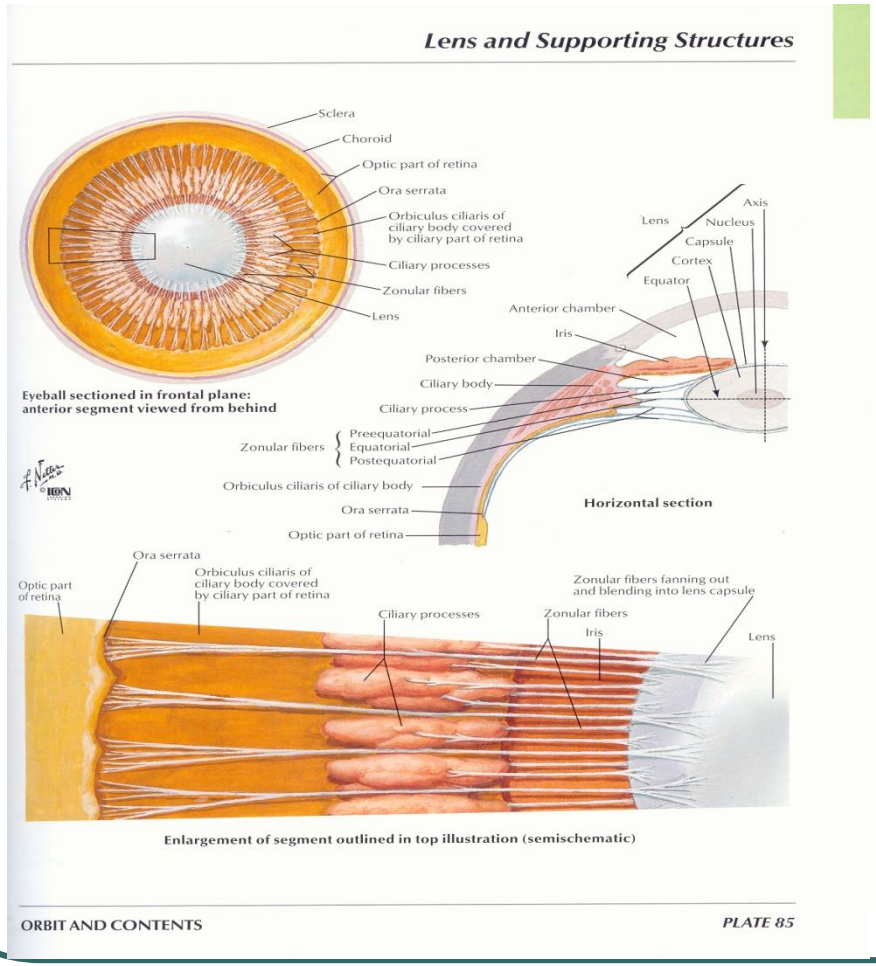
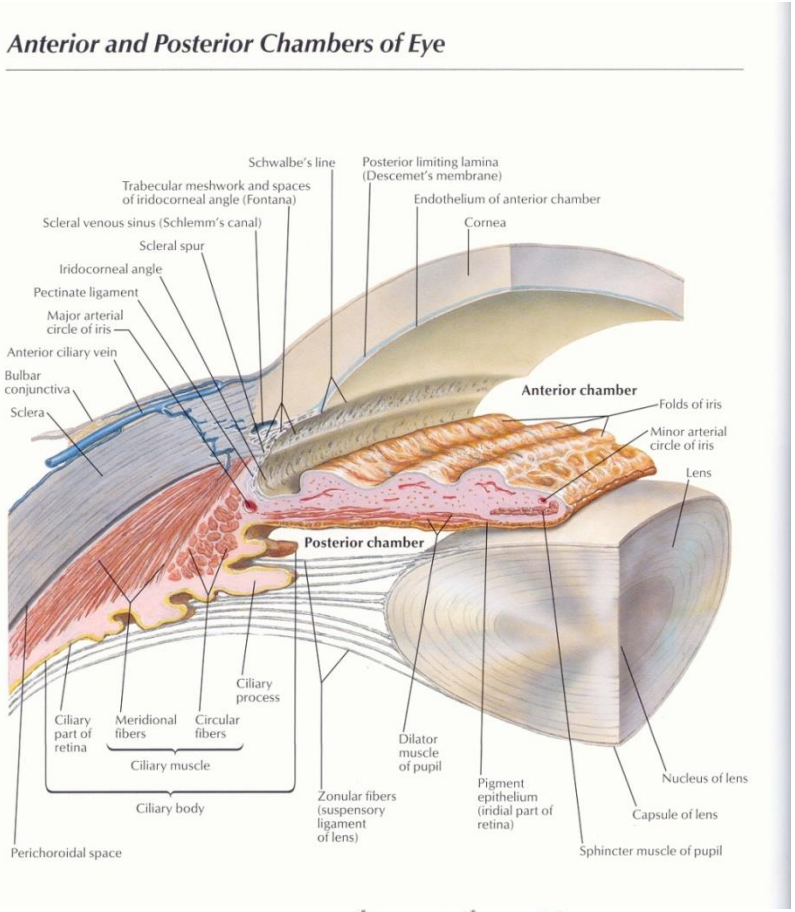
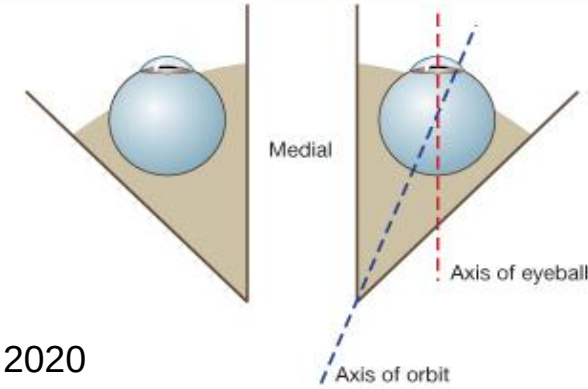
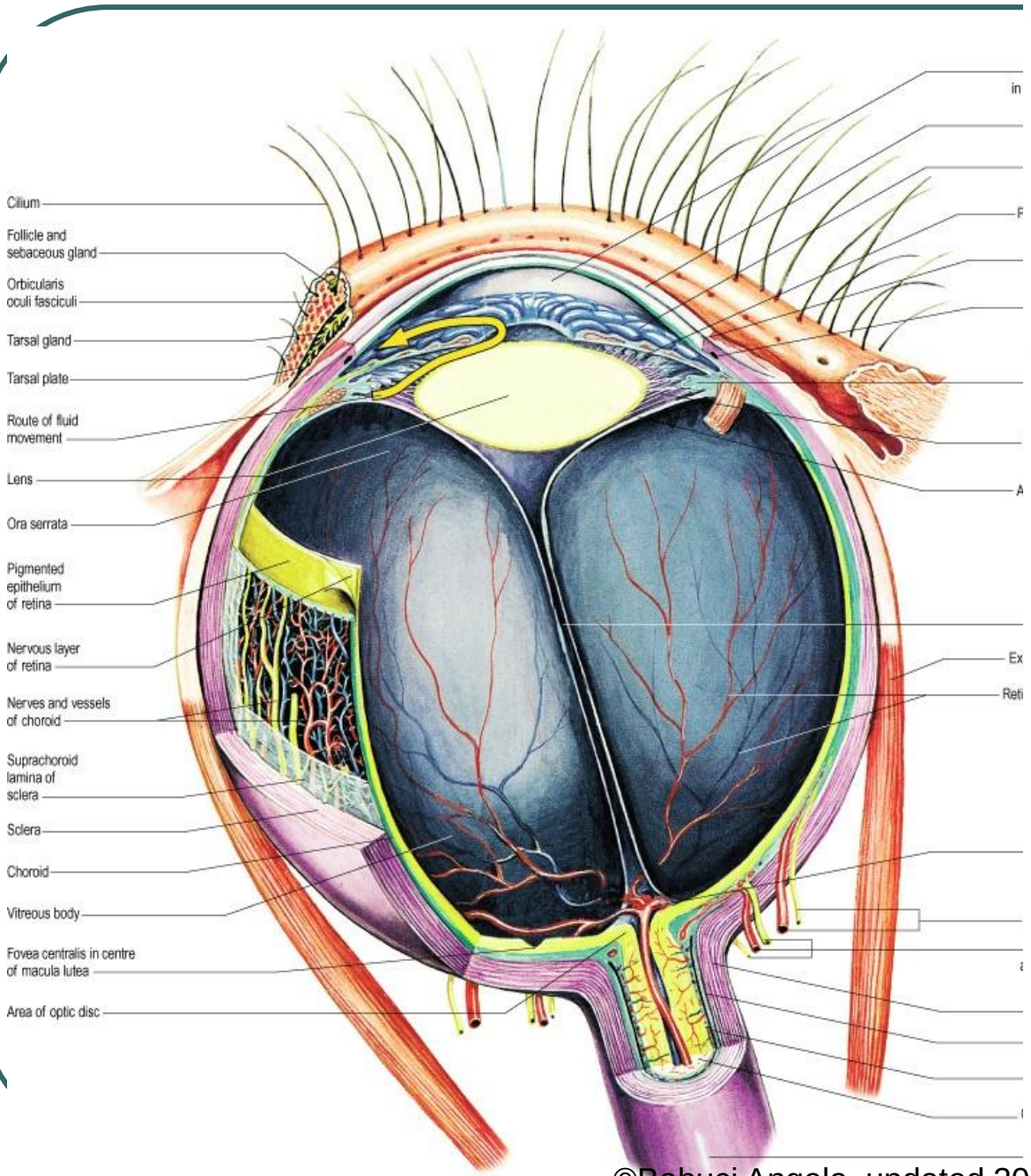


