Physiology

Modified no. 5

الكاتب: لمى أبو إسماعيل

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الدكتور: فاطمة ريالات

Neurophysiology

Color code

- Slides
- Doctor
- Additional info
- Important

Vision 1

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Welcome to the 5th physiology lec in the CNS 🎉

- In this lecture many info will be repeated.
- Don't worry about slides number, a lot of info has been discussed in MSS system.
- Say “ بسم الله“ and let’s start 😊

Protective mechanisms in the eye

- Several mechanisms help protect the eyes from injury:
- Except for its anterior portion, the eyeball is sheltered by the bony socket in which it is positioned. [the posterior 2/3 are protected by skull bones]
- The eyelids act like shutters to protect the exposed part of the eye, the anterior 1/3 from environmental insults. They close reflexly to cover the eye under threatening circumstances, as when something comes close to it.
- They blink frequently & spontaneously to spread tears & protect the eye.
- Eyelashes trap fine, airborne debris such as dust before it can fall into the eye.

Tears

- Frequent spontaneous blinking of the eyelids helps disperse the lubricating, cleansing, bactericidal tears.

- Tears are produced continuously by the lacrimal gland in the upper lateral corner under the eyelid.

- This eye-washing fluid flows across the anterior surface of the eye and drains into puncta, and then to tiny canals in the medial corner of each eye called nasolacrimal ducts, eventually emptying into the back of the nasal passageway. **check the next slide kindly

- This drainage system cannot handle the profuse tear production during crying, so the tears overflow from the eyes. So, in normal case the drainage happens through the nasolacrimal ducts, while in crying there's an overload on this pathway, So the tears come out of your eyes and run down your cheeks.

may God always make your tears, tears of happiness 😊

- Tears have many chemicals and constituents that are important for vision and protection from bacteria, pathogens, and environmental factors.

- Regarding the drainage point, some babies could have a problem with this drainage system. Parents come to the pediatrics clinic asking about the over-secretions from their baby's eyes, which could be due to a **blockage** in the duct, so the doctor will advise them to do a **fine massage** for this duct. Within approximately a week, things will return to normal

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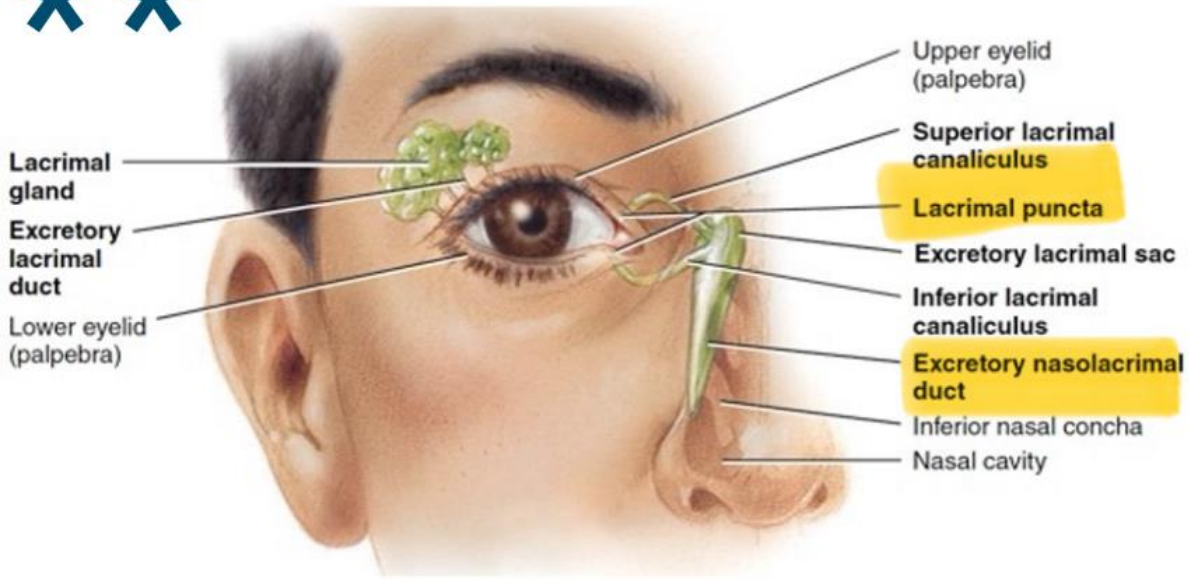


Layers

Eye is a spherical, fluid-filled structure enclosed by three layers (From outermost to innermost):

- (1) the sclera/cornea, the outermost one, it's a strong layer, fibrous, wide in shape and whitish in color.
- The sclera will continue anteriorly as **cornea** (**transparent**), keep in mind that light needs the cornea to be transparent so it can pass till it reaches the photoreceptors in the innermost layer (retina).

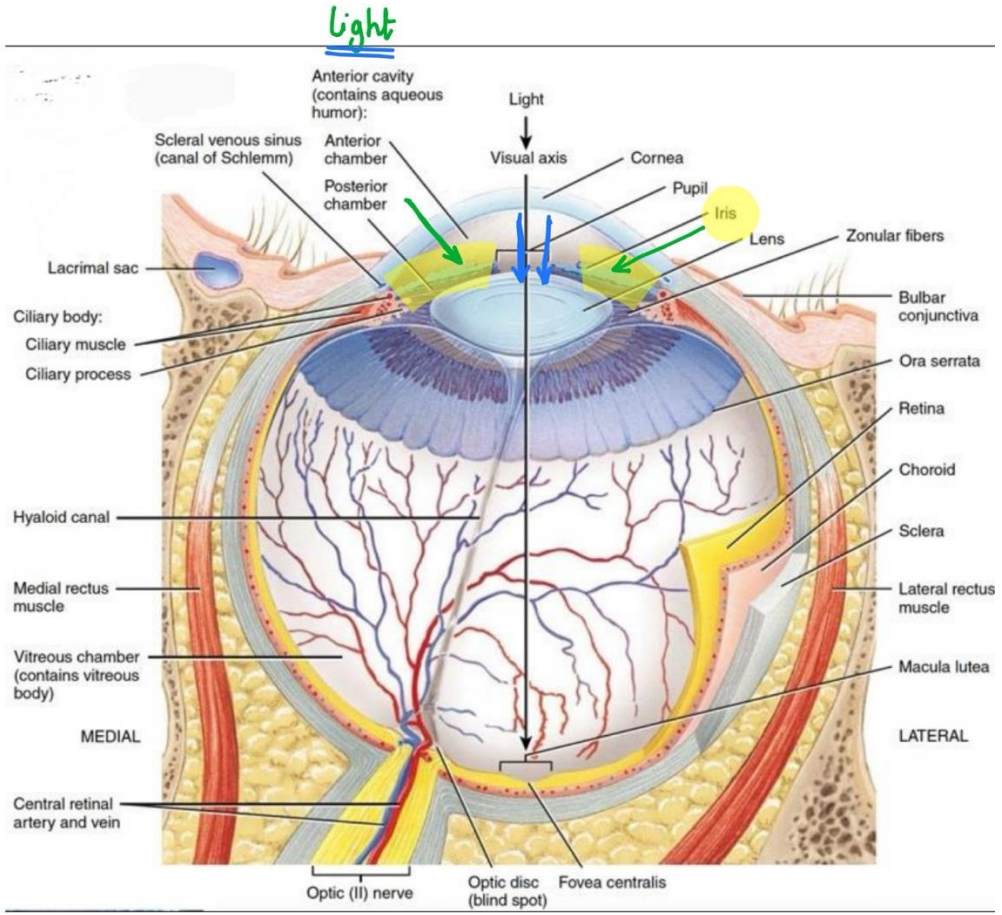
- (2) the choroid/ciliary body/iris, they are pigmented & highly vascular. This pigment absorbs light and prevents scattering of it . The choroid continues anteriorly as **ciliary body & iris.**
- The **Iris** consists of 2 types of muscles & a central opening "the pupil".

