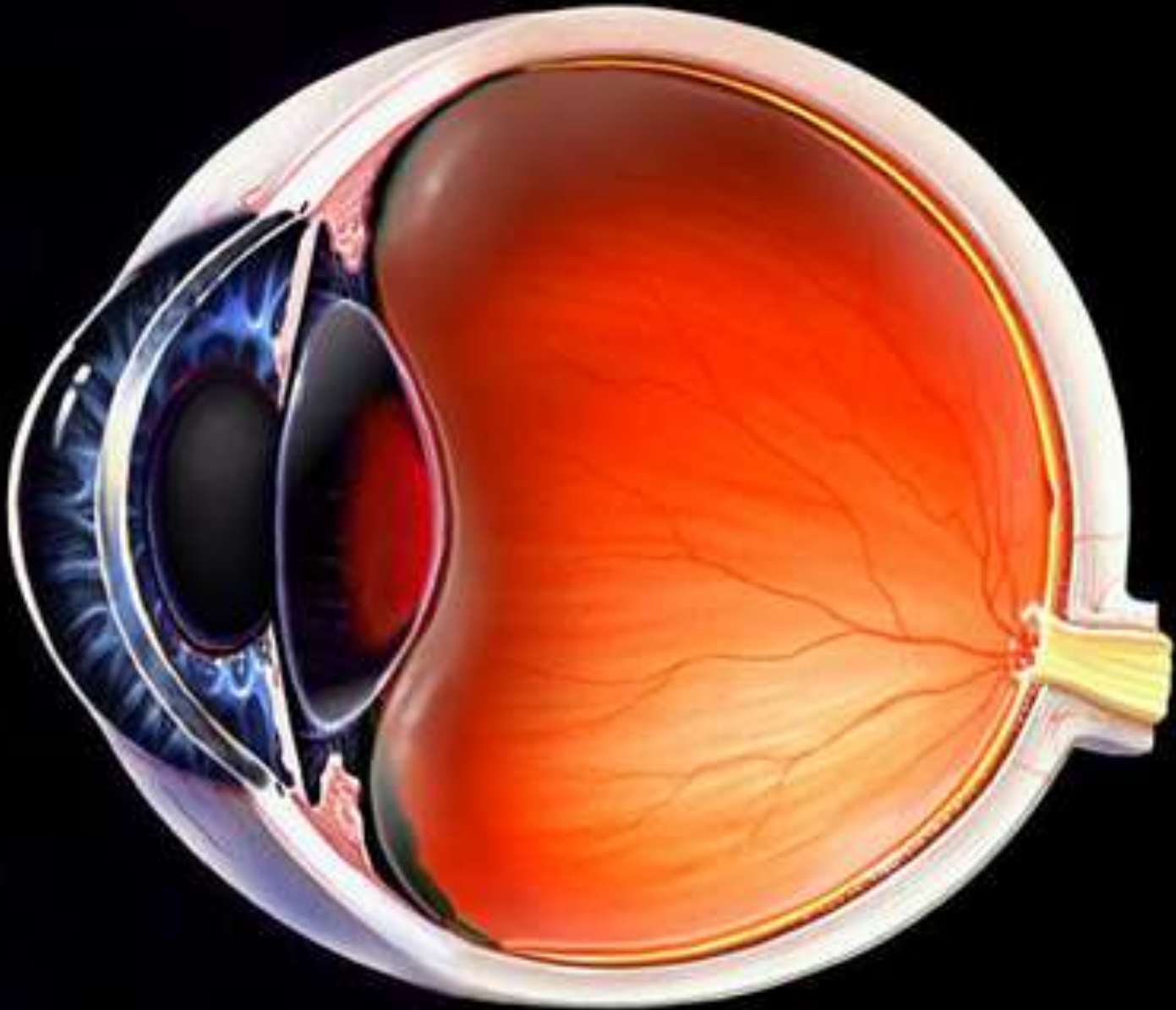
THE HUMAN EYE



Anatomy of the Human Eye

Human Eye

- ***A human eyeball is like a simple camera!***

– **Sclera**: outer walls, hard, like a light-tight box.

– **Cornea and crystalline lens (eyelens**): the two lens system.

– **Retina:** at the back of eyeball, like the film.

– **Iris**: like diaphragms or stop in a camera.

– **Pupil**: camera aperture.

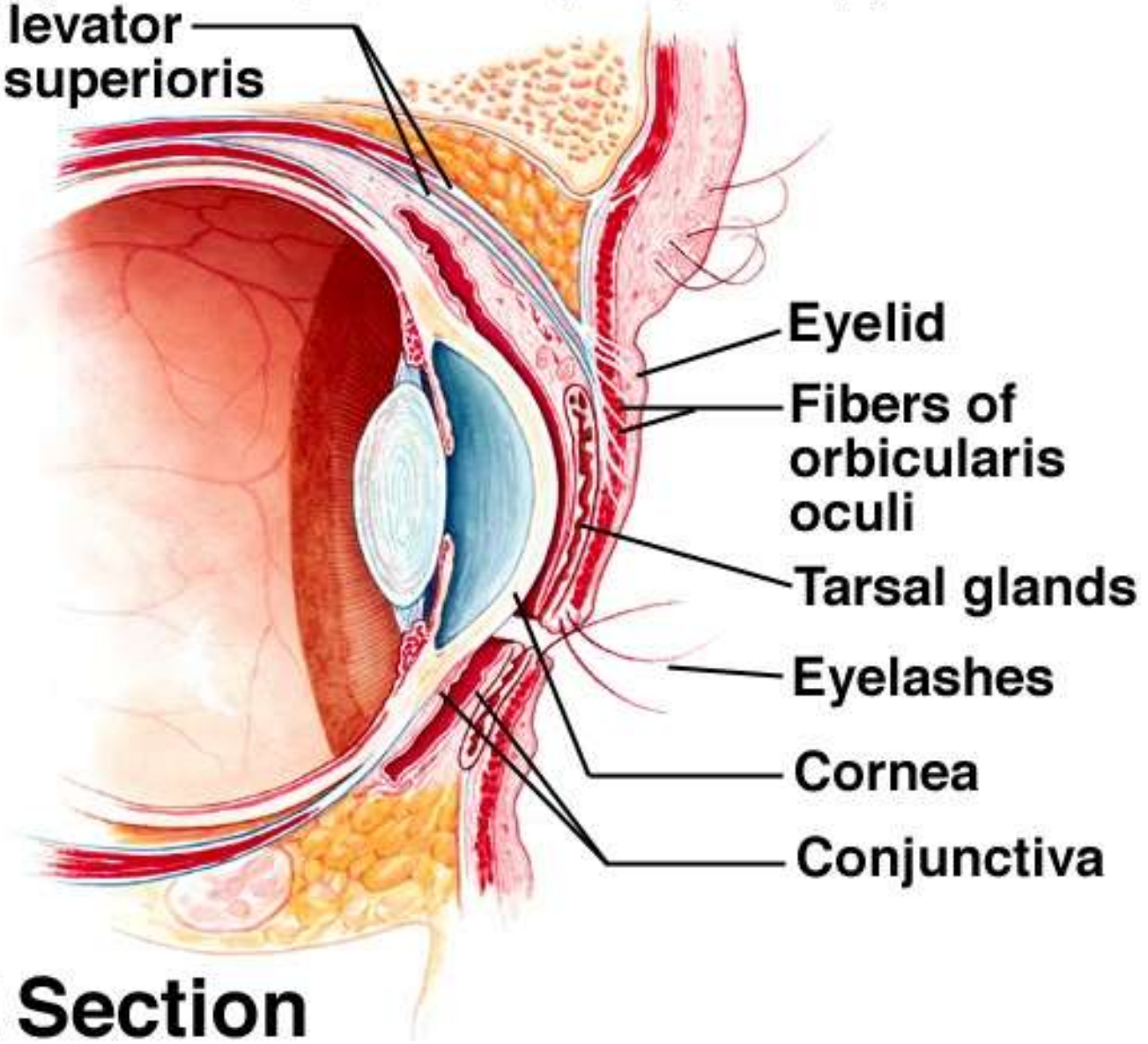
– **Eyelid**: lens cover.

The Eye

Accessory structures or Adnexa

4 layers:

1. Skin – thinnest in the body
2. muscle – orbicularis oculi and levator palpebrae superioris
3. Connective tissue – tarsal plate contains tarsal or Meibomian glands - Chalazion



Eye— Sagittal Section

4. **Conjunctiva** – mucous membrane

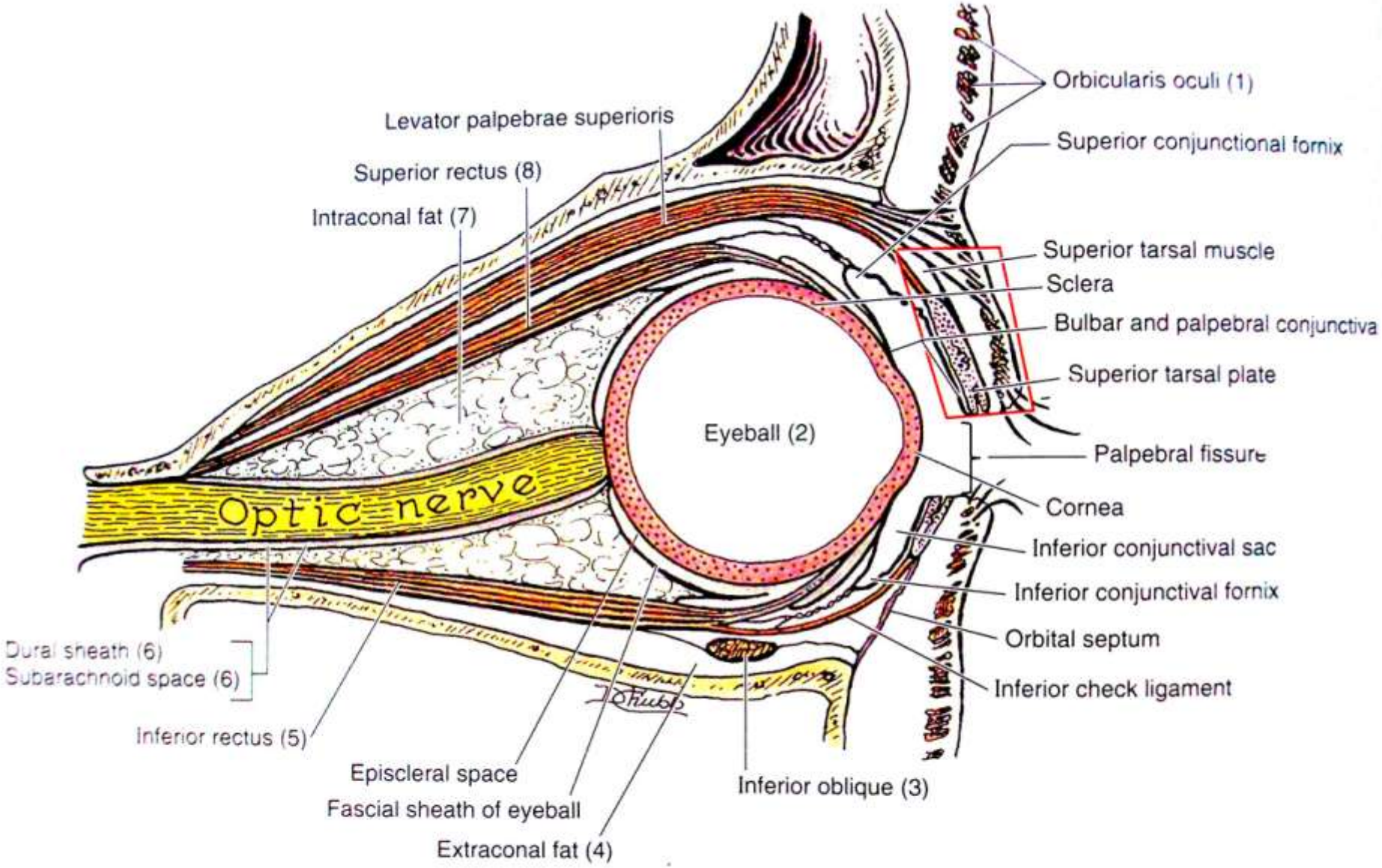
palpebral conjunctiva

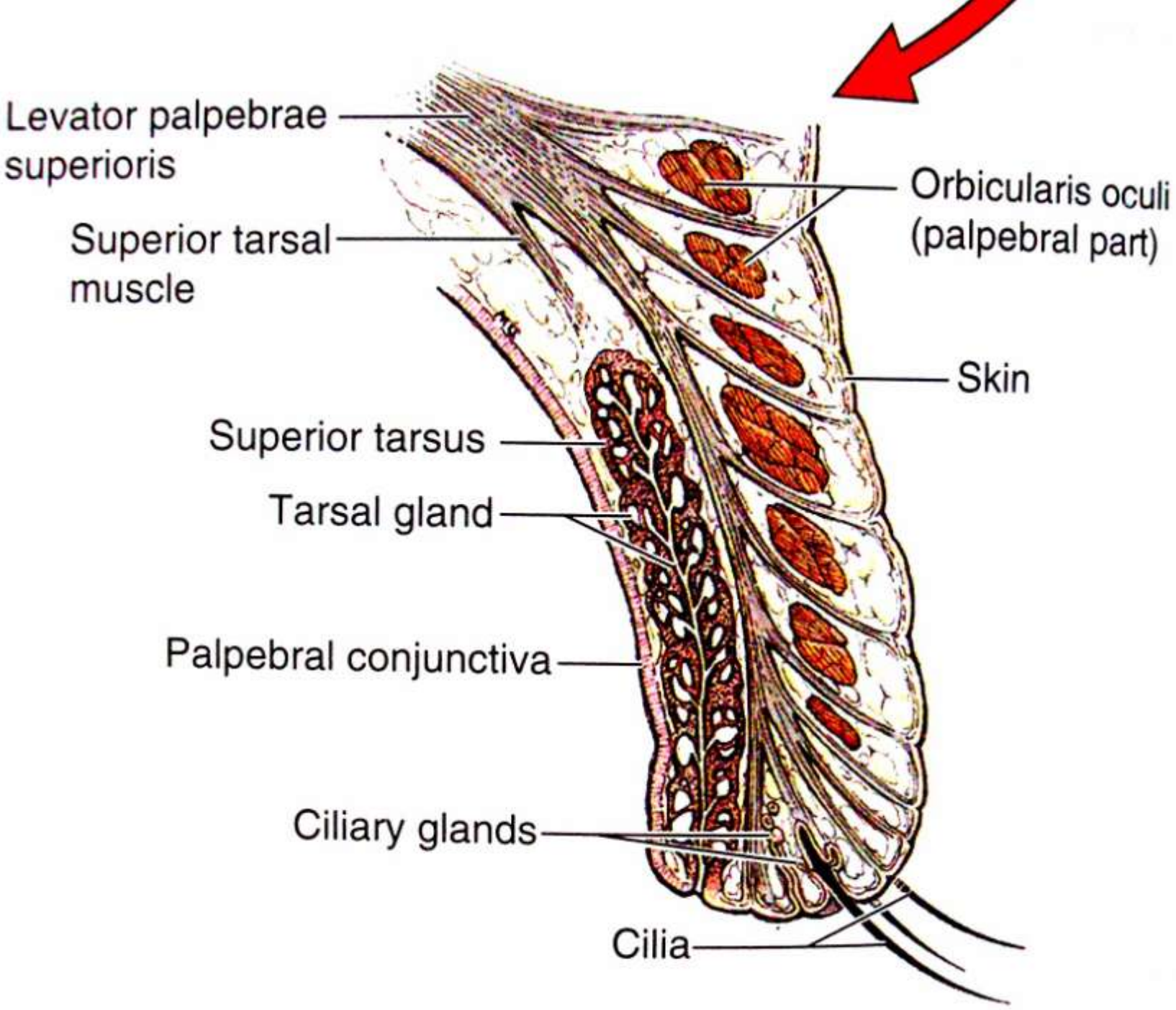
bulbar conjunctiva

Eyelashes

sebaceous ciliary glands at base of hair follicles – hordeolum or stye

Lacrimal apparatus – forming and draining tears.

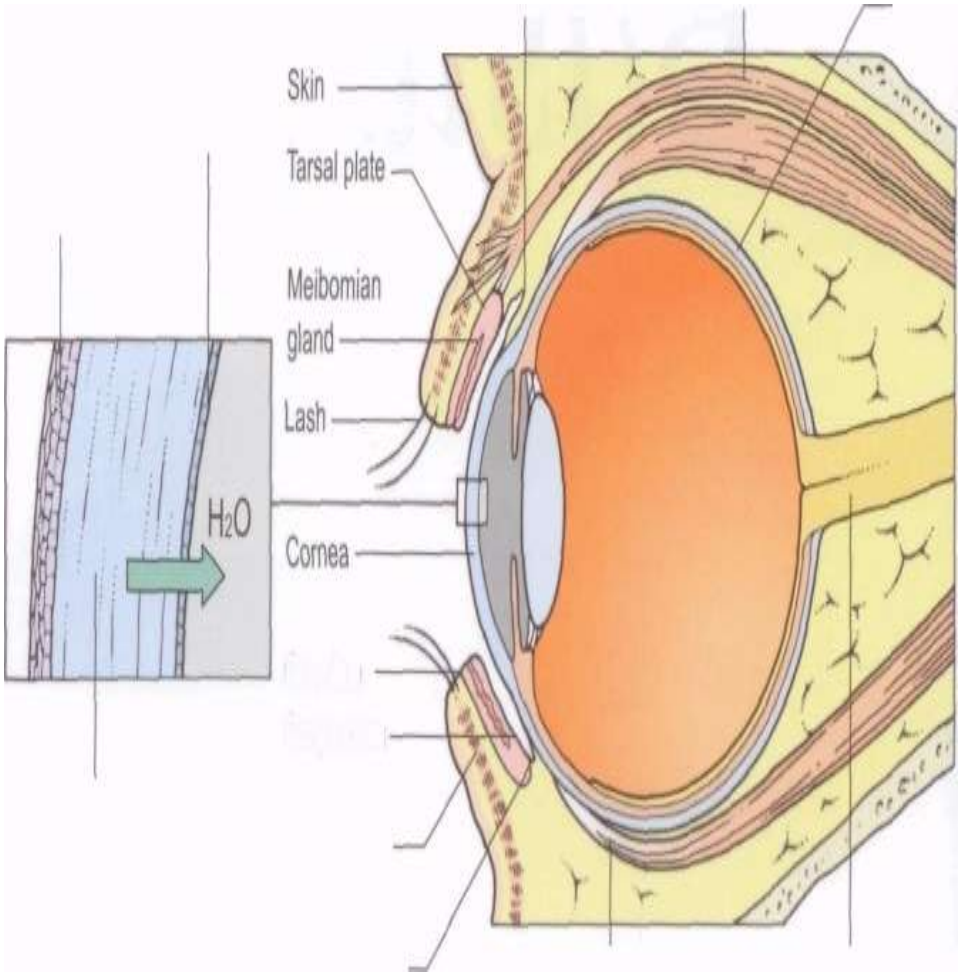

Orbicularis oculi (1)
Levator palpebrae superioris
Superior conjunctional fornix
Superior rectus (8)
Intraconal fat (7)
Superior tarsal muscle
Sclera
Bulbar and palpebral conjunctiva
Superior tarsal plate
Eyeball (2)
Palpebral fissure
Optic nerve
Cornea
Inferior conjunctival sac
Inferior conjunctival fornix
Orbital septum
Dural sheath (6)
Subarachnoid space (6)
Inferior check ligament
Inferior rectus (5)
Episcleral space
Fascial sheath of eyeball
Inferior oblique (3)
Extraconal fat (4)


Levator palpebrae superioris
Superior tarsal muscle
Orbicularis oculi (palpebral part)
Skin
Superior tarsus
Tarsal gland
Palpebral conjunctiva
Ciliary glands
Cilia

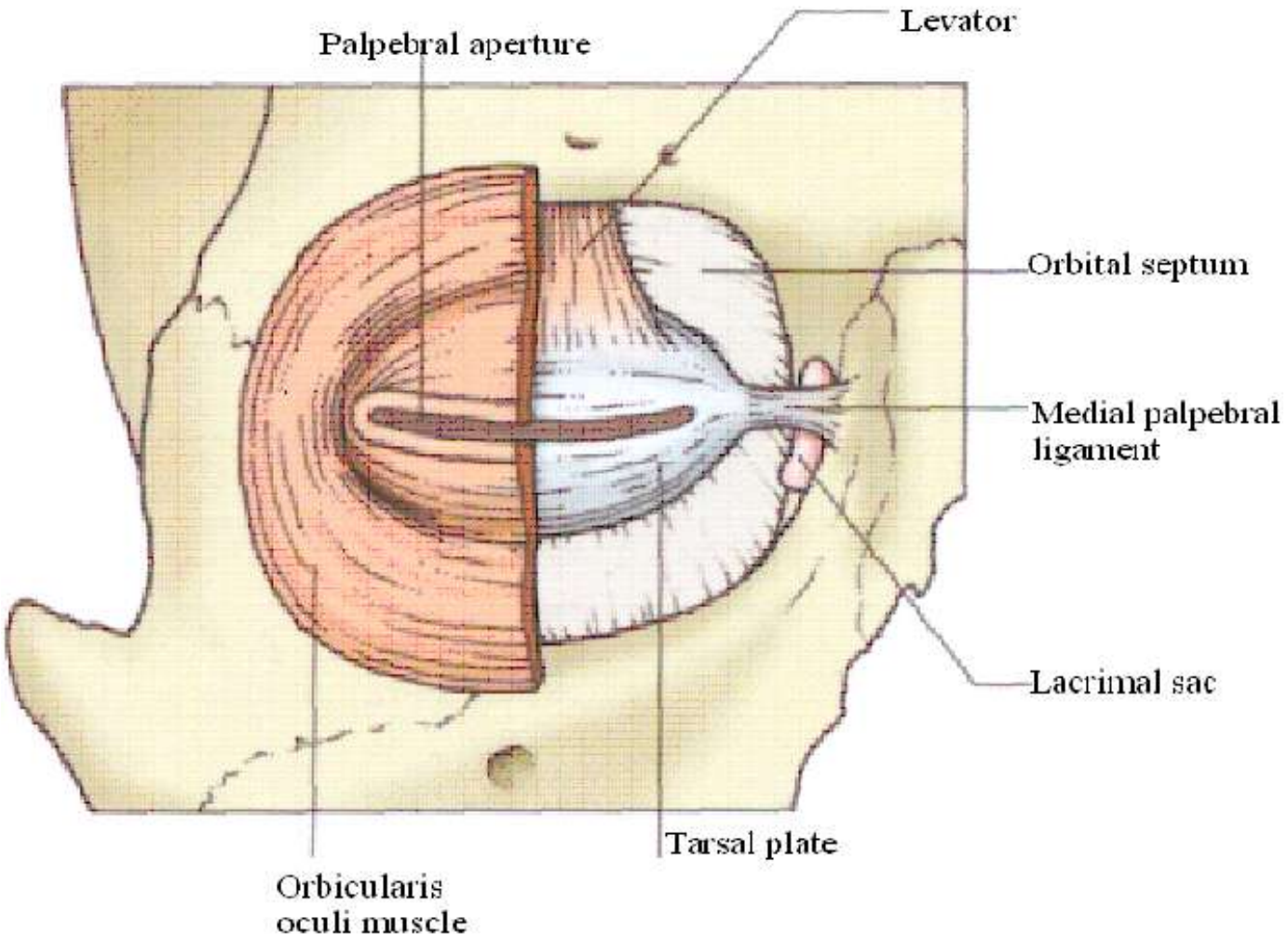
Eyelids and eyeball

Superior fornix of conjunctiva

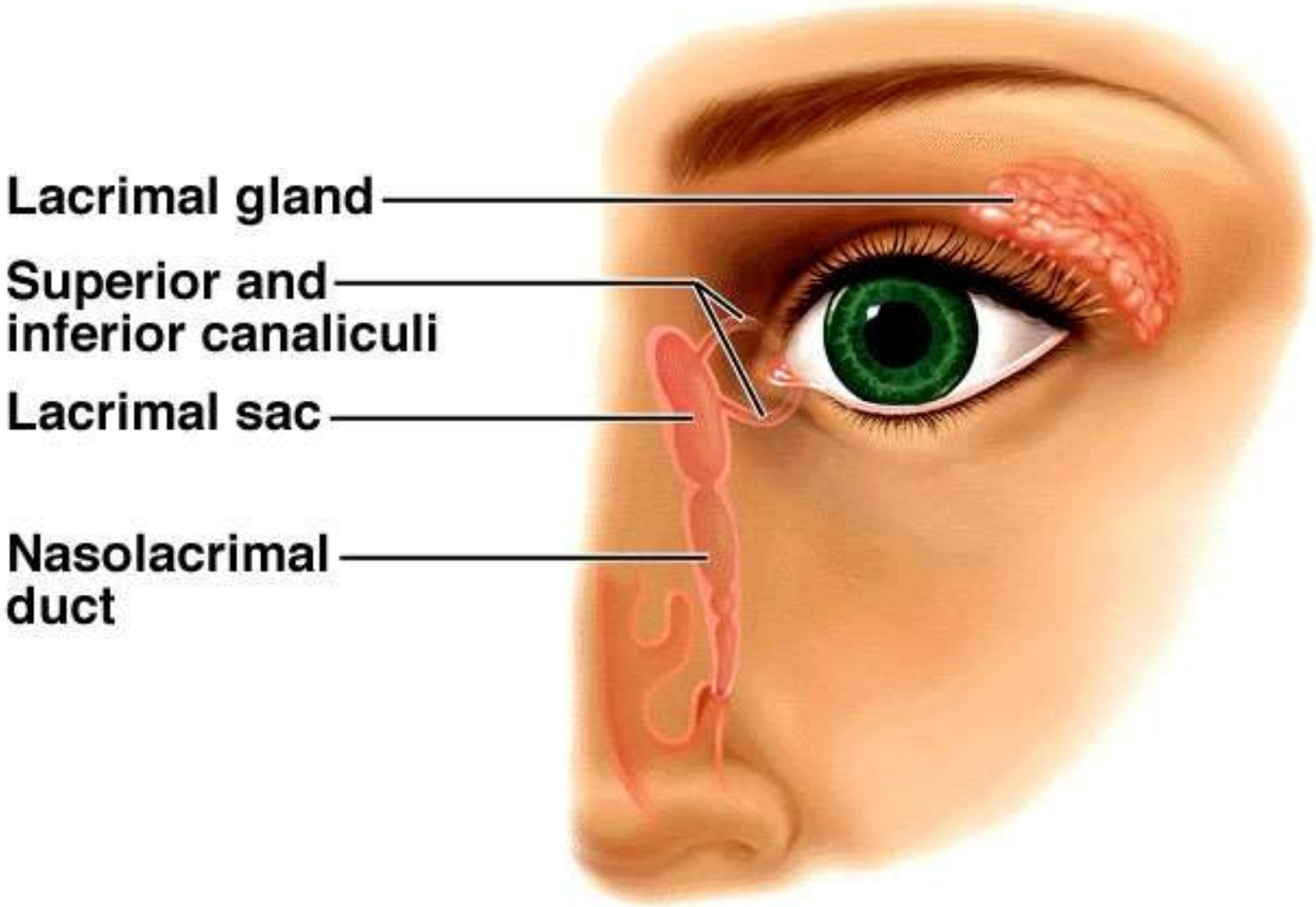
- **Levator muscle**
- **Sclera**
- **Grey line**
- **Conjunctiva**
- **Orbicularis oculi muscle**
- **Inferior fornix of conjunctiva**
- **Extraocular muscle**
- **Optic nerve**



Eyelid structure



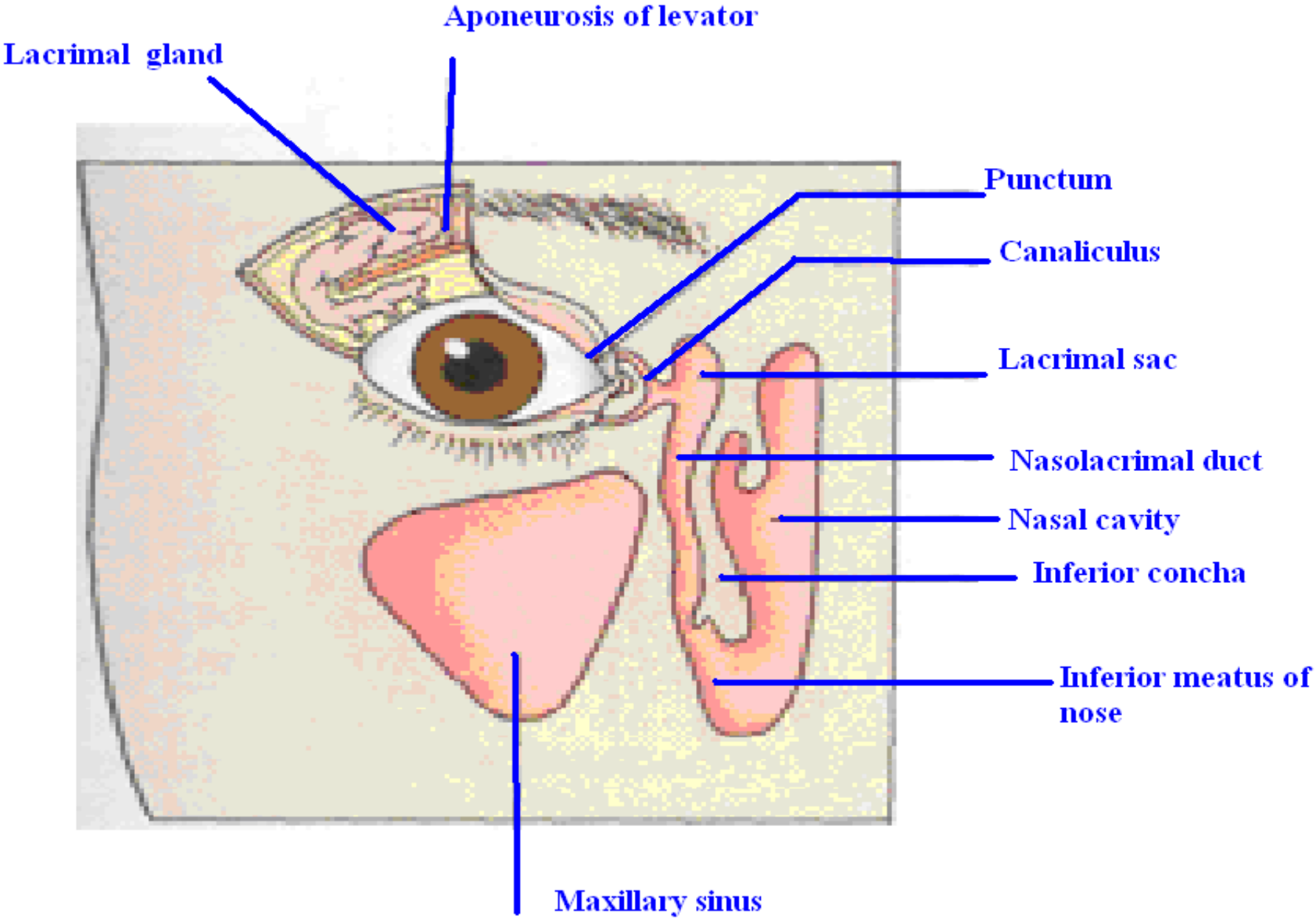
Lacrimal Apparatus

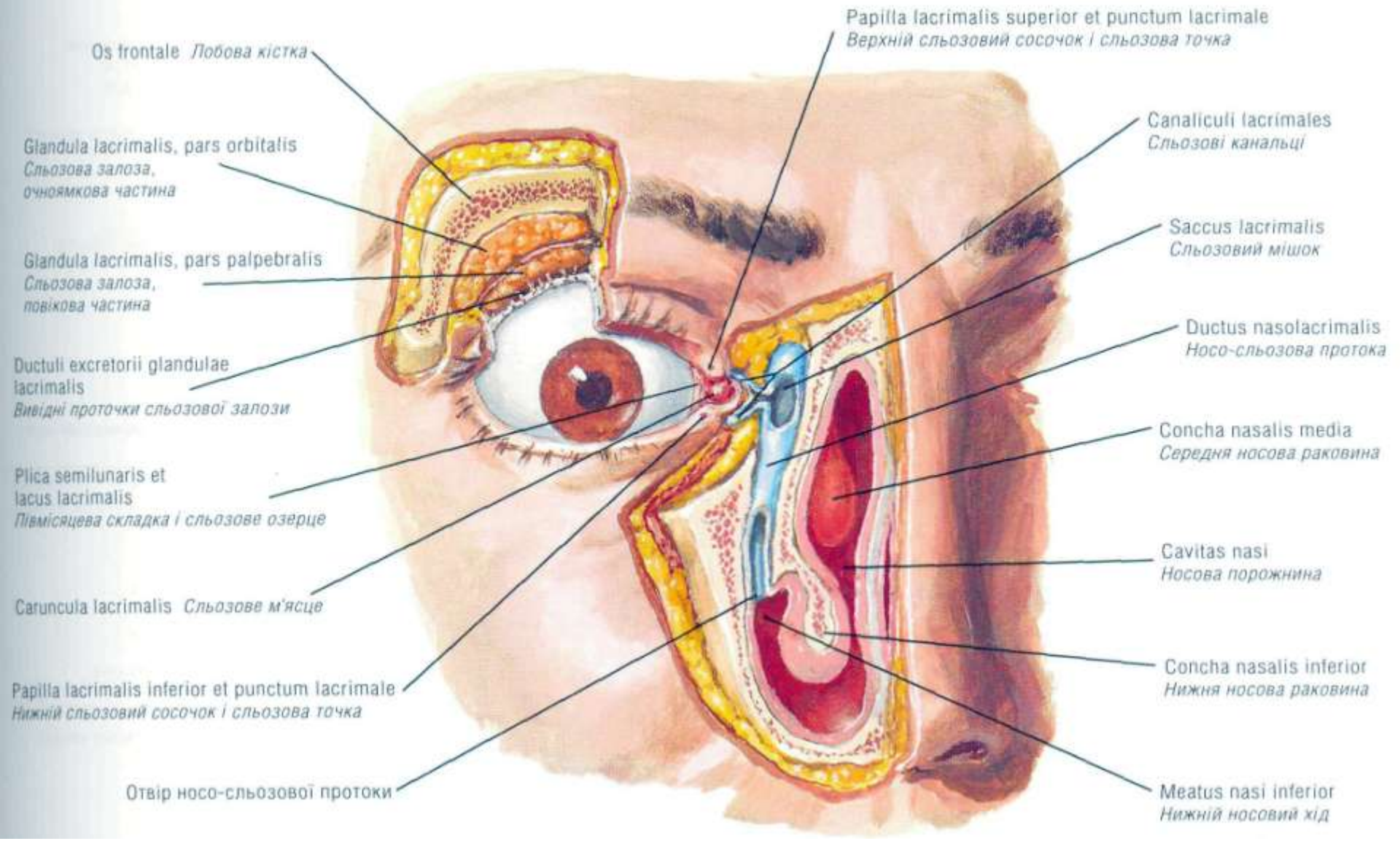


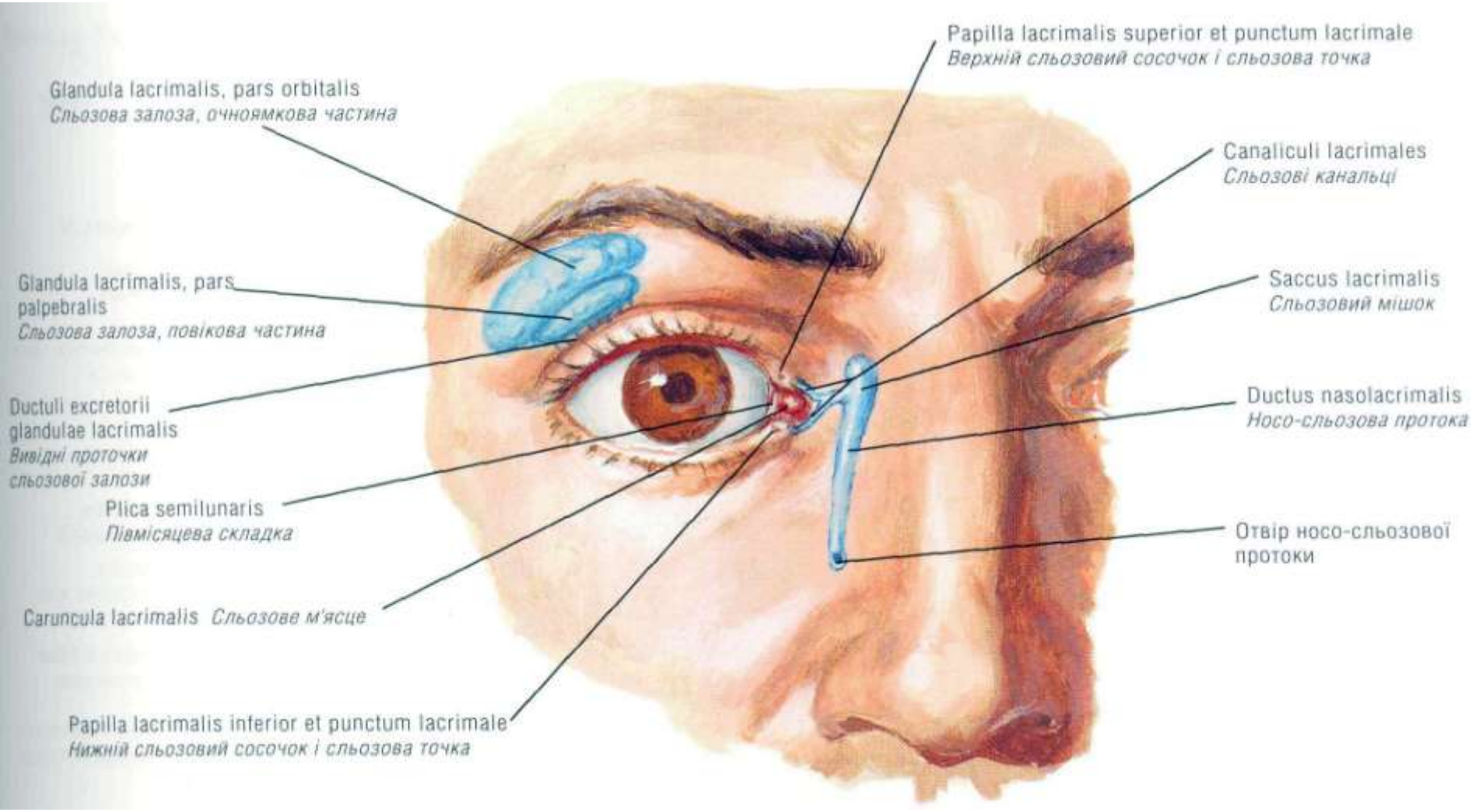
Tear production and drainage

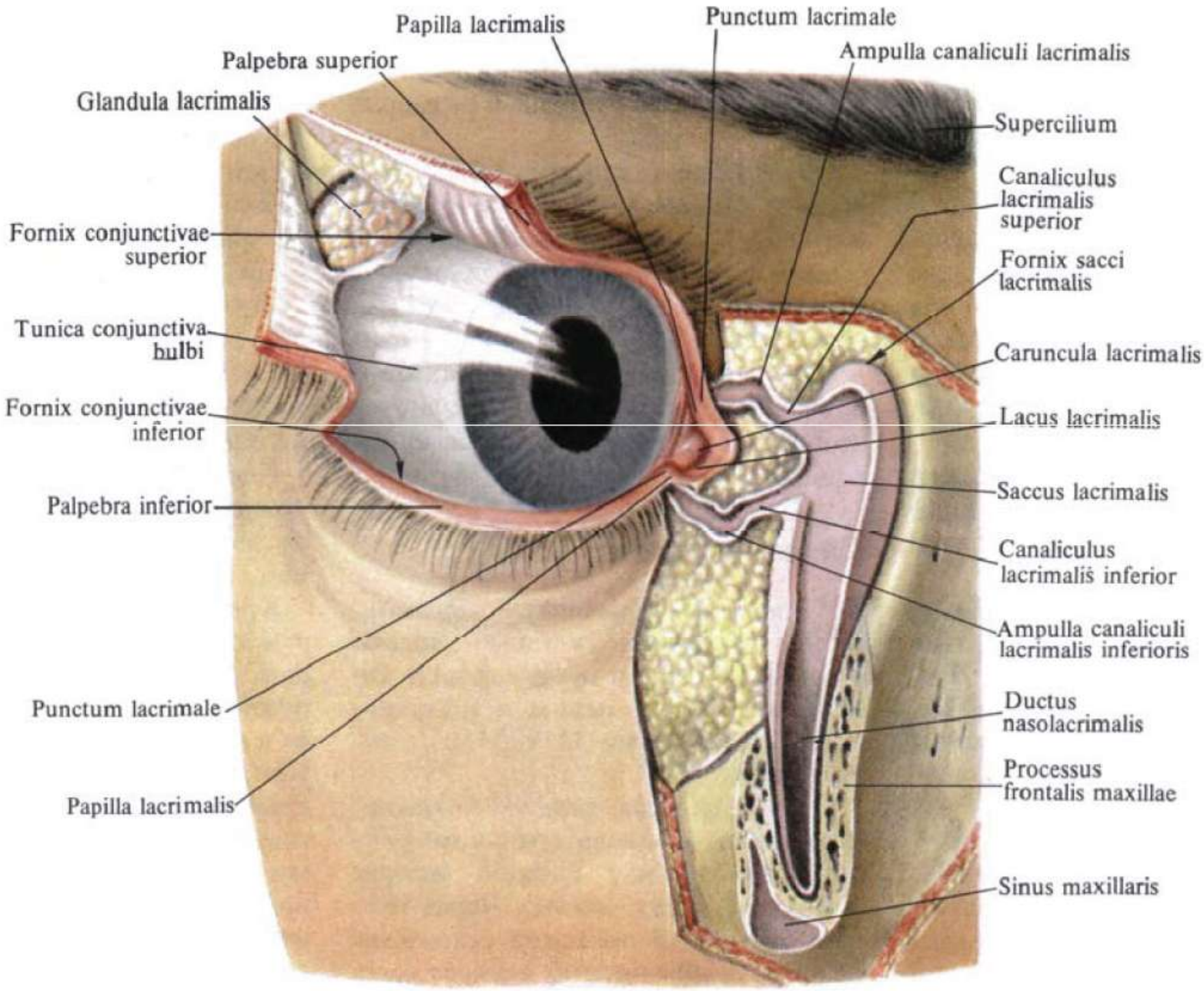
- At birth, the **nasolacrimal duct** may not be fully developed, causing a watery eye.