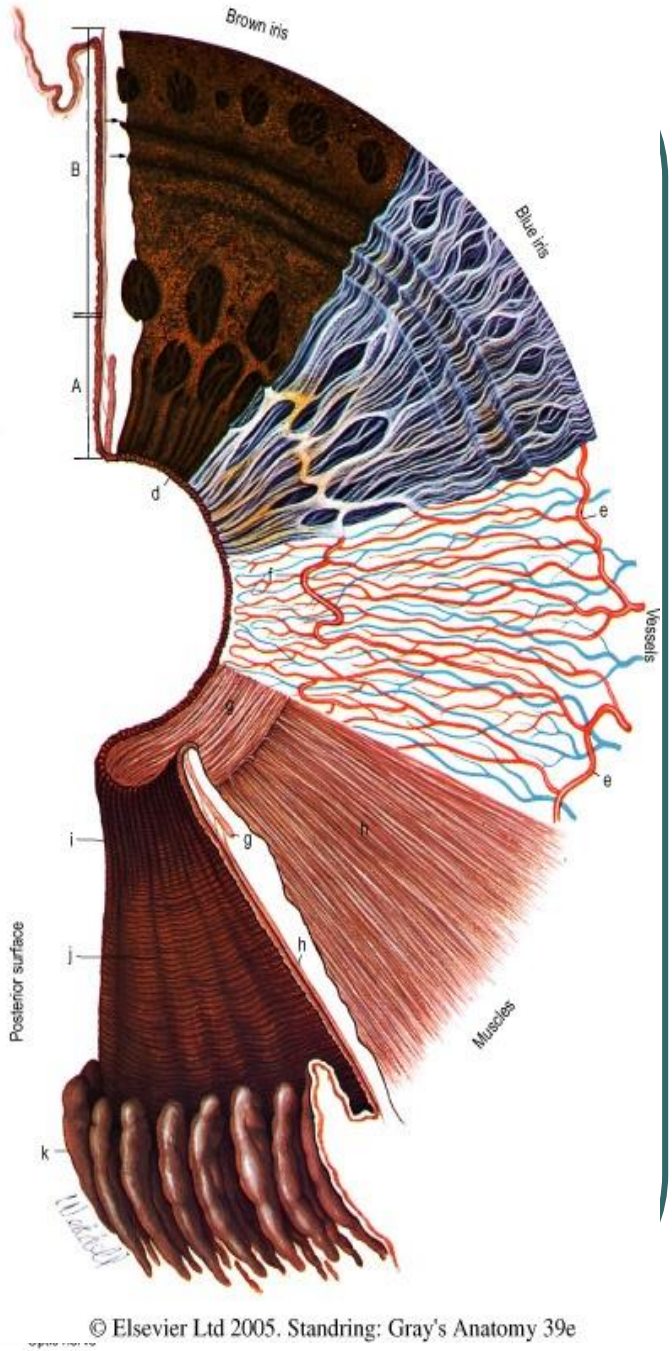
Structure of the ciliary body











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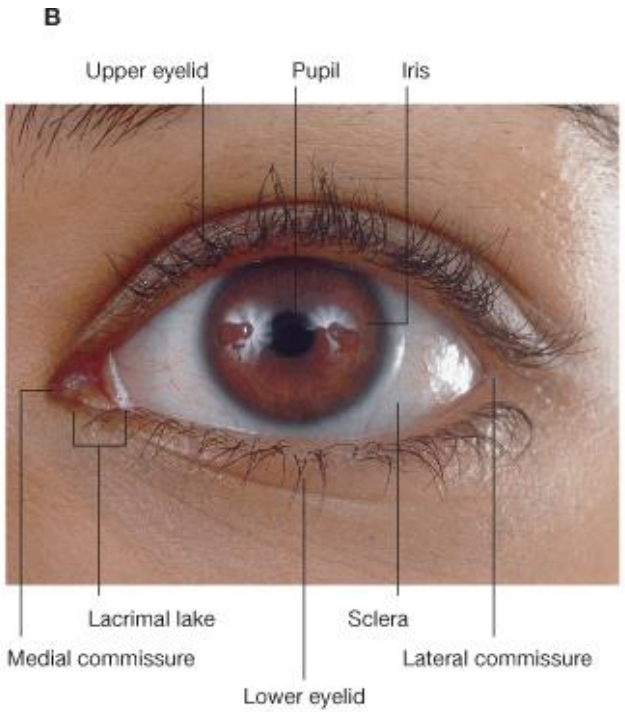
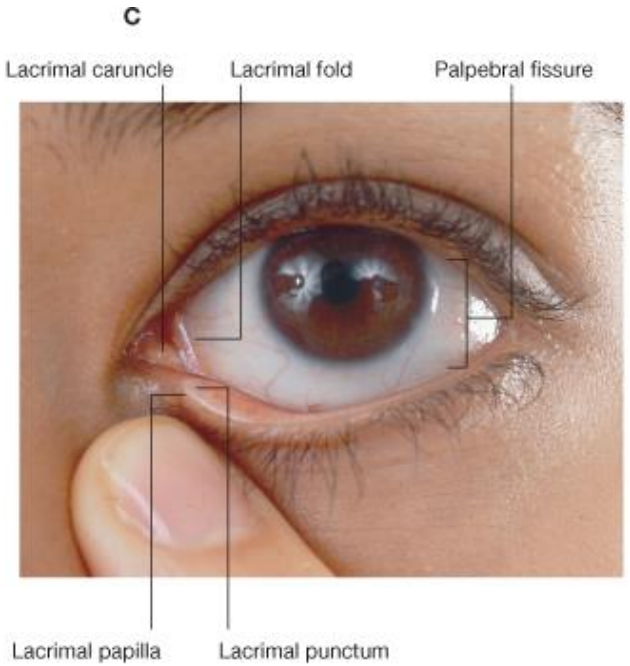
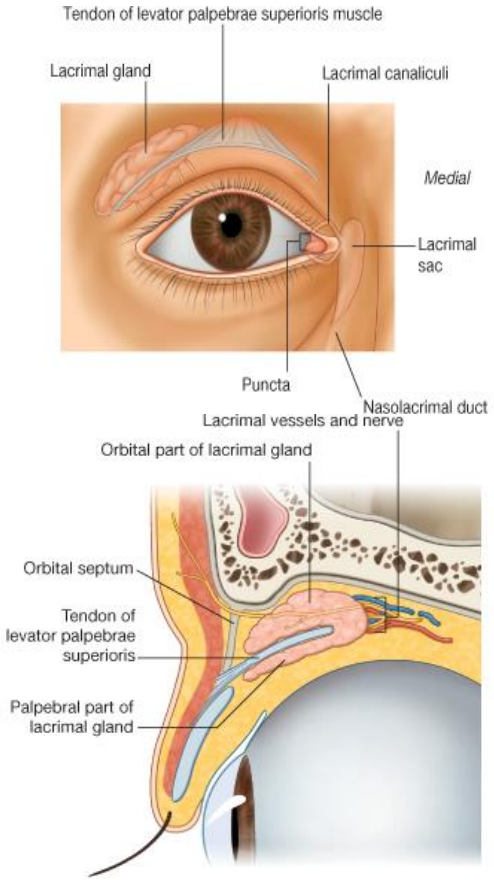
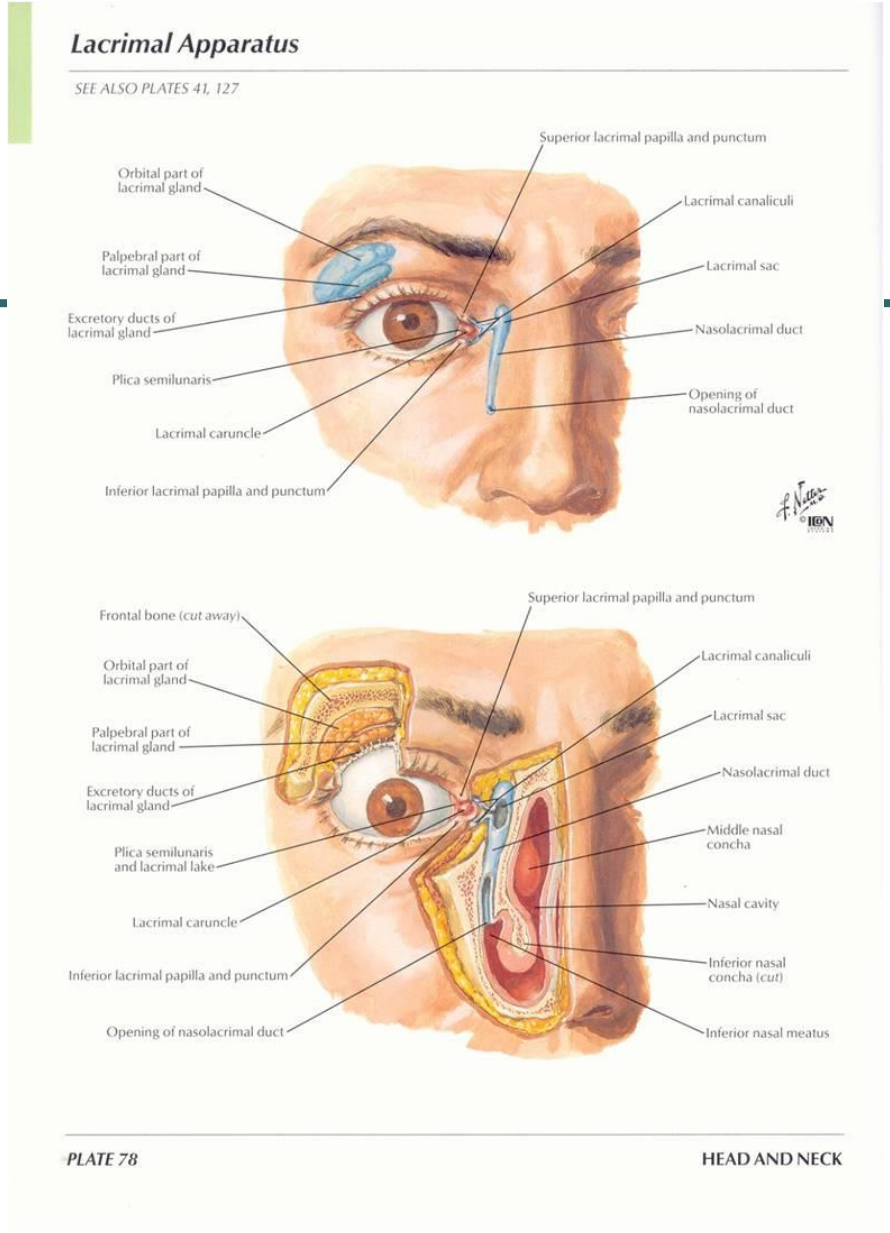
Auxiliary apparatus of the eye