•(3) the retina. Where **photoreceptors** [cones & rods] are located, specifically in the **neural layer** of retina, and they are responsible for the transduction of light and its conversion into a receptor potential.

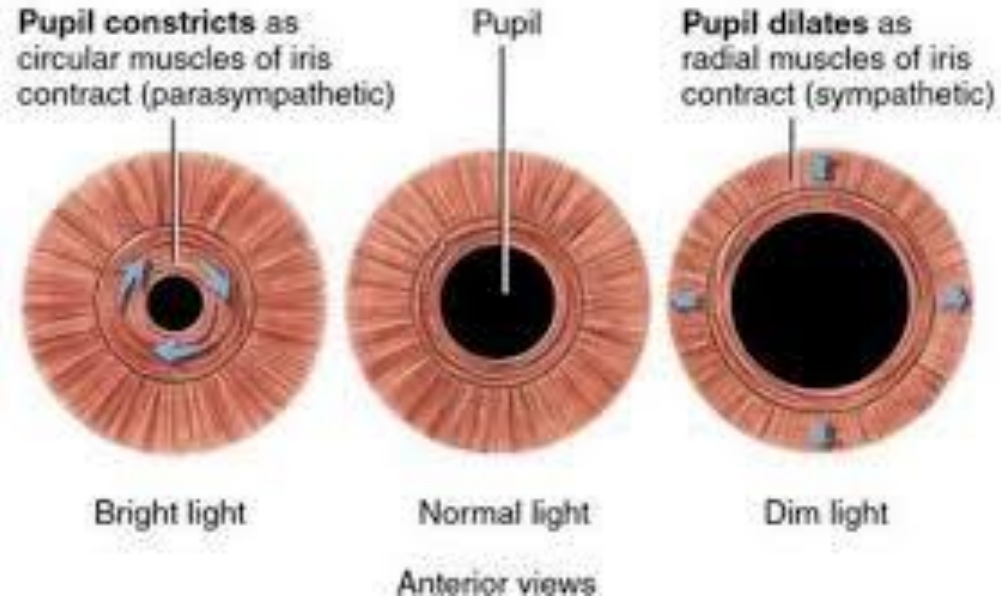
- As you can see here, light is coming from different directions (arrows) passing through the cornea, but not all of it will continue till reaching the retina, the blue arrows will pass through the opening, while the green arrows will not, since the iris is a muscle & is not transparent.

- The amount of light that will reach the retina is determined based on the size of the opening of the pupil, then what is the iris role in here??

- It is the muscle that surrounds the pupil & it determines the size of it, and thus the amount of light coming in.



- As we said earlier, iris has 2 types of muscles, inner one (circular muscle) & outer one (radial muscle)
- **Circular muscle** : once it contracts, it causes **constriction** of the pupil, and a small amount of light will pass through. It's under the control of **parasympathetic** system.
- **Radial muscle:** once it contracts, it causes **dilation** of the pupil, and a large amount of light will pass through. It's under the control of **sympathetic system** [fight or flight is a crucial situation where you need more light].



Sclera and cornea

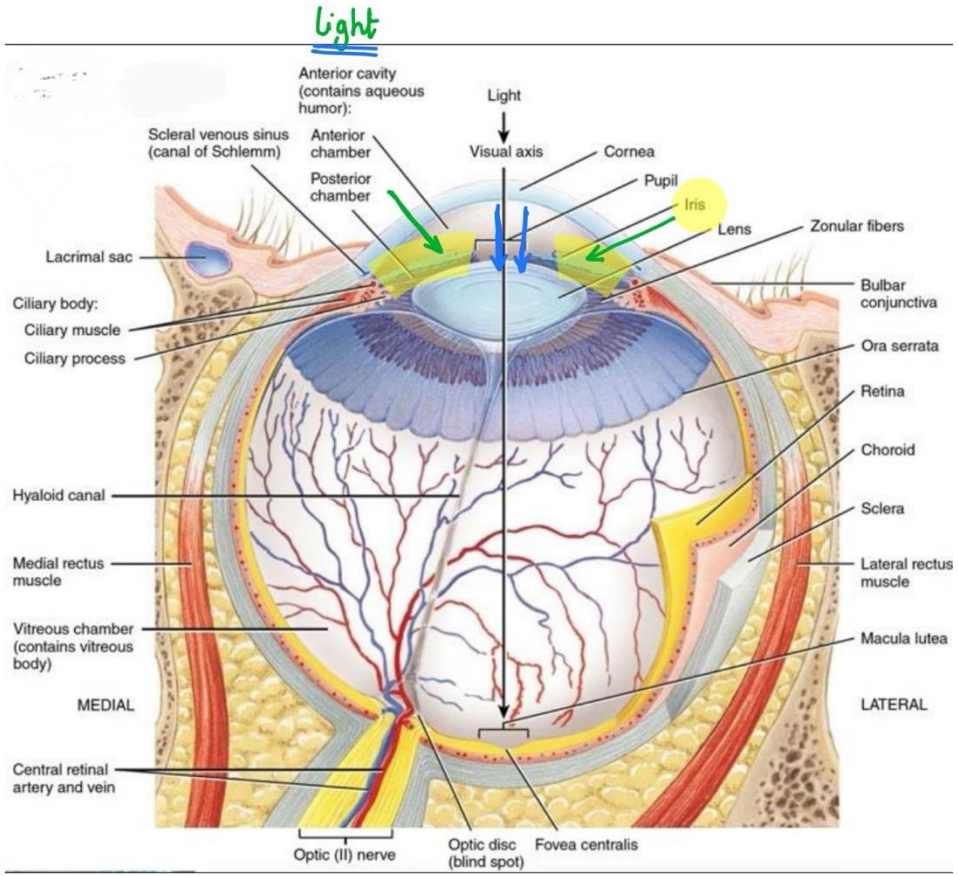
- Most of the eyeball is covered by a tough outer layer of connective tissue, the sclera, which forms the visible white part of the eye.