- Acquired obstruction of the nasolacrimal duct is a common cause of a watery eye in adults. It may lead to an acute infection of the sac.

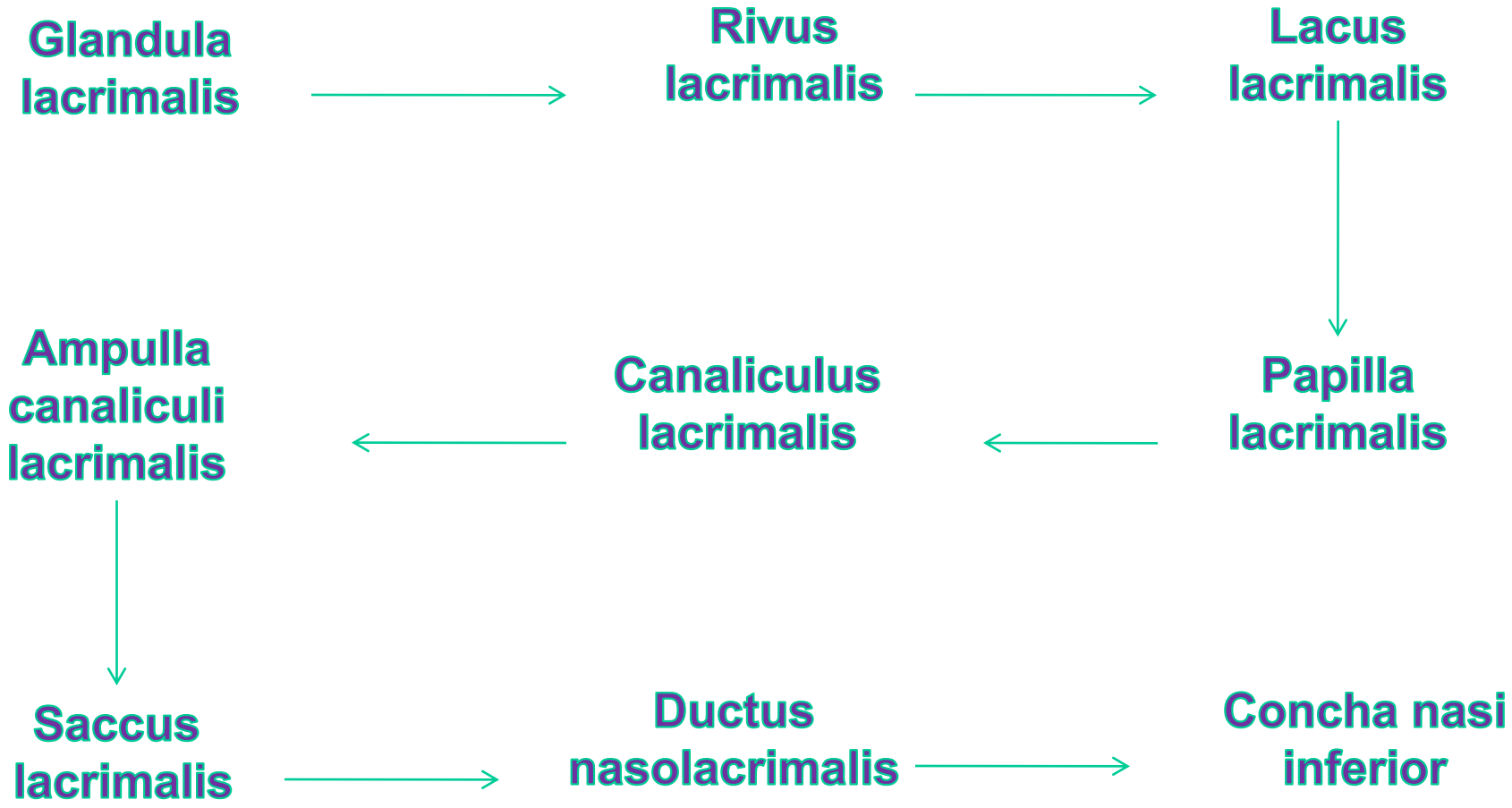

Aponeurosis of levator
Lacrimal gland
Punctum
Canaliculus
Lacrimal sac
Nasolacrimal duct
Nasal cavity
Inferior concha
Inferior meatus of nose
Maxillary sinus


Os frontale Лобова кістка
Glandula lacrimalis, pars orbitalis
Сльозова залоза,
очноямкова частина
Glandula lacrimalis, pars palpebralis
Сльозова залоза,
повікова частина
Ductuli excretorii glandulae lacrimalis
Вивідні протоки сльозової залози
Plica semilunaris et lacus lacrimalis
Півмісяцева складка і сльозове озерце
Caruncula lacrimalis Сльозове м'ясце
Papilla lacrimalis inferior et punctum lacrimale
Нижній сльозовий сосочок і сльозова точка
Отвір носо-сльозової протоки
Papilla lacrimalis superior et punctum lacrimale
Верхній сльозовий сосочок і сльозова точка
Canaliculi lacrimales
Сльозові канальці
Saccus lacrimalis
Сльозовий мішок
Ductus nasolacrimalis
Носо-сльозова протока
Concha nasalis media
Середня носова раковина
Cavitas nasi
Носова порожнина
Concha nasalis inferior
Нижня носова раковина
Meatus nasi inferior
Нижній носовий хід

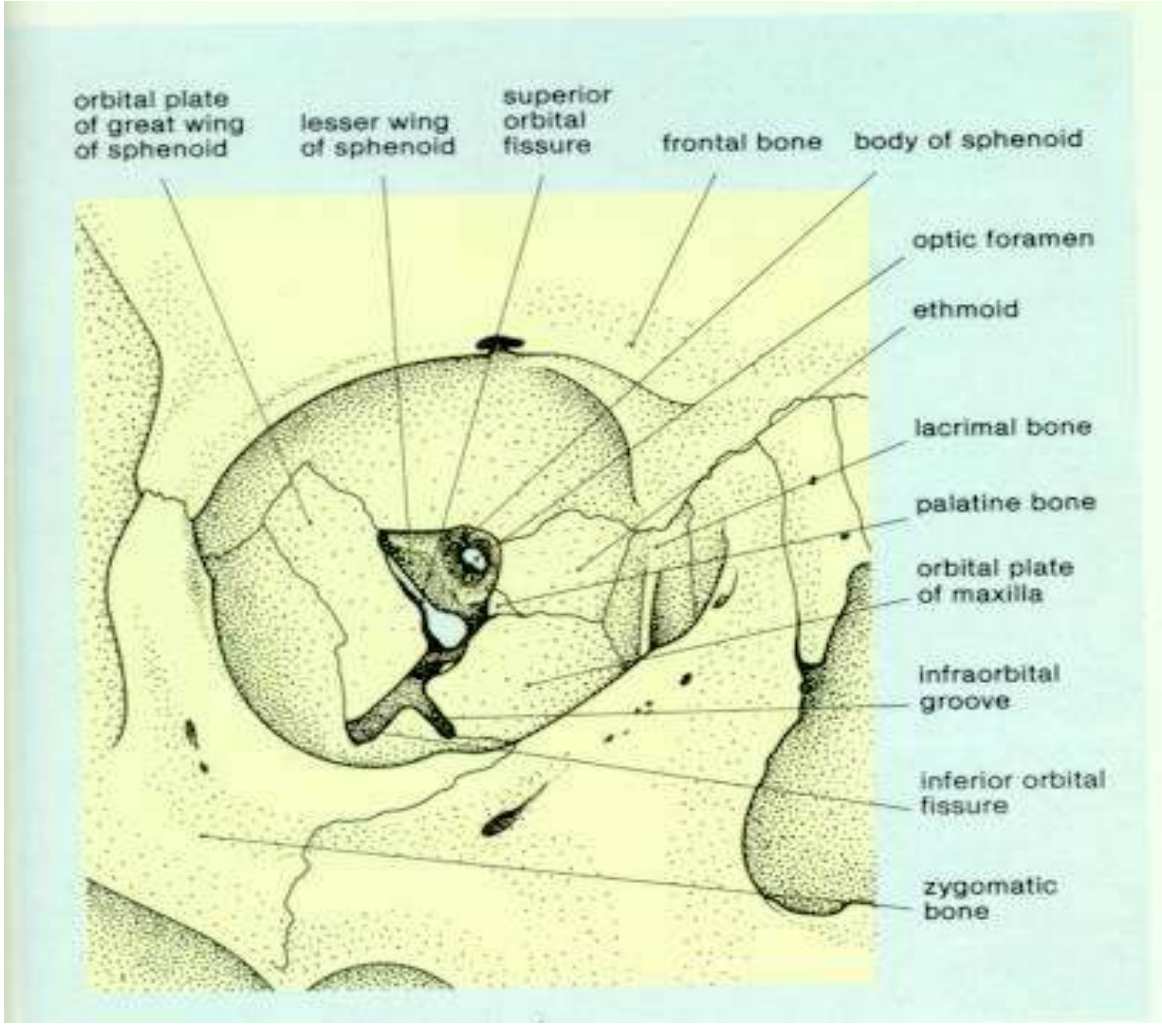

Papilla lacrimalis superior et punctum lacrimale
Верхній сльозовий сосочок і сльозова точка
Glandula lacrimalis, pars orbitalis
Сльозова залоза, очноямкова частина
Canaliculi lacrimales
Сльозові канальці
Glandula lacrimalis, pars palpebralis
Сльозова залоза, повікова частина
Saccus lacrimalis
Сльозовий мішок
Ductuli excretorii glandulae lacrimalis
Вивідні протоки сльозової залози
Ductus nasolacrimalis
Носо-сльозова протока
Plica semilunaris
Півмісяцева складка
Отвір носо-сльозової протоки
Caruncula lacrimalis Сльозове м'ясце
Papilla lacrimalis inferior et punctum lacrimale
Нижній сльозовий сосочок і сльозова точка


Papilla lacrimalis
Punctum lacrimale
Ampulla canaliculi lacrimalis
Palpebra superior
Glandula lacrimalis
Supercilium
Canaliculus lacrimalis superior
Fornix conjunctivae superior
Fornix sacci lacrimalis
Tunica conjunctiva bulbi
Caruncula lacrimalis
Fornix conjunctivae inferior
Lacus lacrimalis
Saccus lacrimalis
Palpebra inferior
Canaliculus lacrimalis inferior
Ampulla canaliculi lacrimalis inferioris
Punctum lacrimale
Ductus nasolacrimalis
Processus frontalis maxillae
Papilla lacrimalis
Sinus maxillaris

Tear goes this way:

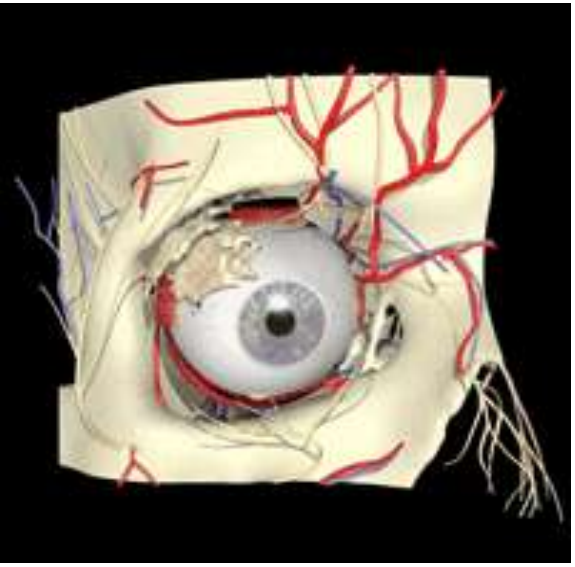
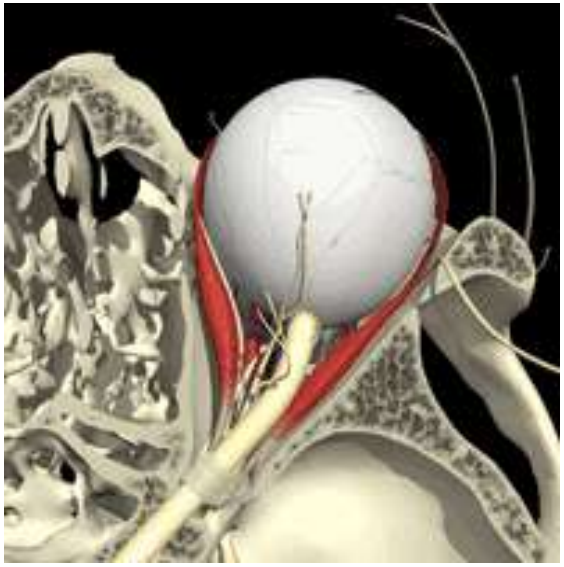
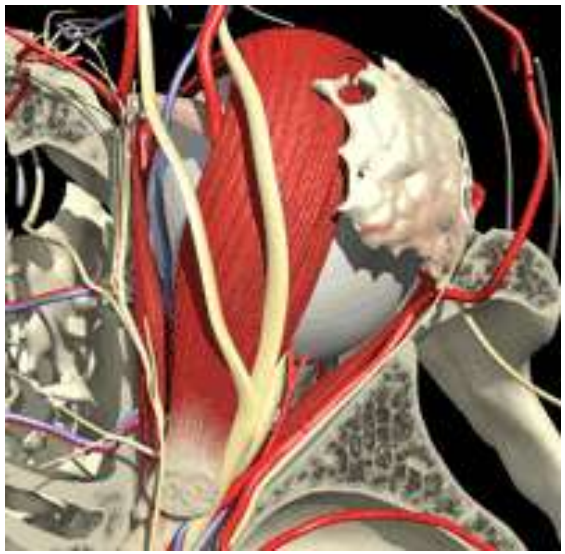
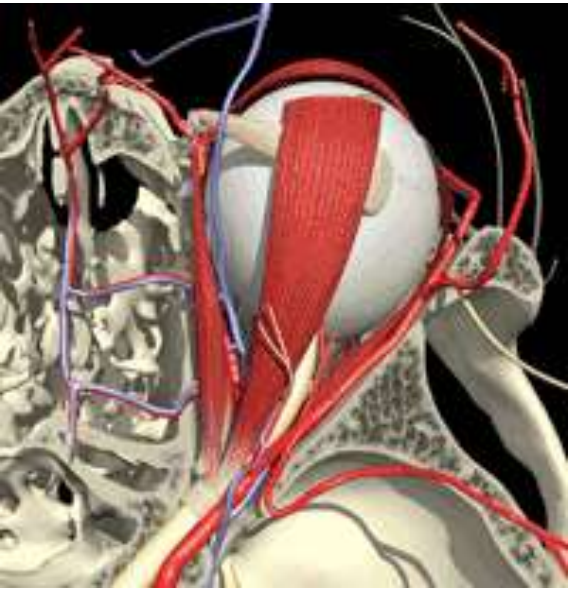
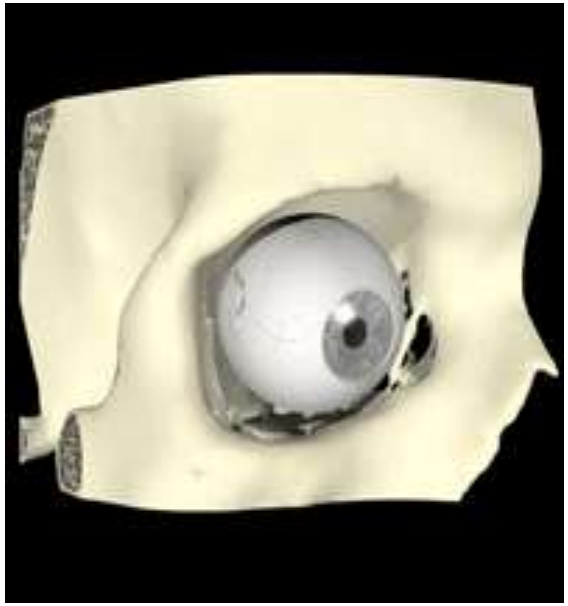
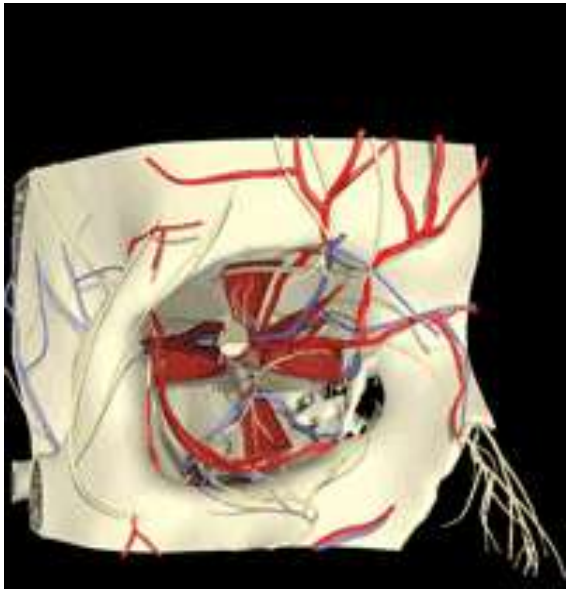


Orbital Walls



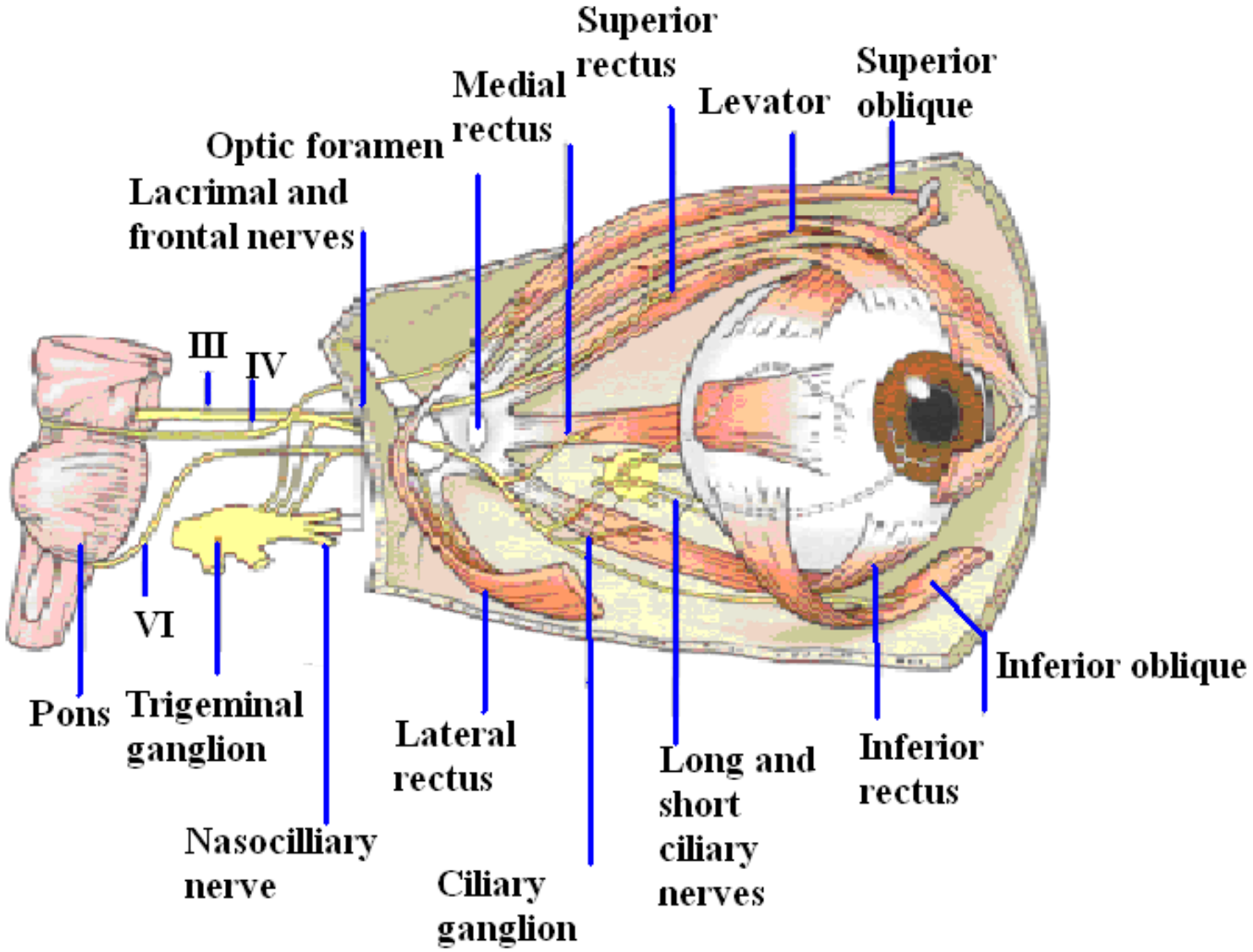
Nerves of the Orbit

- **Branches of the ophthalmic division of the trigeminal (fifth) nerve are sensory to the eyeball (especially the cornea), the conjunctiva and the skin of the eyelids extending up across the forehead and back towards the occiput Hence.**
- **The nasociliary nerve is the branch to the eyeball, but it does not terminate there. The nerve passes on into the medial orbital wall and emerges on the side of the nose.**

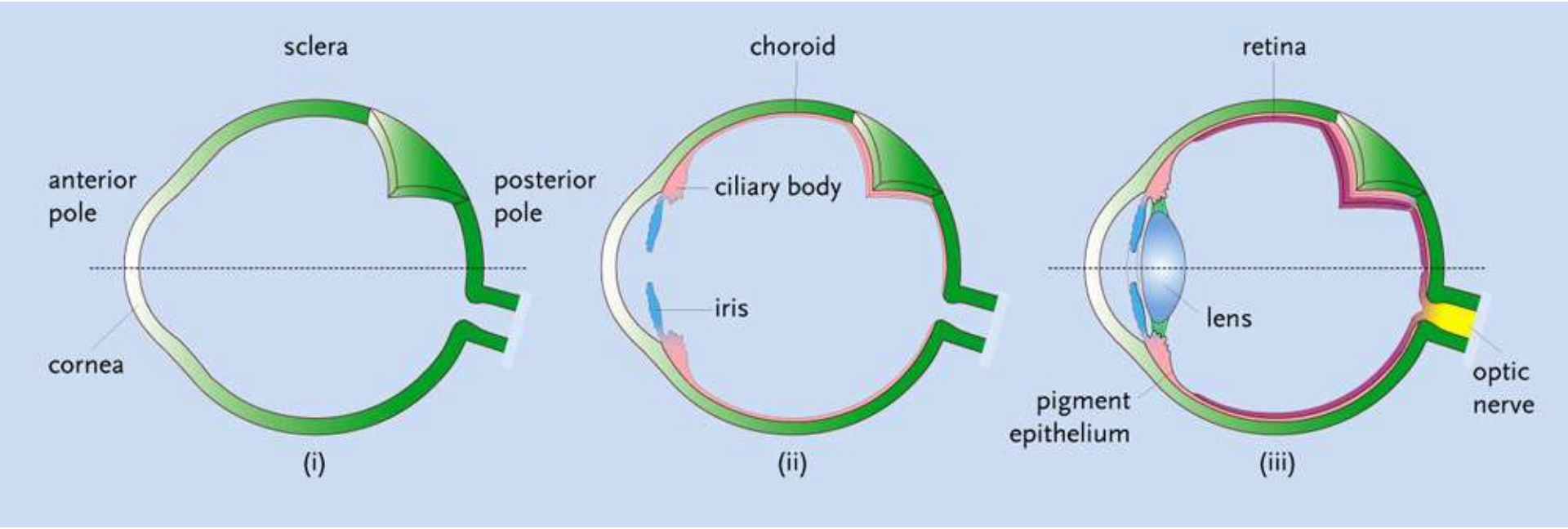







Nerves of the Orbit

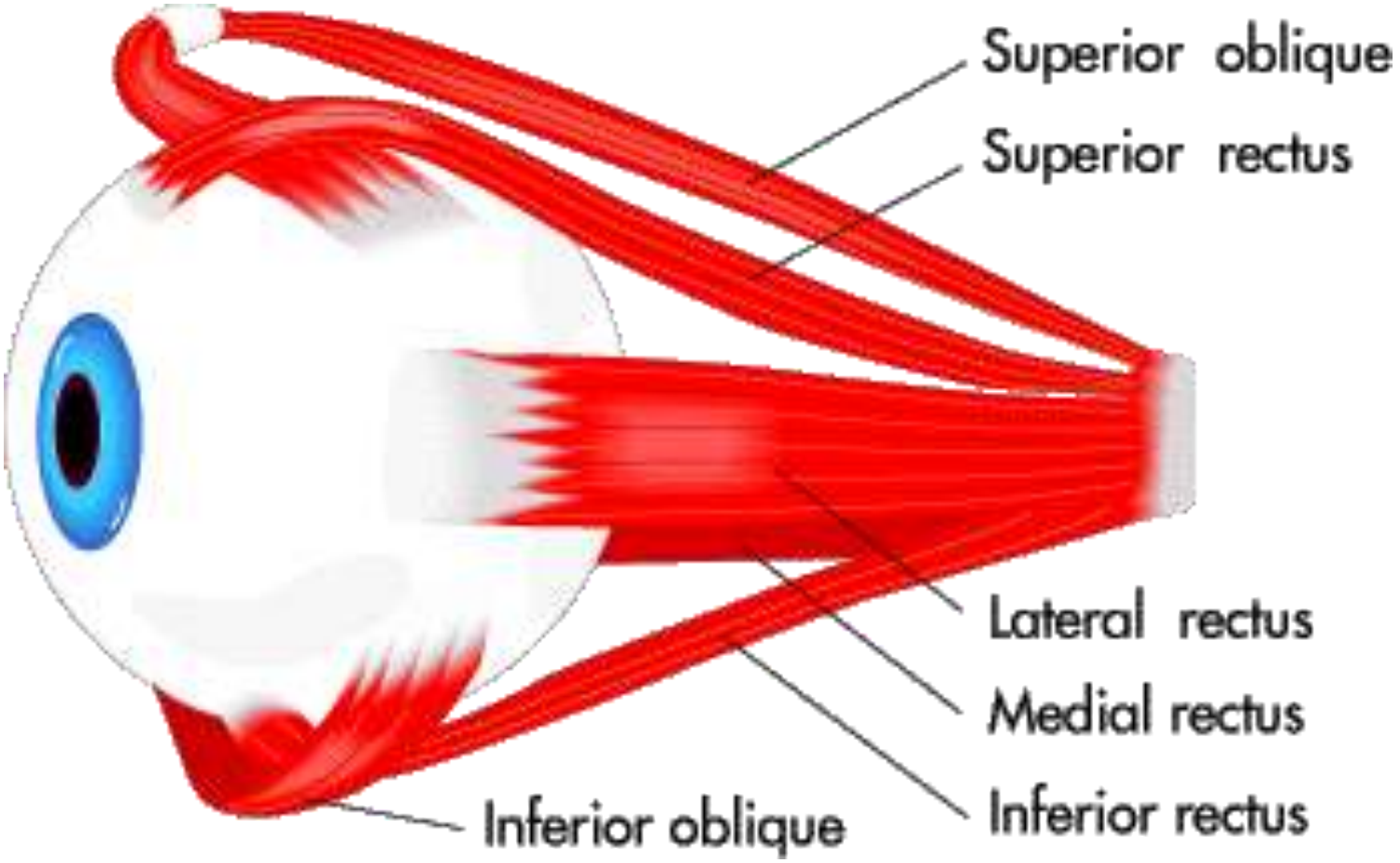
- **Parasympathetic fibres to the lacrimal gland pursue a complex course, passing with the facial nerve and then following the maxillary division of the trigeminal.**
- **The sensory and parasympathetic nerve fibres reach the eyeball via the short and long ciliary nerves which pierce the sclera posteriorly.**

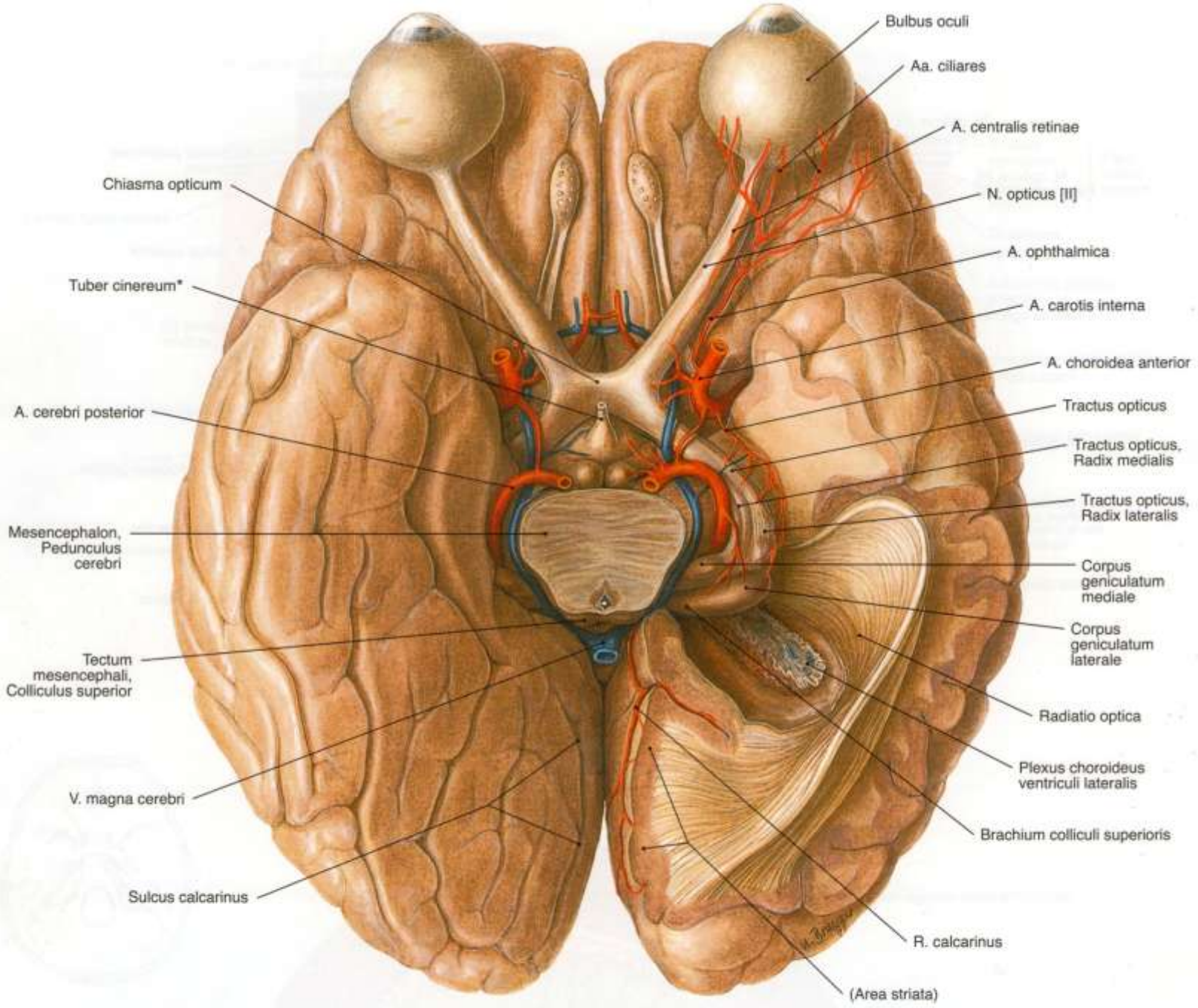

Superior rectus
Medial rectus
Levator
Superior oblique
Optic foramen
Lacrimal and frontal nerves
III
IV
VI
Pons
Trigeminal ganglion
Nasocilliary nerve
Lateral rectus
Ciliary ganglion
Long and short ciliary nerves
Inferior rectus
Inferior oblique