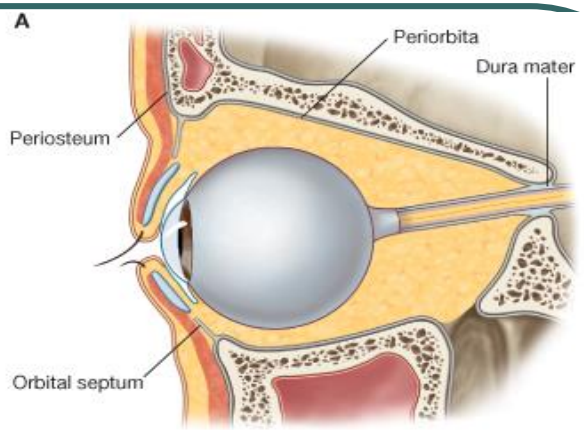


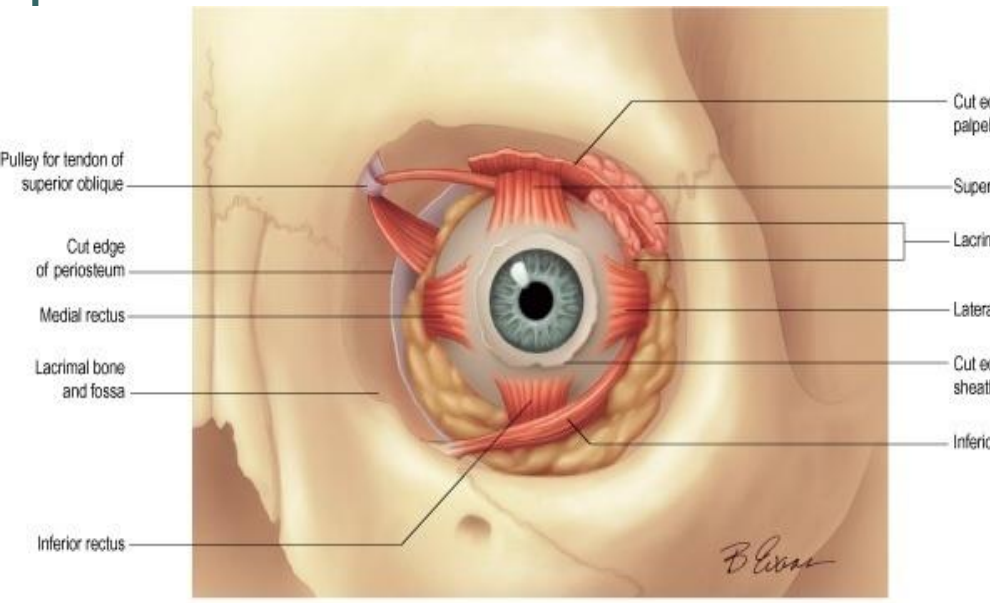
The lacrimal apparatus

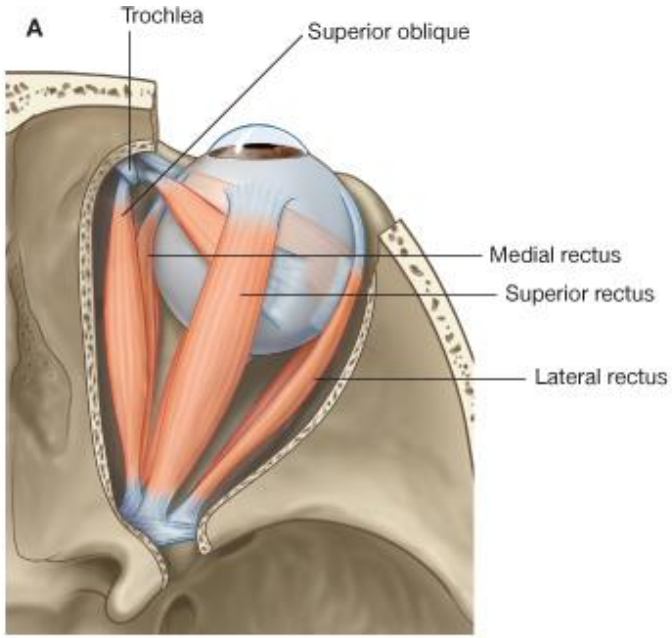




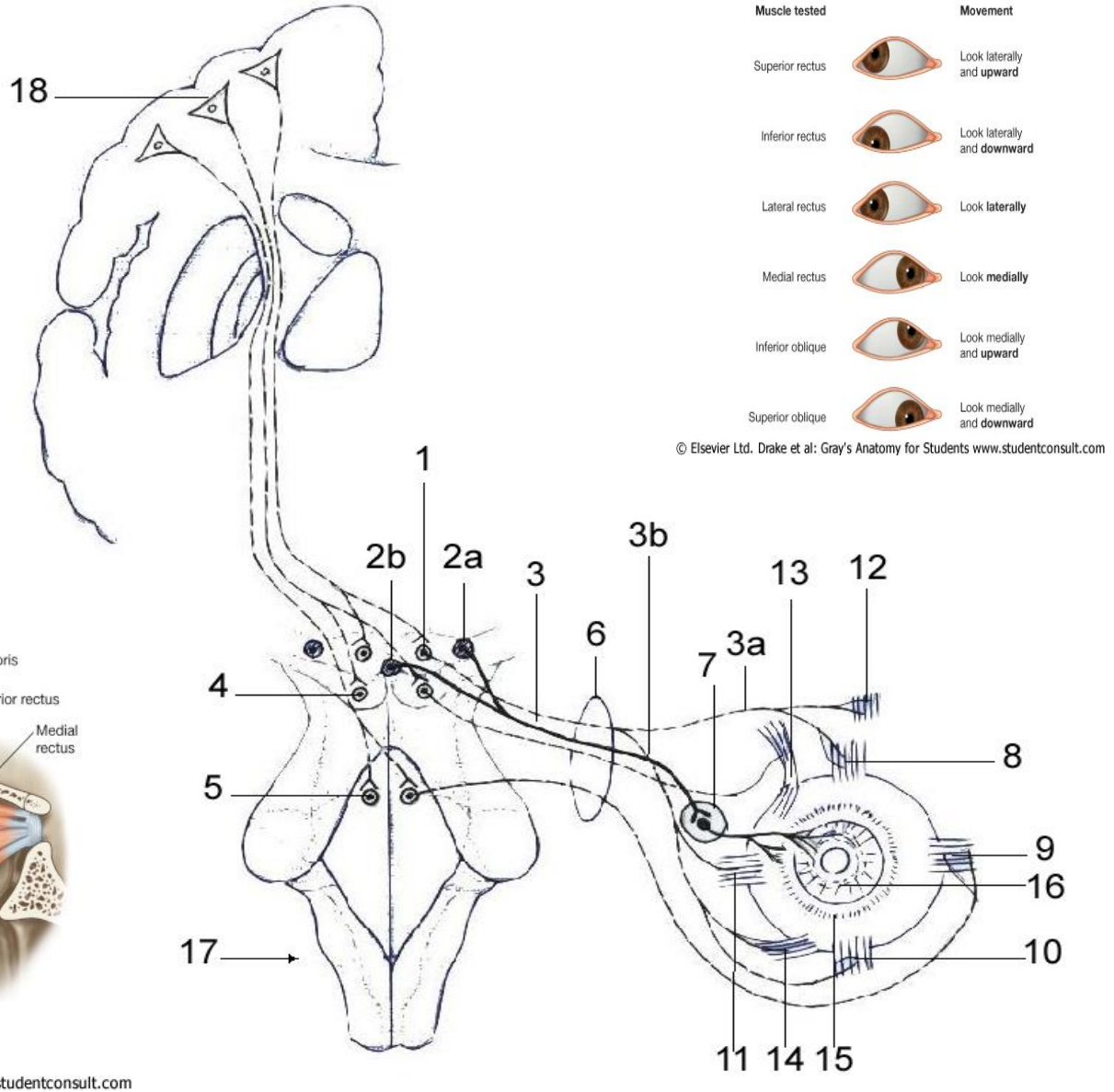
The striated muscles of the eye

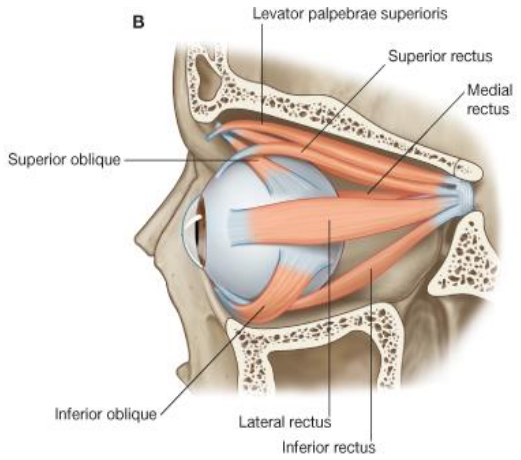




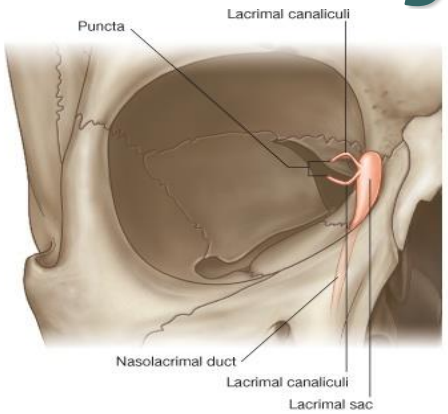


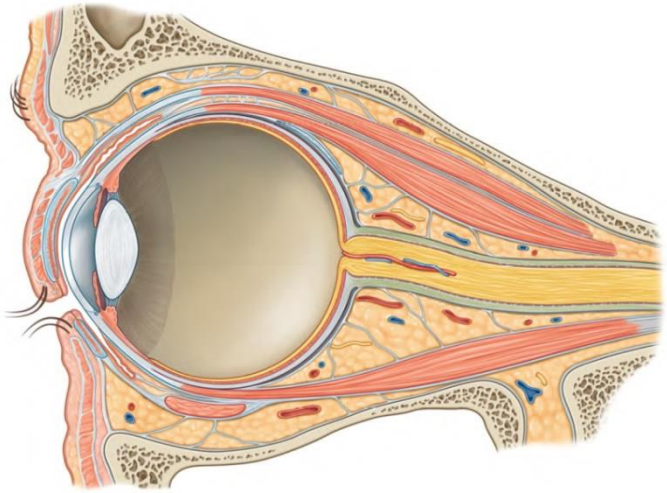
Innervation of the striated muscles of the eye