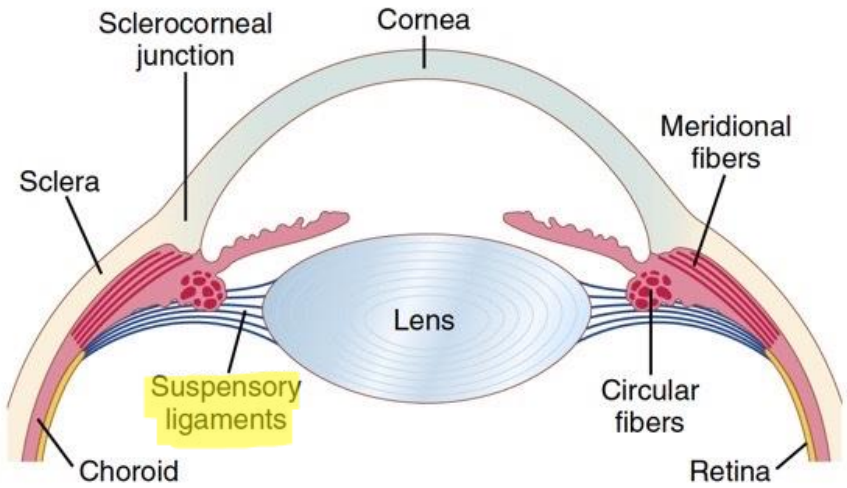
- Anteriorly, the outer layer consists of the transparent cornea, through which light rays pass into the interior of the eye.

Choroid

- The middle layer underneath the sclera is the highly pigmented choroid, which contains many blood vessels that nourish the retina.
- The choroid layer becomes specialized anteriorly to form the ciliary body and iris.
- the pigment in the choroid and retina absorbs light after it strikes the retina to prevent reflection or scattering of light within the eye.

- Ciliary body has ligaments that are called; **suspensory ligaments** and they are attached to the lens of the eye.
- So, the lens appears as if it is suspended by these ligaments.
- Normally these ligaments are tensed so they are stretching the lens, so it is kind of **flat**.
- The lens curvature can be changed, since these ligaments tension could be changed based on certain situations.





Retina

- The innermost coat under the choroid is the retina, which consists of an outer pigmented layer and an inner nervous-tissue layer.

- The nervous layer contains the rods and cones, the photoreceptors that convert light energy into nerve impulses.

- The eye is separated into two compartments via the lens:
  -The anterior compartment/chamber.
  -The posterior chamber.

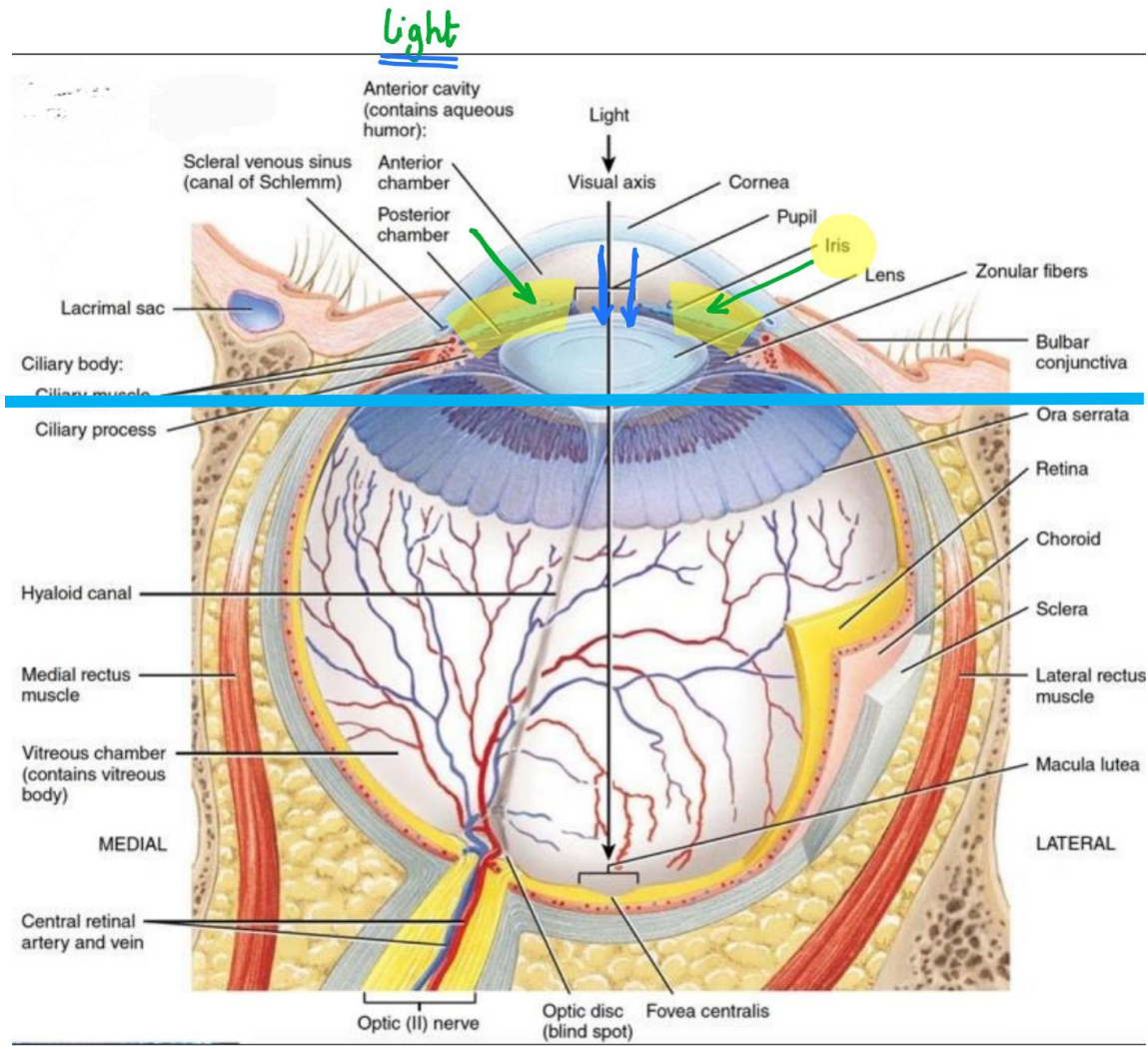
- Each one of these chambers is filled with a different type of fluid.

The posterior chamber is filled with vitreous humor/body.

- A gelatinous thick fluid.

- Maintains the spherical shape of the eye.

- Usually there is no exchange here, maybe some certain diffusion would happen but there's no flow of fluid .