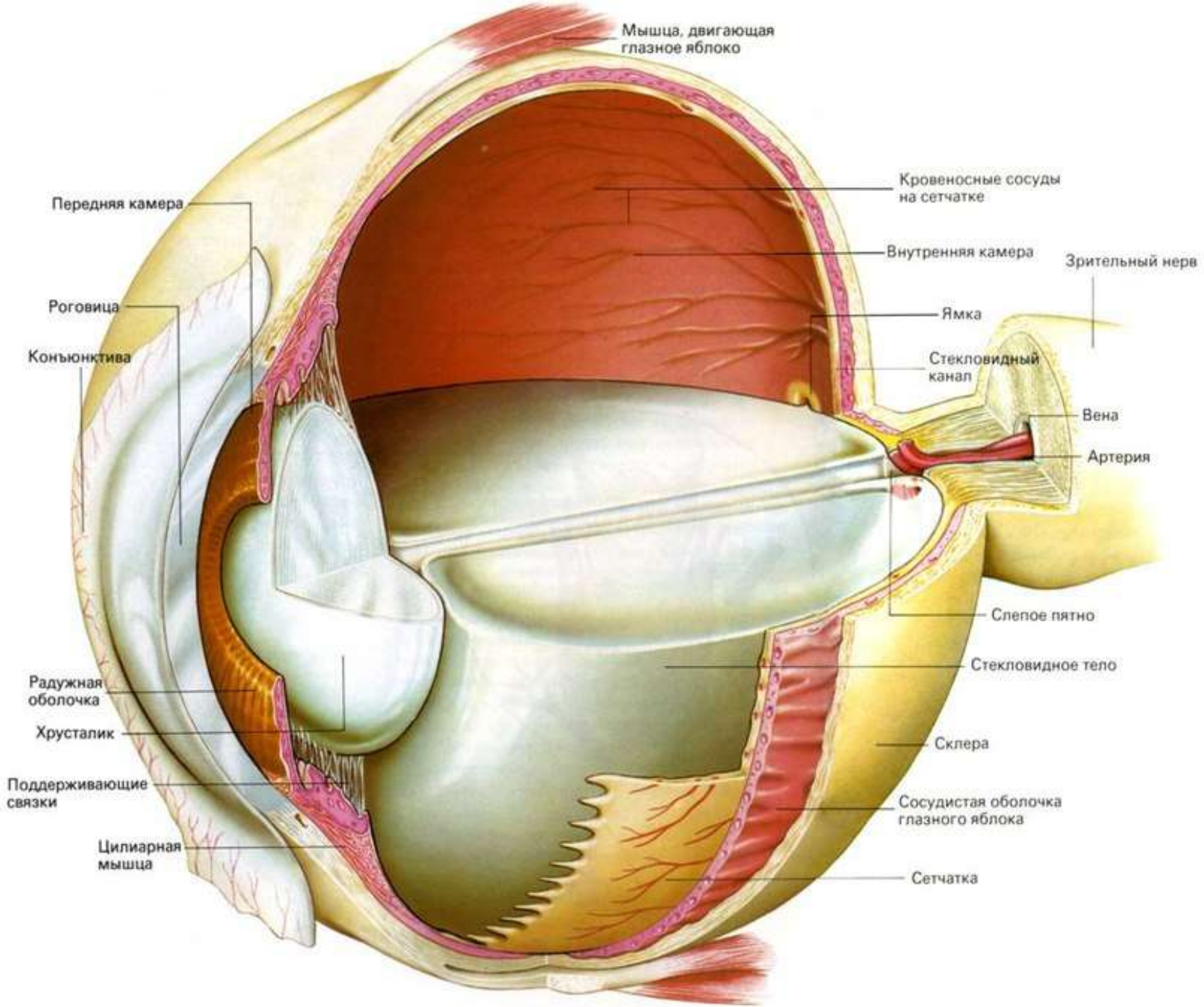
Layers of the Eye



- Sclera: outer white layer; maintains shape of eye; muscles attached control eye movement
- Choroid: contains blood vessels


Superior oblique
Superior rectus
Lateral rectus
Medial rectus
Inferior rectus
Inferior oblique

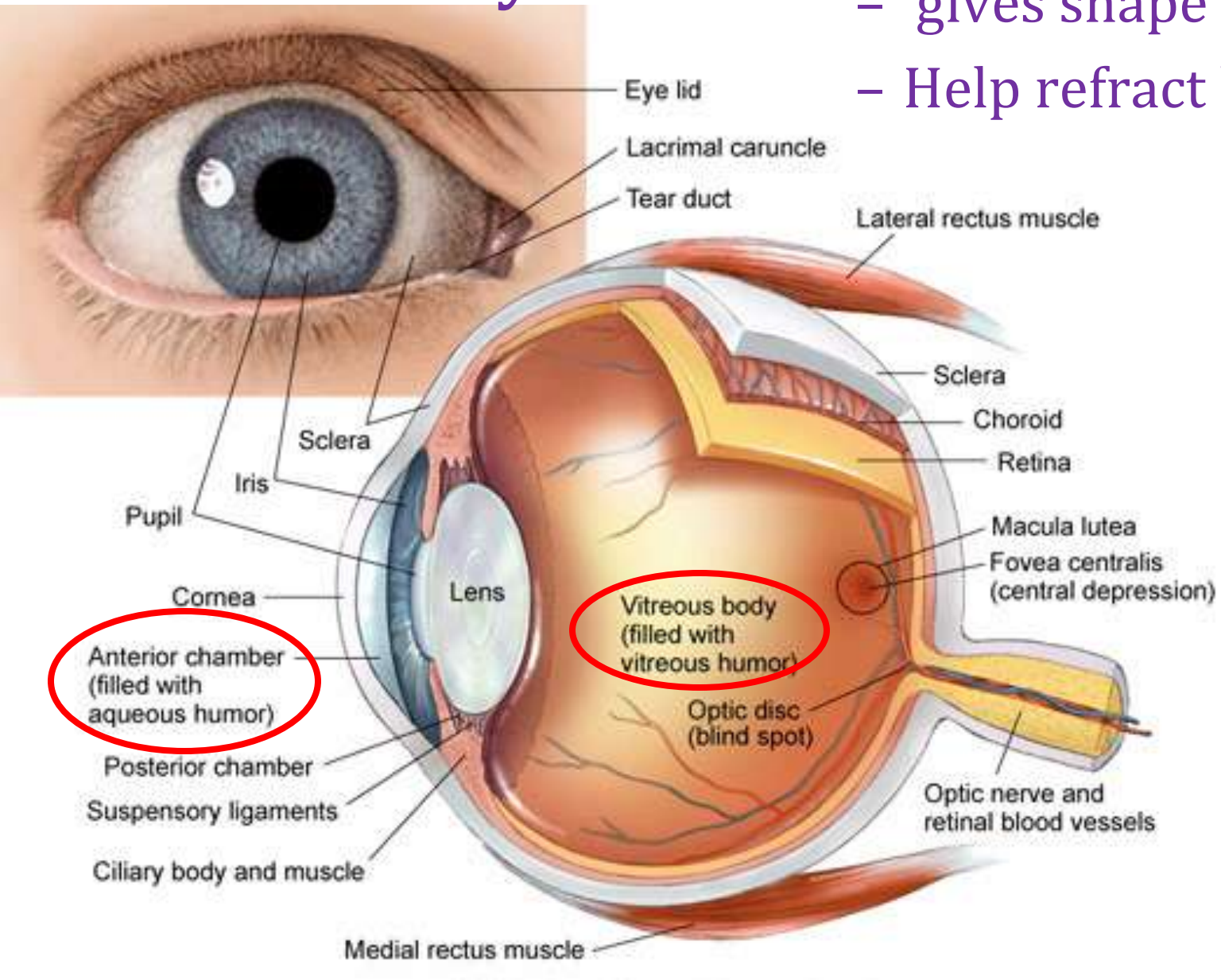

Bulbus oculi
Aa. ciliares
A. centralis retinae
Chiasma opticum
N. opticus [II]
A. ophthalmica
Tuber cinereum*
A. carotis interna
A. choroidea anterior
A. cerebri posterior
Tractus opticus
Tractus opticus, Radix medialis
Tractus opticus, Radix lateralis
Mesencephalon, Pedunculus cerebri
Corpus geniculatum mediale
Corpus geniculatum laterale
Tectum mesencephali, Colliculus superior
Radiatio optica
Plexus choroideus ventriculi lateralis
V. magna cerebri
Brachium colliculi superioris
Sulcus calcarinus
R. calcarinus
(Area striata)


Мышца, двигающая глазное яблоко
Передняя камера
Кровеносные сосуды на сетчатке
Внутренняя камера
Зрительный нерв
Роговица
Ямка
Конъюнктива
Стекловидный канал
Вена
Артерия
Слепое пятно
Стекловидное тело
Радужная оболочка
Хрусталик
Склера
Поддерживающие связки
Сосудистая оболочка глазного яблока
Цилиарная мышца
Сетчатка

Chambers & Fluids of Eye

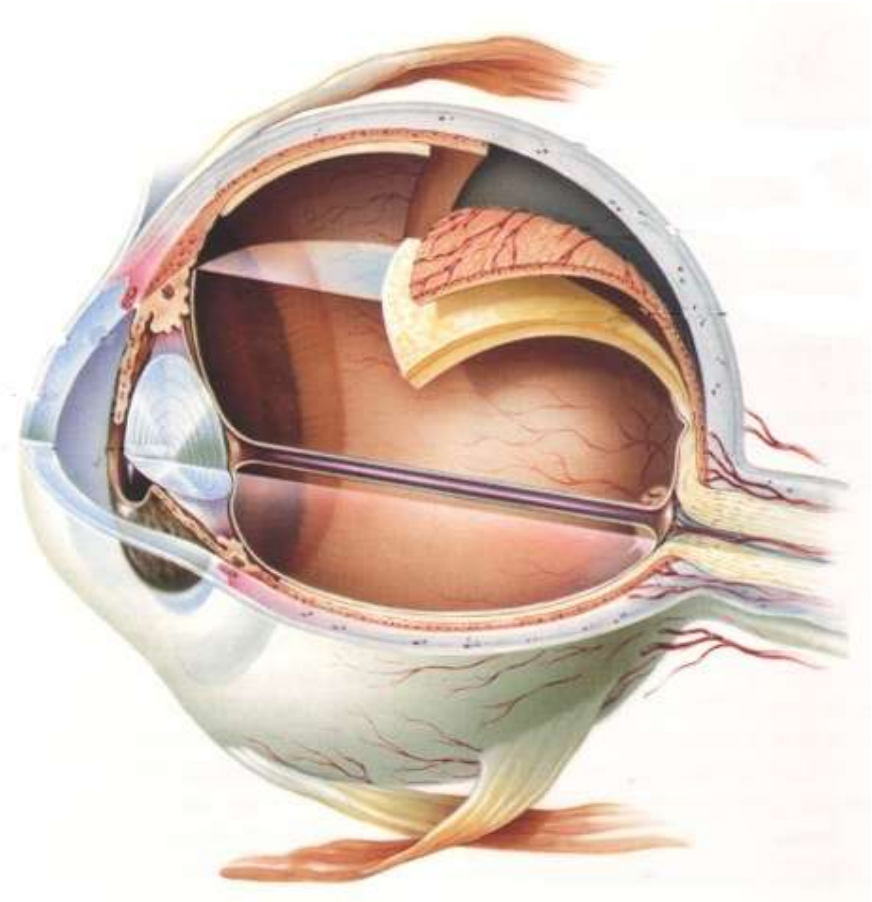
Liquids (humour):

- gives shape to eye
- Help refract light rays

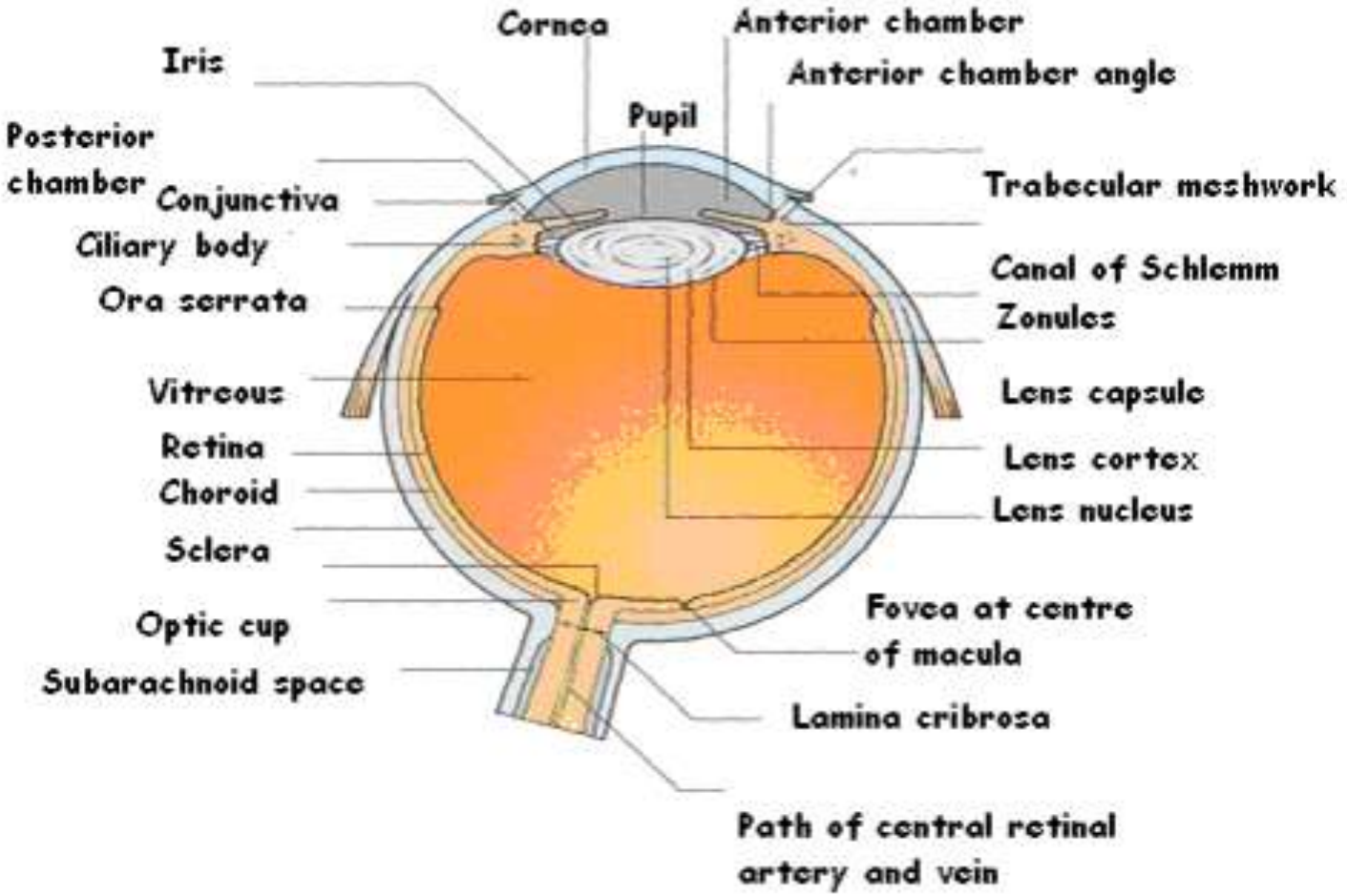


Sagittal section of the eye

- Fibrous tunic of eye
- Choroid
- Retina

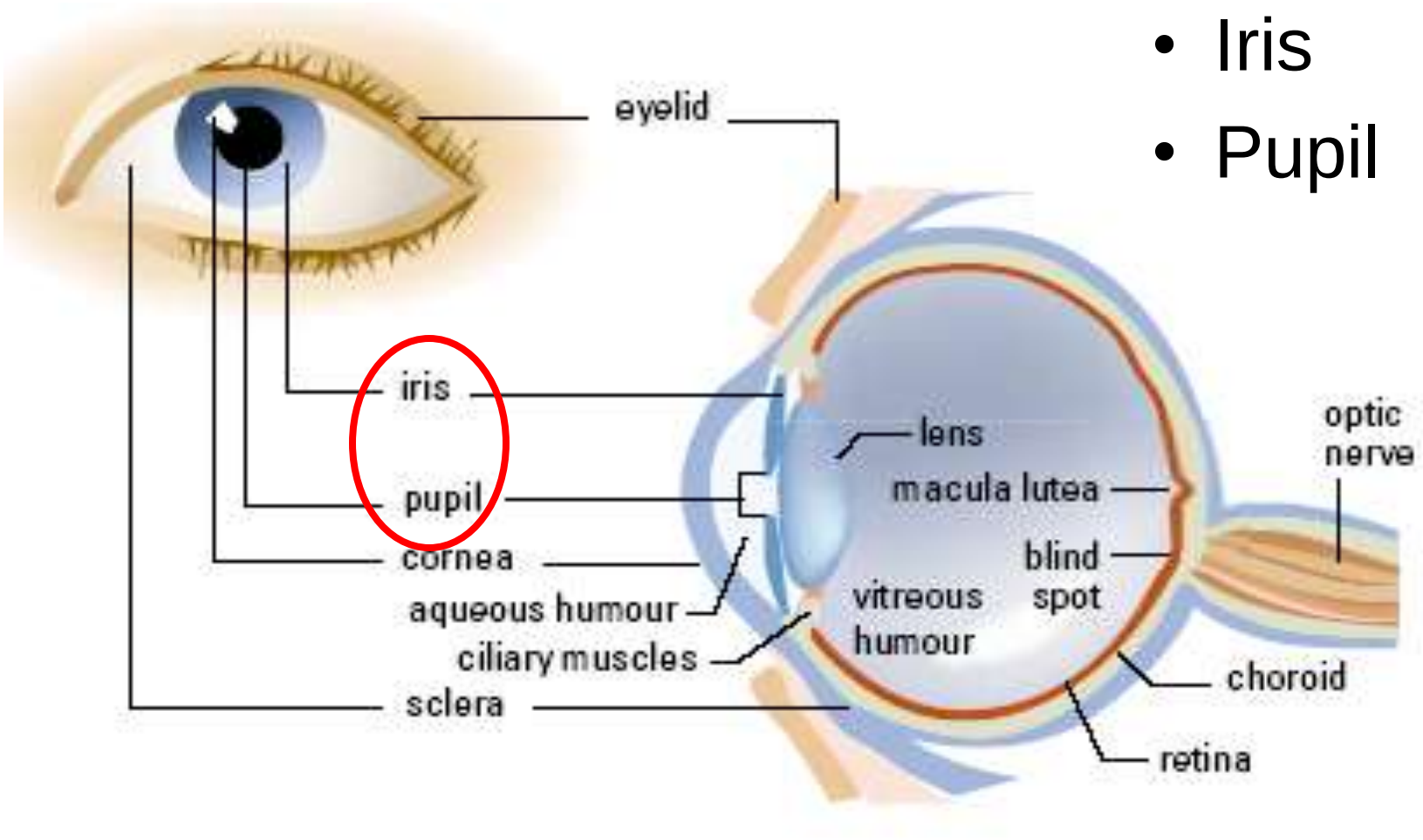


Sagittal section of the eye



Regulating Amount of Light

- Iris
- Pupil



contracted pupil

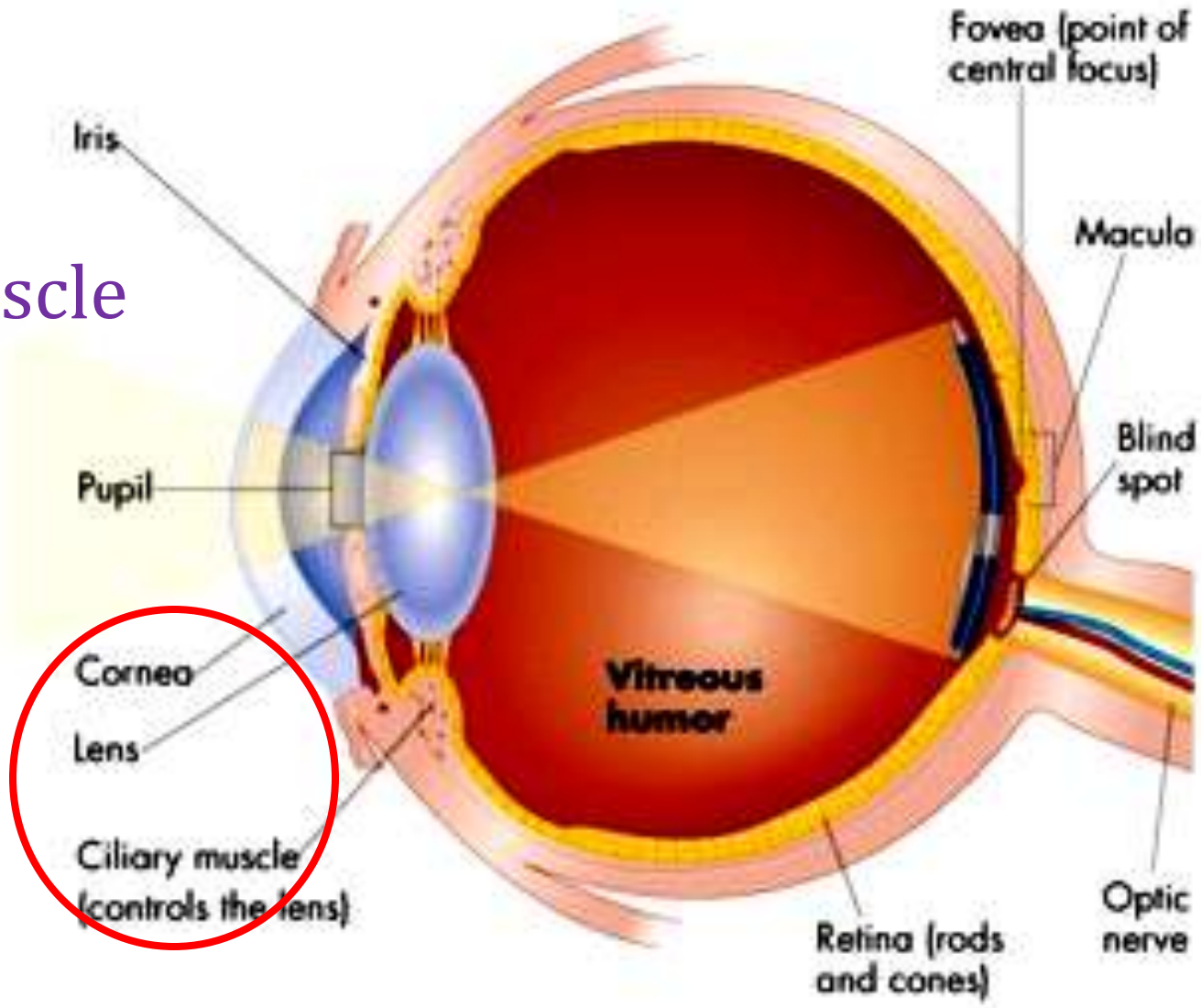
dilated pupil

Regulating amount of light

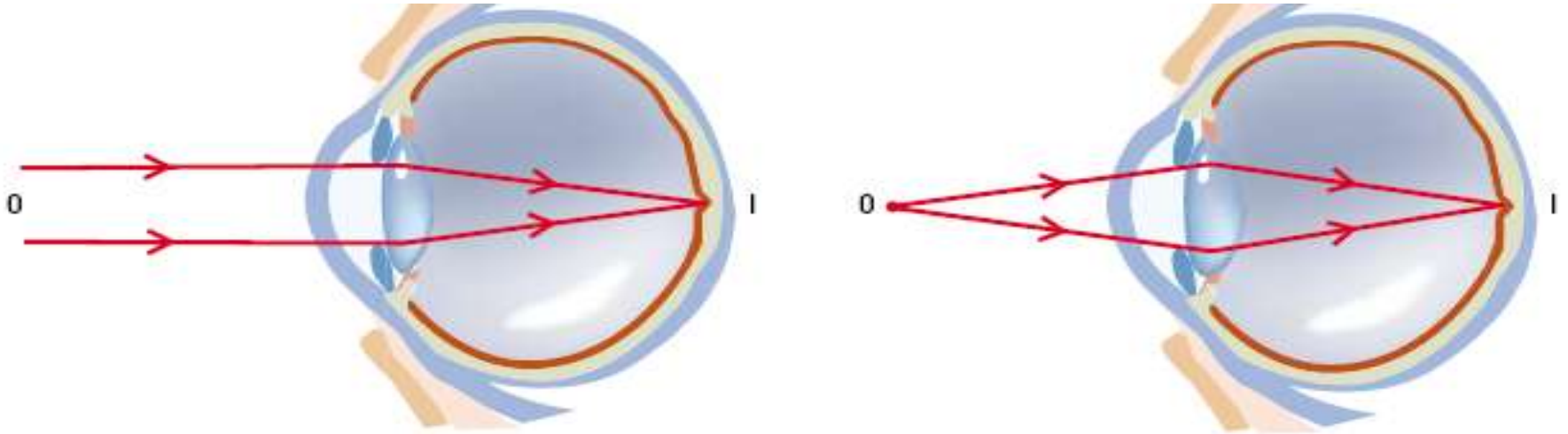
Parts	Description	Function	Analogy
Iris	coloured ring	open and closes to control the amount of light entering eye	diaphragm in microscope
Pupil	black centre	hole of iris where light enters eye	aperture in camera

Focusing Light Rays

- Cornea
- Lens
- Ciliary muscle



Focusing Light Rays



- Light rays from distant objects enter the eye **parallel** to one another
- Light rays from close objects **diverge**.

Nearby Objects

Distant Objects

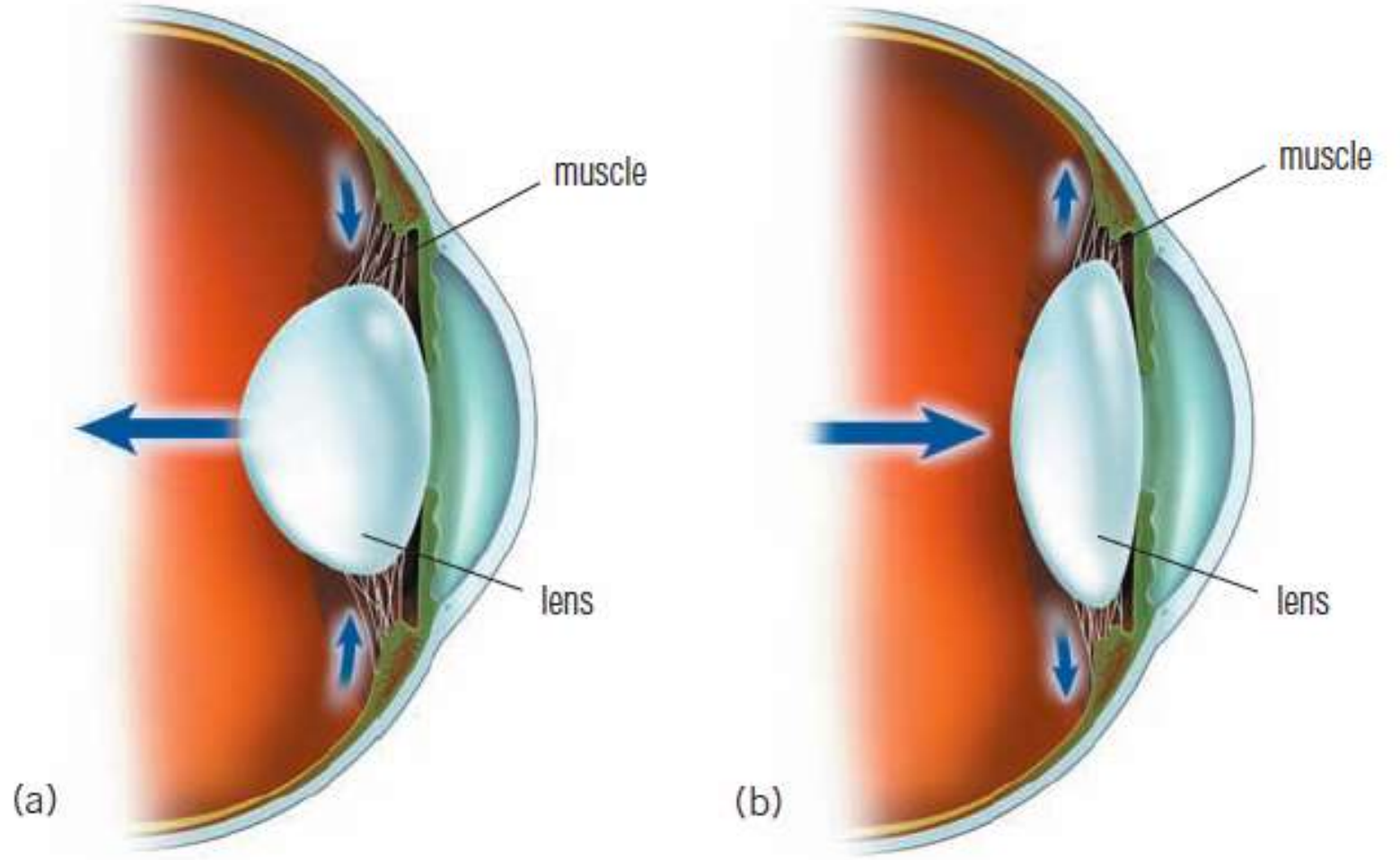
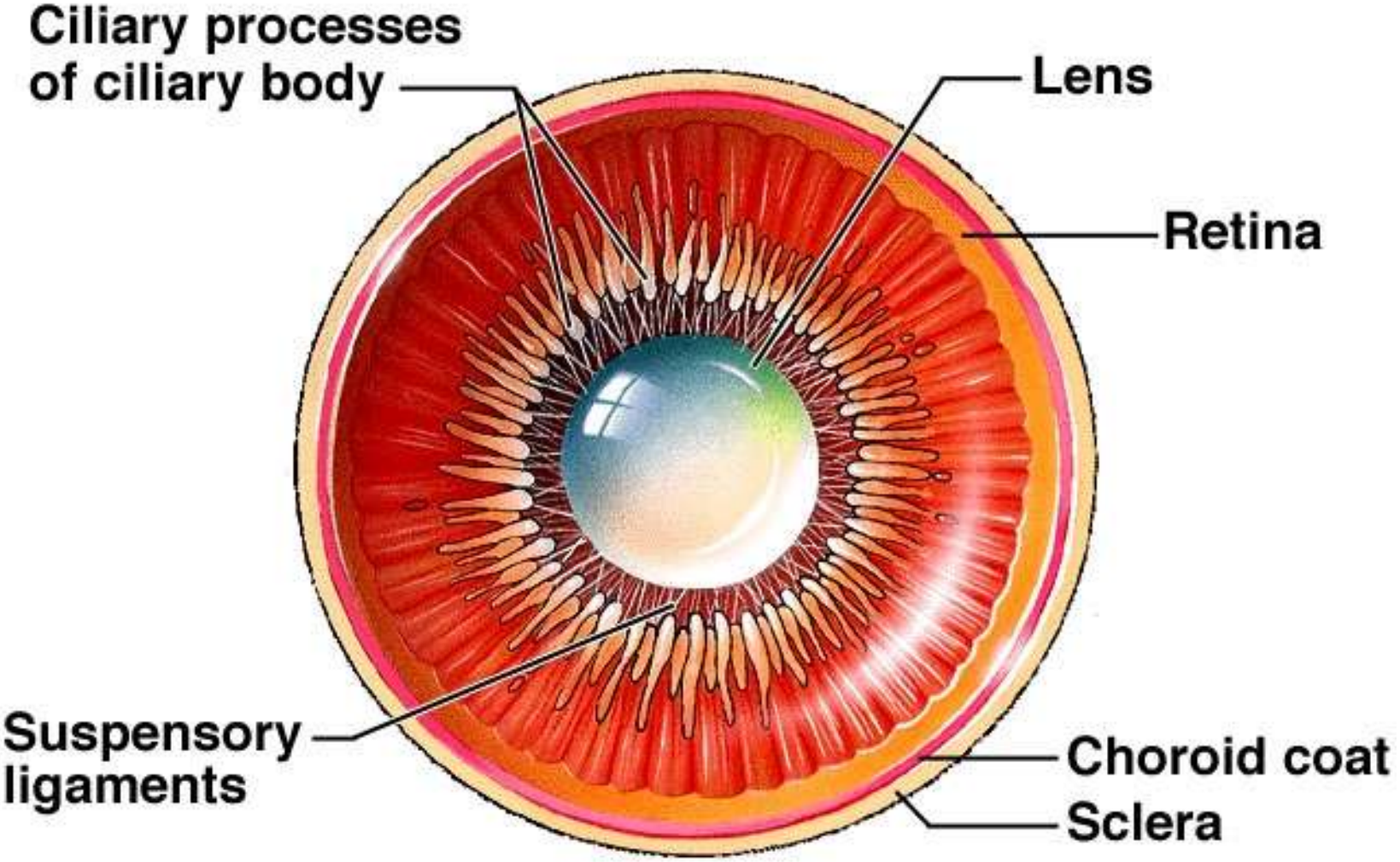
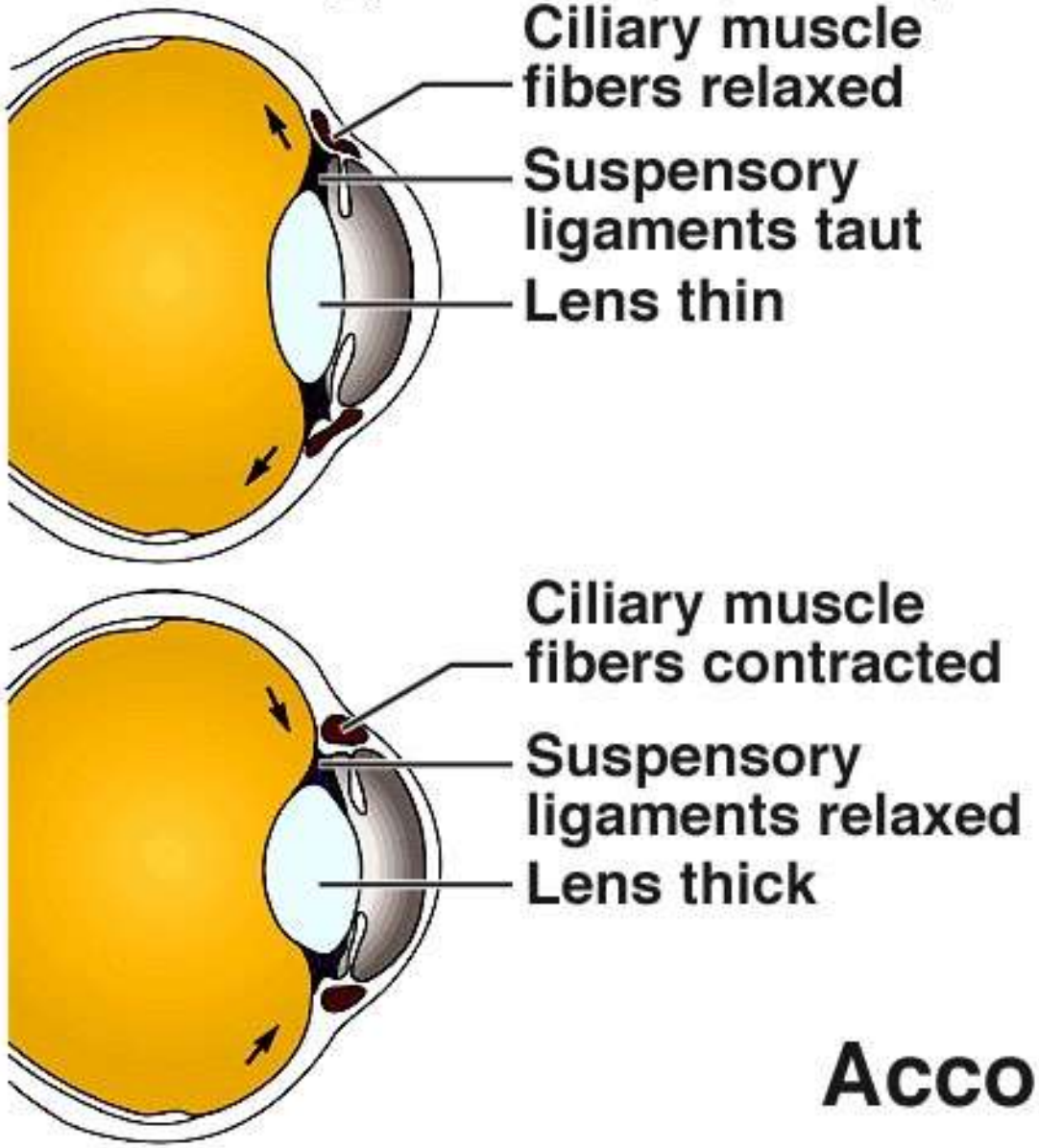


Figure 12.9 The muscles change the shape of the lens so you can focus on objects at various distances. (a) Position of muscles and shape of lens when focussing on nearby objects and (b) distant objects

Lens and Ciliary Body



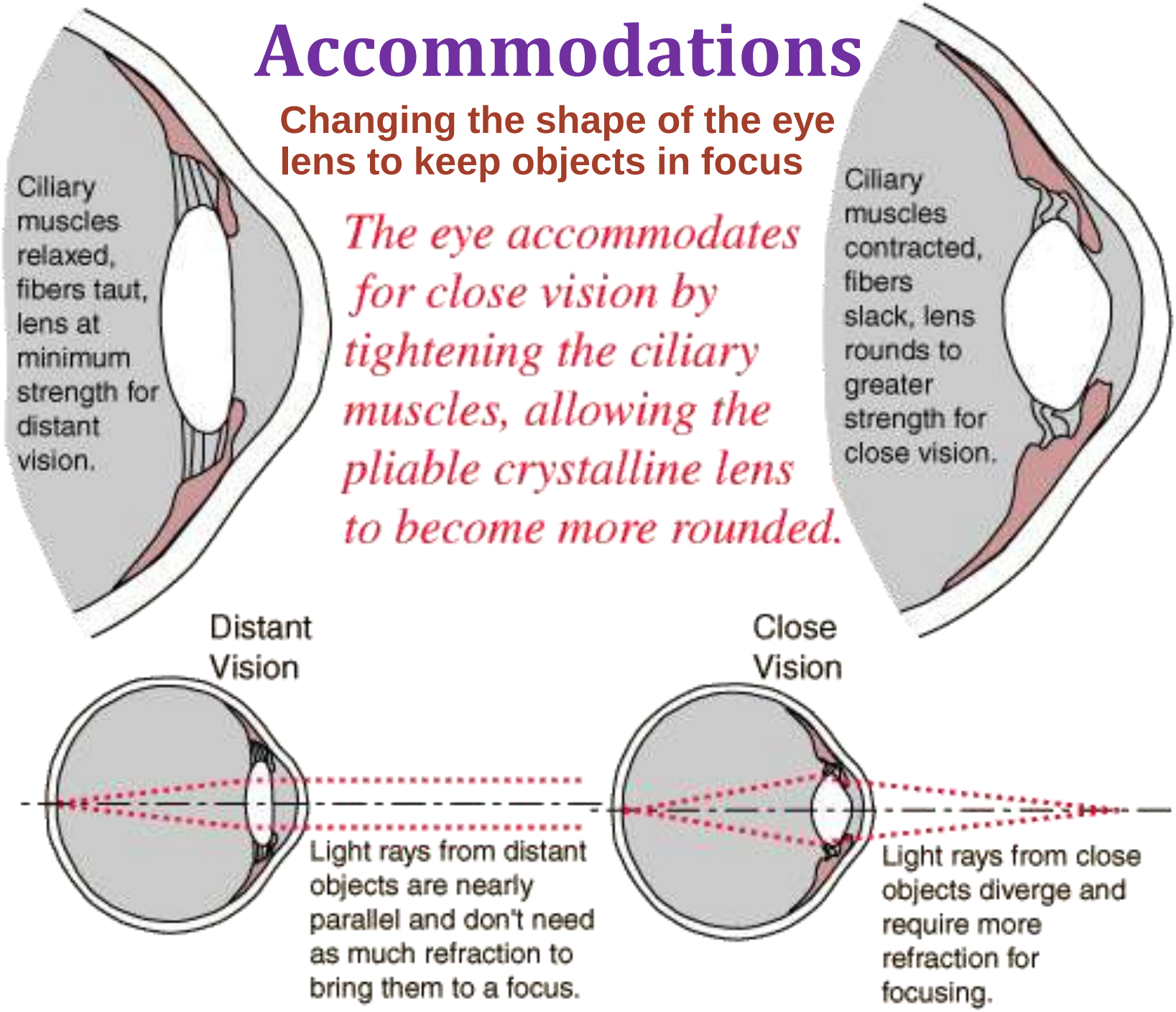


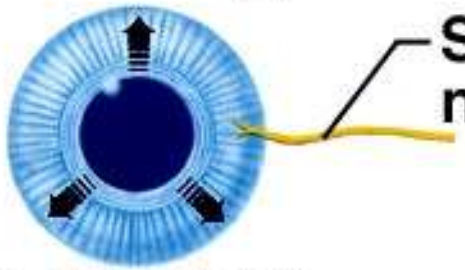
Accommodation

Accommodations

Changing the shape of the eye lens to keep objects in focus

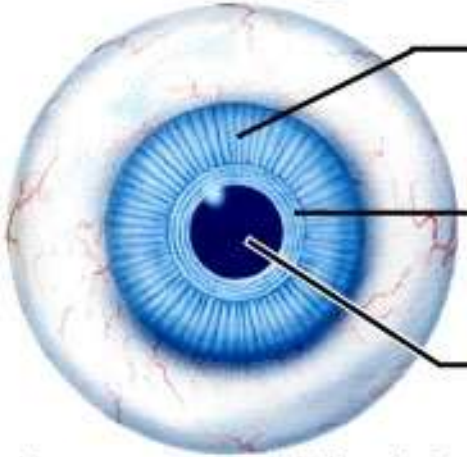
The eye accommodates for close vision by tightening the ciliary muscles, allowing the pliable crystalline lens to become more rounded.