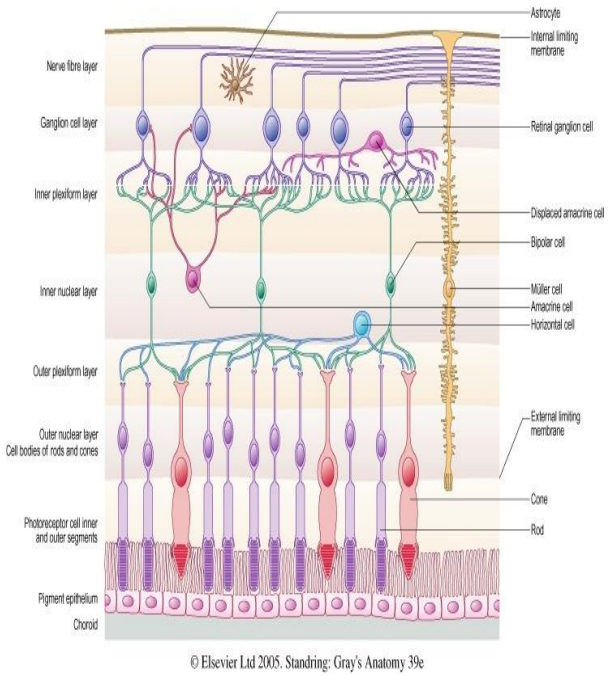
Auxiliary apparatus of the eye





- Outside the eye is enveloped by *fascia bulbi* (Tenon's capsule), separating it from the orbital fat, and forming a socket for the eyeball.
- The inner surface of the Tenon's capsule is loosely attached to the sclera by delicate bands of **episcleral connective** tissue.
- Posteriorly, it is traversed by ciliary vessels and nerves.
- It fuses with the sclera and with the sheath of the optic nerve where it enters the eyeball.
- The Tenon's capsuleis is strongly connected to the sclera posteriorly and at the level of the corneoscleral junction at the limbus.
- The *fascia bulbi* is perforated by the tendons of the extraocular muscles and it continues as muscular fascia.

Pathways of the optic analyser



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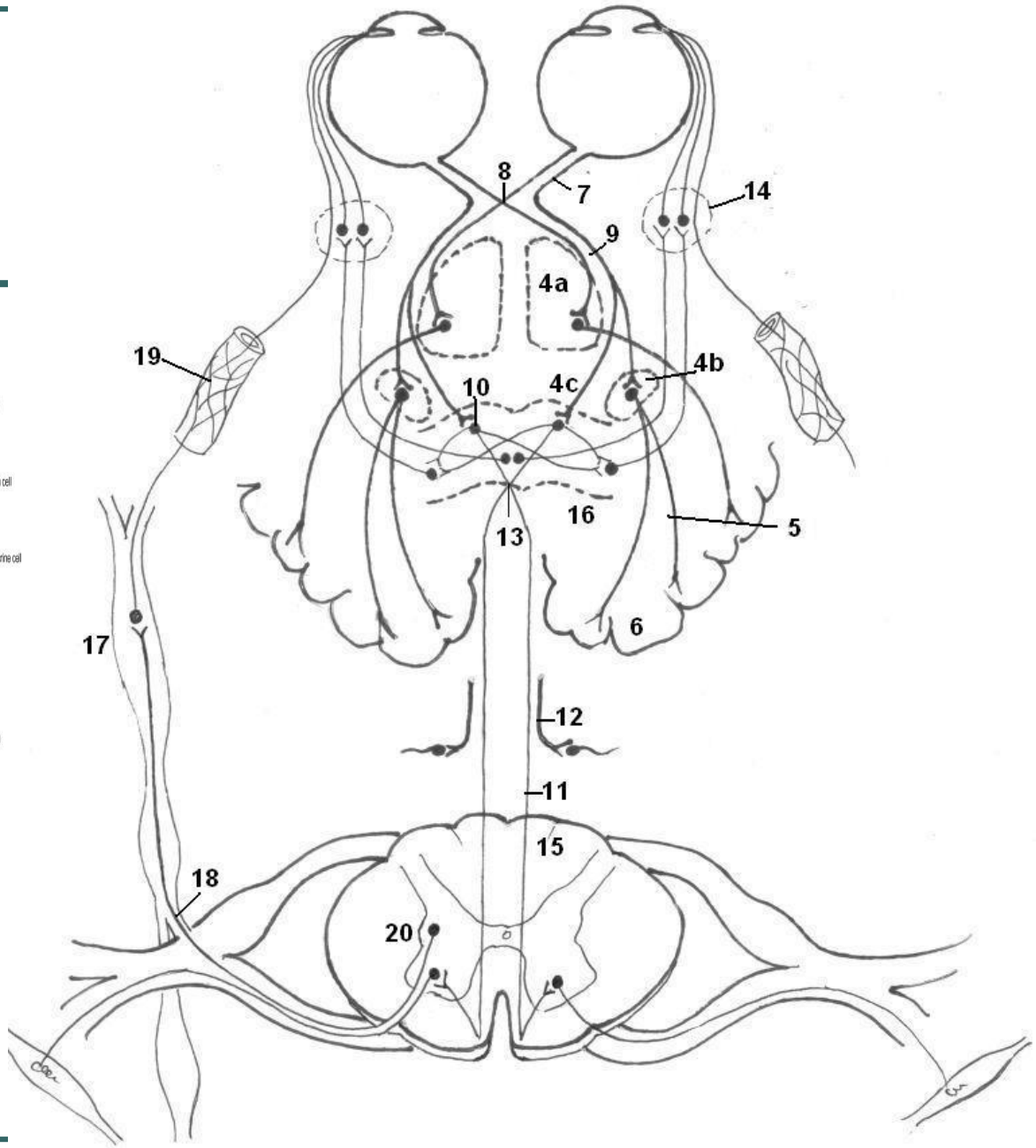


Examination of the fundus of the eye

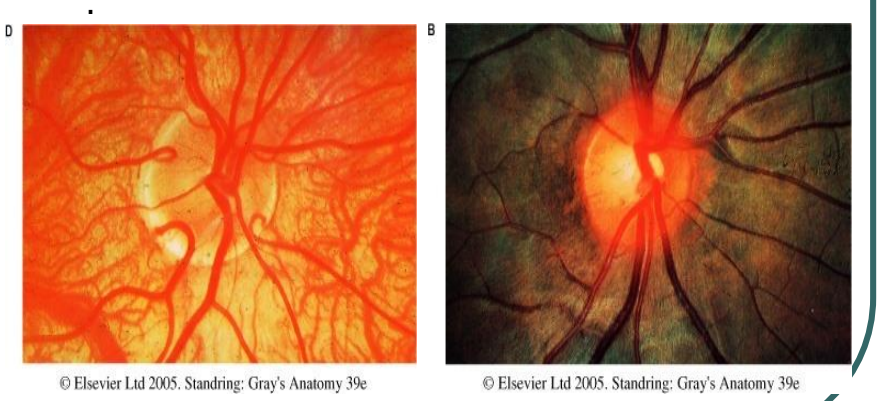
Gray‘s anatomy, 40th edition.

- Fundus photograph of the right eye.

a) The central retinal vessels are seen emanating from the optic disc.

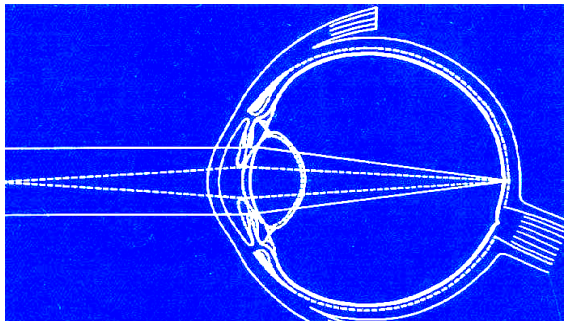
b) Retinal arteries are lighter in colour and narrower than the veins.

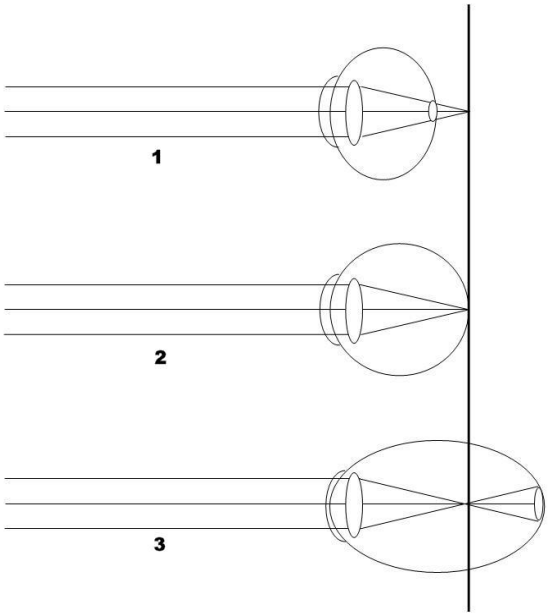
c) The avascular centre of the macular region can be seen laterally to the disc.