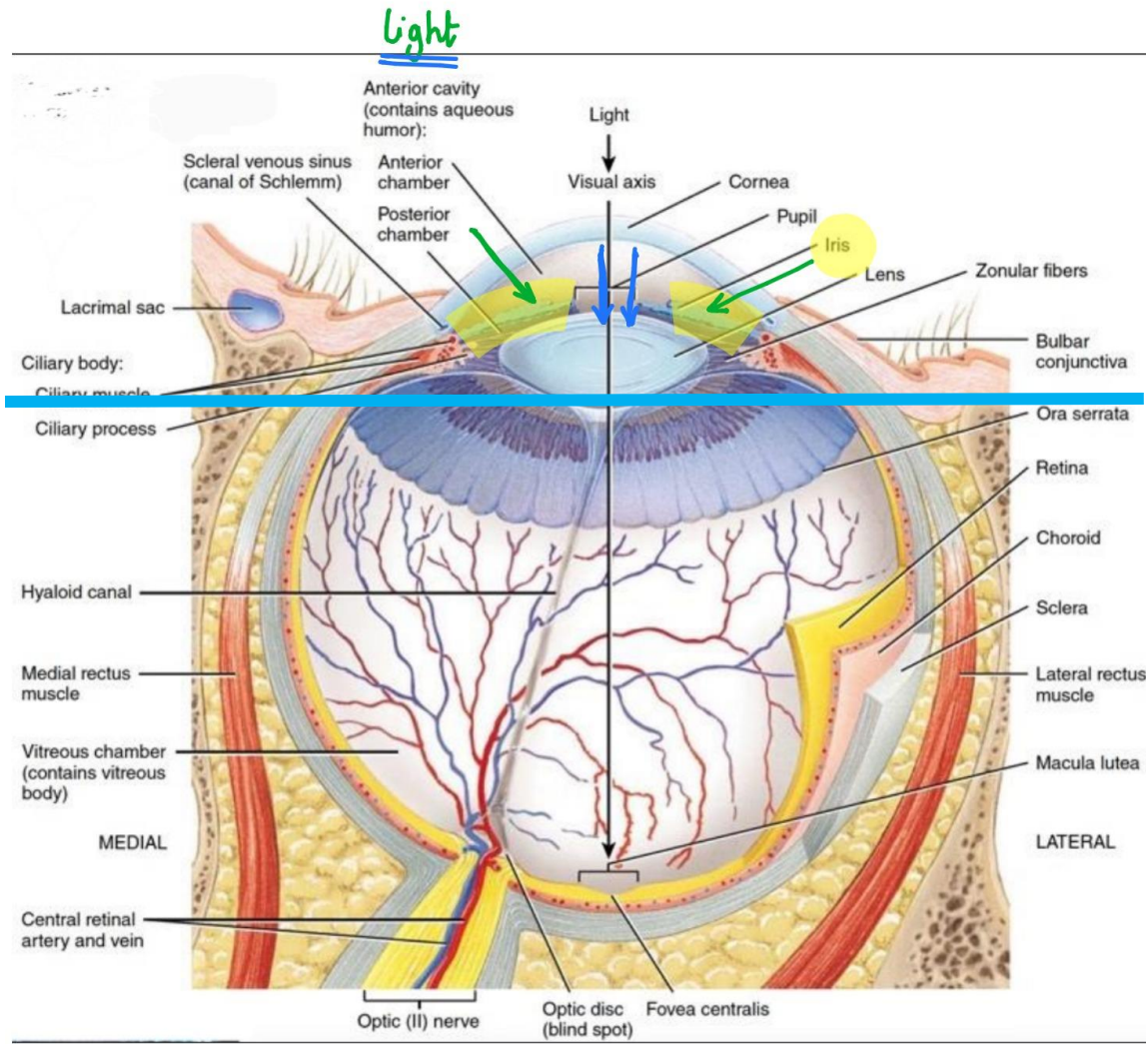


The anterior chamber is filled with aqueous humor.

- A watery fluid, provides nutrition for the cornea and lens, since they're avascular.

- If they have blood vessels, we lose their transparency feature.

- For this fluid to continue providing nutrients, it should be continuously secreted. This continuous secretion is combined with a continuous reabsorption [to avoid an increase in pressure due to an increase in volume]



Lens

- The interior of the eye consists of two fluid-filled cavities, separated by a lens which is an elastic structure, all of which are transparent to permit light to pass through the eye from the cornea to the retina.

- about 70 suspensory ligaments attach radially around the lens, pulling the lens edges toward the outer circle of the eyeball.

- These ligaments are constantly tensed by their attachments at the anterior border of the choroid and retina.

- The tension on the ligaments causes the lens to remain relatively flat under normal eye conditions.

Cataract

- Since there aren't DNA and other structures for the regeneration of lens cells with aging (**lens cells don't regenerate**) certain pathologies could occur due to denaturation of its proteins, leading to their coagulation. Therefore, the lens becomes opaque, and the patient starts complaining of blurred vision and scattering of light. This is called "cataract".

- "Cataracts" are an especially common eye abnormality that occurs mainly in older people. The only treatment for it is **surgery**, to replace the lens with an artificial one.

- A cataract is a cloudy or opaque area (or areas) in the lens.

- In the early stage of cataract formation, the proteins in some of the lens fibers become denatured.

- Later, these same proteins coagulate to form opaque areas in place of the normal transparent protein fibers.

Intraocular fluid

- The aqueous humor is a freely flowing fluid, whereas the vitreous humor, sometimes called the vitreous body, is a gelatinous mass held together by a fine fibrillar network composed primarily of greatly elongated proteoglycan molecules.

- Aqueous humor is continually being formed and reabsorbed.

- Aqueous humor is formed almost entirely as an active secretion by the epithelium of the ciliary processes.

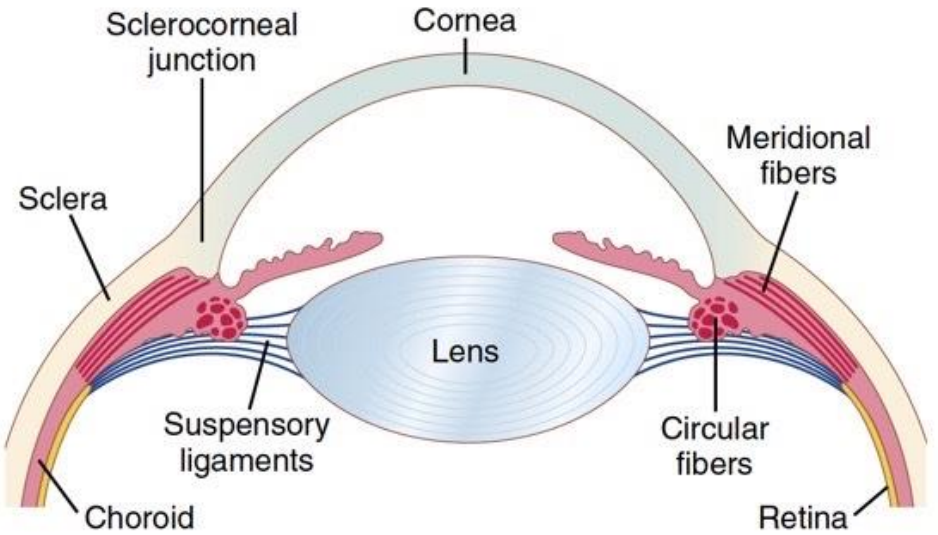
- The balance between formation and reabsorption of aqueous humor regulates the total volume and pressure of the intraocular fluid.