Sympathetic motor nerve fiber

In dim light

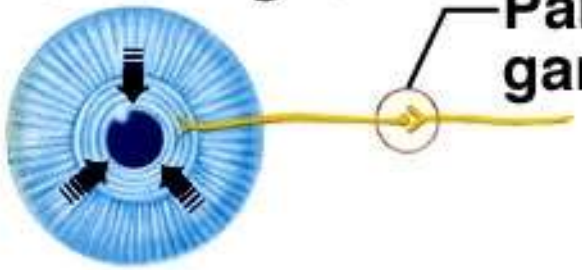


Radially arranged smooth muscle fibers of the iris

Circularly arranged smooth muscle fibers of the iris

Pupil

In normal light



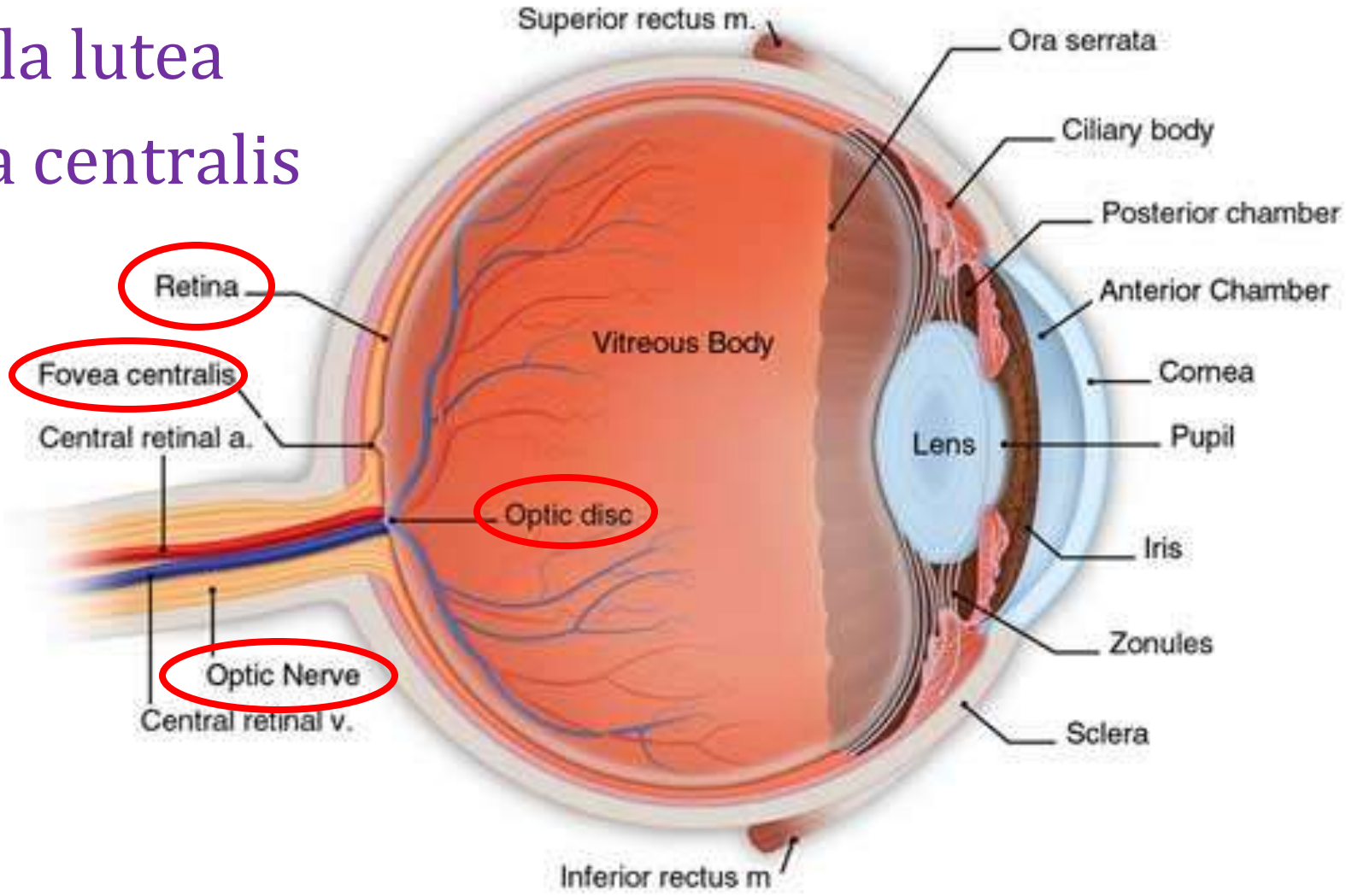
Parasympathetic ganglion

In bright light

Pupil Dilation and Constriction

Image Production

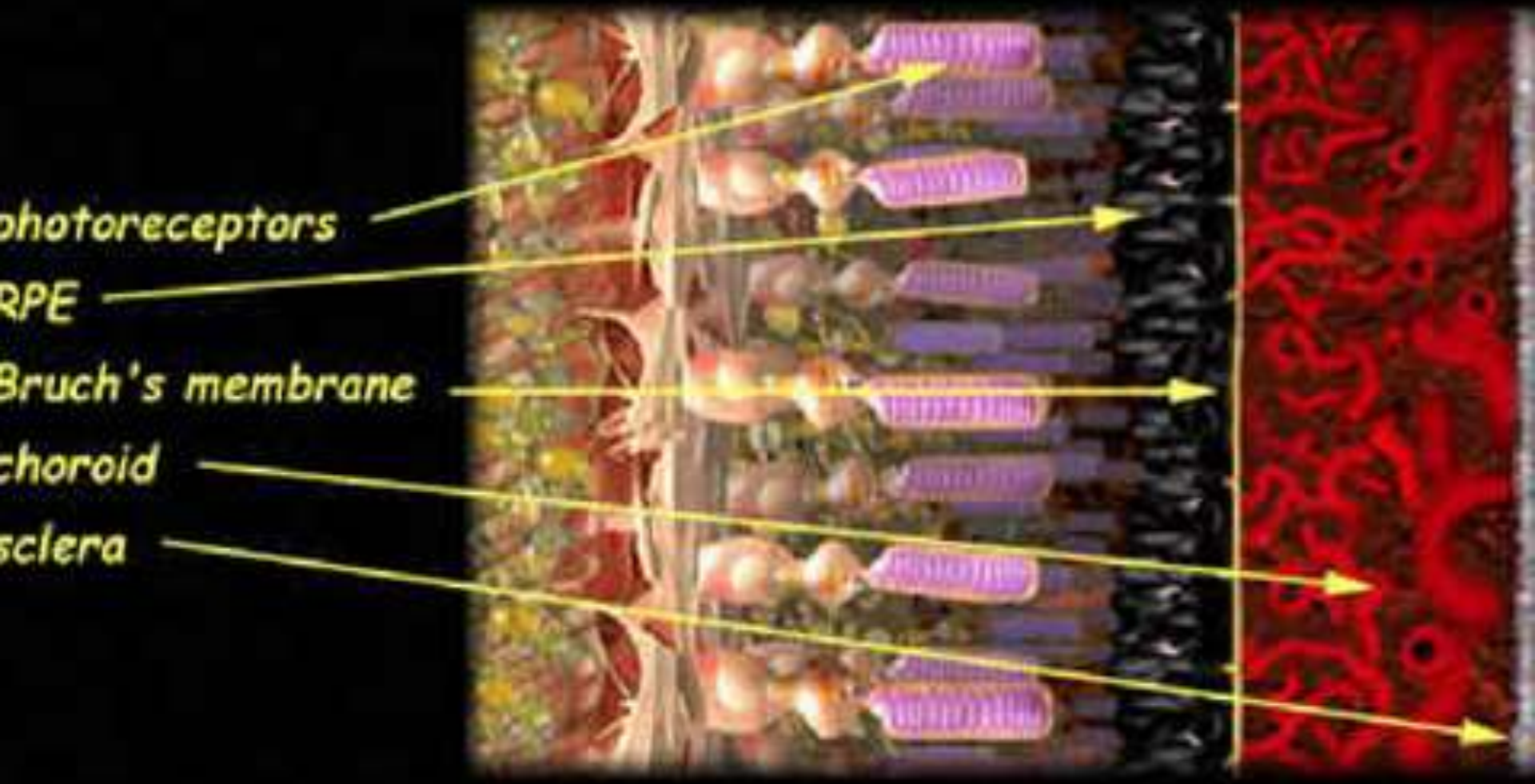
- Retina
- Optic nerve
- Optic disc
- Macula lutea
- Fovea centralis



Retina

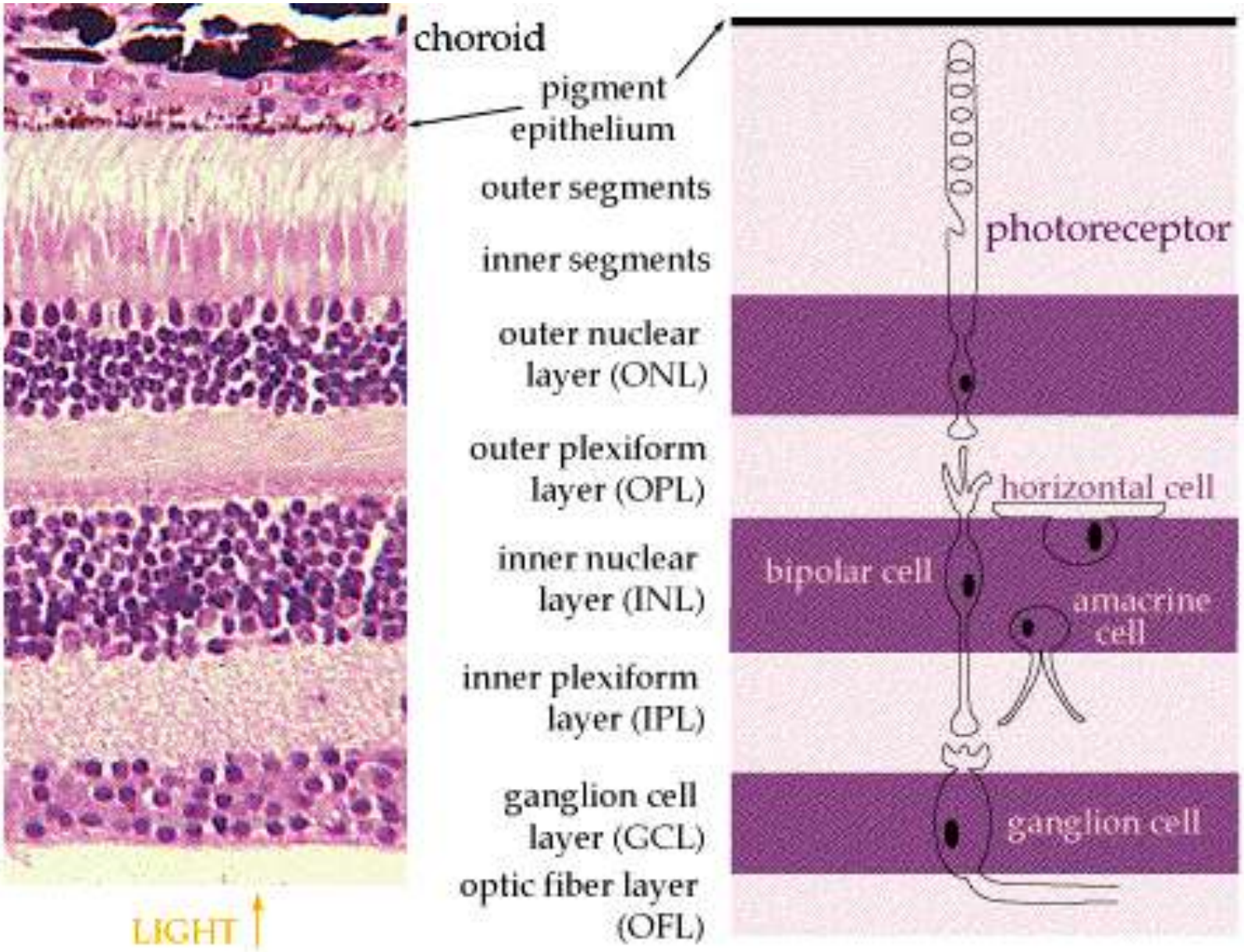
- At the back of the eye
- Consist of 2 types of light-sensitive cells: rods and cones
- Converts light signal into an electrical signal that is transmitted to the brain through the optic nerve

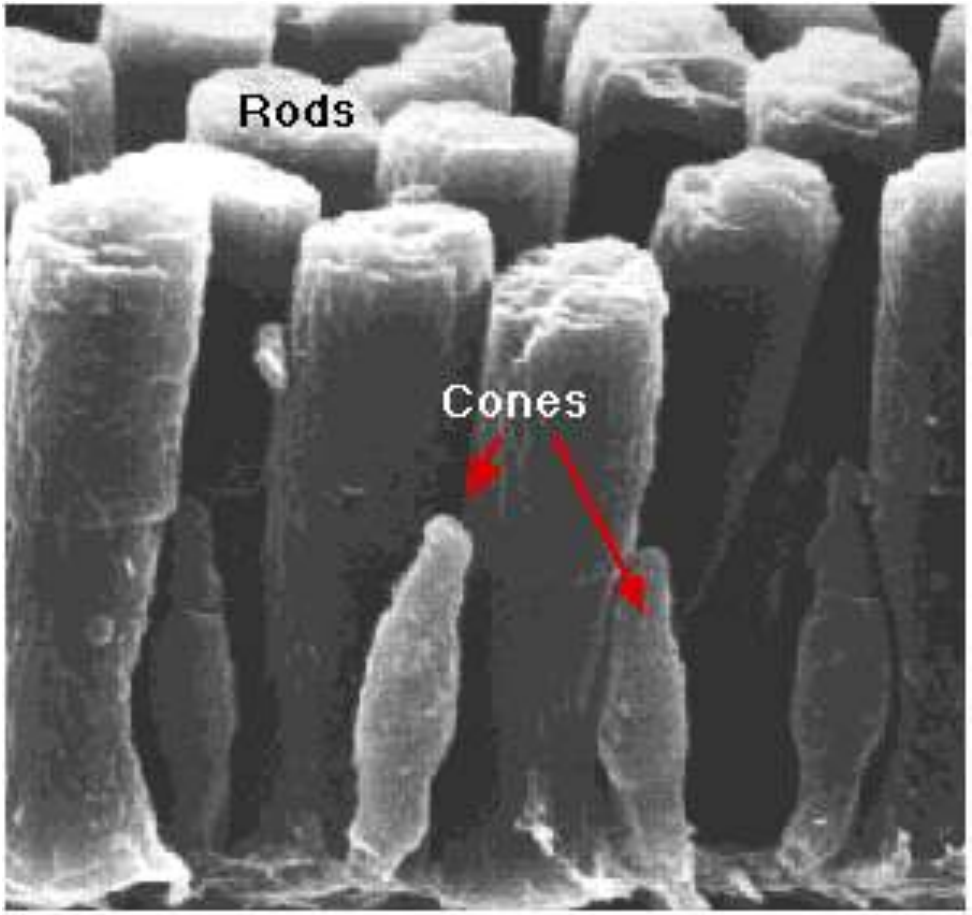
Anatomy of the Retina



Retina Structure

- Light sensitive layer is made of photo-receptors: rods (120 millions) and cones (7 millions) which absorb the light.
- Plexiform Layer: nerve cells that process the signals generated by rods and cones and relay them to the optical nerve.
- Choroid: carries mayor blood vessels to nourish the retina and absorb the light so that it will not be reflected back (dark pupil!)


choroid
pigment epithelium
outer segments
inner segments
outer nuclear layer (ONL)
outer plexiform layer (OPL)
inner nuclear layer (INL)
inner plexiform layer (IPL)
ganglion cell layer (GCL)
optic fiber layer (OFL)
LIGHT
photoreceptor
horizontal cell
bipolar cell
amacrine cell
ganglion cell


Rods
Cones

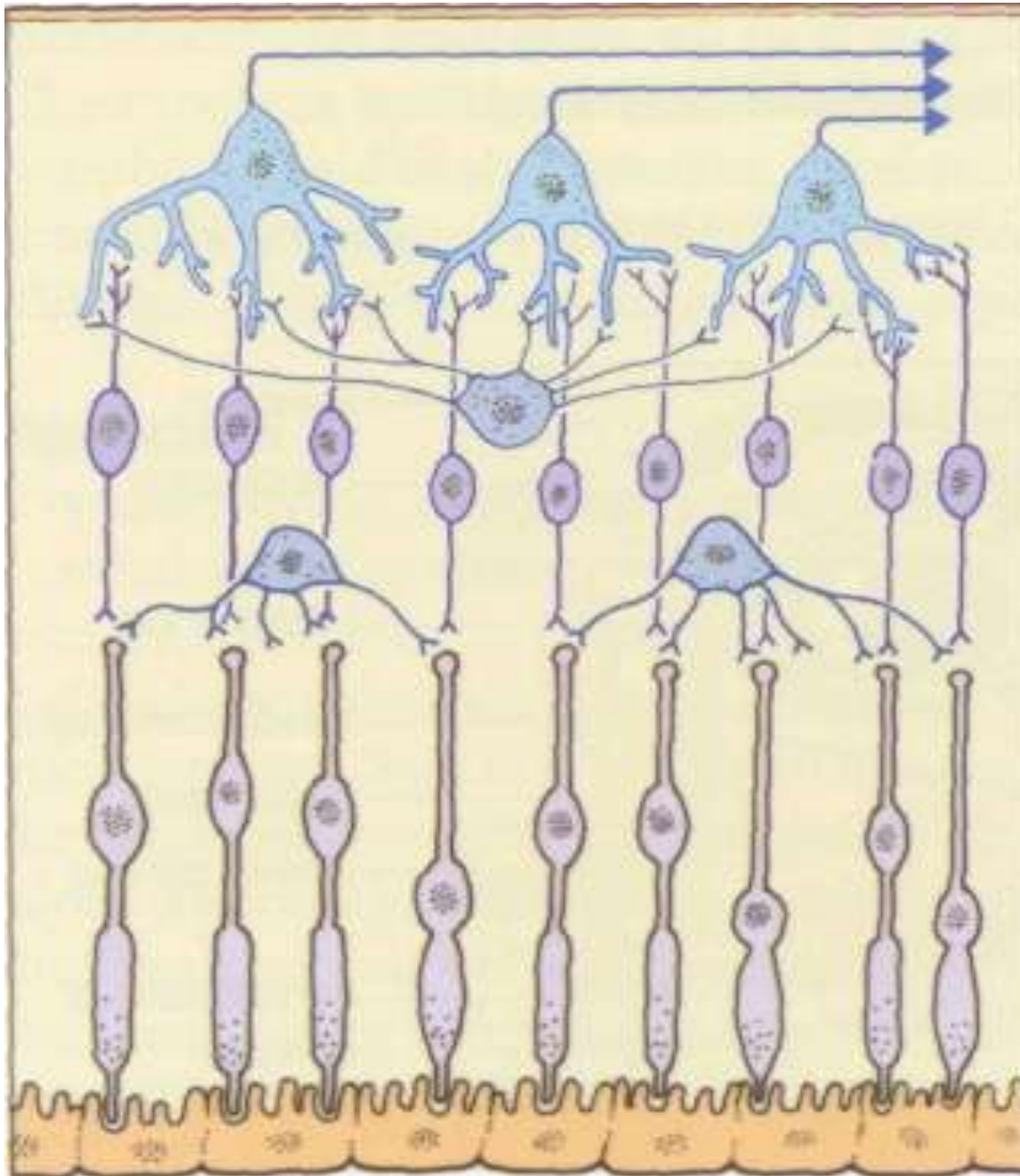
Layers of the retina

Ganglion cells

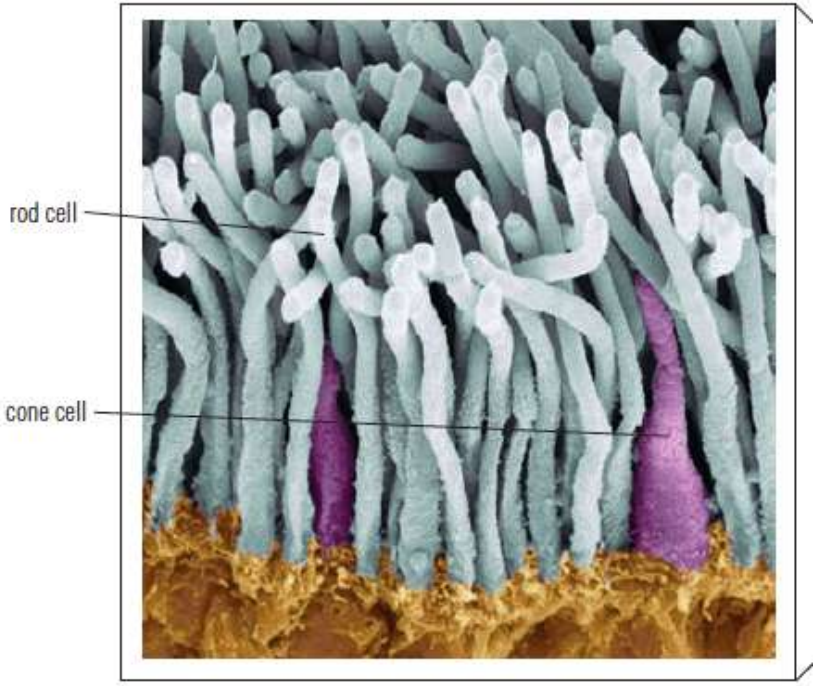
Connecting and processing cells

Photoreceptor rods and cones

Retinal pigment epithelium



Rods and Cones



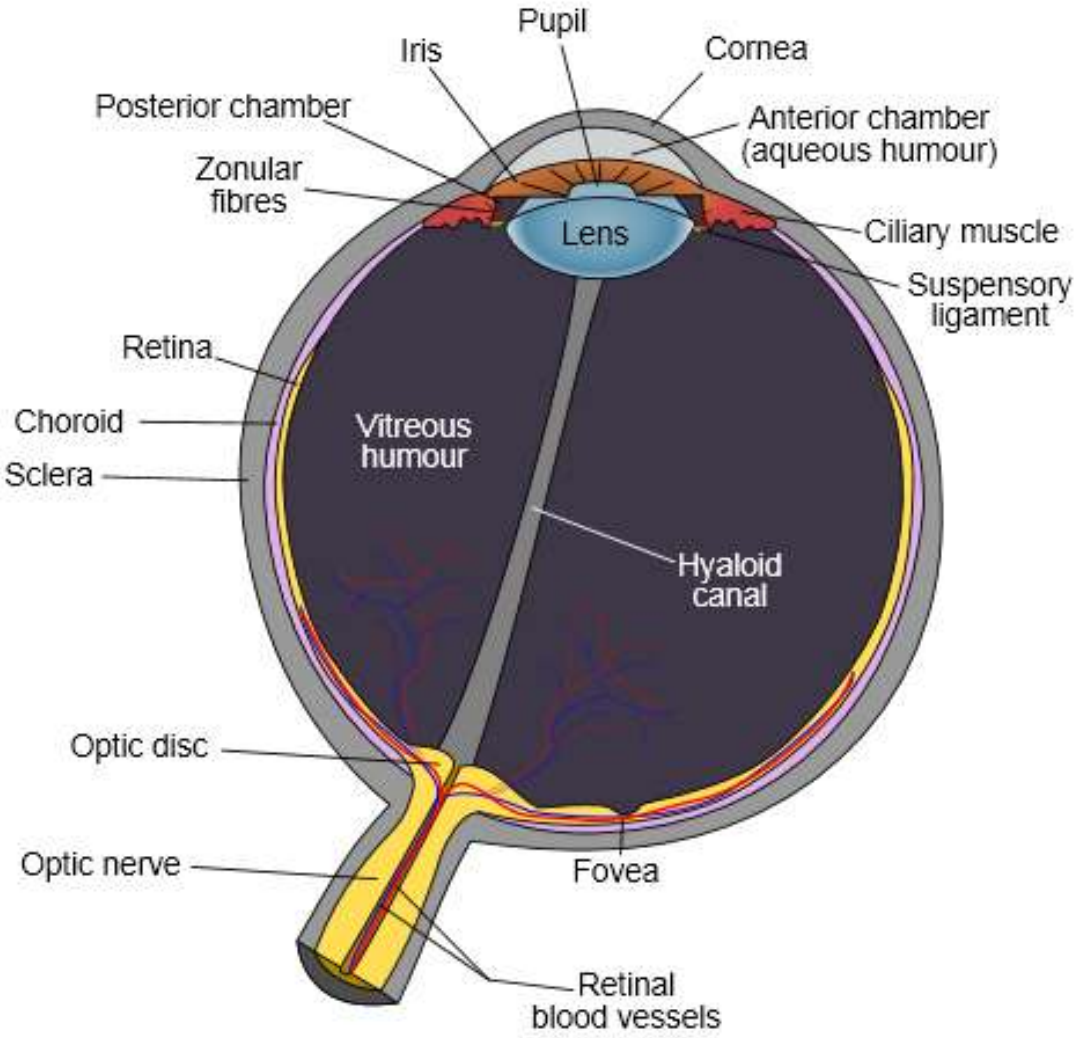
- **rod** cells: **light** sensors
  - 120 million
  - Functions in less intense light
  - Used in peripheral vision
  - Responsible for night vision
  - Detects black, white and shades of grey
- **cone** cells: detects **colour**
  - 7 million
  - Highest concentration at fovea centralis
  - Functions best in bright light
  - Perceives fine details
  - 3 types of cone cells, each sensitive to one of the three primary additive colours: red, green, and blue

Macula Lutea

- Small yellowish area of the retina near the optic disc (“yellow spot”)
- Area that provides the most acute vision (clear vision)
- When the gaze is fixed on any object, the centre of the macula, the centre of the lens, and the object are in a straight line

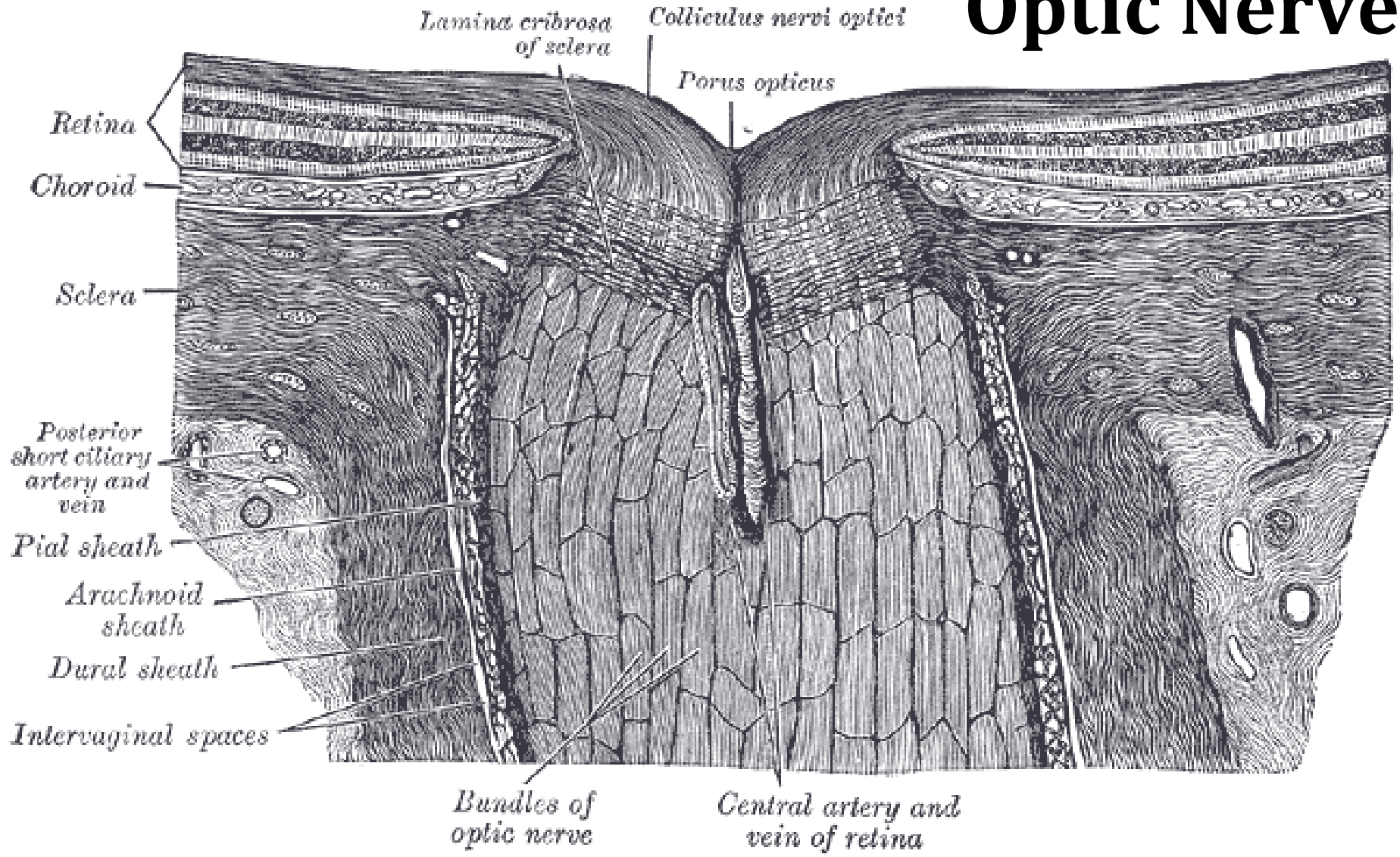
Fovea Centralis (Central Fovea)

- A pit in the centre of the macula lutea
- Contains no rod cells
- Has high concentration of cone cells
- Recall: cones are associated with colour vision and perception of fine detail
- No blood vessels to interfere with vision
- Provides sharp detailed vision (e.g. needed during reading, driving etc.)