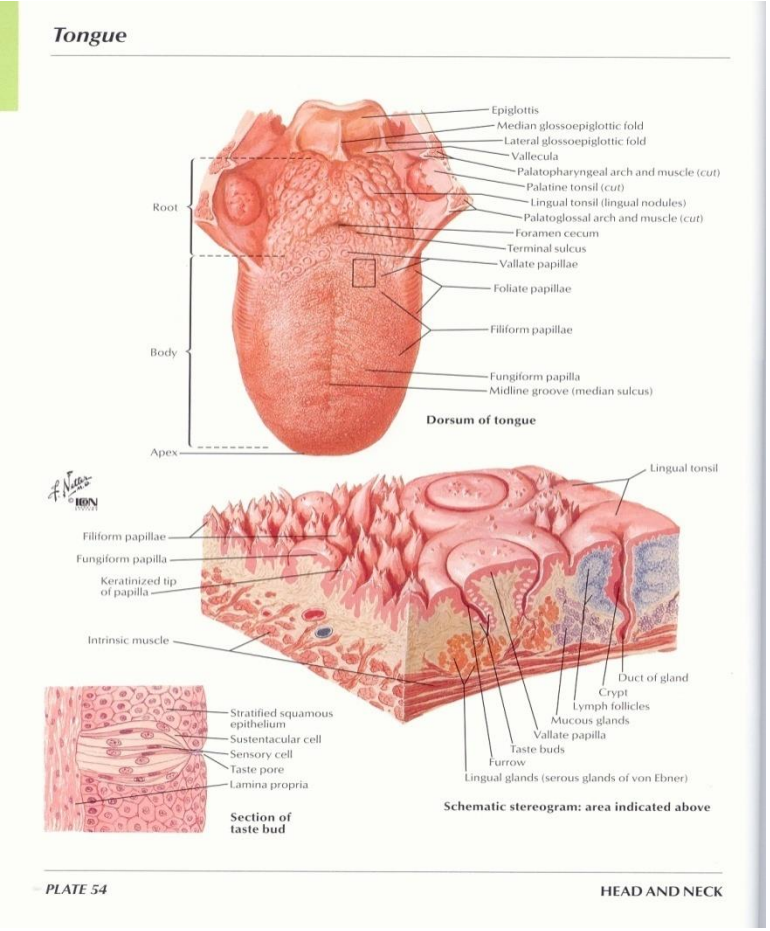
Refraction and functional impairments of the eye

- ***Myopia*** (nearsightedness) is an elongation of the eyeball that causes light waves to focus at a point in the vitreous body in front of the retina.
- ***Hypermetropia*** (farsightedness) is a condition in which the eye is too short.
- ***Presbyopia*** is a condition in which the lens tends to lose its elasticity and ability to accommodate.
- ***Astigmatism*** is a condition in which an irregular curvature of the cornea or lens of the eye is present.



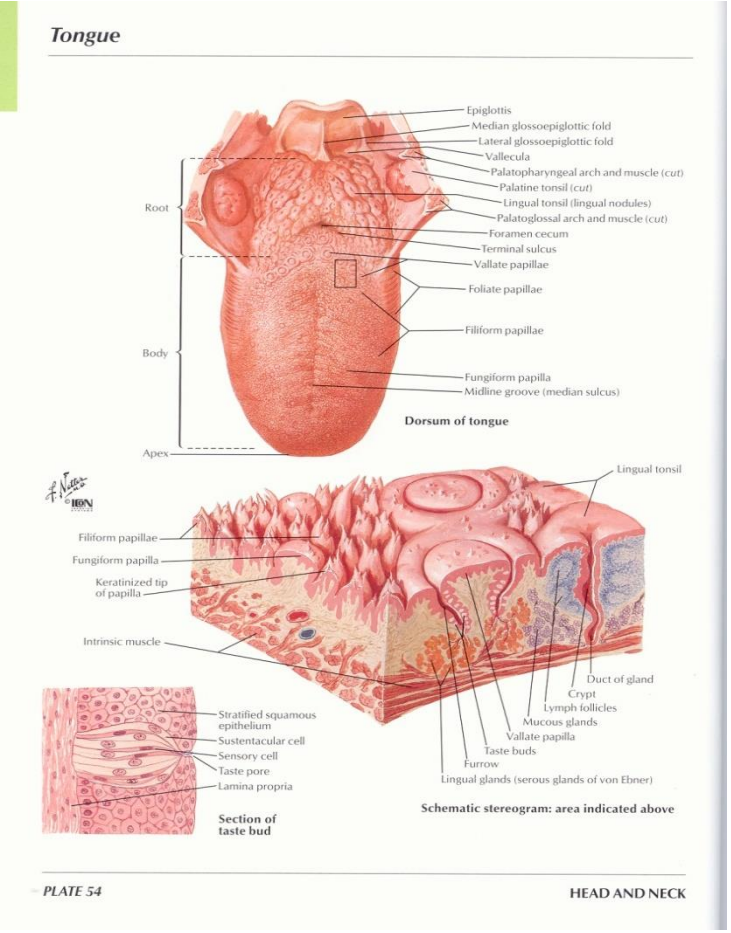


Organ of taste



- Taste receptors are specialized epithelial cells grouped together into ***taste buds***.
- Taste buds are most numerous on the surface of the tongue but are also present on the soft palate and walls of the oropharynx.

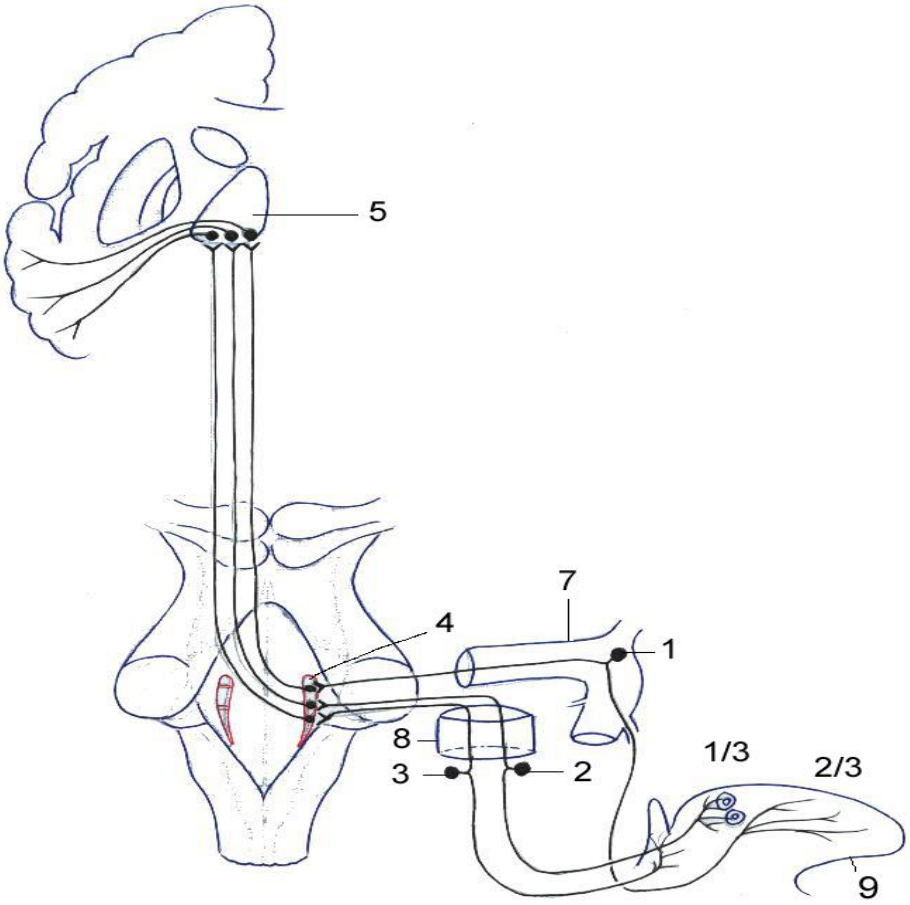
Organ of taste



- Taste buds are elevated by surrounding connective tissue and epithelium to form papillae.
- ***Fife types of papillae can be identified:***

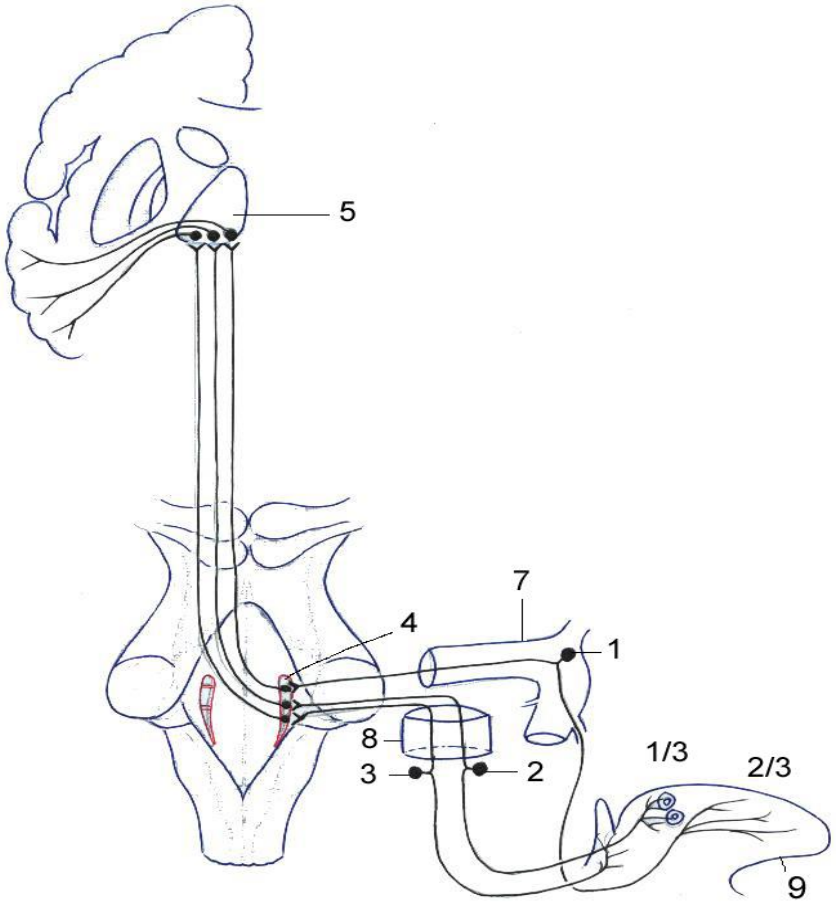
a) ***Vallatae***
b) ***Fungiformes***
c) ***Foliatae***
d) ***Conicae***
e) ***Filiformes***

Pathways of the taste analyser



From the taste receptors the nervous impulse is conducted towards the somatic ganglia of the cranial nerves, solitary tract nucleus and finally to the brain cortex of the ***insula*** and ***frontoparietal operculum***.