Aqueous humor

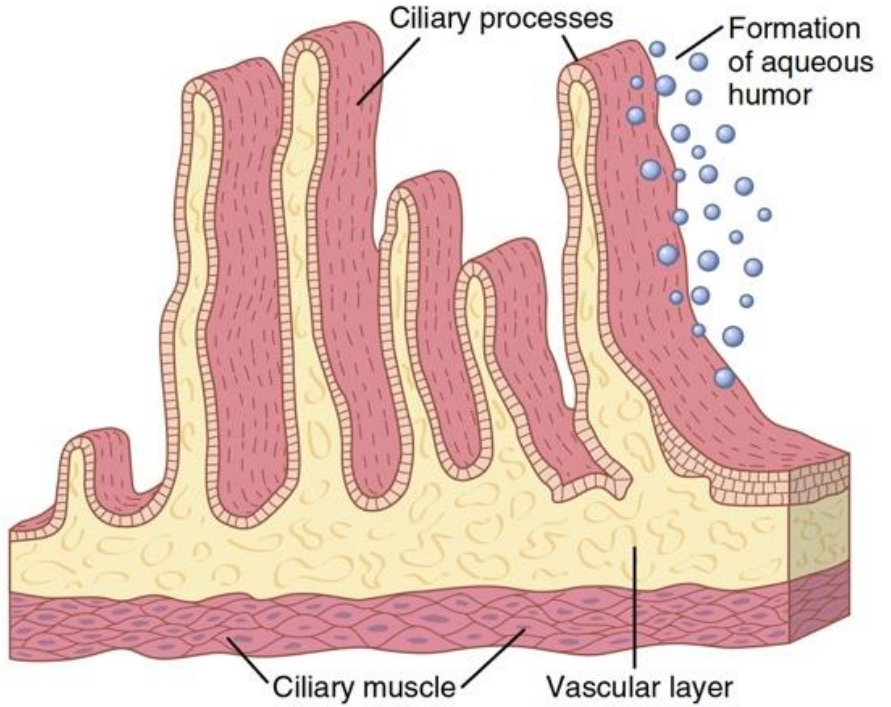
- The anterior cavity between the cornea and the lens contains a clear, watery fluid, the aqueous humor.

- The aqueous humor carries nutrients for the cornea and lens, both of which lack a blood supply. Blood vessels in these structures would impede the passage of light to the photoreceptors.

- As we said before, ciliary body is a continuation of choroid.
- These ciliary bodies have "ciliary processes"



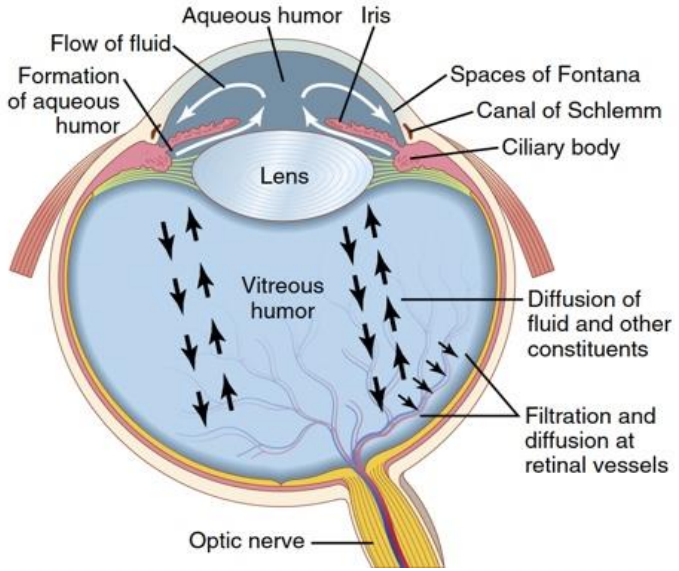
- Ciliary processes look like villi in the GIT, which increase the surface area of the intestines for example, and the same concept applies here, as we need continuous secretion.
- These ciliary processes are lined by secretory epithelium & are in close proximity to the vascular layer, so extensive capillaries exist here.
- This secretory epithelium will actively secret $Na^{+,}$ Cl^{-} ,H_2O and maybe glucose or amino acids. So, whatever the cells in the anterior compartment need, it will be secreted by these ciliary processes.



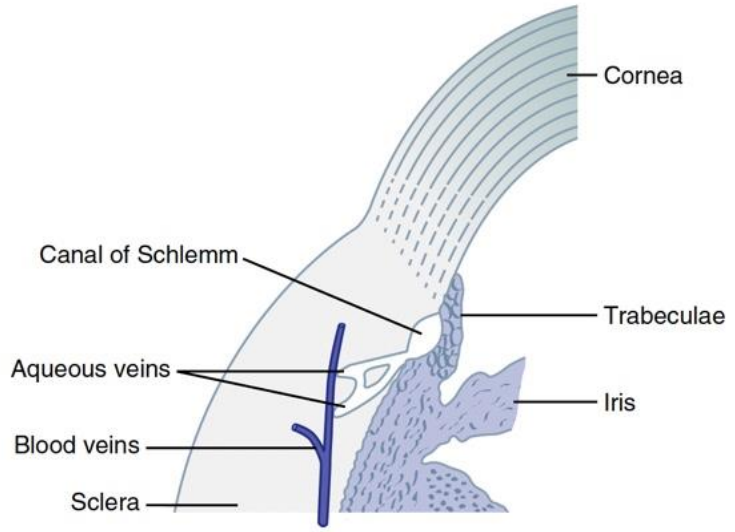
Aqueous humor

- The aqueous humor is produced at a rate of about 5 mL/day by a capillary network within the ciliary body.
- This fluid drains into a canal at the edge of the cornea and eventually enters the blood.
- If the aqueous humor is not drained as rapidly as it forms, the excess accumulates in the anterior cavity, causing the pressure to rise within the eye. This condition is known as glaucoma.

- The white arrows show the pathway of aqueous humor secretion.
- Production happens from the ciliary body.
- Then, it will go toward the Ant. chamber, getting distributed to the needed sites.
- Then, reabsorption and drainage (at the tip of the second white arrow)
- As you can see, there is an **angle** that is formed **between the cornea & the iris** we call it "**iridocorneal angle**"



- There is a special structure located here, and it is responsible for **reabsorbing excess fluid**.
- There is a mesh of **trabeculae** that will send this excess fluid to the **canal of Schlemm**, which is a **specialized part of the venous system.**
- Then this fluid will leave through the **aqueous vein** to the **optic vein** and then get drained into the circulation.