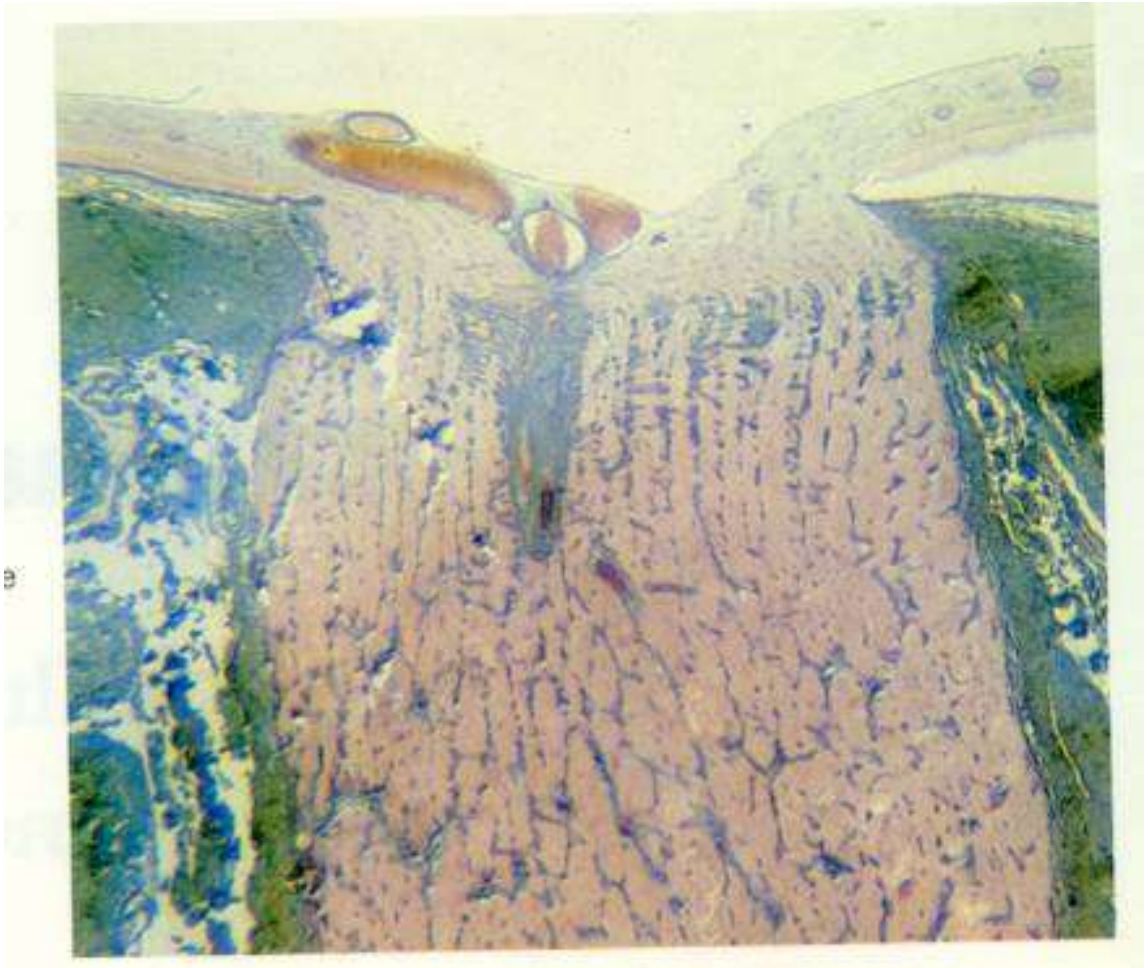
http://www.britannica.com/EBchecked/topic/355512/macula-lutea

Optic Nerve

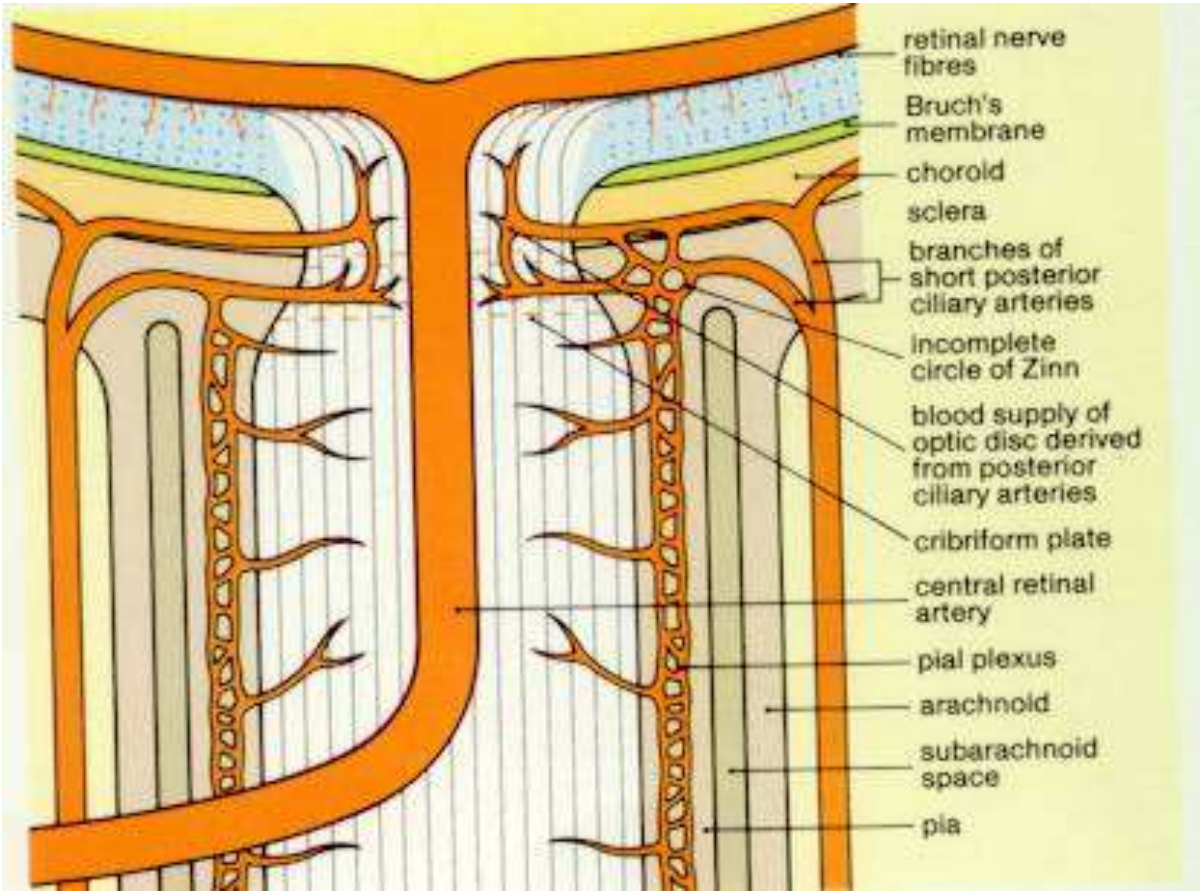


- Nerve cells that transmit message from light-sensitive cells in retina to the brain

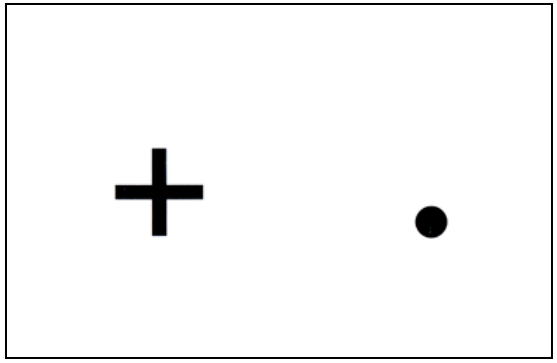
Optic Nerve



Vascular Supply of the Optic Nerve



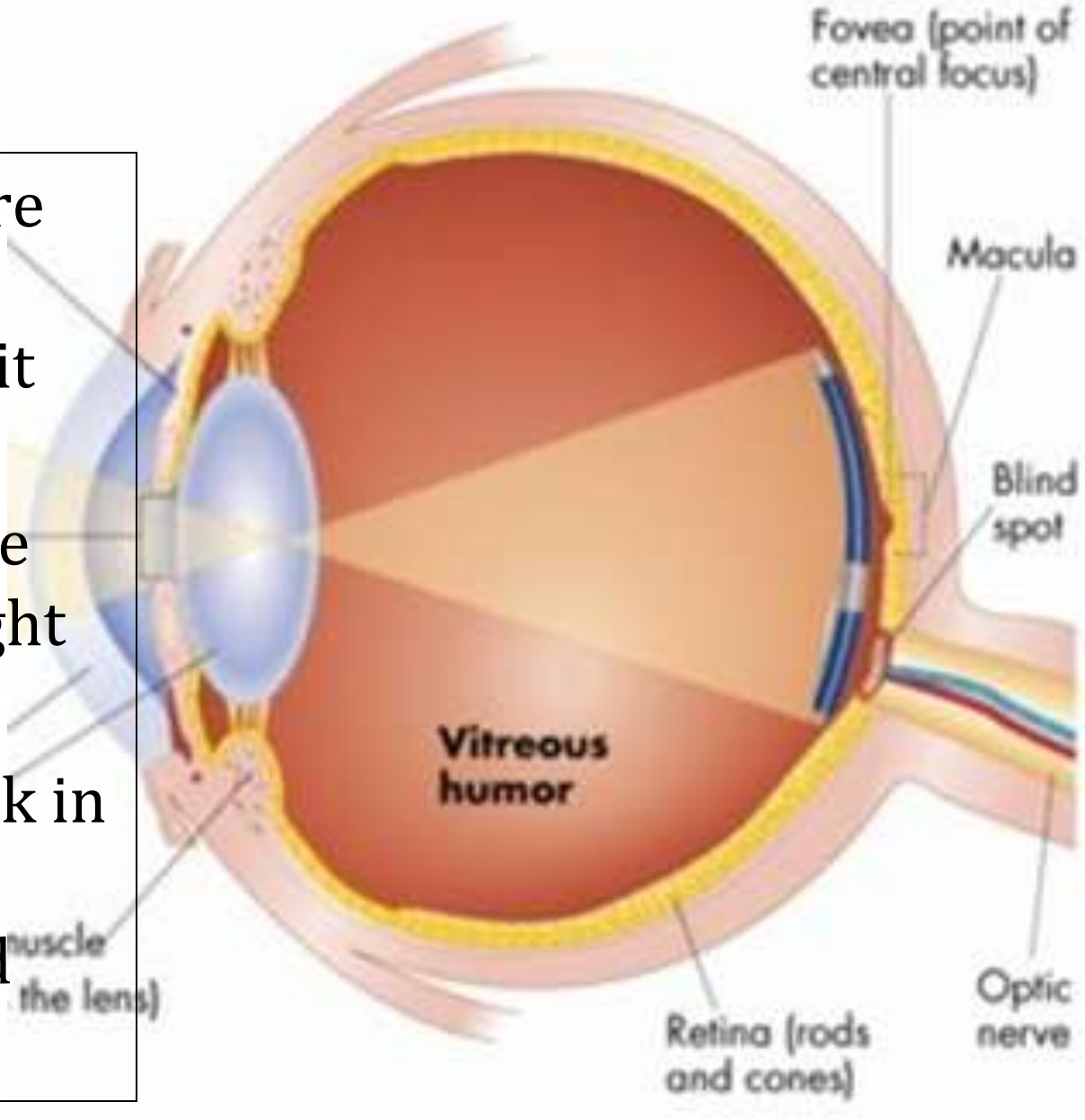
Activity: The reappearing dot

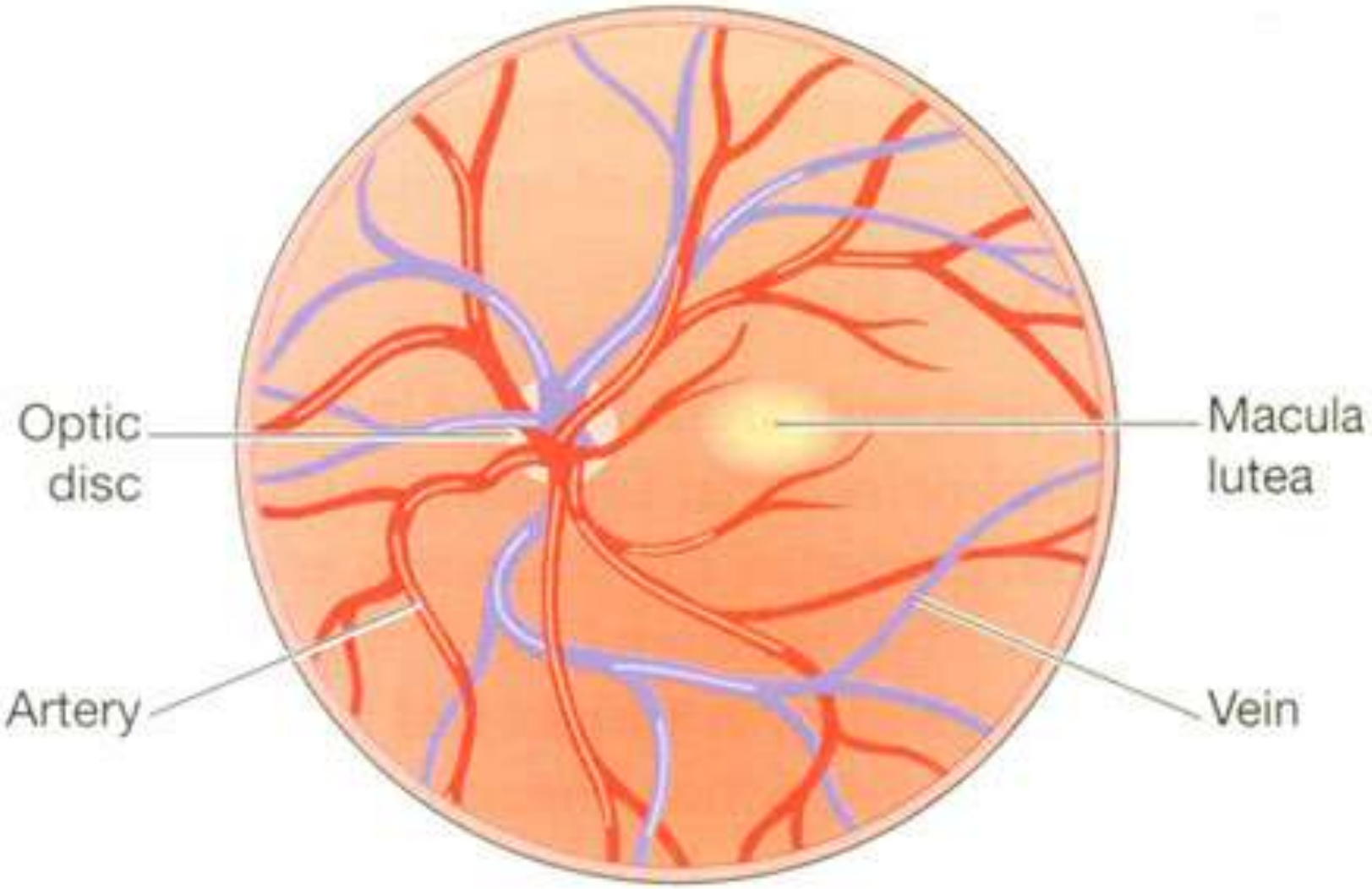


- Draw an X on a piece of paper. Then draw a dot 6 cm to the right of the X.
- Cover your left eye with your left hand.
- Hold the paper with your right hand at arms length away.
- Focus your right eye on the X but keep the dot in your peripheral vision.
- Slowly move the paper towards your face and notice when the dot “disappears” and “reappears”.

Blind Spot

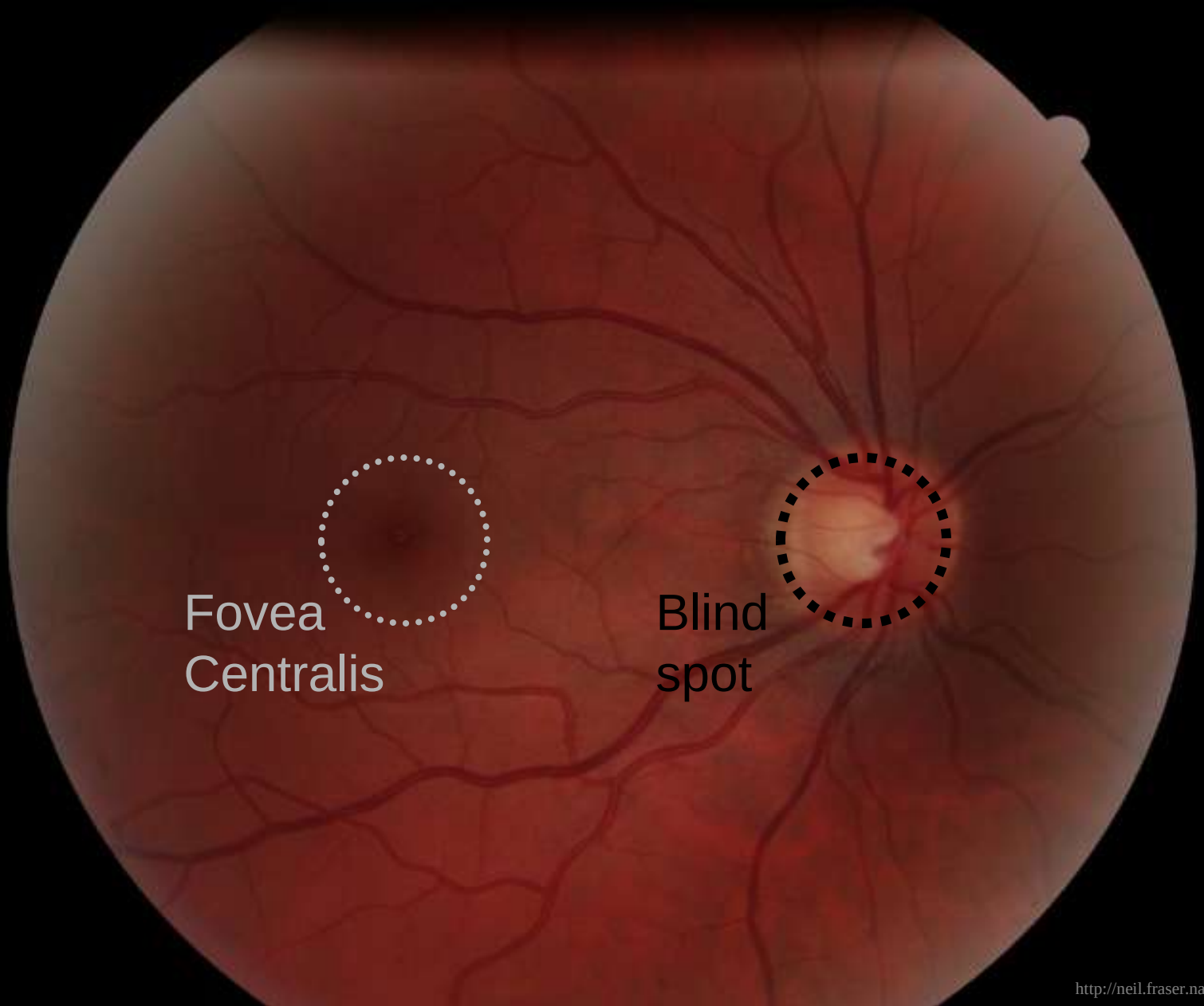
- **Optic disc**: where the optic nerves converge and exit the eye
- No light-sensitive cells to detect light rays
- Results in a break in the visual field, known as a blind spot





The retina as seen through the pupil with an ophthalmoscope.

Right Eye



http://neil.fraser.name/news/2008/11/22/

Nervous Tunic – Retina

several layers “inside out”

Pigmented epithelium

Rods and Cones (photoreceptors)

Bipolar cells

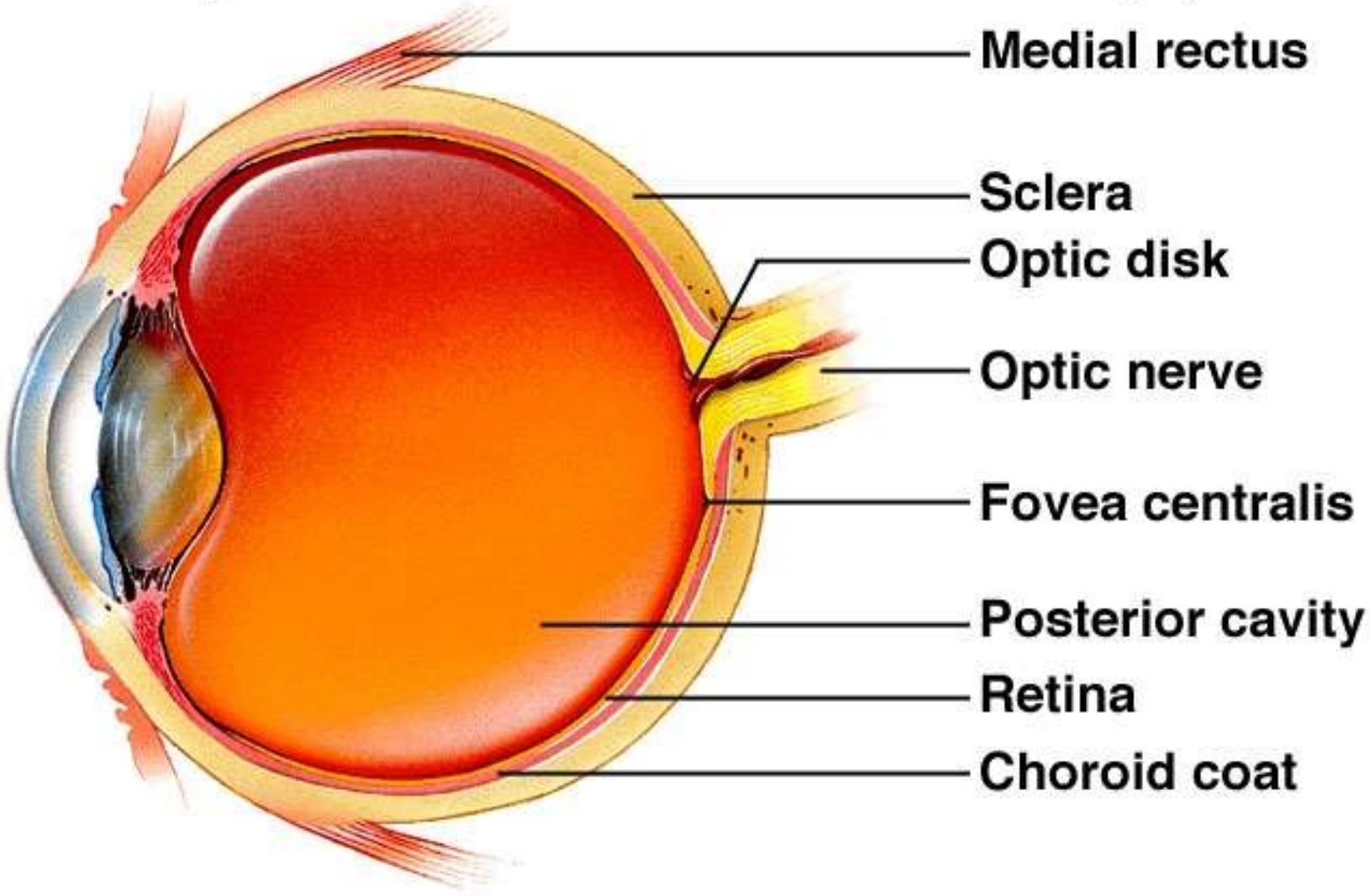
Ganglion cells

(vitreous humor)

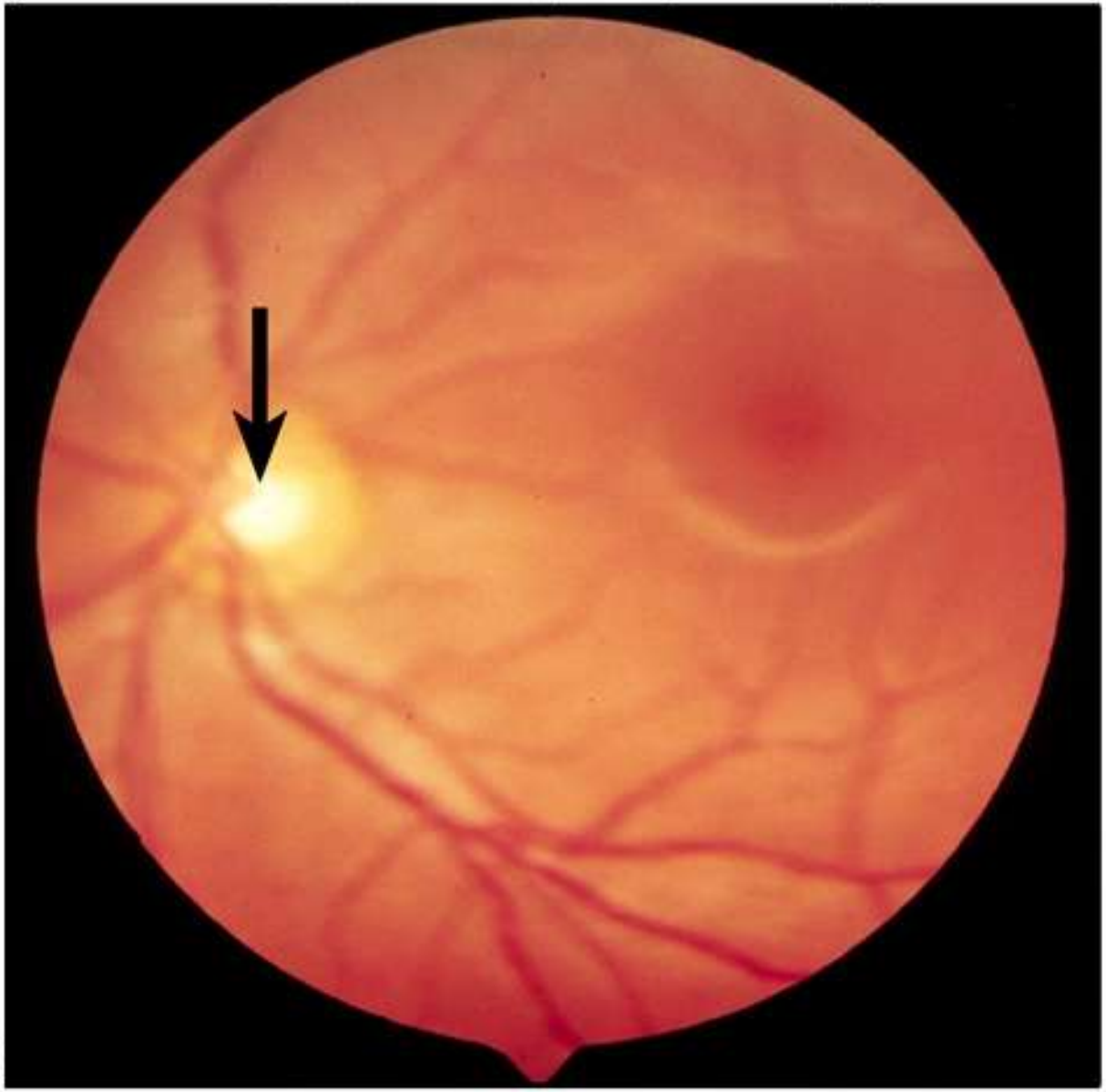
Light is focused by **cornea** and **lens** on the Fovea centralis (“central pit”)which is in the center of the Macula lutea (“yellow spot”)

The third refractive component is the **length of the eyeball**.

Eye — Transverse Section (2)

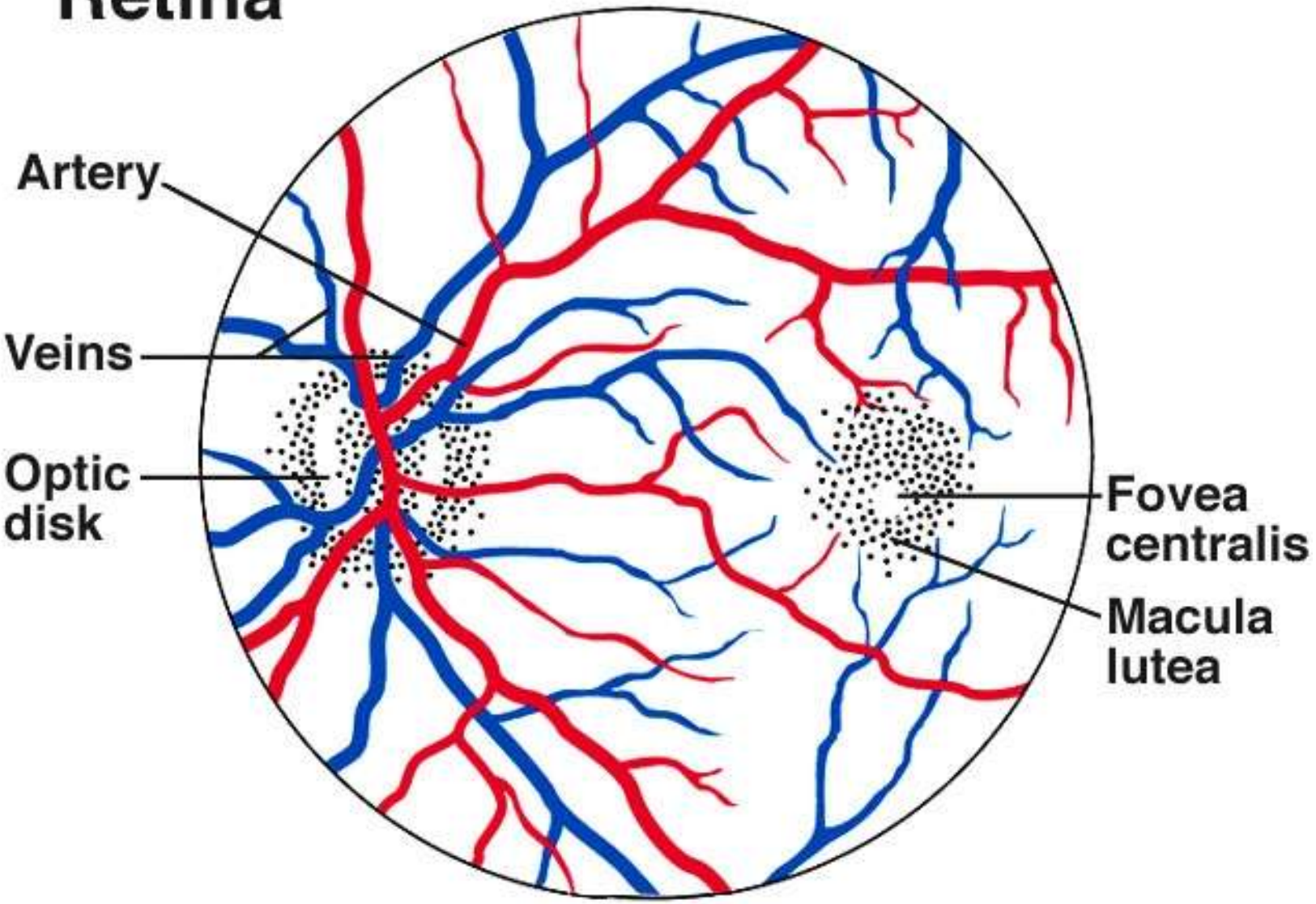


Optic Disk



(a)

Retina



Refractive Disorders

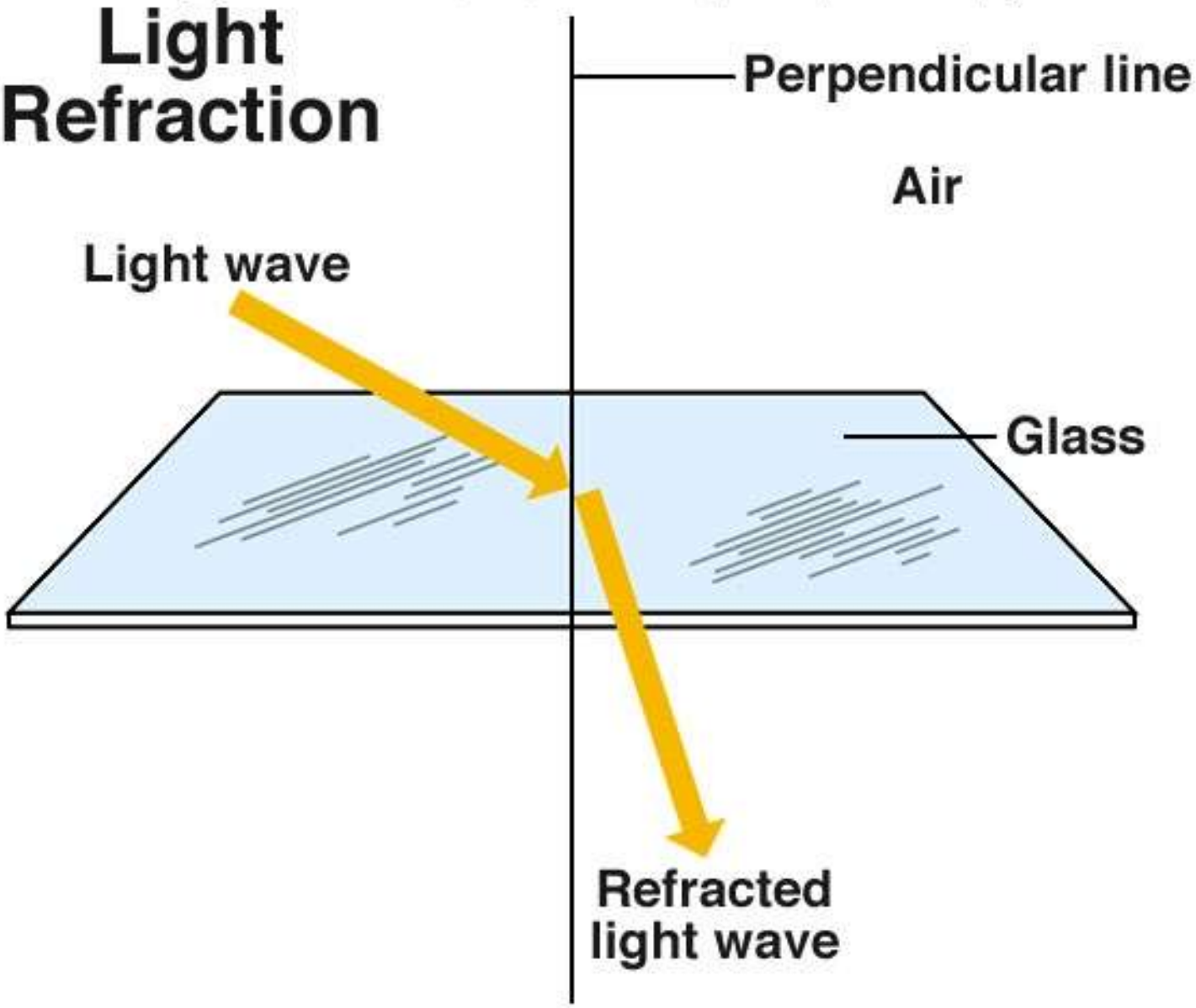
Emmetropia – good vision 20/20

Myopia – nearsightedness

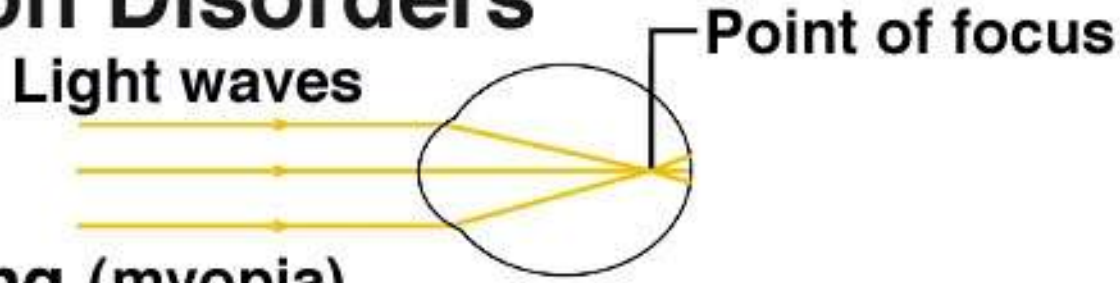
Hyperopia – farsightedness

Astigmatism – light does not focus to a single point on the retina

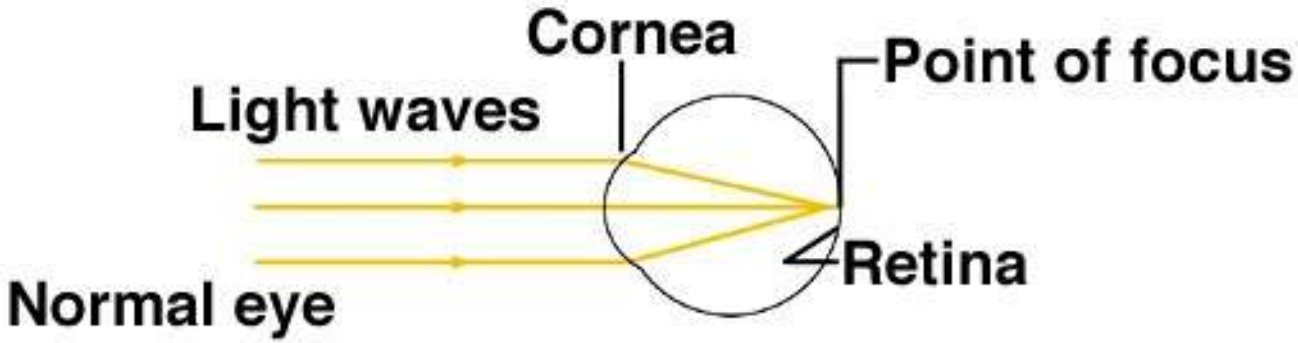
Presbyopia – “old sight” – loss of ability to accommodate or see up close



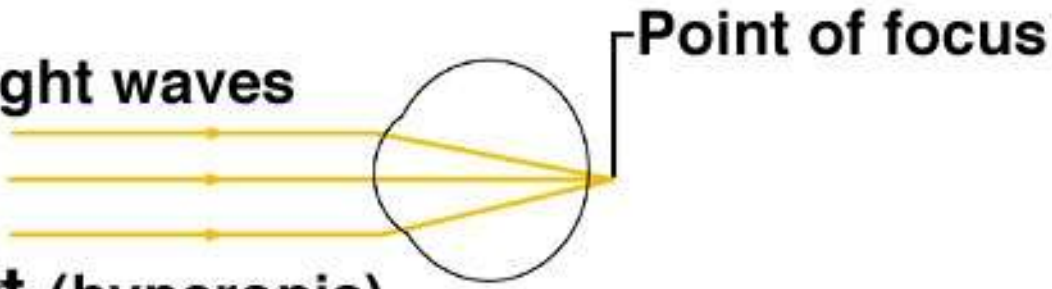
Refraction Disorders



Eye too long (myopia)