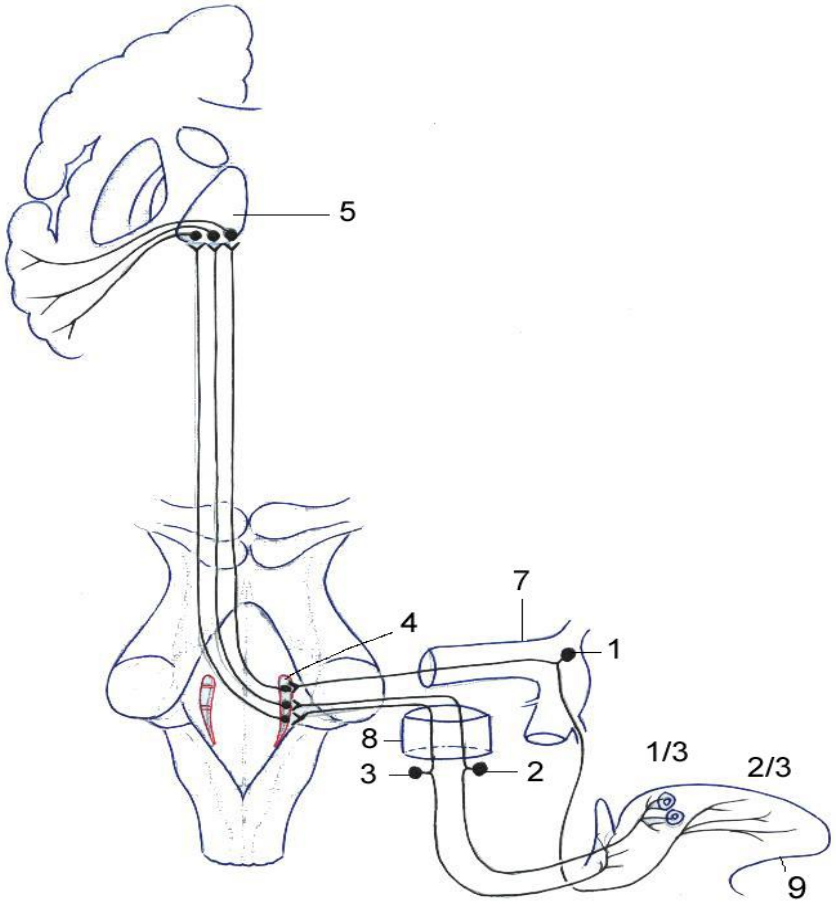
Pathways of the taste analyser



Location of the body of the first neuron

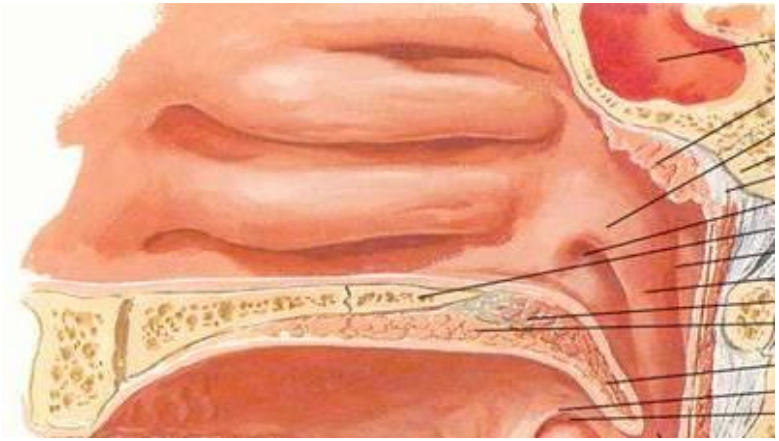
- The **ganglion of the facial nerve** (***ganglion geniculi***) receives special sensory fibers by the *chorda tympani nerve (anterior 2/3)* within the sensory root of the facial nerve (*n. intermedius).*
- The **inferior ganglion of the glossopharyngeal nerve,** receives sensory fibers within the lingual and tonsilar branches of the glossopharyngeal nerve *(posterior 1/3 of the tongue, soft palate and palatine arches).*
- The **inferior ganglion of the vagus nerve**. as a part of the superior laryngeal nerve receives sensory fibers from the epiglottis and root of the tongue.

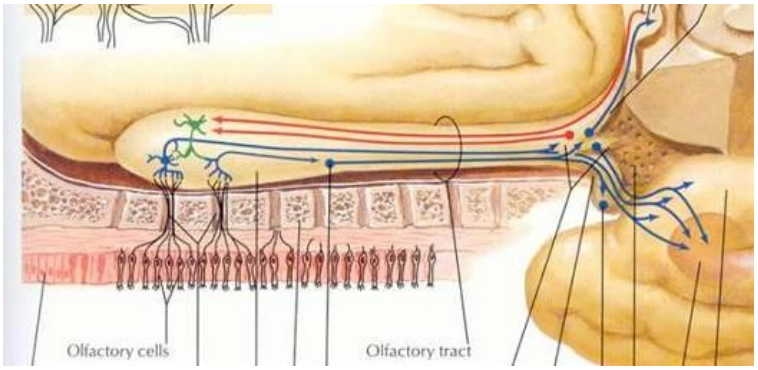
Pathways of the taste analyser



- All above mentioned taste fibers end in the medulla oblongata and pons within **the *nucleus of the tractus solitarius***, where the body od the **second neuron** is located.
- The processes of the second neurons ascend from the medulla oblongata and pons to the thalamus, where the body of the ***third neuron*** is located and further by the posterior limb of the internal capsule the axons extend to the cortical end of the taste analyzer.
- The ***taste analyzer*** ends in the cortex of the ***frontoparietal operculum*** and **insula** (in old sources the uncus was given as a cortical end).

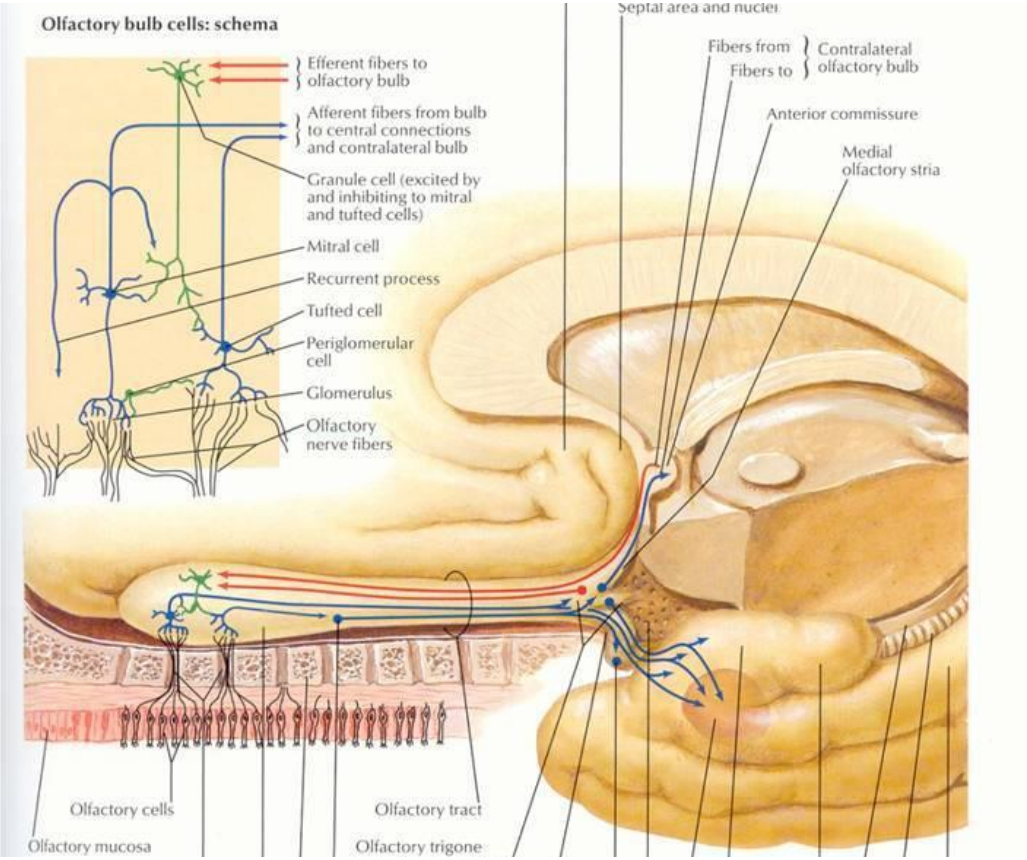
Pathways of the olfactory analyser





- The **olfactory region** in man is placed at the level of the superior nasal conchae and opposite side of the nasal septum.
- The body of the 1st neuron is represented by the **olfactory neuroreceptor cells**.

Pathways of the olfactory analyser



From the nasal cavity the olfactory nerves (16-20 in number, named *fila olfactoria*), enter the cranial cavity through the *cribriform plate* of the ethmoid bone.

In the olfactory bulb the olfactory nerves form synapses with the **mitral cells**, (body of the **2nd neuron)**.

The axons of the mitral cells continue within the olfactory tract towards the olfactory triangle.

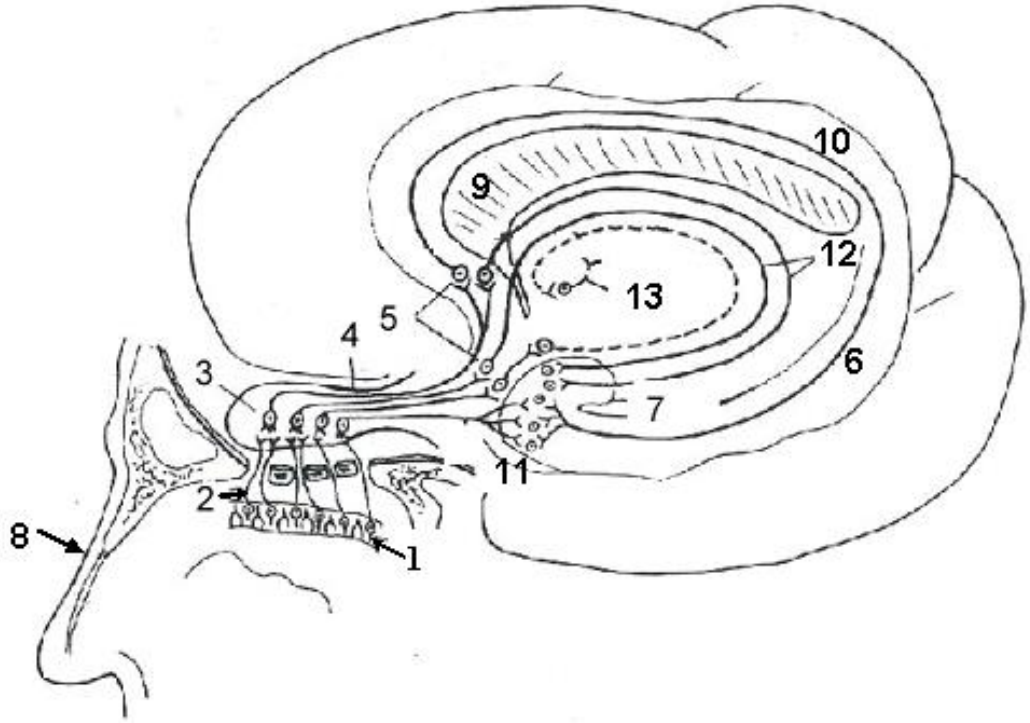
Within the olfactory tract the fibers form three olfactory striae:

a) stria olfactoria lateralis;

b) stria olfactoria intermedia;