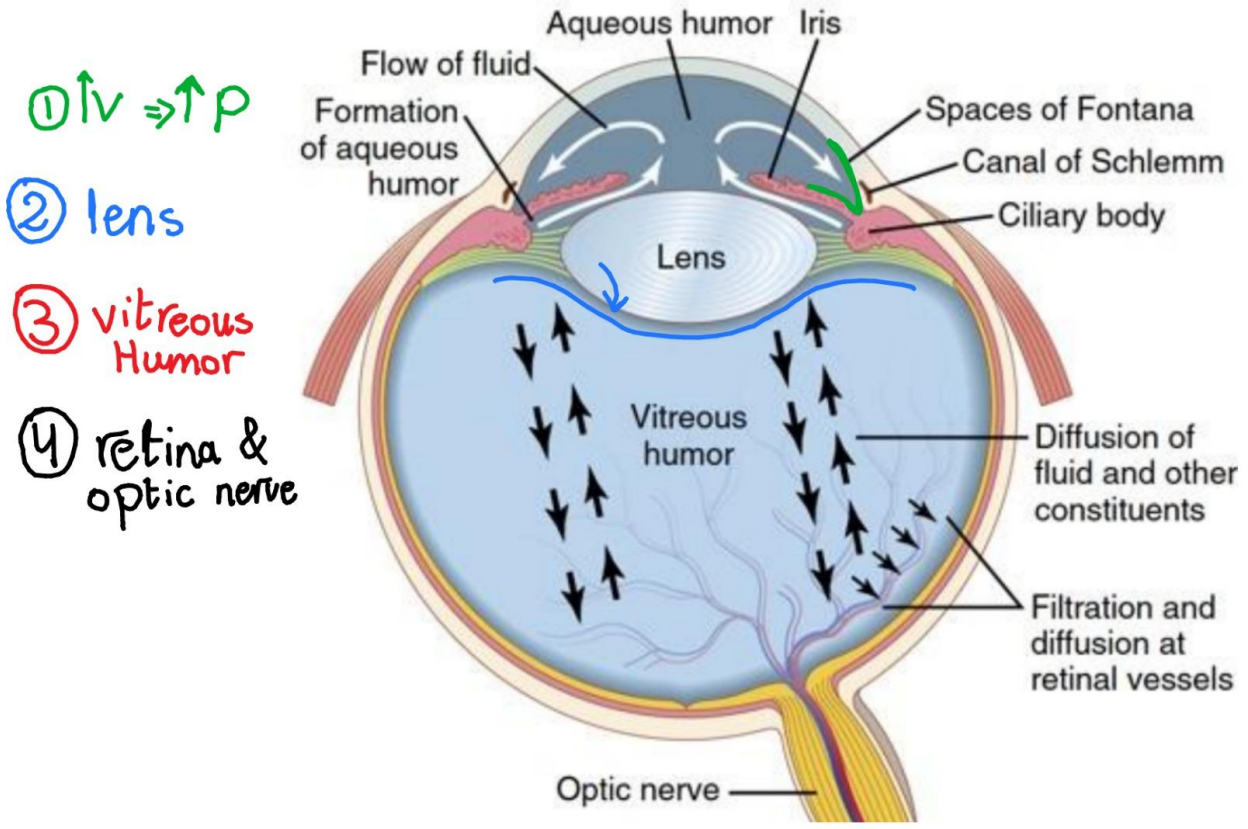
Aqueous humor

- When large amounts of debris are present in the aqueous humor, as occurs after hemorrhage into the eye or during intraocular infection, the debris is likely to accumulate in the trabecular spaces leading from the anterior chamber to the canal of Schlemm.

- this debris can prevent adequate reabsorption of fluid from the anterior chamber, sometimes causing “glaucoma”.

- However, on the surfaces of the trabecular plates are large numbers of active reticuloepithelial cells & phagocytic cells, they are present all the time to get rid of this debris to maintain adequate reabsorption of these fluids. Glaucoma happens when debris exceed the abilities of the phagocytic cells, leading to accumulation in trabeculae & blockage of drainage to canal of Schlemm.

- Once blockage occurs & reabsorption decreases=> volume increases => Pressure increases
- Since this area is closed, the pressure will affect the lens.
- The lens is an elastic structure, so it will bend.
- Then it will compress the vitreous humor, which is also in a closed space.
- Vitreous humor will compress the retina & the optic nerve.
- So those patients may end with **blindness**.
- This pathology, which is related to an increased intraocular pressure, is called; glaucoma.



Intraocular pressure

- The average normal intraocular pressure is about 15 mm Hg, with a range from 12 to 20 mm Hg.
- Measured by tonometry.
- Increased IOP may lead to blindness.

Glaucoma

- in acute eye inflammation, white blood cells and tissue debris can block these trabecular spaces and cause an acute increase in intraocular pressure.
- In chronic conditions, especially in older persons, fibrous occlusion of the trabecular spaces appears to be likely.
- Glaucoma can sometimes be treated by placing drops in the eye that contain a drug that diffuses into the eyeball and reduces the secretion or increases the absorption of aqueous humor.
- When drug therapy fails, operative techniques help.

Vitreous humor

- The larger posterior cavity between the lens and the retina contains a clear, jellylike substance, the vitreous humor.

- The vitreous humor helps maintain the spherical shape of the eyeball.

Iris

- Not all light passing through the cornea reaches the light sensitive photoreceptors because of the presence of the iris, a thin, pigmented smooth muscle that forms a visible ringlike structure within the aqueous humor.
- The pigment in the iris is responsible for eye color.

Pupil

- The round opening in the center of the iris through which light enters the interior portions of the eye is the pupil.
- The size of this opening can be adjusted by variable contraction of the iris smooth muscles to admit more or less light as needed.

Iris

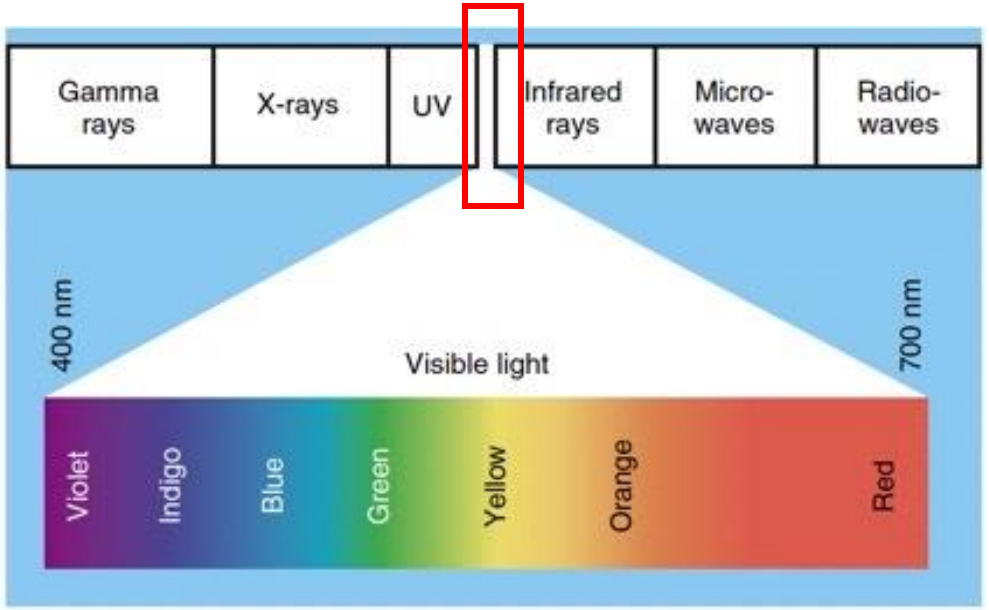
- The iris contains two sets of smooth muscle networks, one circular and the other radial.
- Because muscle fibers shorten when they contract, the pupil gets smaller when the circular (or constrictor) muscle contracts and forms a smaller ring.
- This reflex pupillary constriction occurs in bright light to decrease the amount of light entering the eye.