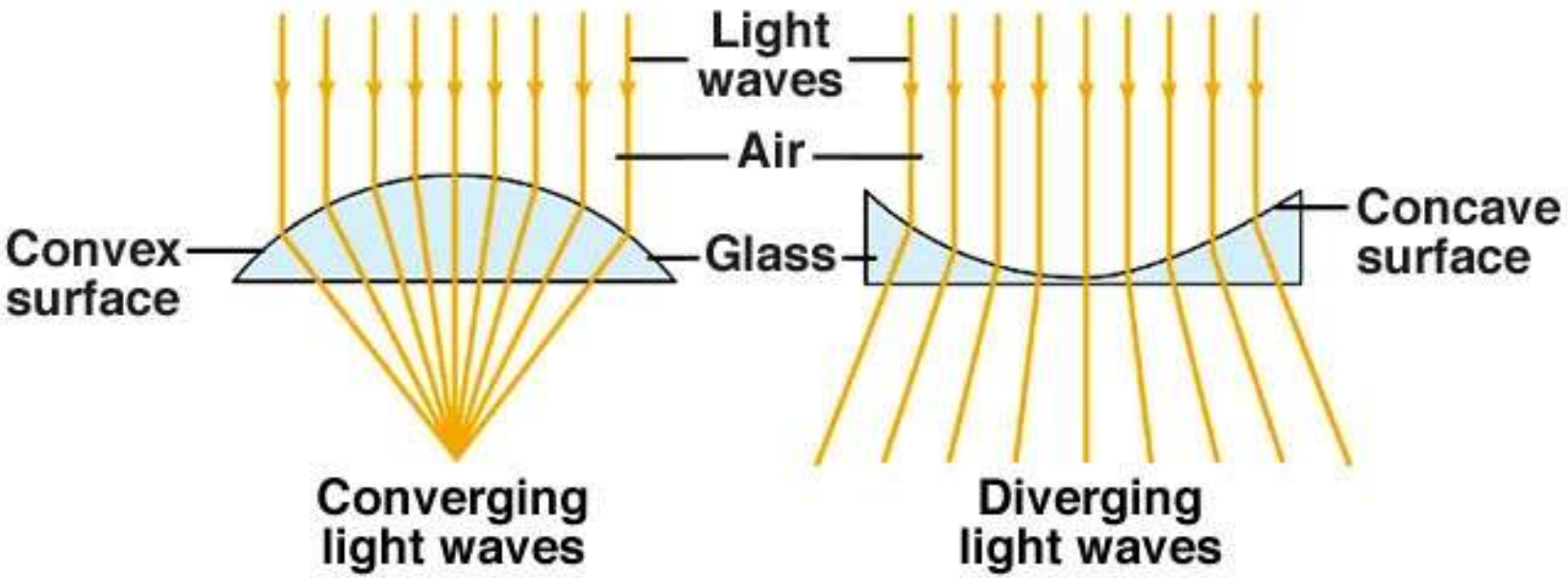


Normal eye

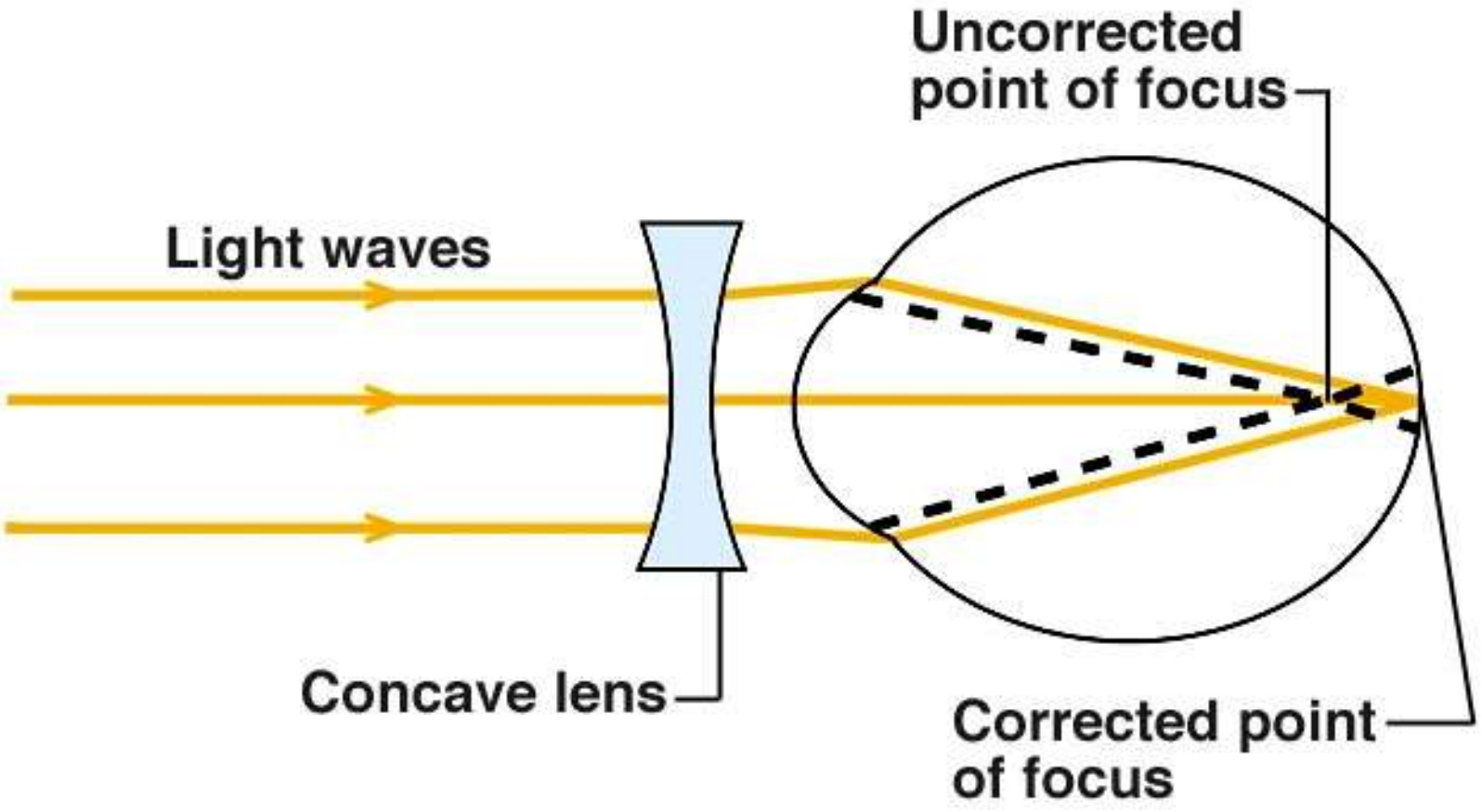


Eye too short (hyperopia)

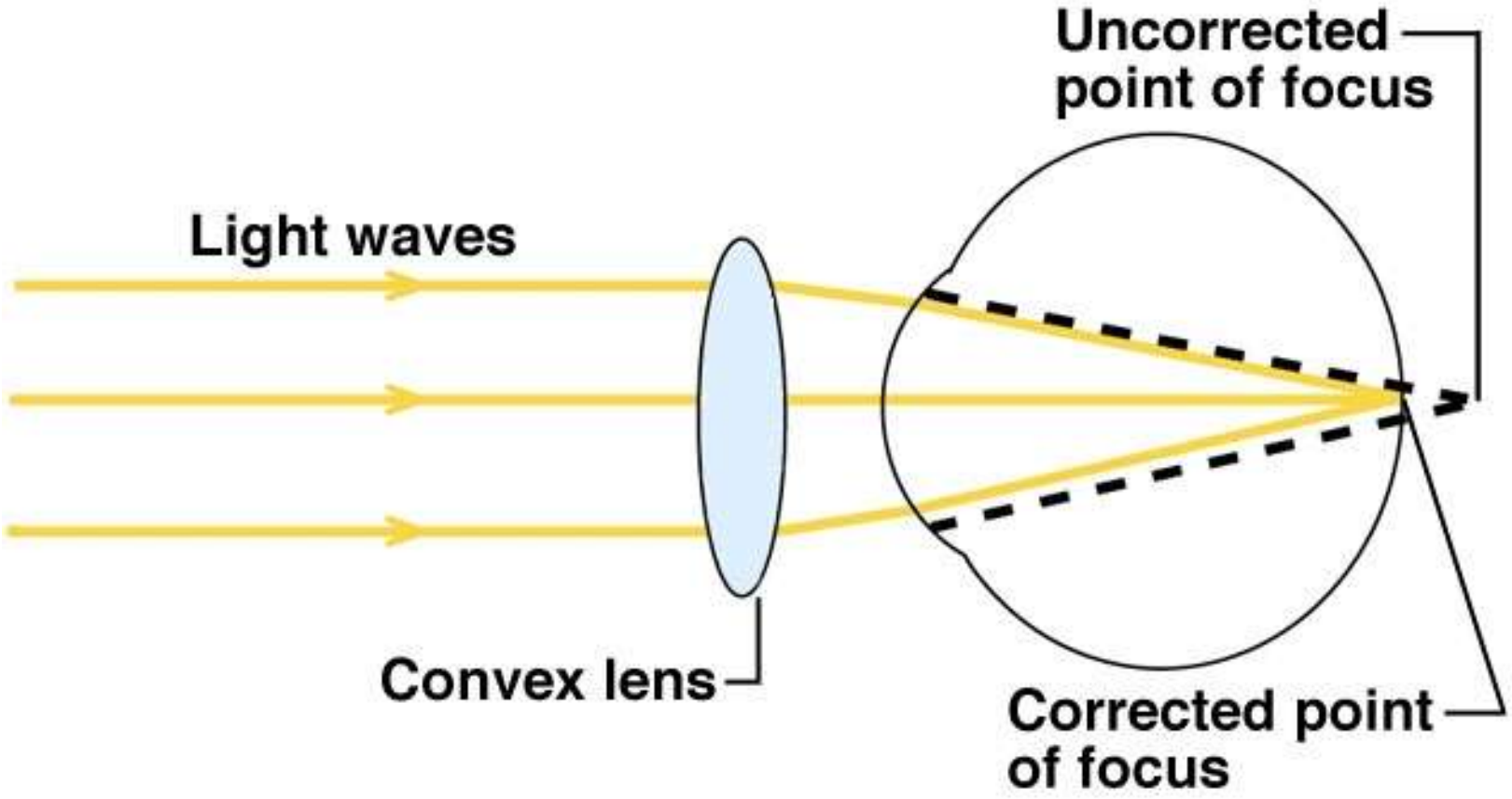
Convex and Concave Lens



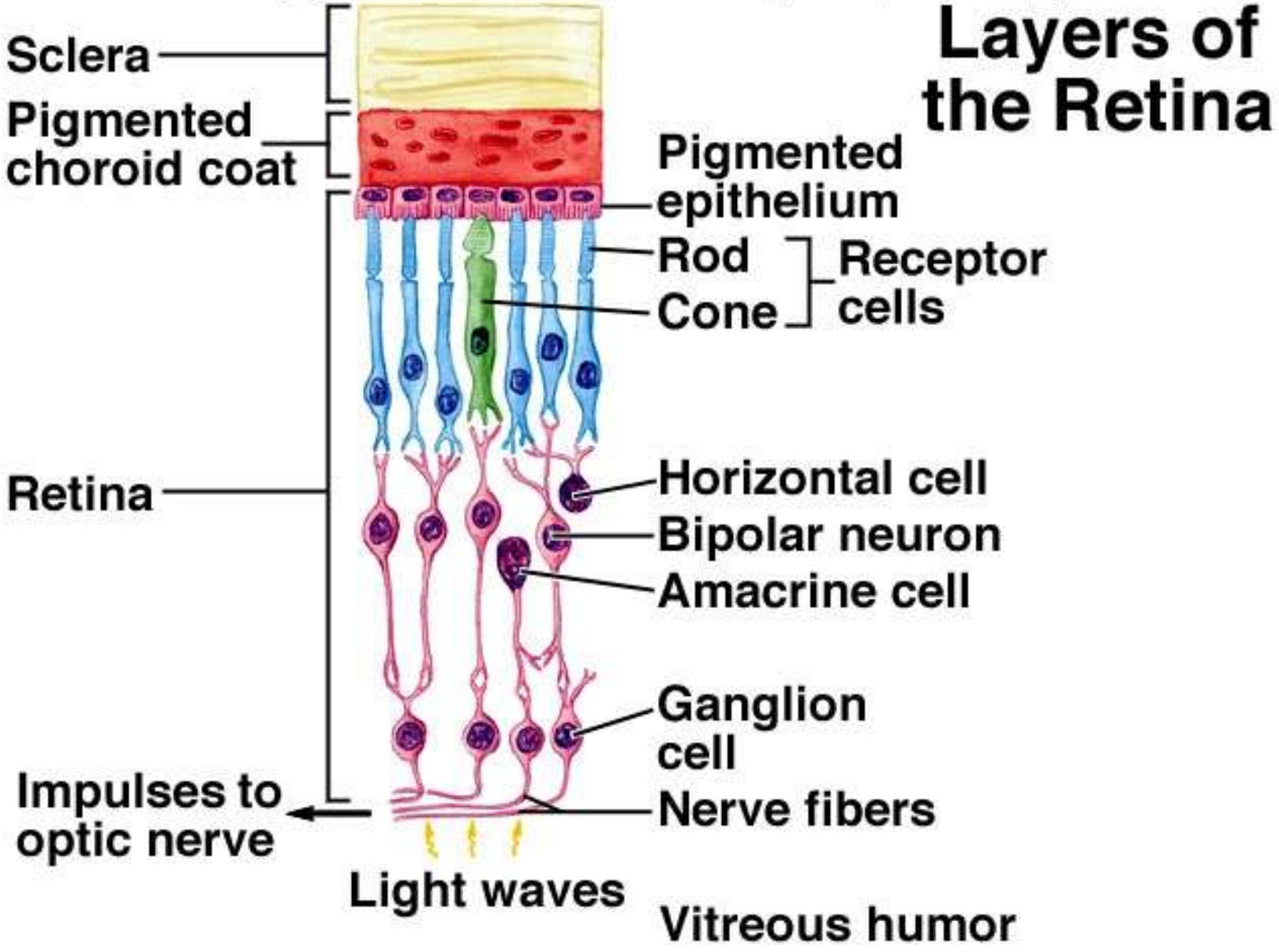
Correction of Nearsightedness



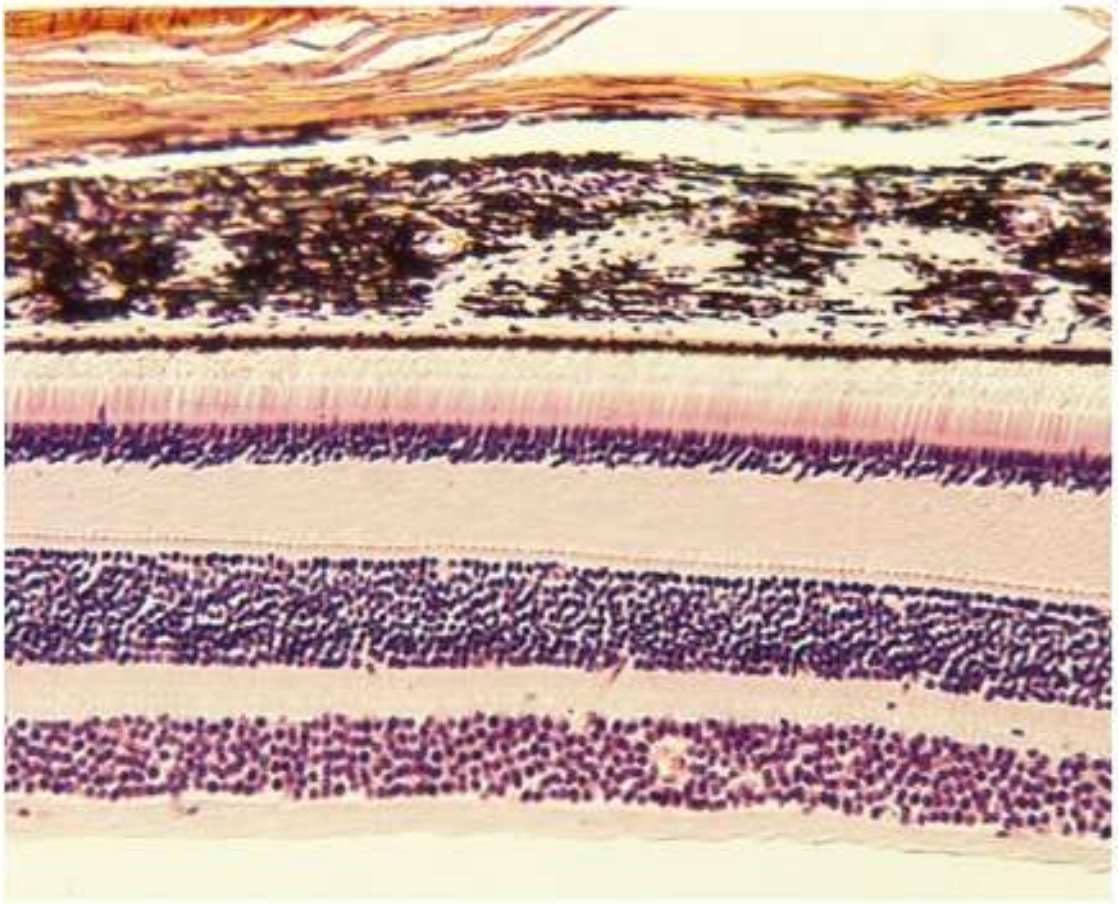
Correction of Farsightedness



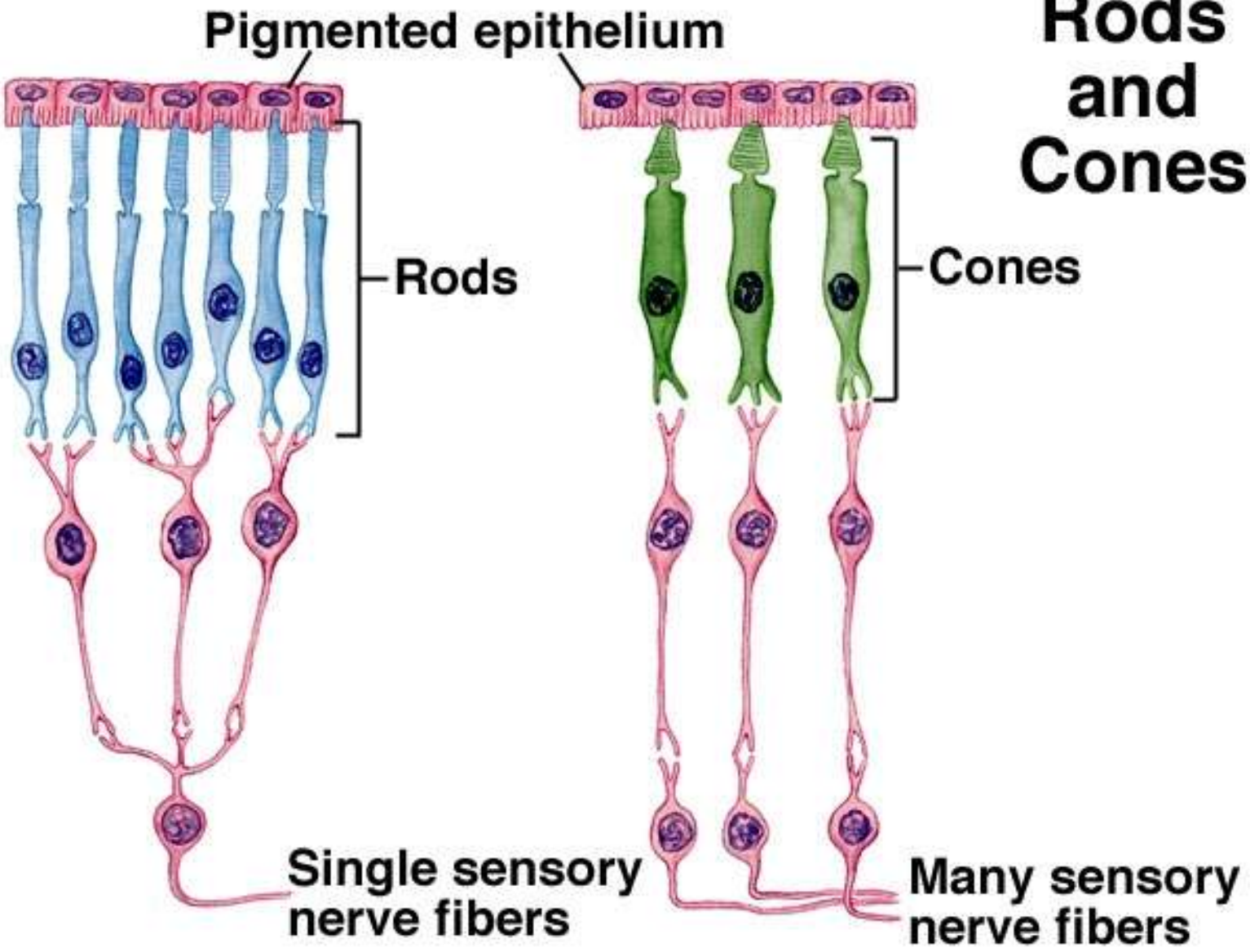
Layers of the Retina



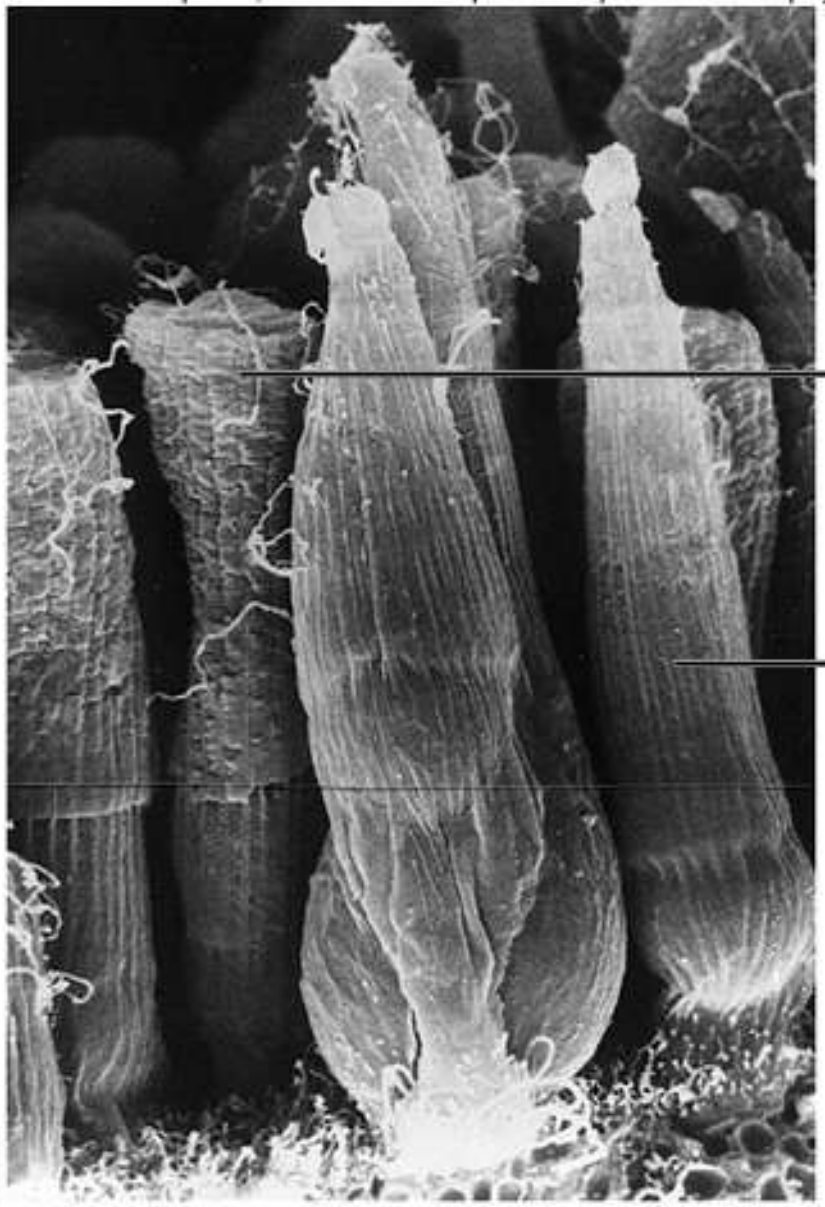
Layers of the Retina



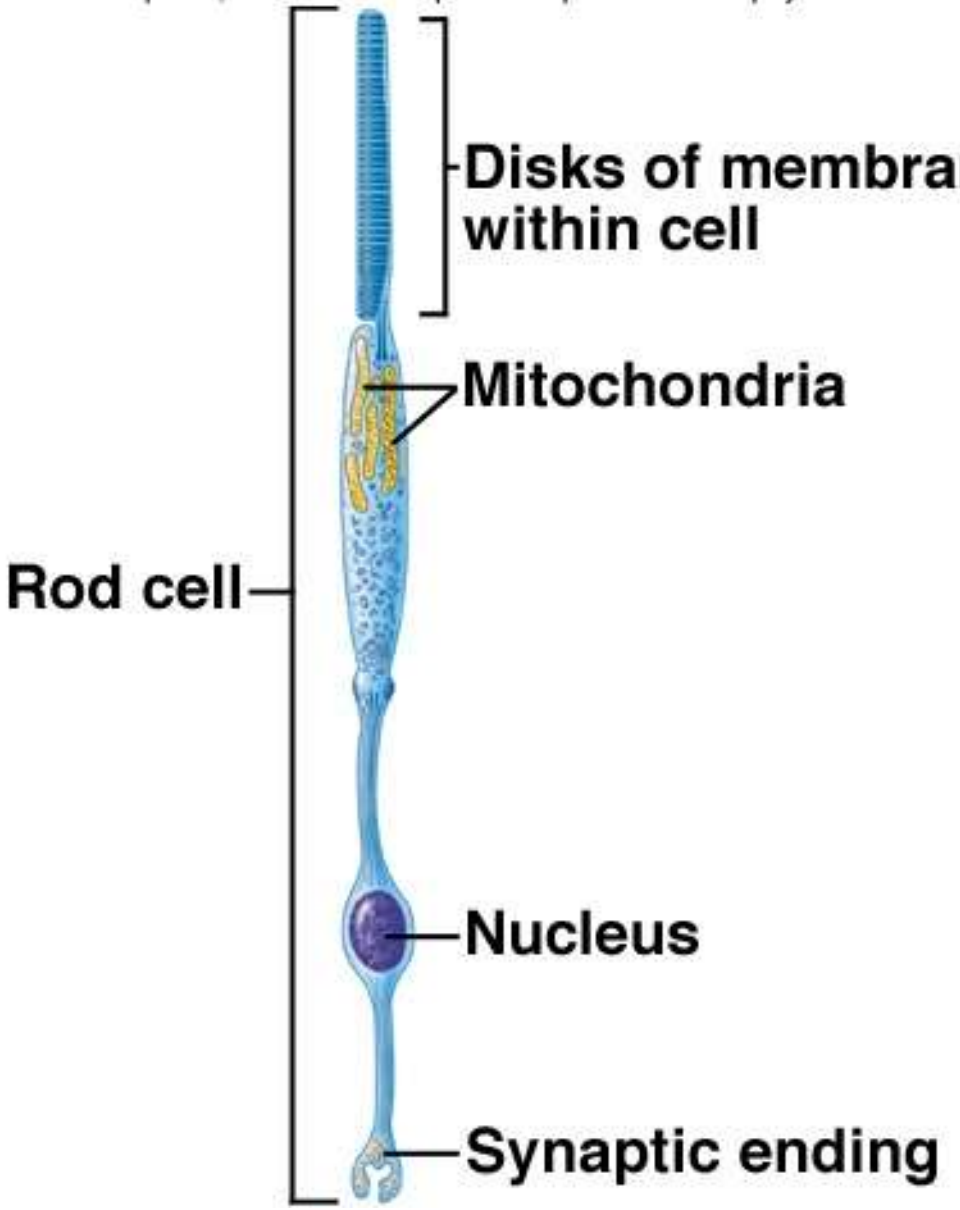
Rods and Cones



Rods and Cones



Rhodopsin Pigment in Rod Cell

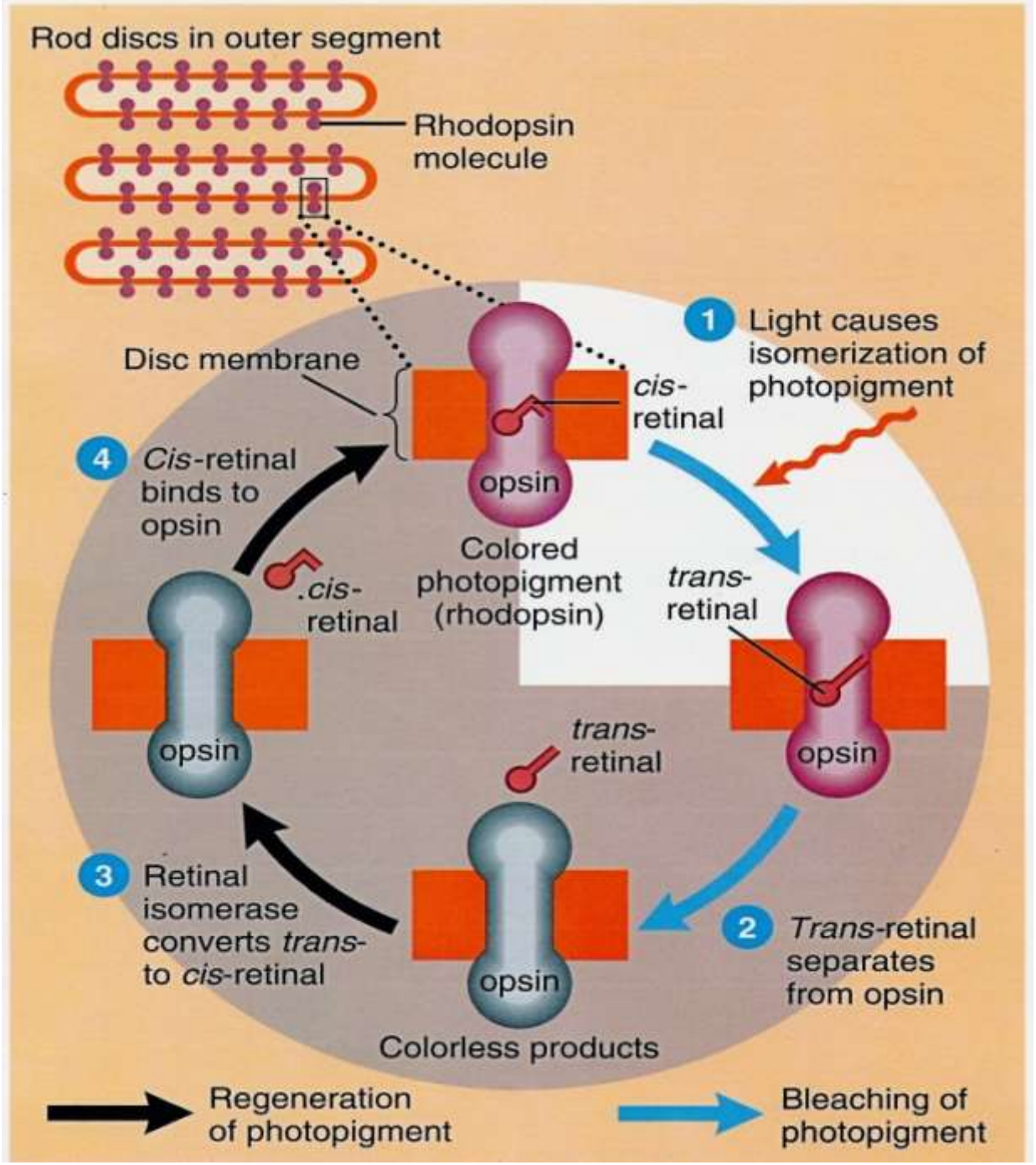


Physiology of vision

In the dark, Na+ channels are held open by a nucleotide called cyclic GMP (guanosine monophosphate)

Inflow of sodium (“dark current”) triggers the continual release of neurotransmitter .

This neurotransmitter is inhibitory- it prevents bipolar cells from firing by hyperpolarizing them.


Rod discs in outer segment
Rhodopsin molecule
Disc membrane
1 Light causes isomerization of photopigment
cis-retinal
opsin
Colored photopigment (rhodopsin)
trans-retinal
opsin
2 Trans-retinal separates from opsin
trans-retinal
opsin
Colorless products
3 Retinal isomerase converts trans- to cis-retinal
cis-retinal
opsin
4 Cis-retinal binds to opsin
Regeneration of photopigment
Bleaching of photopigment

When light strikes the retina, retinal (from vitamin A) which is bent, straightens out, and no longer fits into the opsin.

The two separate – this is called bleaching.

The opsin becomes an active enzyme, that activates other enzymes that break down cyclic GMP.

Without cyclic GMP, the Na+ channels close.

The receptor hyperpolarizes, stopping the release of inhibitory neurotransmitter.

This decrease in inhibition allows the bipolar cells to fire, and information is sent to the visual cortex.

Differentiation of color is assisted by horizontal cells.

In darkness, retinal isomerase converts trans-retinal back to cis-retinal, which binds with opsin forming a functional photopigment.

Color vision

Uses three different photopigments :
blue, green and red

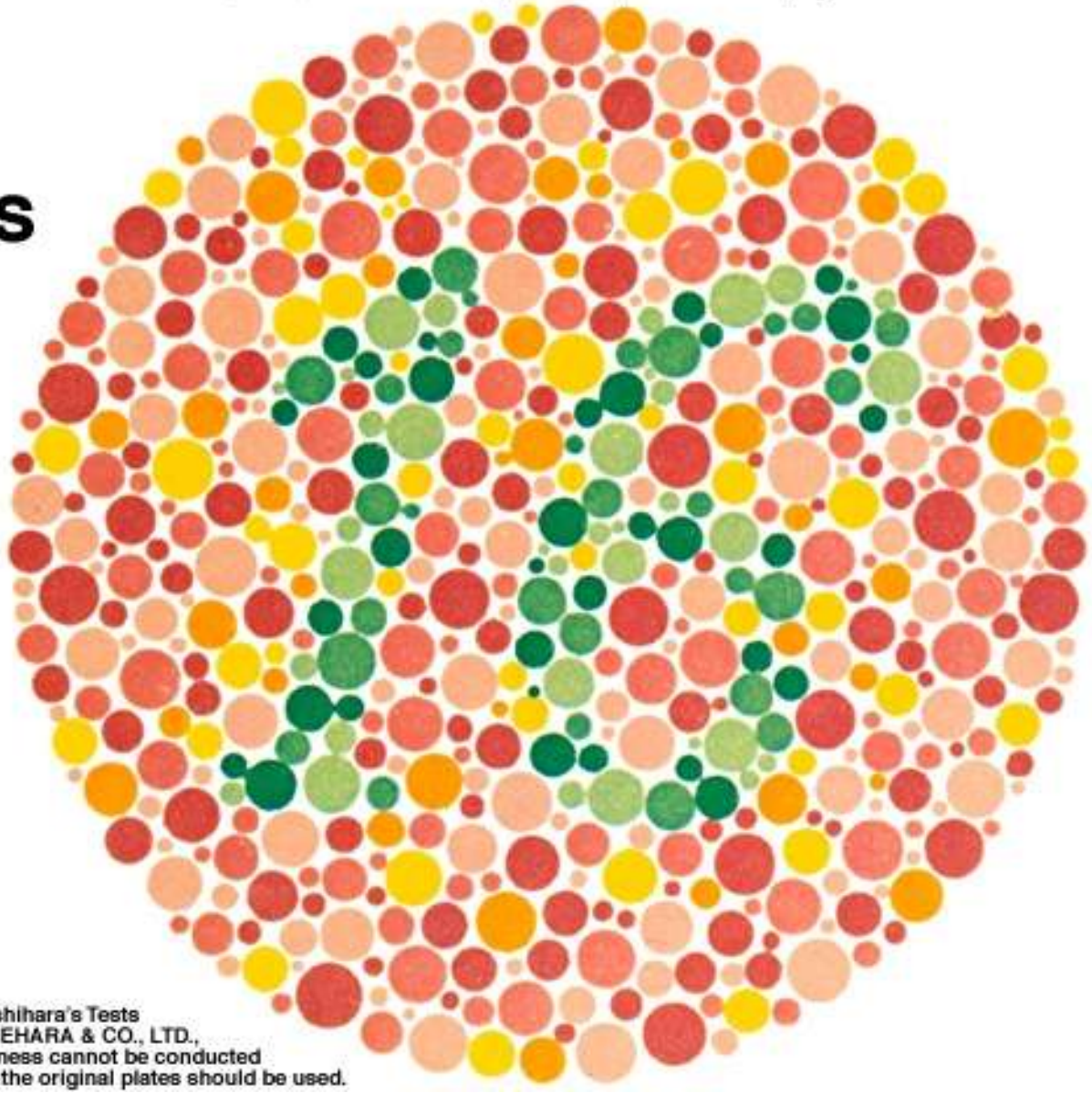
Wavelength of pigments may be shifted, causing color blindness

Red – green color blindness most common

Sex-linked trait carried on X chromosome

(Males only have **one** gene for color vision)

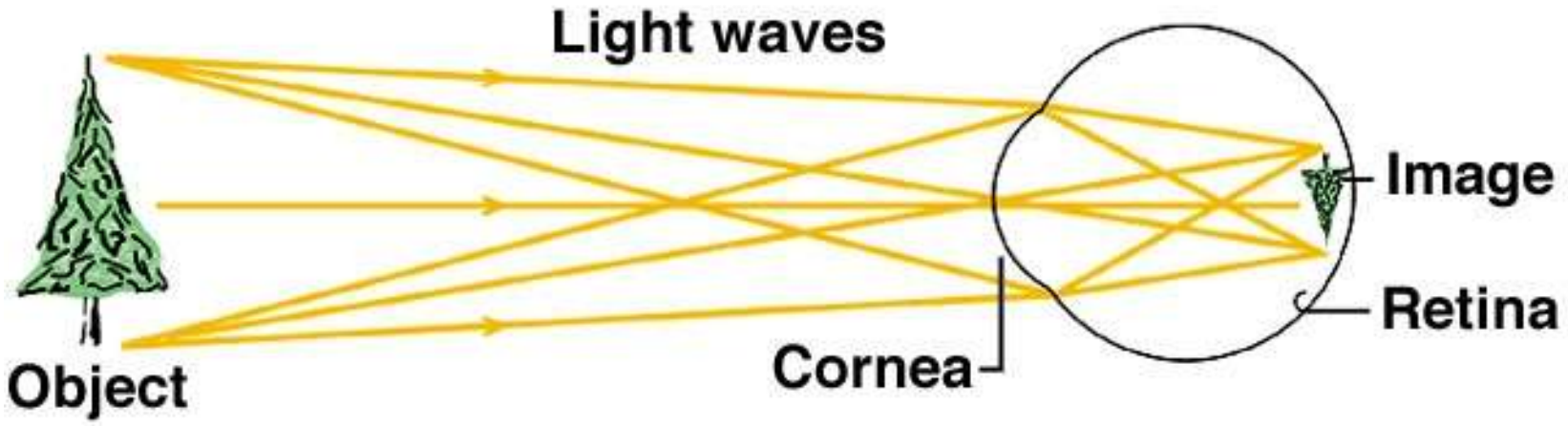
Test for Color Blindness



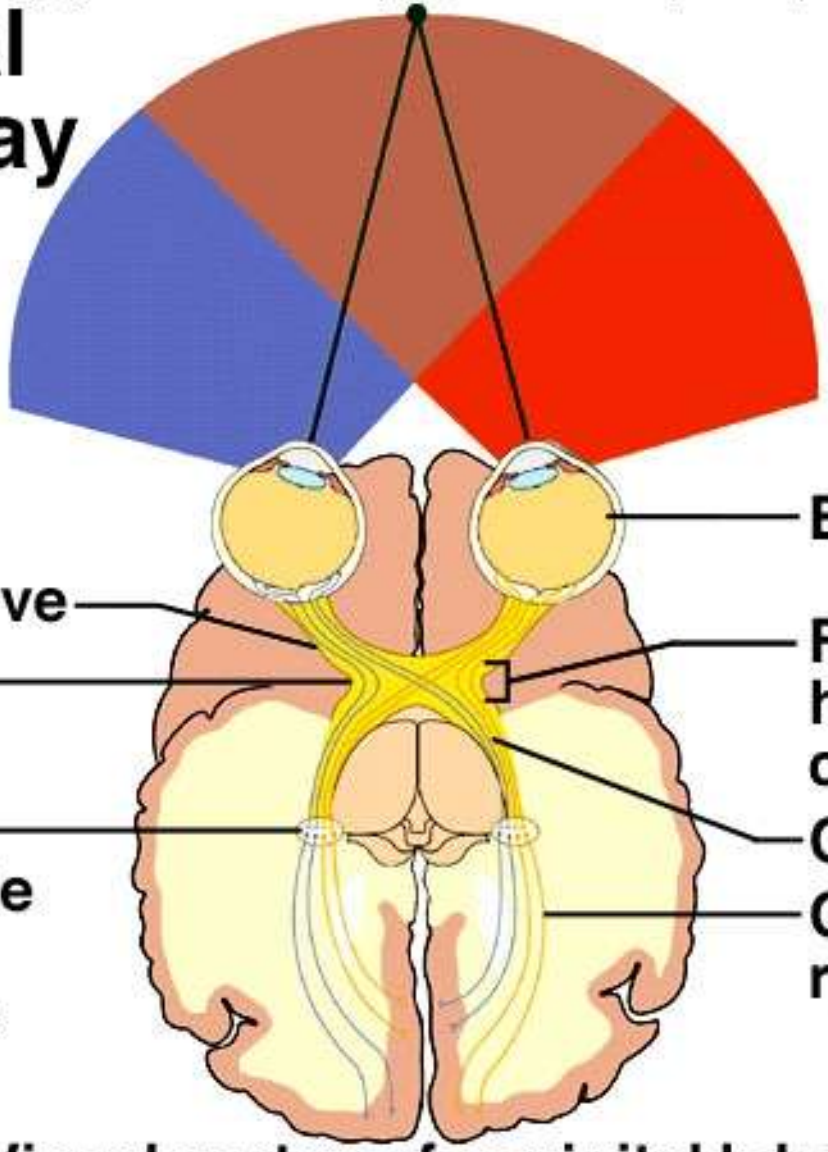
The above has been reproduced from Ishihara's Tests for Colour Blindness published by KANEHARA & CO., LTD., Tokyo, Japan, but tests for colour blindness cannot be conducted with this material. For accurate testing, the original plates should be used.