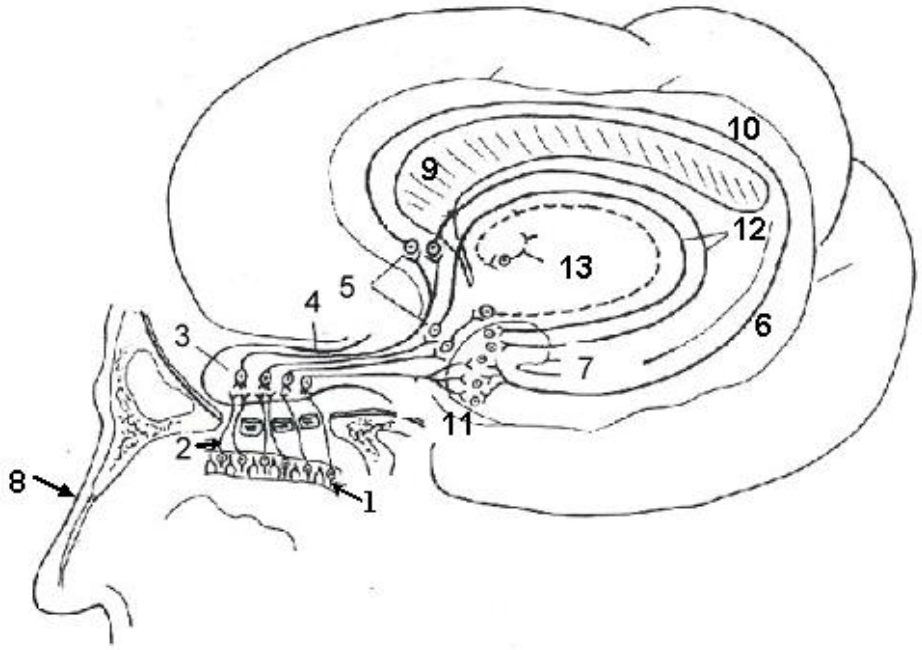
***c) stria olfactoria medialis*.**

Pathways of the olfactory analyser



- The body of the 3rd neuron for the most part of fibers of the olfactory striae is located in the *anterior perforated substance.*
- Then the fibers pass through the *septum pellucidum, fornix*, *the parahypocampal gyrus* to get to the *uncus*, where the cortical end of the olfactory analyser is located.

Pathways of the olfactory analyser

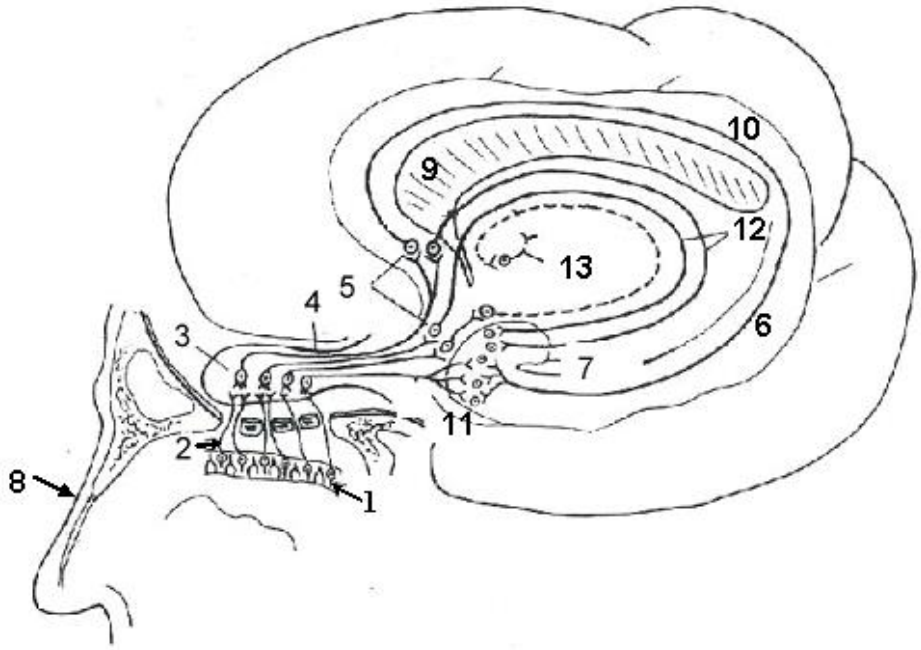


- The **medial olfactory stria** reaches the *area subcallosa where* it splits into two bundles of fibers.

a) One part of fibers of the medial olfactory stria runs within the *gyrus fornicatus* and then through the *gyrus fasciolaris, gyrus dentatus* ends in the ***uncus***.

b) Another part of fibers runs through the *septum pellucidum, fornix, fimbria hyppocampi* and reaches the ***uncus***.

Pathways of the olfactory analyser



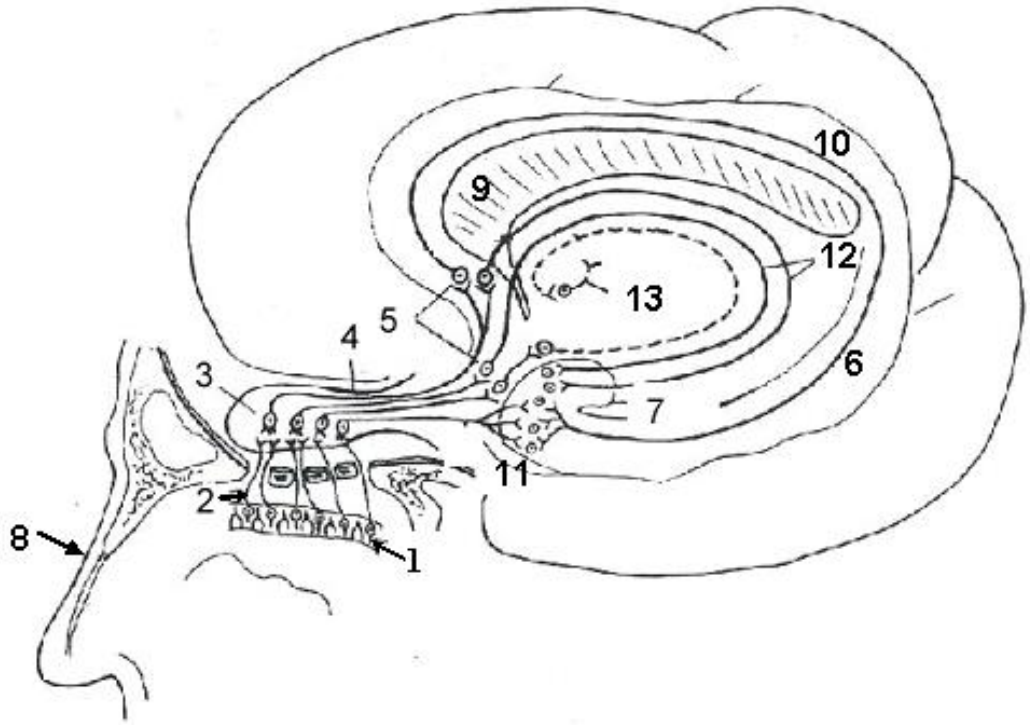
- The ***intermediate olfactory stria***:

a) a part of its fibers ends on the neurons of the *anterior perforated substance* on the ipsilateral side.

b) Another portion of fibers runs through the *anterior cerebral commissure* to the opposite side, where they also end on the neurons of the anterior perforated substance.

- Axons of the neurons of the anterior perforated substance run through the *septum pellucidum* to the *fornix*, then they pass through the *fimbria hyppocampi* and reach the ***uncus***.

Pathways of the olfactory analyser



- The ***lateral olfactory stria*** is the thickest one, and it continue its way backward sending fibers:

a) a part of its fibers runs to the ***uncus***;

b) another part runs to the ***amygdaliod body***, where they form a synapse with the body of the **3rd neuron** and then it enters the *fimbria hyppocapi, the fornix* to reach the *mamillary bodies*.

c) From the mamillary bodies they continue within the ***mamillothalamic tract, or Vicq d 'Azyr***.

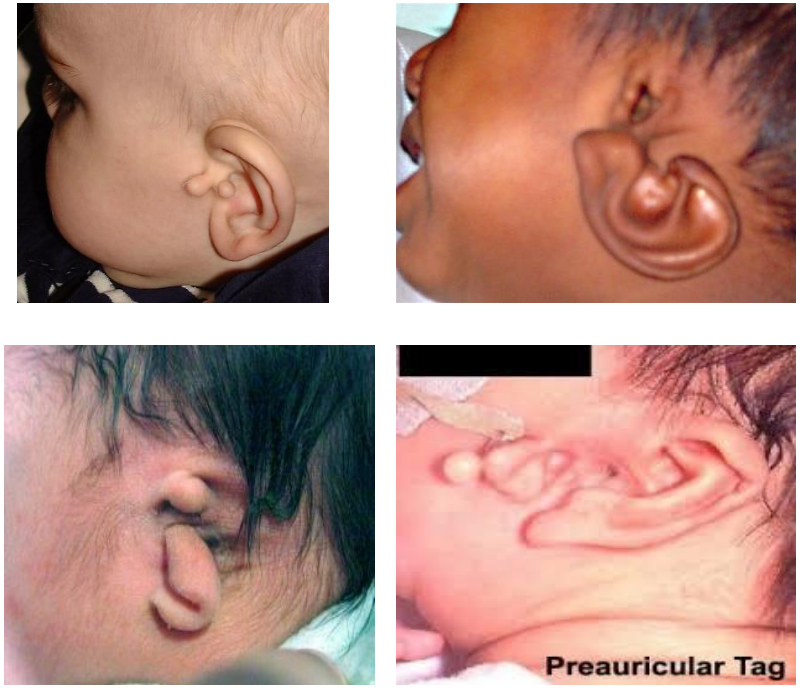
Abnormalities of the ear

- Congenital deafness, usually associated with deaf – mutism (most forms are caused by genetic factors).