Iris

- When the radial (or dilator) muscle shortens, the size of the pupil increases.
- Such pupillary dilation occurs in dim light to allow the entrance of more light.
- Iris muscles are controlled by the autonomic nervous system. Parasympathetic nerve fibers innervate the circular muscle (causing pupillary constriction), and sympathetic fibers supply the radial muscle (causing pupillary dilation).

Light

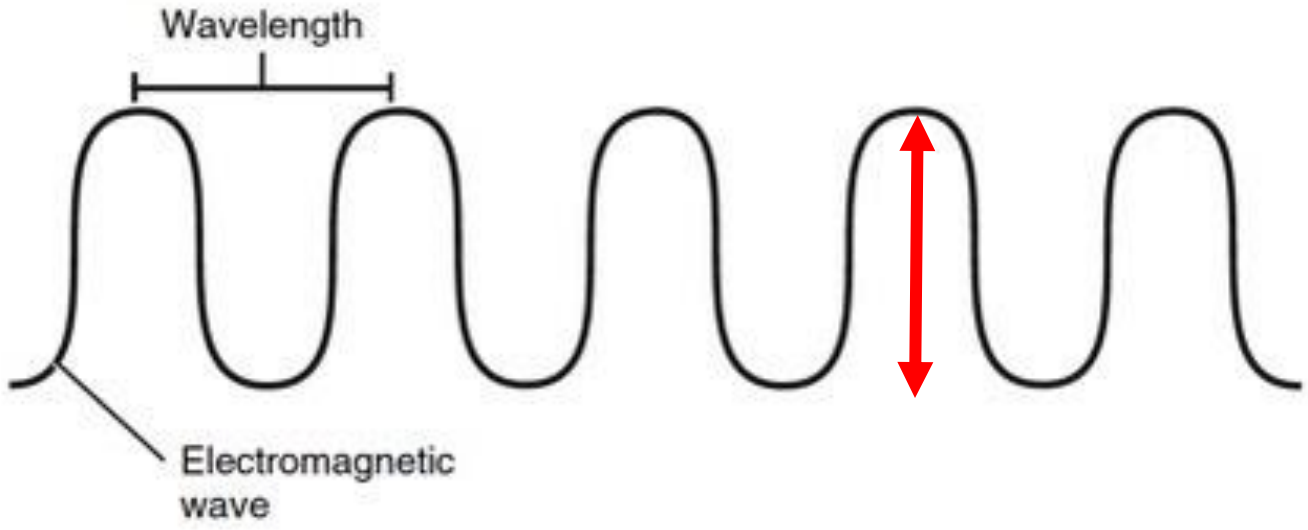
- Light is a form of electromagnetic radiation. The distance between two wave peaks is known as the wavelength.
- The photoreceptors in the eye are sensitive only to wavelengths between 400 and 700 nanometers.
- Light of different wavelengths in this visible band is perceived as different color sensations.



Light waves

- In addition to having variable wavelengths [which is the distance between 2 peaks of 2 consecutive waves, and different colors have different wavelengths], light energy varies in intensity—that is, the amplitude of the wave (intensity or brightness).

- The higher the amplitude, the higher the intensity of light, so we see a bright color instead of a dim one.



- Light rays, once they leave an object, will travel in a parallel and then diverging manner, maintaining a certain speed.

- Let's say these rays reach another medium with a different density. What will happen?
- The velocity will change. The highest velocity is in the air, so anywhere else, it will be lower.

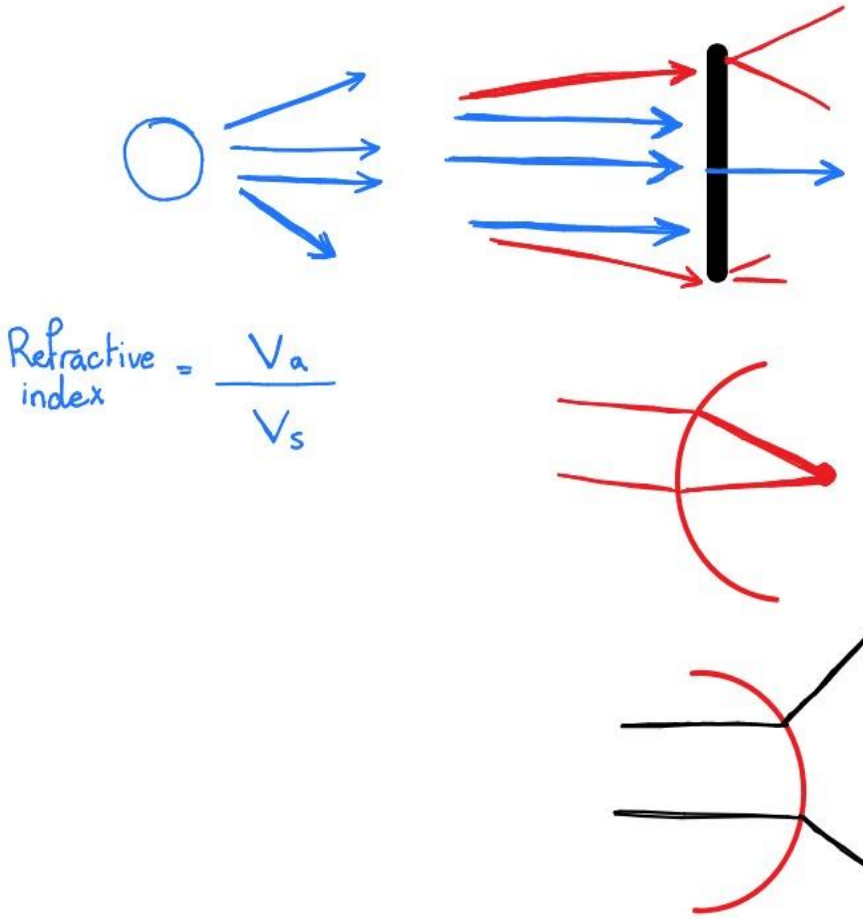
- The ratio between the velocity in the air (Va) and the velocity of any substance (Vs) is:

- **Va/Vs = refractive index**

- The refractive index will be ≥1. If the velocities are equal, it is 1. If not, the air velocity will be higher, so the index will be >1.

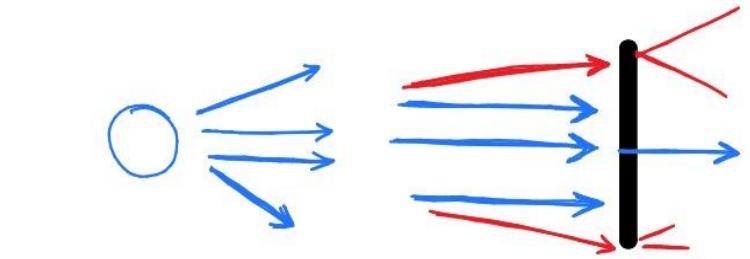
- The perpendicular rays on the new surface will not bend; only the velocity will change.