Rods:	**Cones:**
Can see in dim light	Require more light
See in black and white	See in color
Respond to movement	Give best acuity
Found more in periphery	More central, esp. in fovea centralis

Retinal Image



Visual Pathway



Eye

Optic nerve

Optic chiasma

Fibers from nasal half of each retina crossing over

Lateral geniculate body of thalamus

Optic tract

Optic radiations

Visual cortex of occipital lobe

Stereopsis

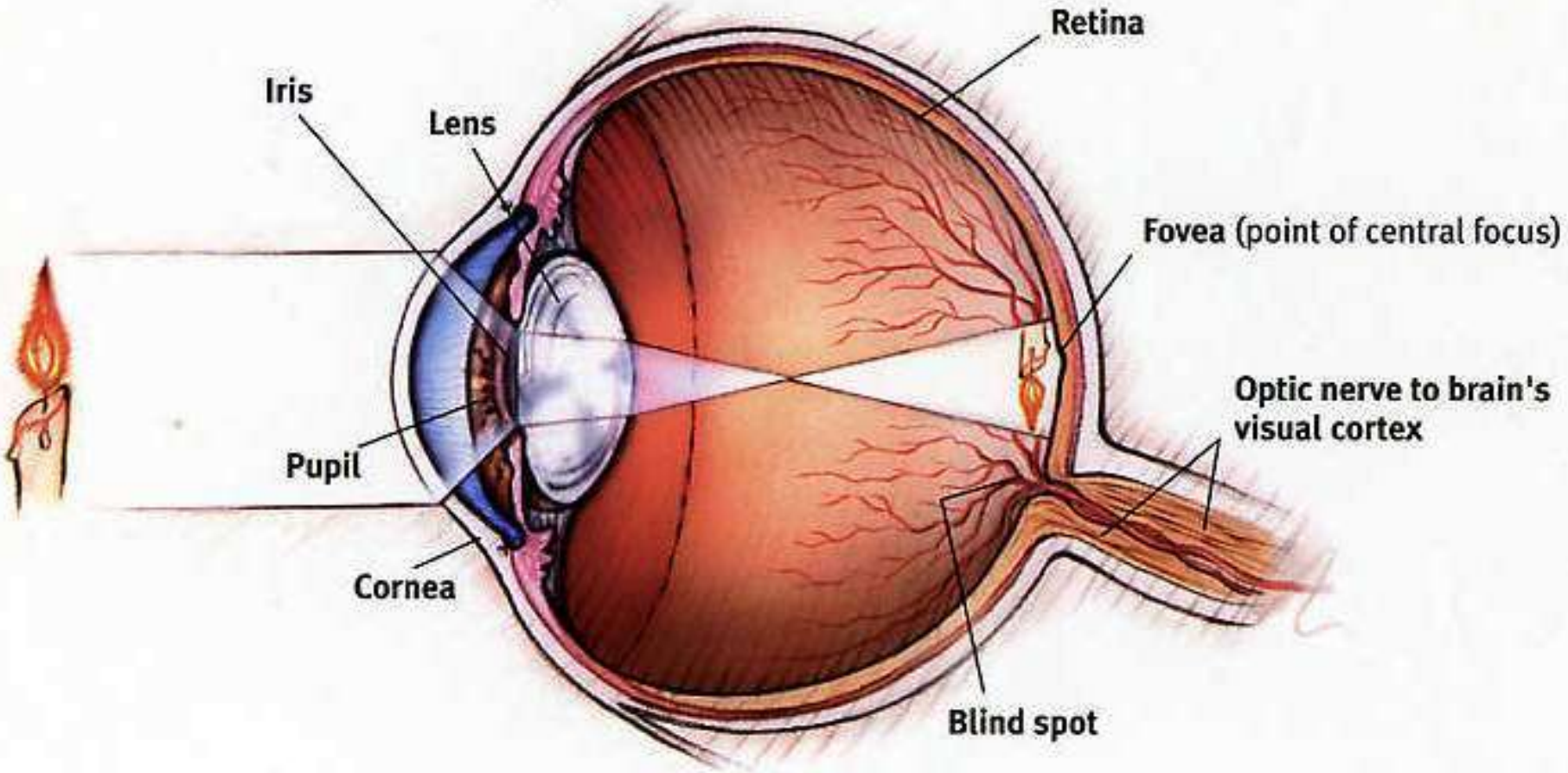
Use both eyes to perceive depth – “depth perception”

Nasal fibers cross at the optic chiasm

Temporal fibers do not cross over

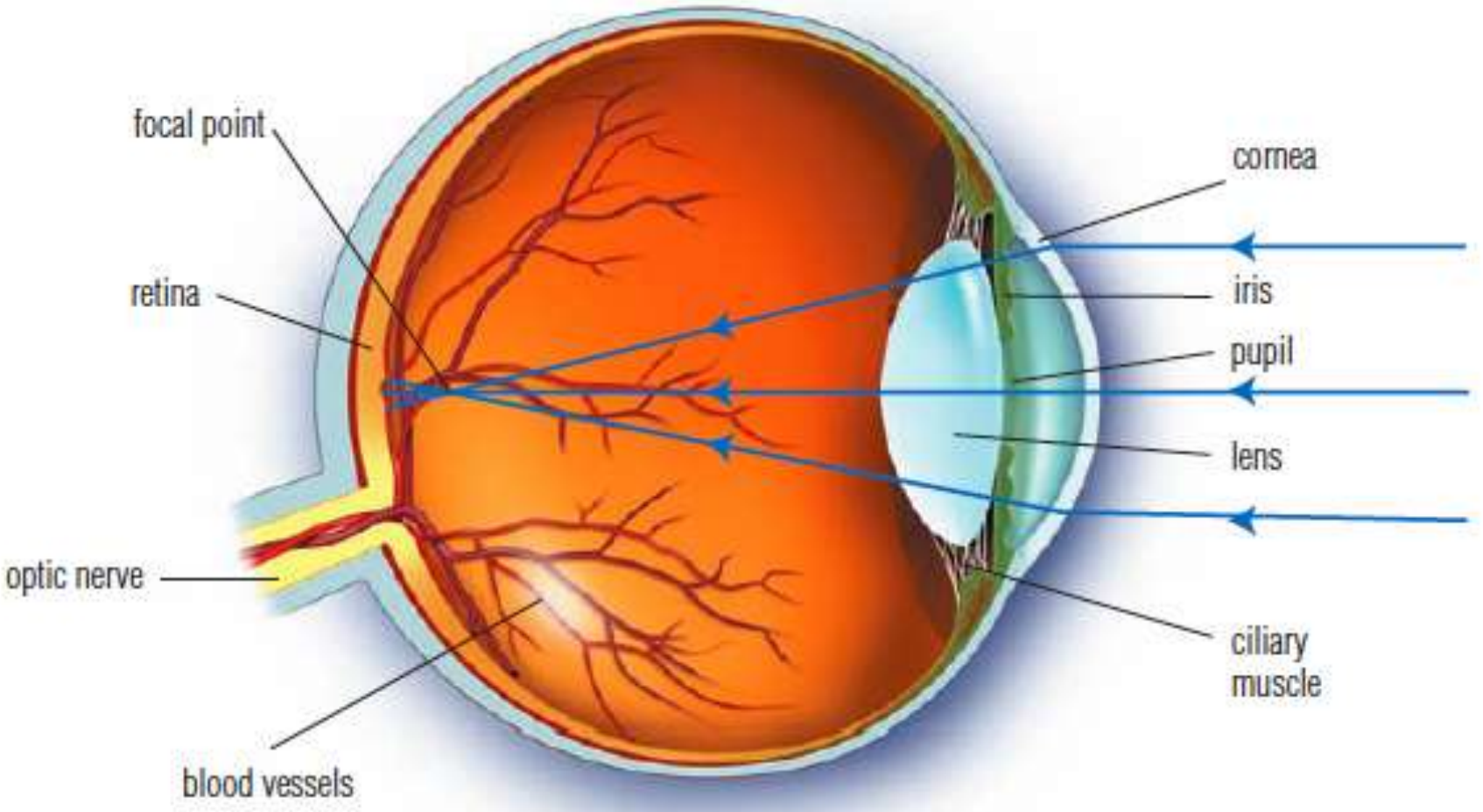
Each visual cortex (R &L) receives information from both eyes so it can compare what each eye sees.

Producing an Image



The converging lens produces an inverted image which the brain interprets as being upright

Producing an Image



- Cells on retina trigger a nerve impulse
- Nerve cells sends an electrical signal to the brain via the optic nerve

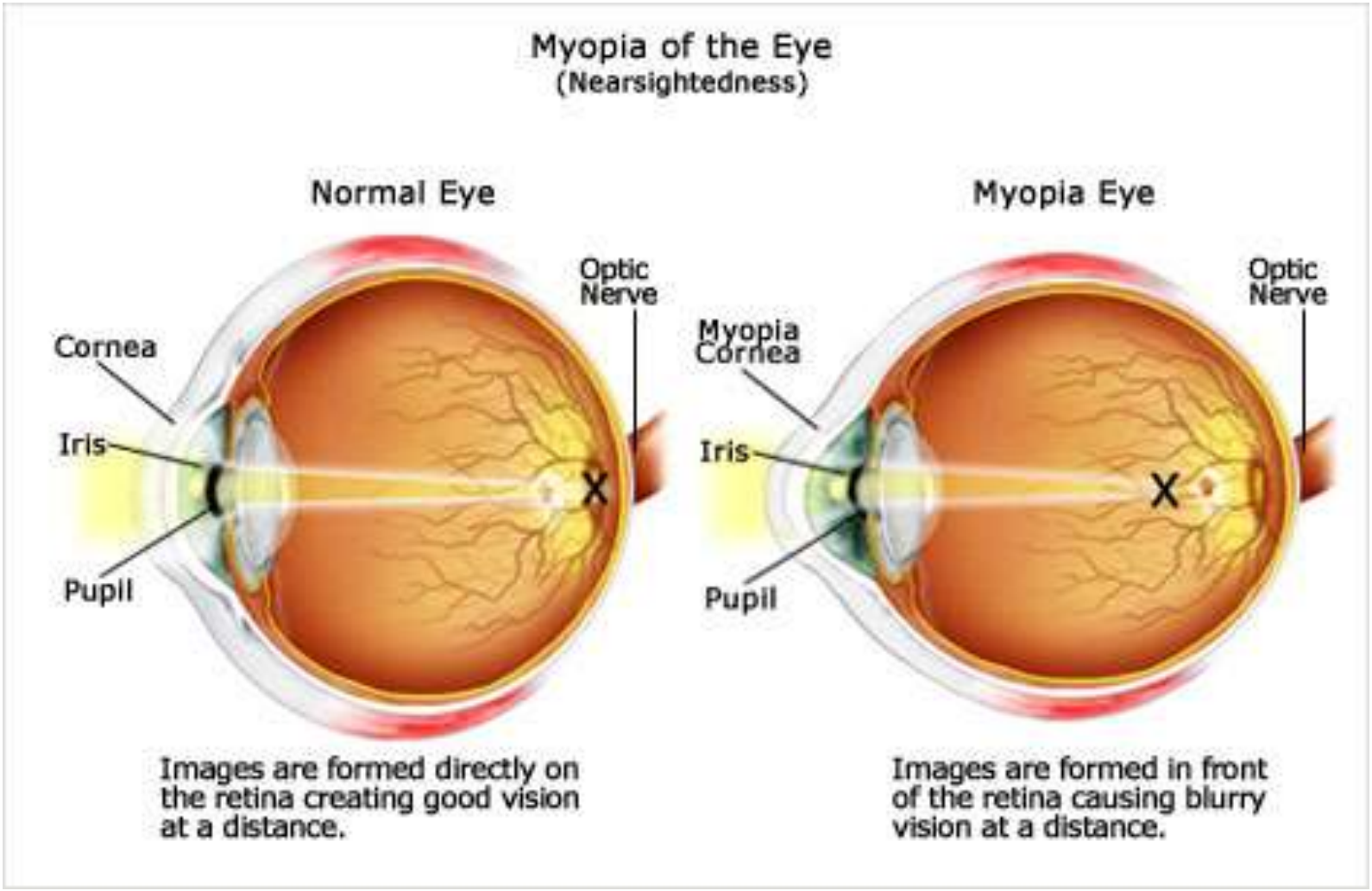
Visual pathway

- Retina
- Optic nerve
- Optic chiasm
- Optic tract
- Optic radiation
- Occipital lobe (Visual center)

Video: How the Human Eye Works

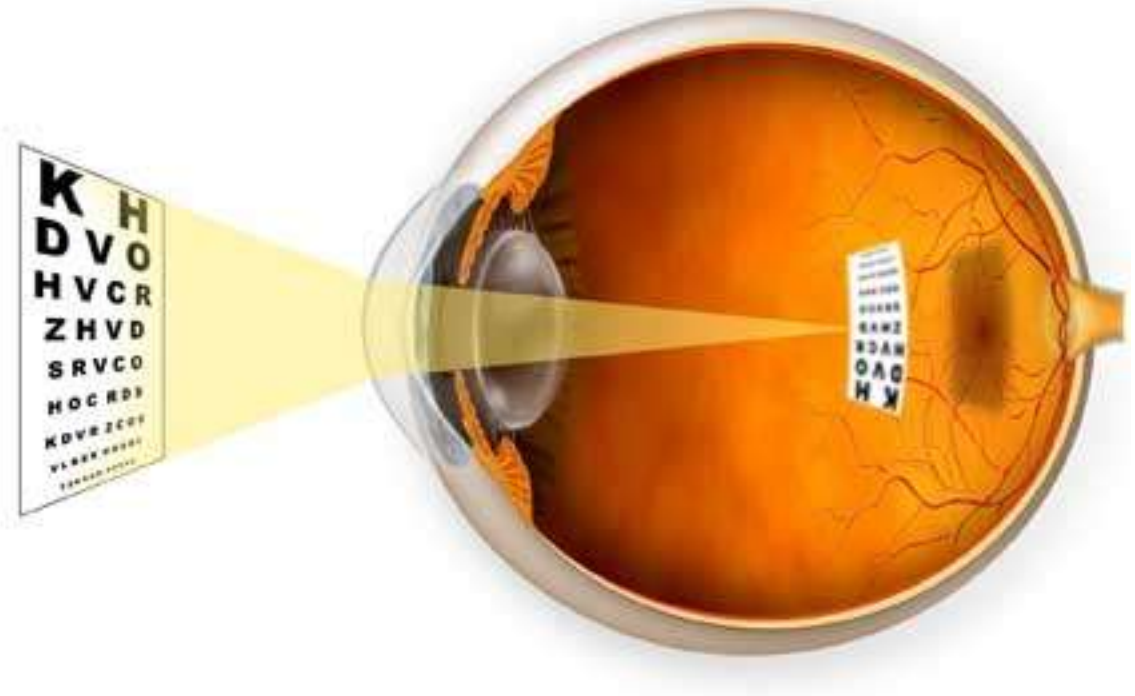
Vision Problems

- Myopia (near sightedness)
- Hyperopia (far sightedness)
- Presbyopia
- Astigmatism

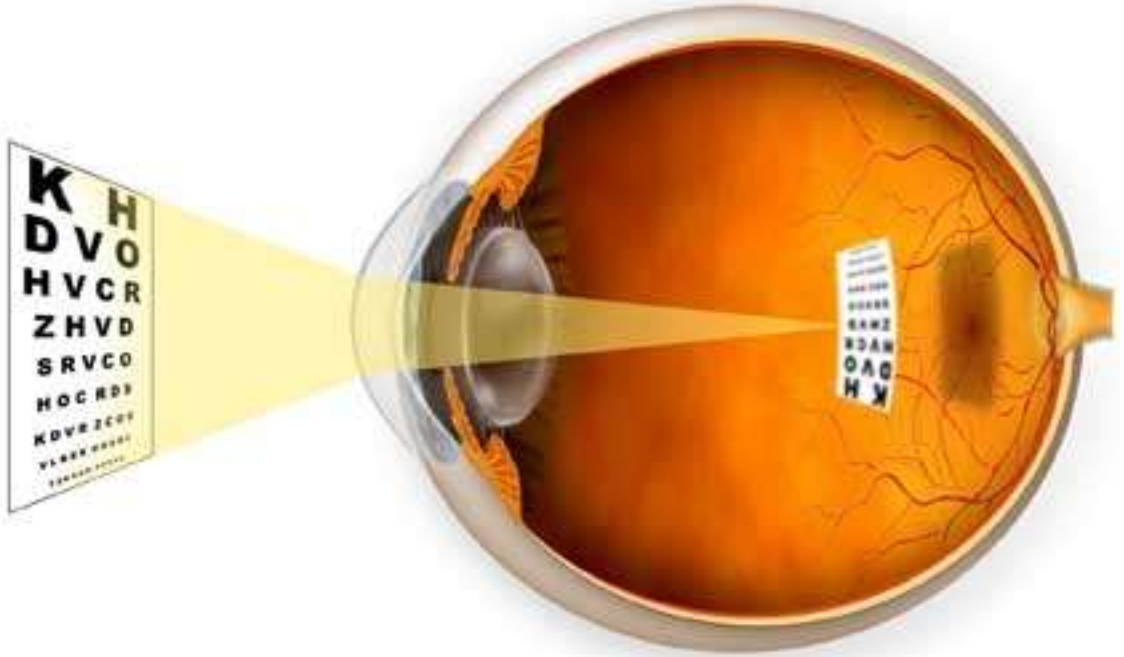

Myopia of the Eye
(Nearsightedness)
Normal Eye
Optic Nerve
Cornea
Iris
Pupil
Images are formed directly on the retina creating good vision at a distance.
Myopia Eye
Optic Nerve
Myopia Cornea
Iris
Pupil
Images are formed in front of the retina causing blurry vision at a distance.

Myopia (near-sightedness)

- inability of the eye to focus light from distant objects
- see close objects clearly
- image focuses in front of the retina



Myopia
(near-sightedness)

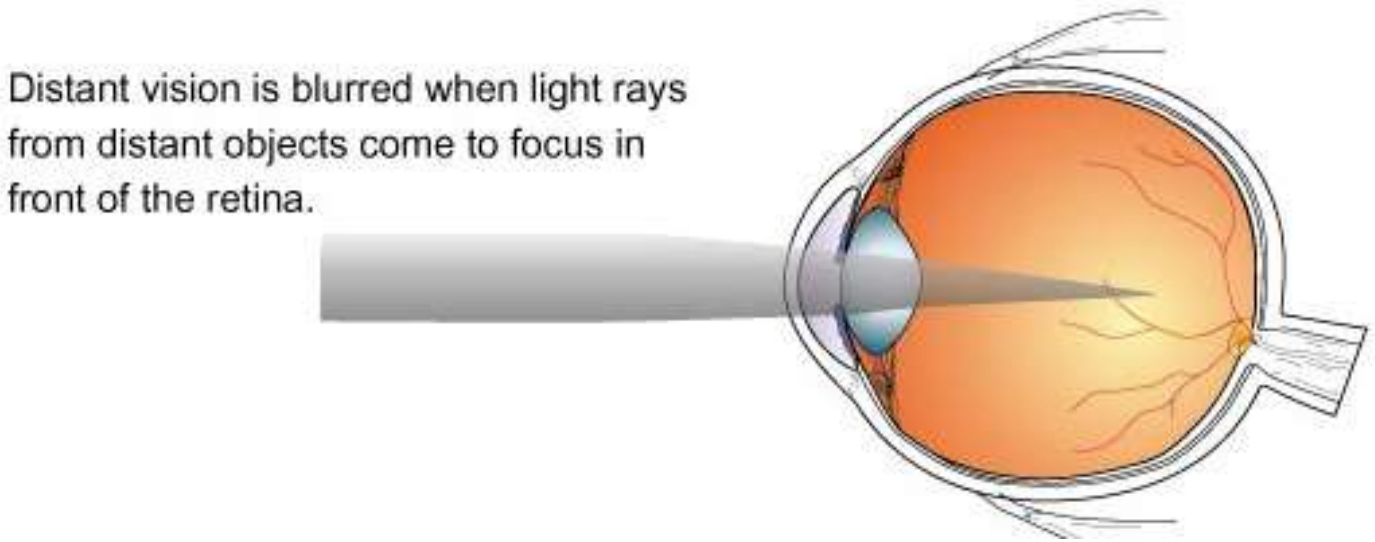


- Develops in childhood and progressively worsens
- Tends to stabilize in adulthood
- Has a genetic component
- Affects a major part of the population

Myopia (near-sightedness)

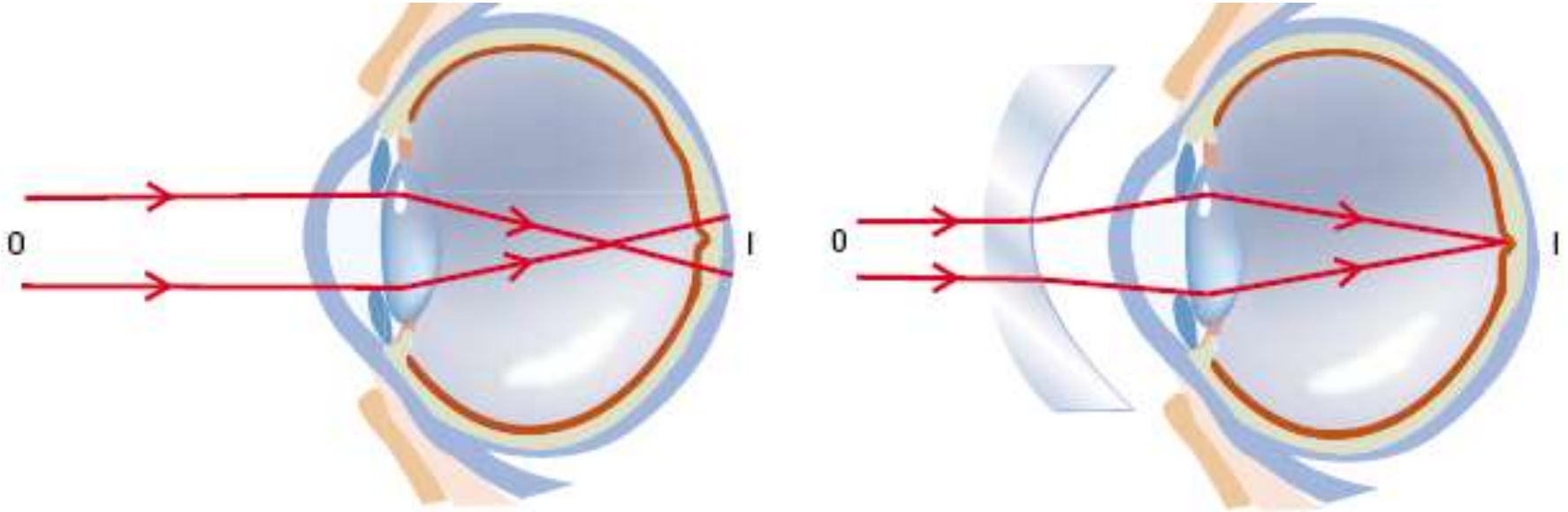
Cause:

- Distance between lens and retina is too long (long eyeball)
- Cornea & lens converge light too strongly (strong refractive power)



Myopia (near-sightedness)

- Corrected with a diverging lens
- Negative meniscus: lens shape where edge of lens is thicker than the middle but modified from a basic diverging lens to make it more cosmetically appealing



Myopia (near-sightedness)

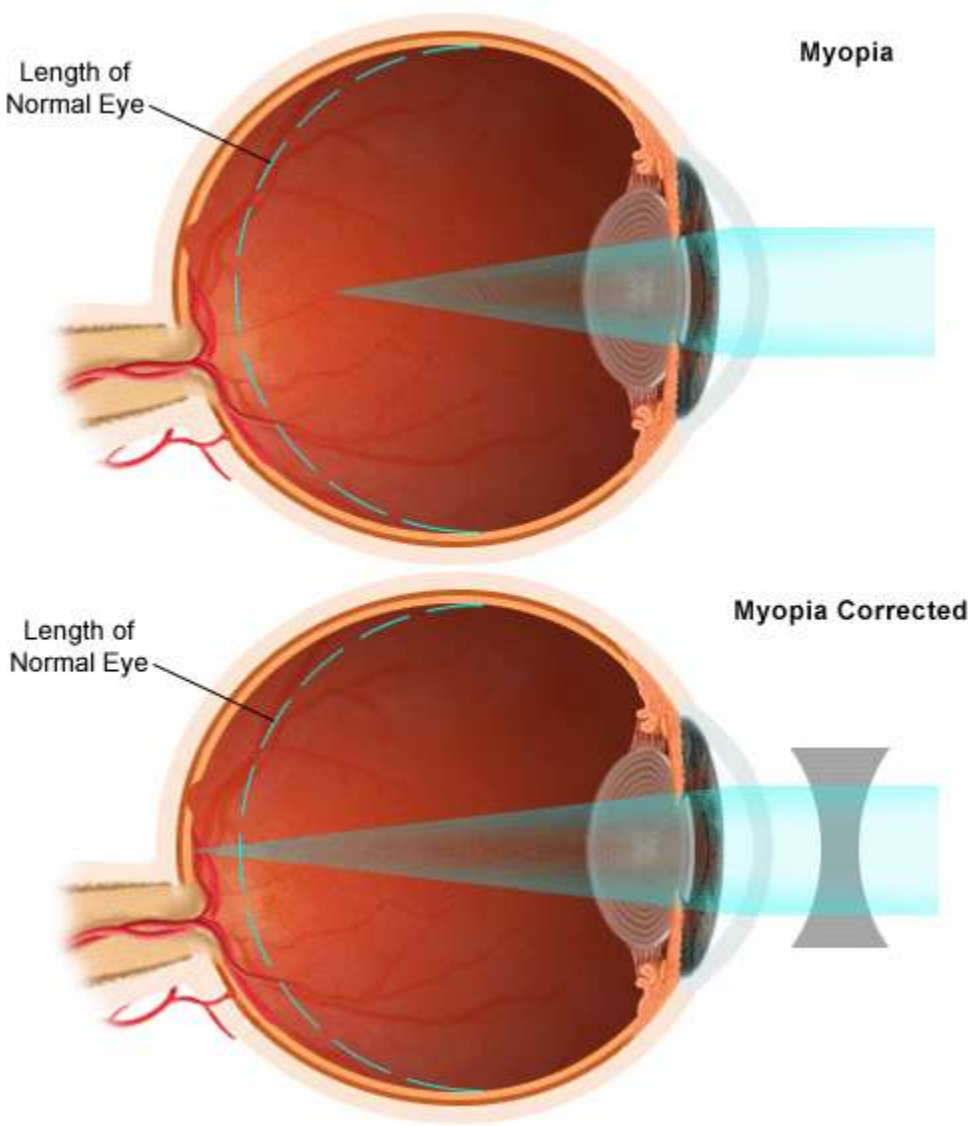
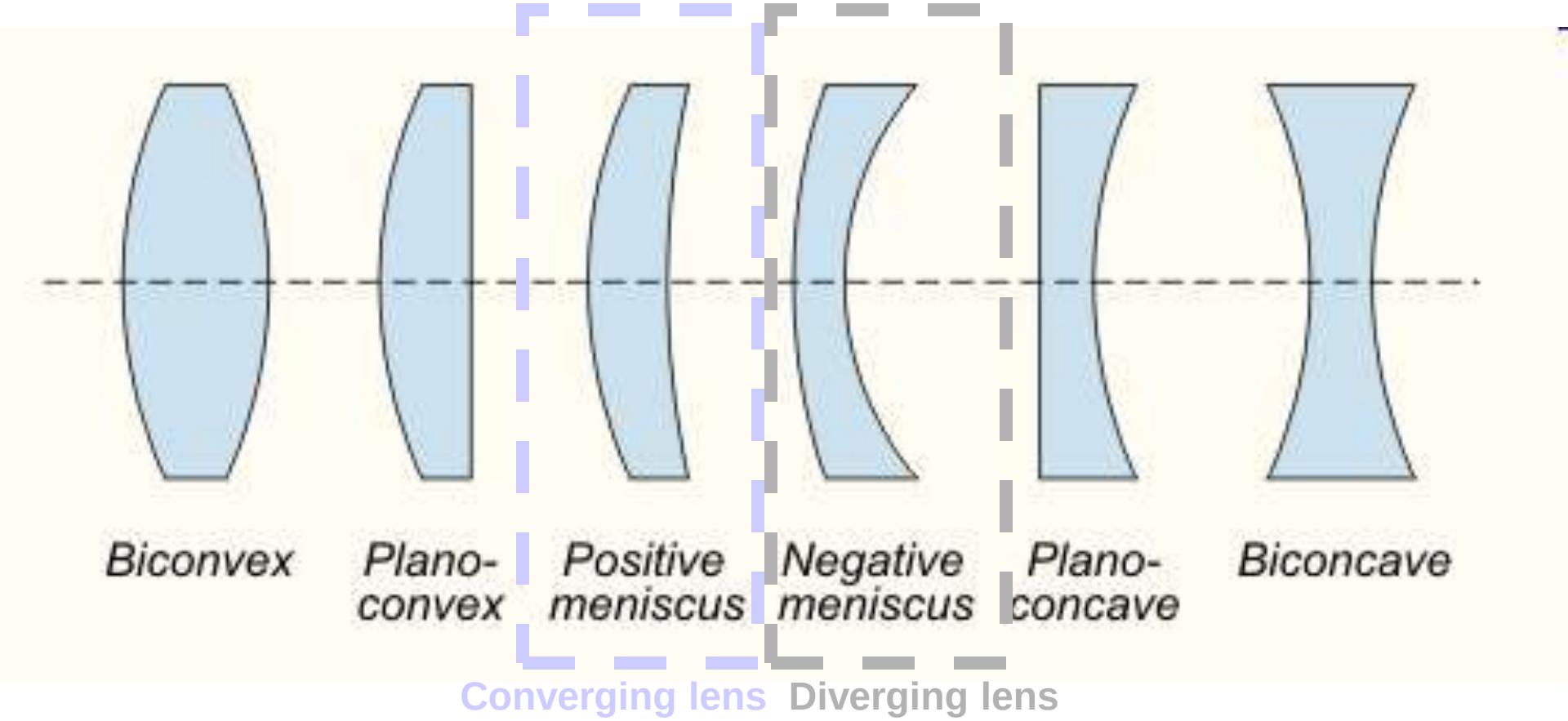


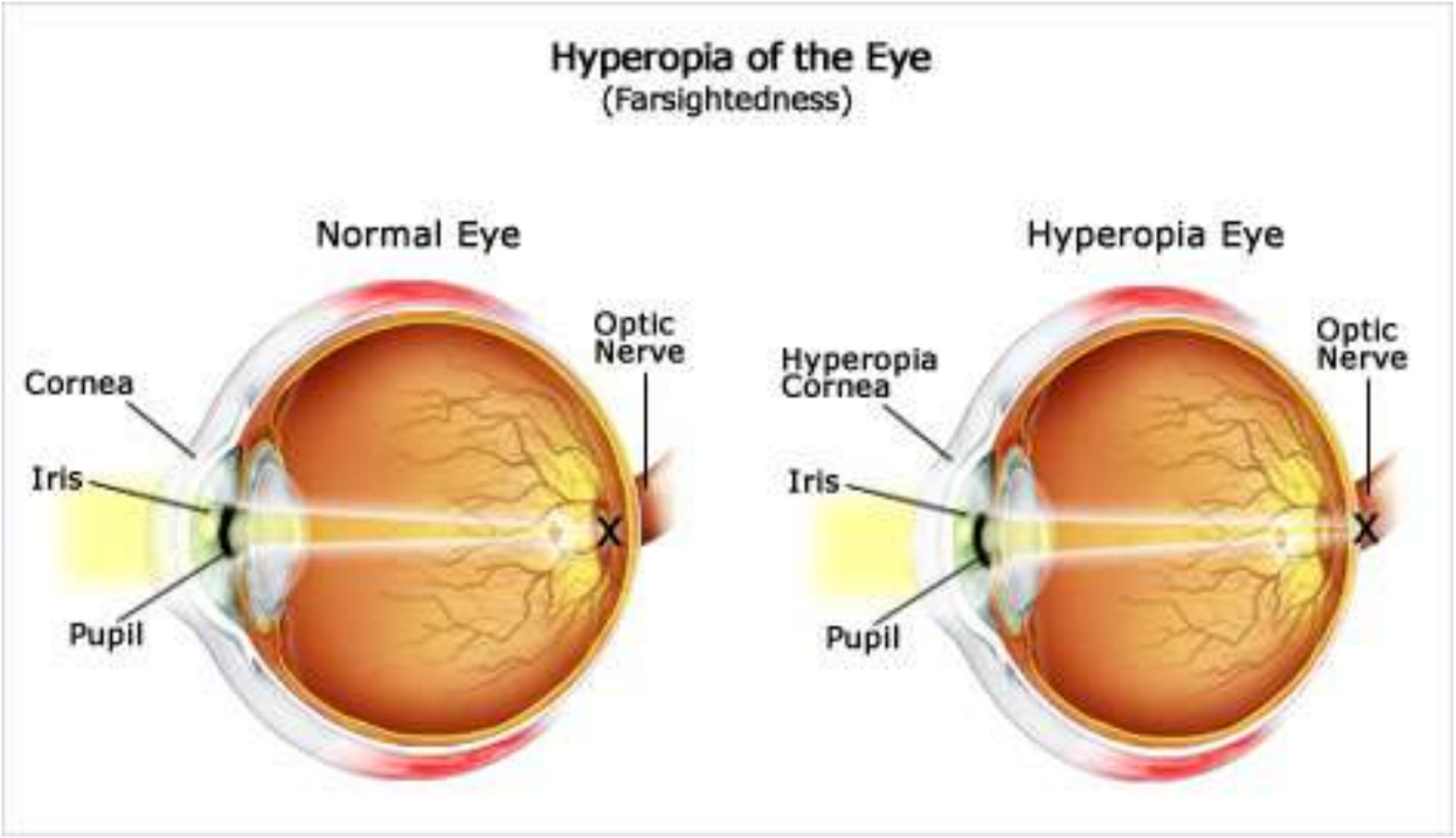
Image focuses BEFORE reaching the retina

negative meniscus (-):
a diverging lens

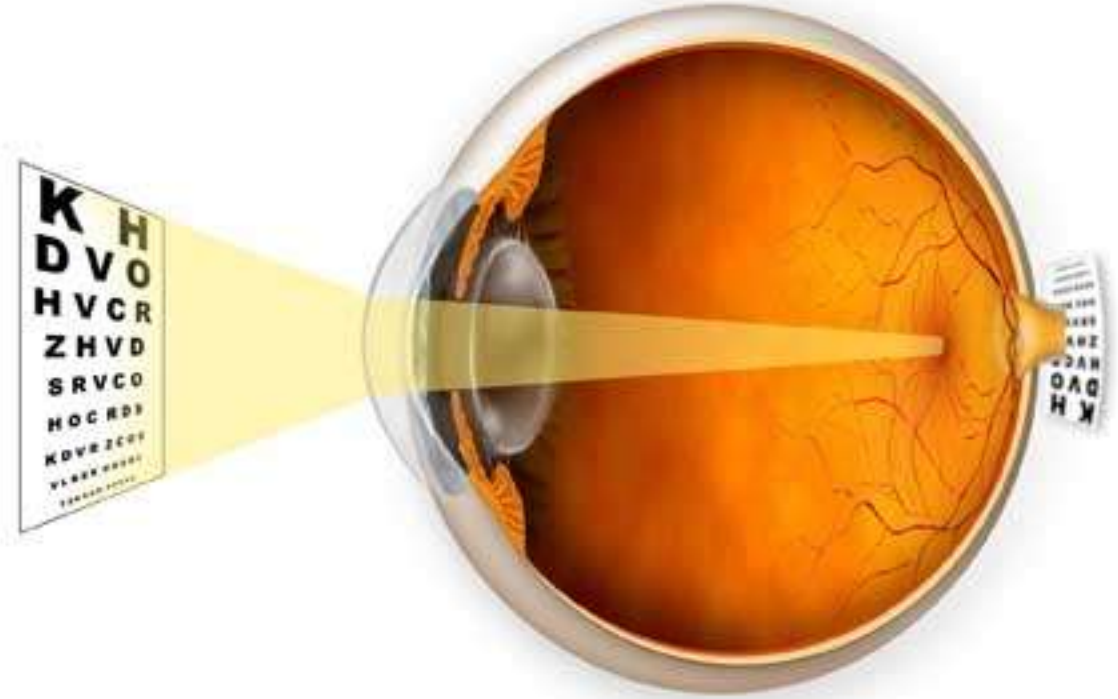
Types of Lenses



Different types of lenses can correct different types of vision.