- The poliomyelitis, *erythroblastosis fetalis*, diabetes, hypothyroidism, toxoplasmosis, rubella virus can cause damage to the organ of Corti that results in congenital severe deafness.

Abnormalities of the ear

- External ear defects might be minor or severe abnormalities.
- Preauricular appendages and pits are skin tags and shallow depressions, respectively, anterior to the ear.
- The shape of the auricle varies widely in children with chromosomal syndromes causing mental deficiencies.
- Atresia of the external auditory meatus.



Congenital defects of the auricle

Abnormalities of the eye

- ***Microphthalmia*** the eye is too small.
- ***Aniridia*** (absence of the iris).
- The ***iridopupillary membrane*** may persist instead of being resorbed during formation of the anterior chamber.
- There may be various eye anomalies, including ***colobomas*** affecting the lateral third of the lower eyelid (75% of cases) and ***microphthalmia***.
- ***Congenital aphakia*** (absence of the lens).
- The ***hyaliod artery*** may persist to form a cord or cyst.

Anophthalmos and cryptophthalmos

Cyclopia **(single eye) and synophthalmia (fusion of the eyes)**

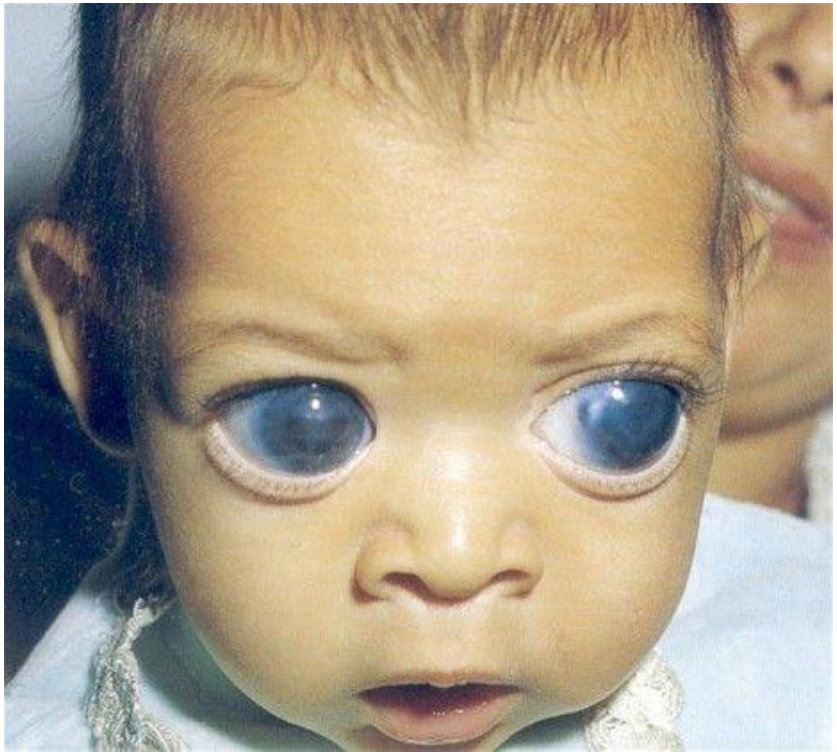
Cyclopia. S.S. Gellis and M. Feingold. Atlas of Mental Retardation Syndromes. 1968.

Figura 3. Foto del recién nacido. Se observa ojo único central, con probóscide, confirmando la etmocefalia.

Heterochromia of the iris

Abnormalities of the eye

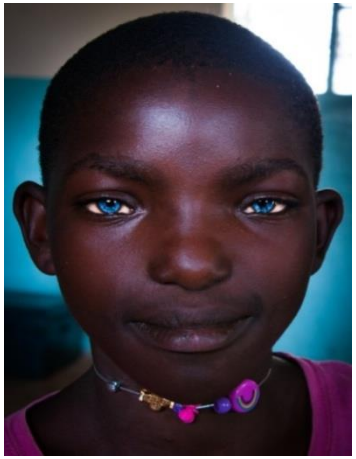
Congenital glaucoma



In congenital cataracts the lens become opaque during intrauterine life.

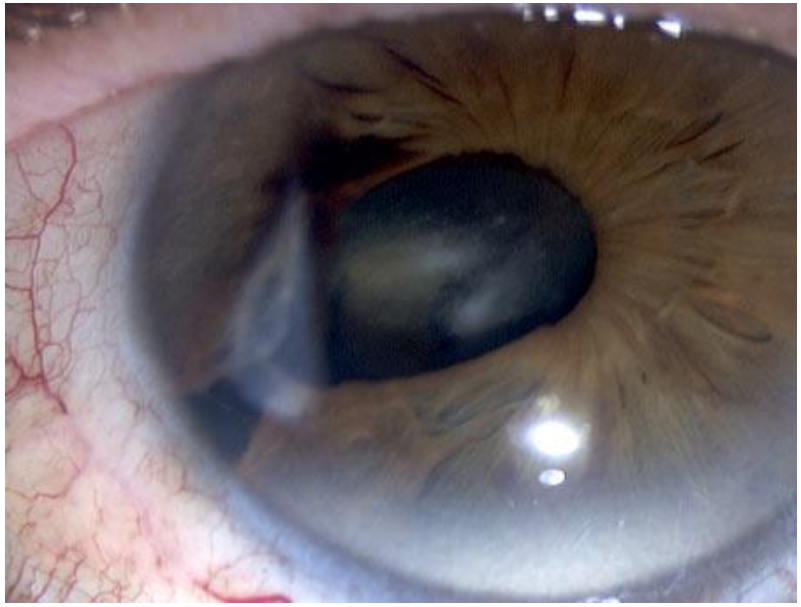
Albinismus

Albinismus

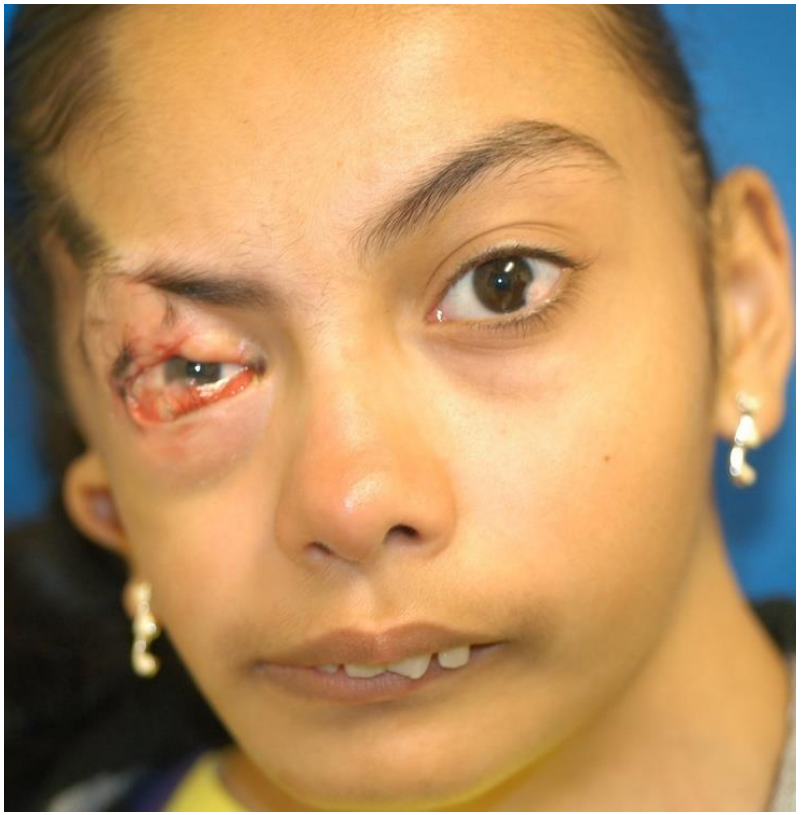


Coloboma of the iris or cat eye

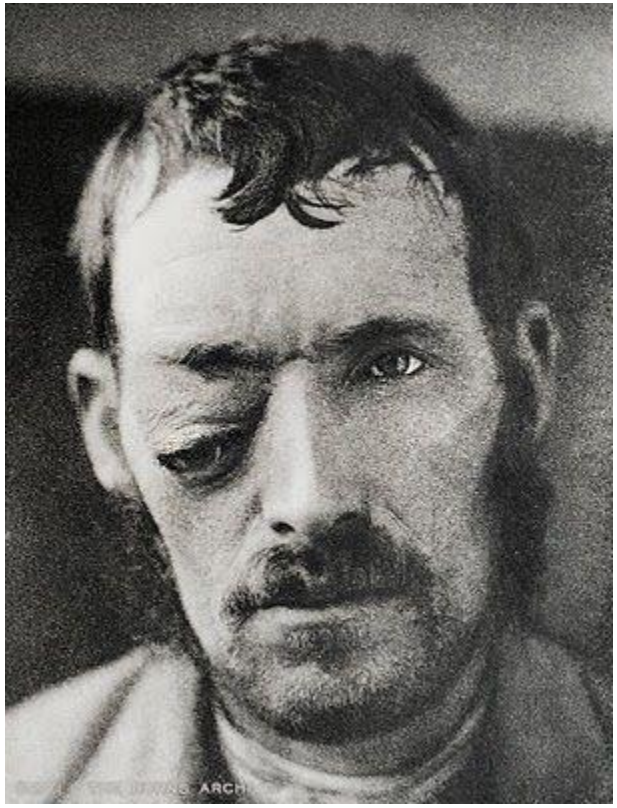
Coloboma may occur if the choroid's fissure fails to close



Deformities of the eyelid



Orbital absence with displacement of eye



Double eye

Pictures

- https://www.google.com/search?q=abnormalities+of+the+eye&source=lnms&tbm=isch&sa=X&ved=2ahUKEwit6LDH3ZfsAhVPDOwKHTymB30Q_AUoAXoECBUQAw&biw=1366&bih=657#imgrc=2SKKN2JiGNkorM
- https://www.google.com/search?q=abnormalities+of+the+ear&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjlx-PI3pfsAhXC_qQKHU1-Dh0Q_AUoAXoECBQQAw&biw=1366&bih=657