Hyperopia of the Eye
(Farsightedness)
Normal Eye
Cornea
Iris
Pupil
Optic
Nerve
Hyperopia Eye
Hyperopia
Cornea
Iris
Pupil
Optic
Nerve

Hyperopia
(far sightedness)

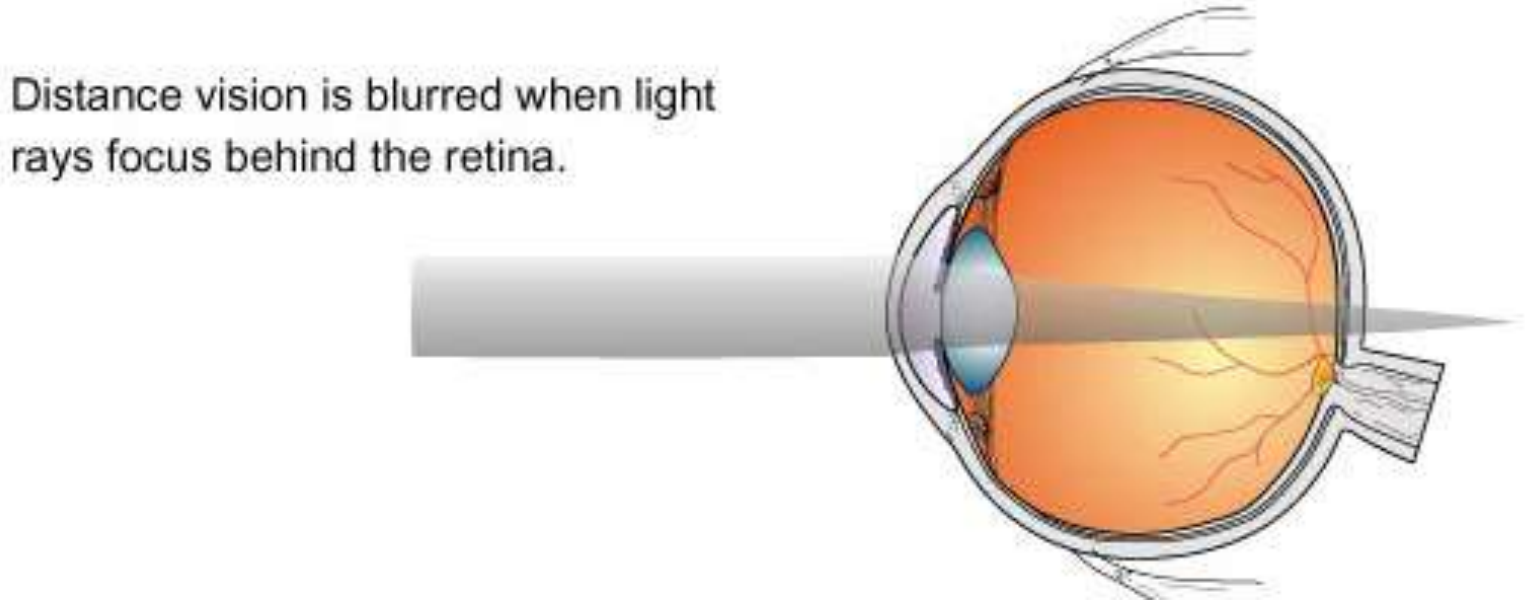


- inability of the eye to focus light from near objects
- no difficulty seeing distant objects
- Babies are born slightly hyperopic. As eye grows, condition fixes itself.
- image focused behind retina

Hyperopia (far sightedness)

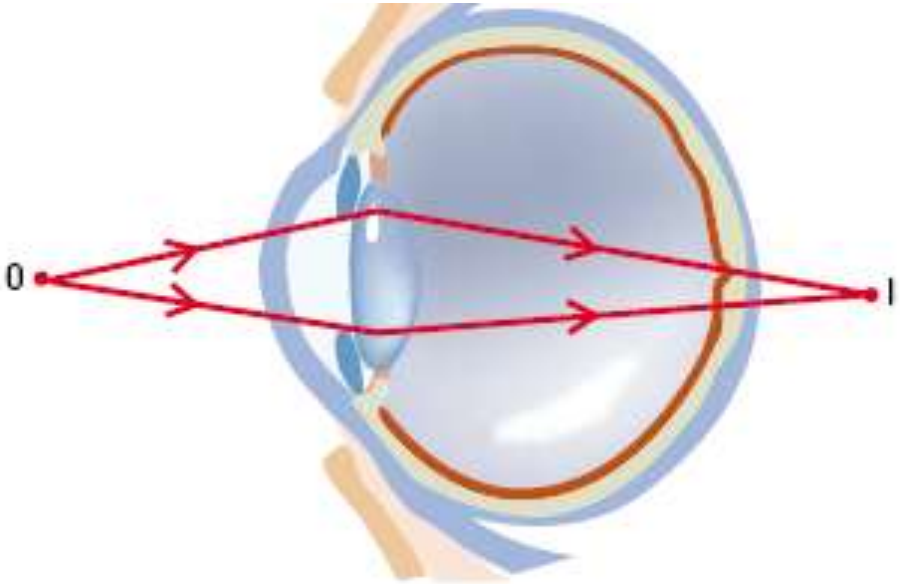
Cause:

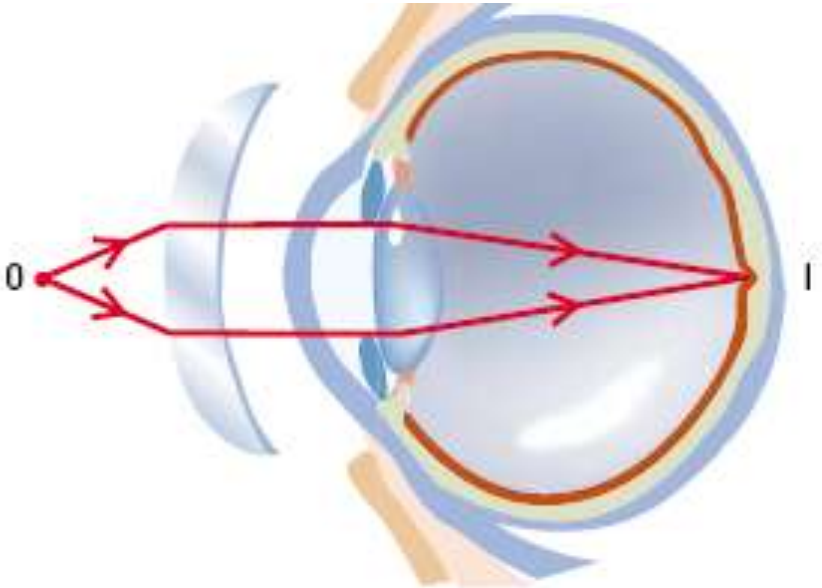
- Distance between lens and retina is too small (short eyeball)
- Cornea & lens is too weak (doesn't diverge rays enough)



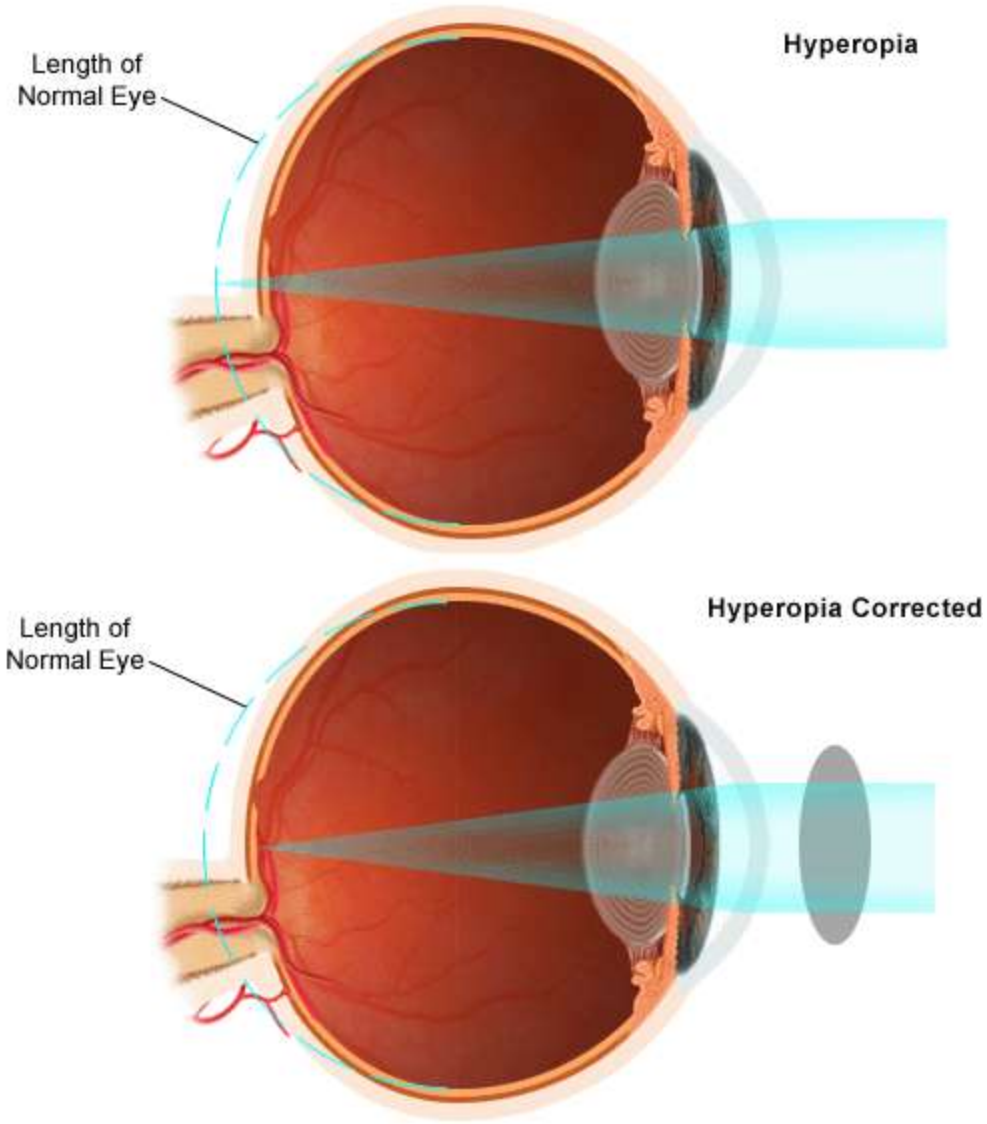
Hyperopia (far sightedness)

- Corrected with converging lens
- Positive meniscus: lens shape where middle part of lens is thicker than the edge but modified from a basic converging lens to make it more cosmetically appealing





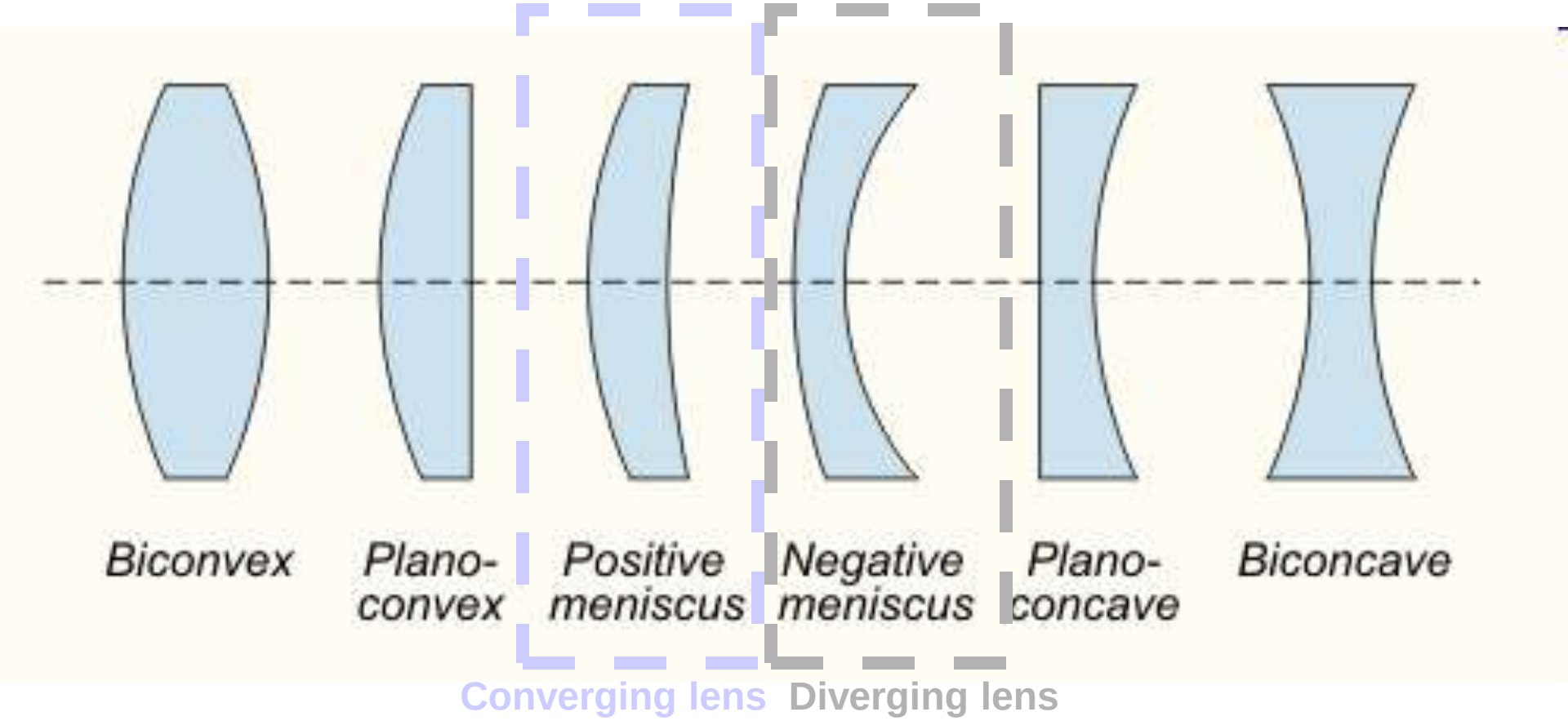
Hyperopia (far-sightedness)



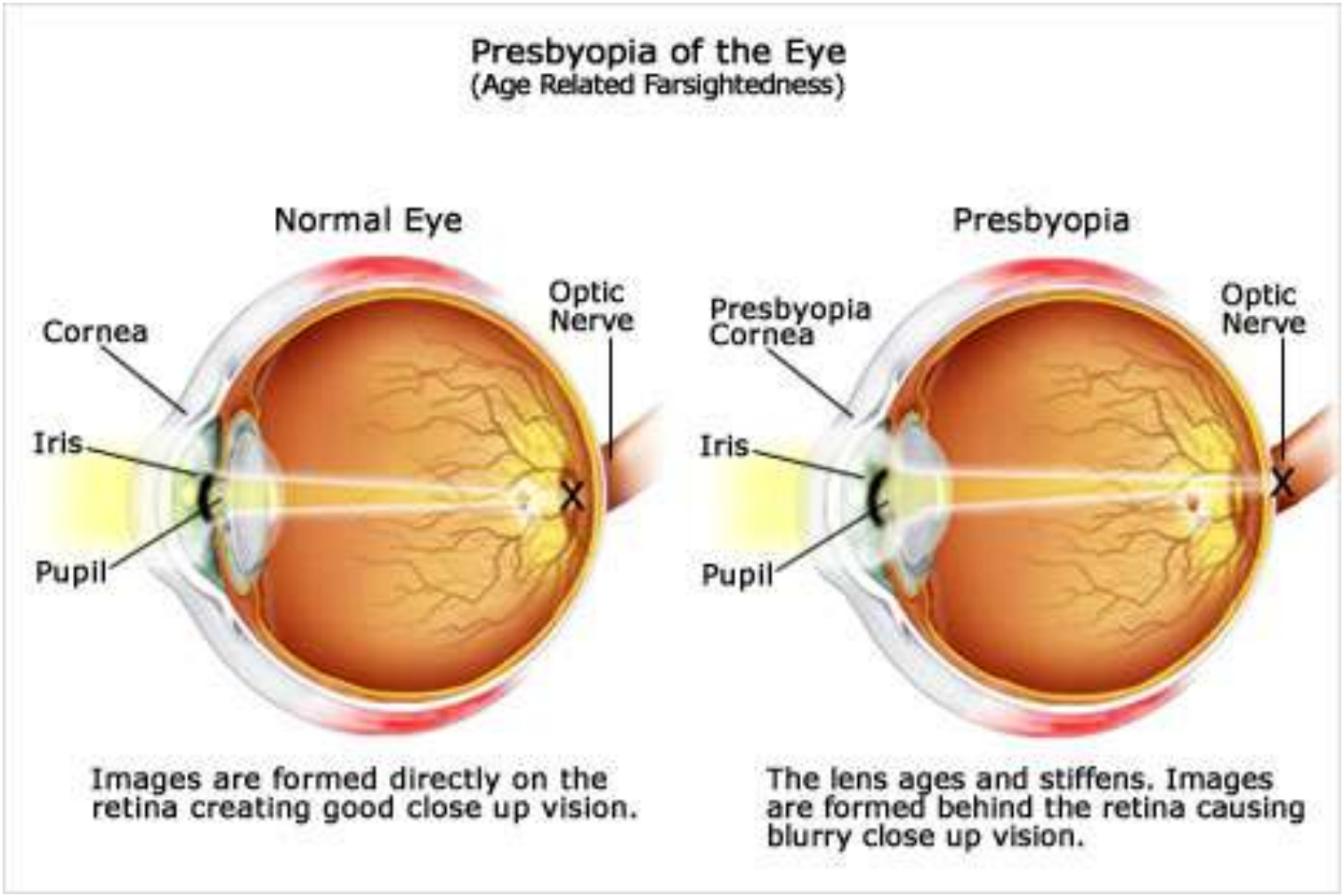
Images focused BEHIND the retina.

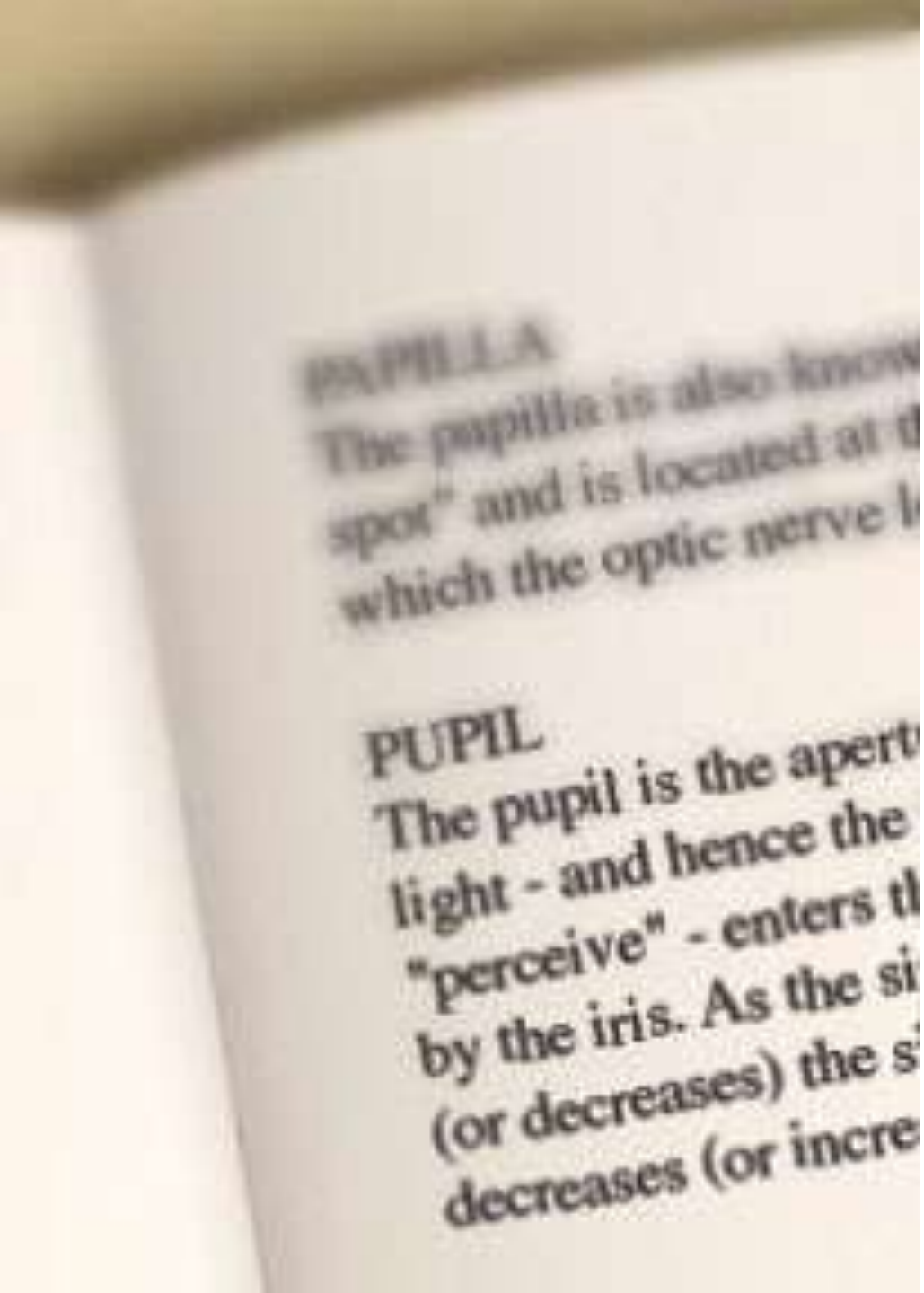
positive meniscus (+): converging lens

Types of Lenses



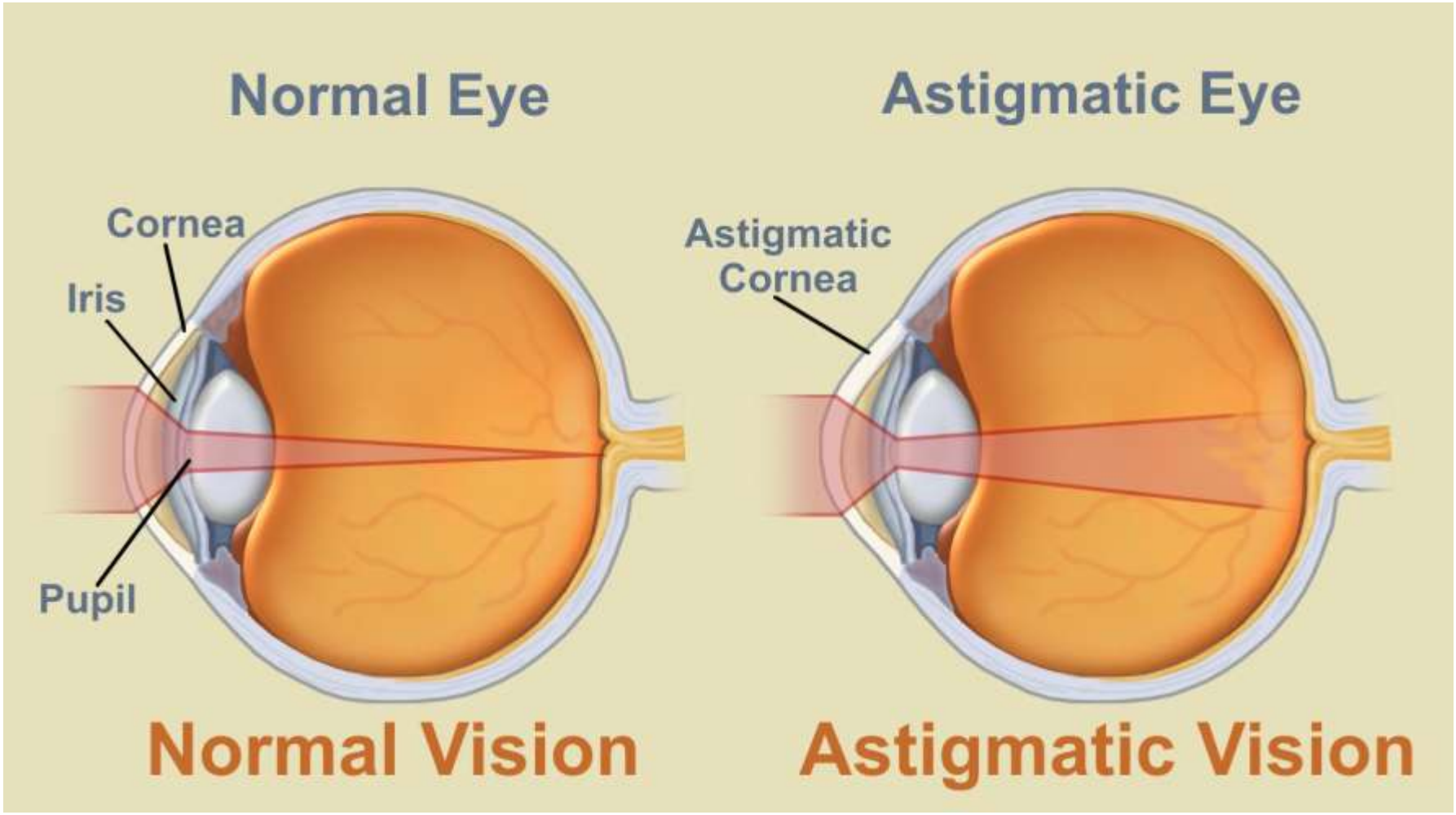
Different types of lenses can correct different types of vision.


Presbyopia of the Eye
(Age Related Farsightedness)
Normal Eye
Cornea
Iris
Pupil
Optic Nerve
Images are formed directly on the retina creating good close up vision.
Presbyopia
Presbyopia Cornea
Iris
Pupil
Optic Nerve
The lens ages and stiffens. Images are formed behind the retina causing blurry close up vision.

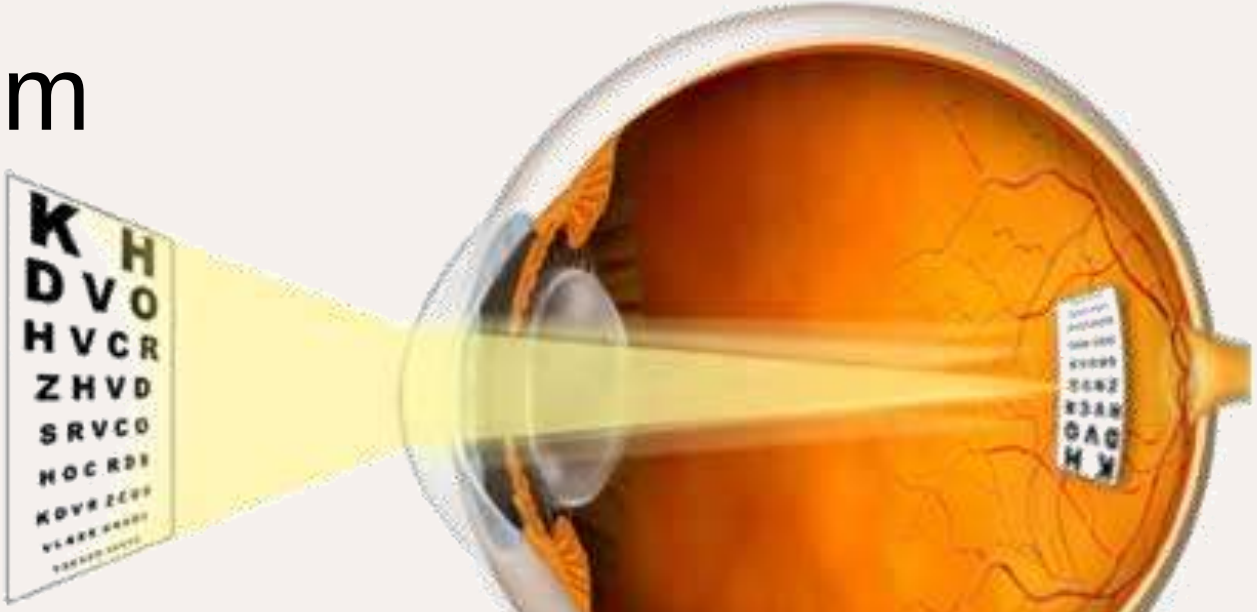


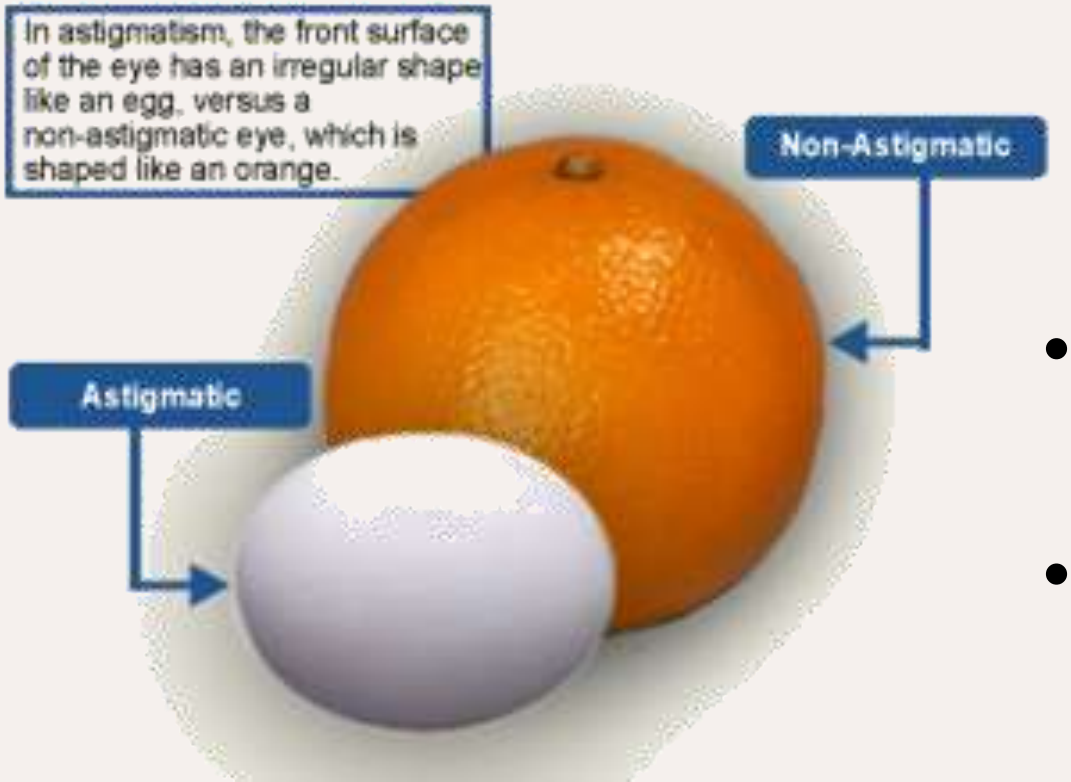
Presbyopia

- A form of hyperopia (far sightedness) that occurs with age
- Cause: eye lens losing elasticity
- Not a result of eyeball being too short
- Correct with converging lens


Normal Eye
Astigmatic Eye
Cornea
Iris
Pupil
Astigmatic
Cornea
Normal Vision
Astigmatic Vision

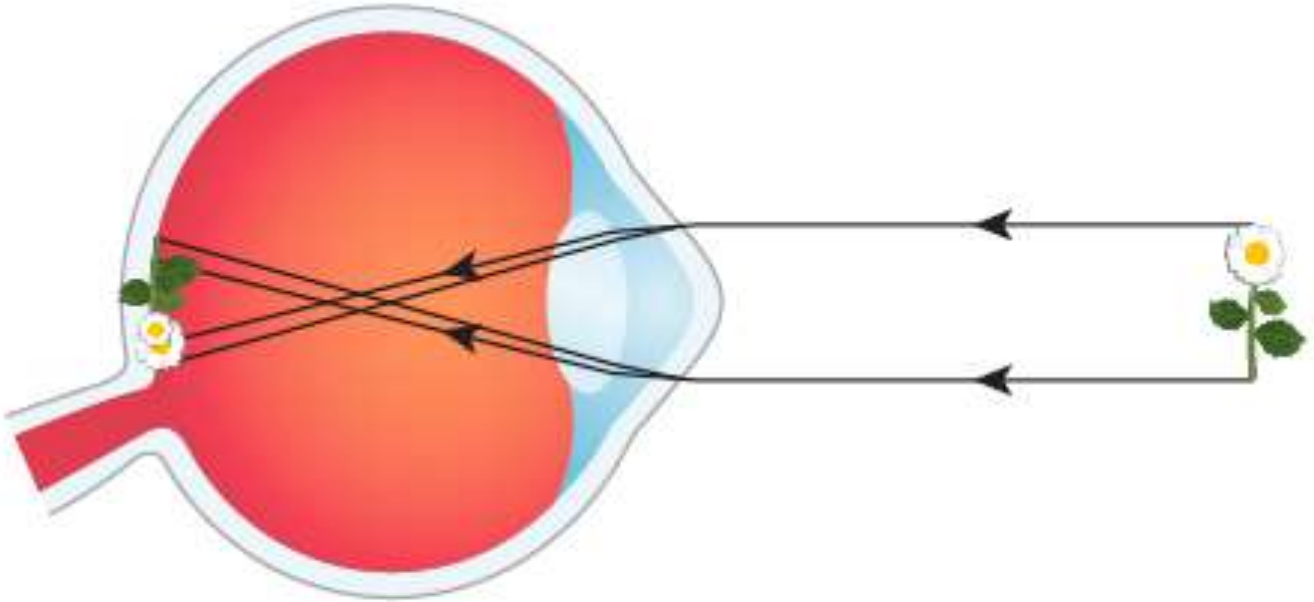
Astigmatism





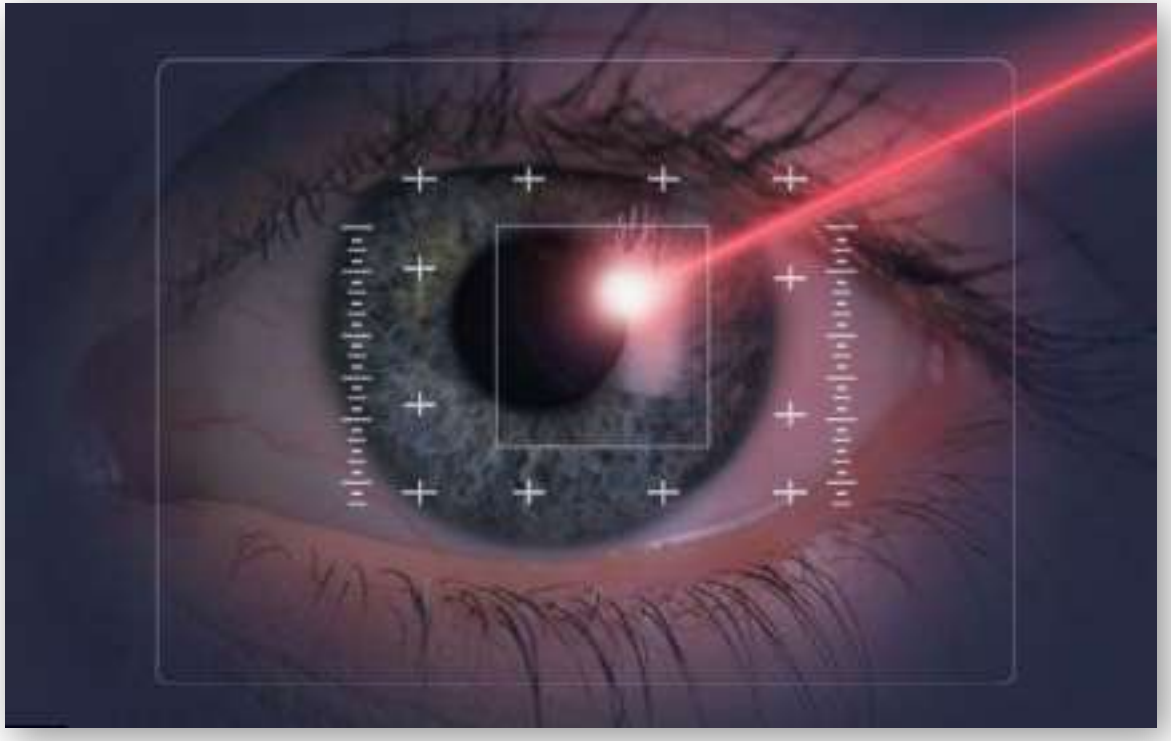
- Irregular shaped cornea “football”
- Two focus points

Astigmatism



Astigmatism is a vision problem that results from a **cornea** that has an irregular **shape**

Video: Laser Eye Surgery



http://www.youtube.com/watch?v=0V4I2xzwGd4