- However, light rays that penetrate the surface at an angle will bend (refraction, which might occur in a different direction as shown in the image, and the degree of bending may vary).

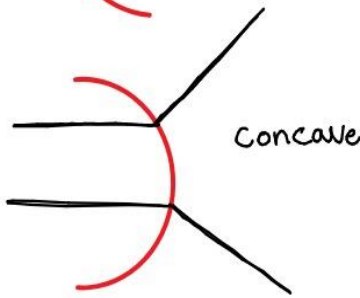


- What controls the direction and degree of bending?
- **Direction:** It is determined by the structure of the surface. So, if it is curved outward **"convex"**, once rays penetrate it, they will **converge** (they will meet at a point called the focal point).
- While if the lens is **concave**, it will cause the light rays to **diverge.**
- Regarding our eye, the lens should be convex so it converges the light rays until they reach a certain point on the retina.

- **Degree of refraction (refractive power):** It is determined by the **curvature** of the lens. The more curved the lens, the more powerful it becomes. For example, the more curved the convex lens, the more convergence will occur. The more curved the concave lens, the more divergence will occur.
- This feature is very important in the eye lens, which is attached to the suspensory ligaments. These ligaments are normally tense, so they stretch the lens and make it flat. Sometimes, we need to increase the power of the lens, so we make it more curved.



$$\text{Refractive index} = \frac{V_a}{V_s}$$



Light rays

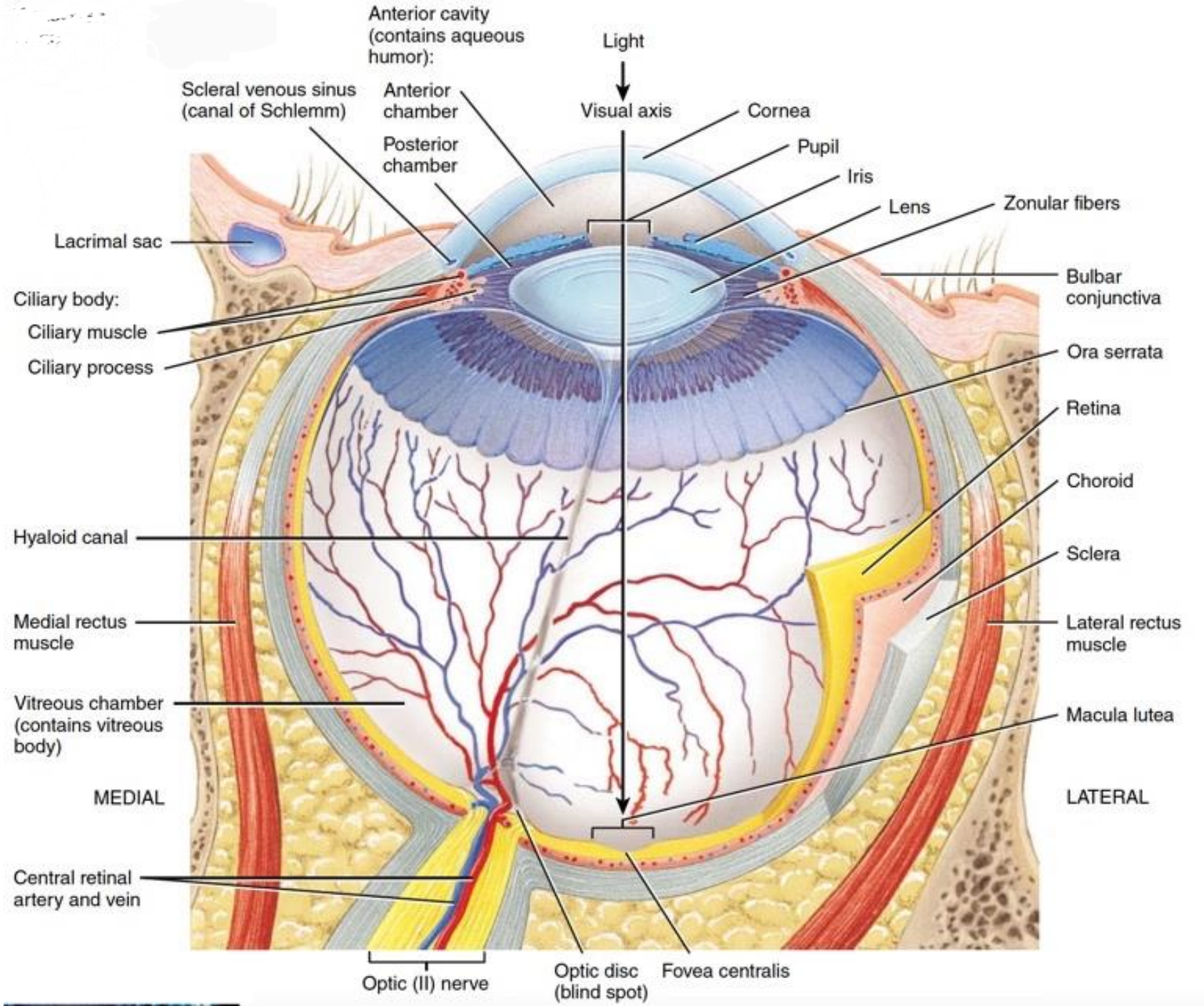
- Light waves diverge (radiate outward) in all directions from every point of a light source.
- The forward movement of a light wave in a particular direction is known as a light ray.
- Divergent light rays reaching the eye must be bent inward to be focused back into a point (the focal point) on the light sensitive retina and provide an accurate image of the light source.

Refraction

- Light travels faster through air than through other transparent media such as water and glass.
- When a light ray enters a medium of greater density, it is slowed down.
- The course of direction of the ray changes if it strikes the surface of the new medium at any angle other than perpendicular.
- The bending of a light ray is known as refraction
- With a curved surface such as a lens, the greater the curvature, the greater is the degree of bending and the stronger the lens.

Refraction

- When a light ray strikes the curved surface of any object of greater density, the direction of refraction depends on the angle of the curvature.
- A convex surface curves outward (like the outer surface of a ball), whereas a concave surface curves inward (like a cave).
- Convex surfaces converge light rays, bringing them closer together.
- Concave surfaces diverge light rays.



When light rays traveling through a transparent substance pass into a second transparent substance with a different density, they bend at the junction between the two substances (**refraction**).

Refraction in the eye

- The lens system of the eye is composed of four refractive interfaces:

- (1) the interface between air and the anterior surface of the cornea.
- (2) the interface between the posterior surface of the cornea and the aqueous humor.
- (3) the interface between the aqueous humor and the anterior surface of the lens.
- (4) the interface between the posterior surface of the lens and the vitreous humor.

Refractive index

- The refractive index of a transparent substance is the ratio of the velocity of light in air to the velocity in the substance.
- The refractive index of air is 1.00.

- The distance beyond a convex lens at which parallel rays converge to a common focal point is called the **focal length** of the lens.

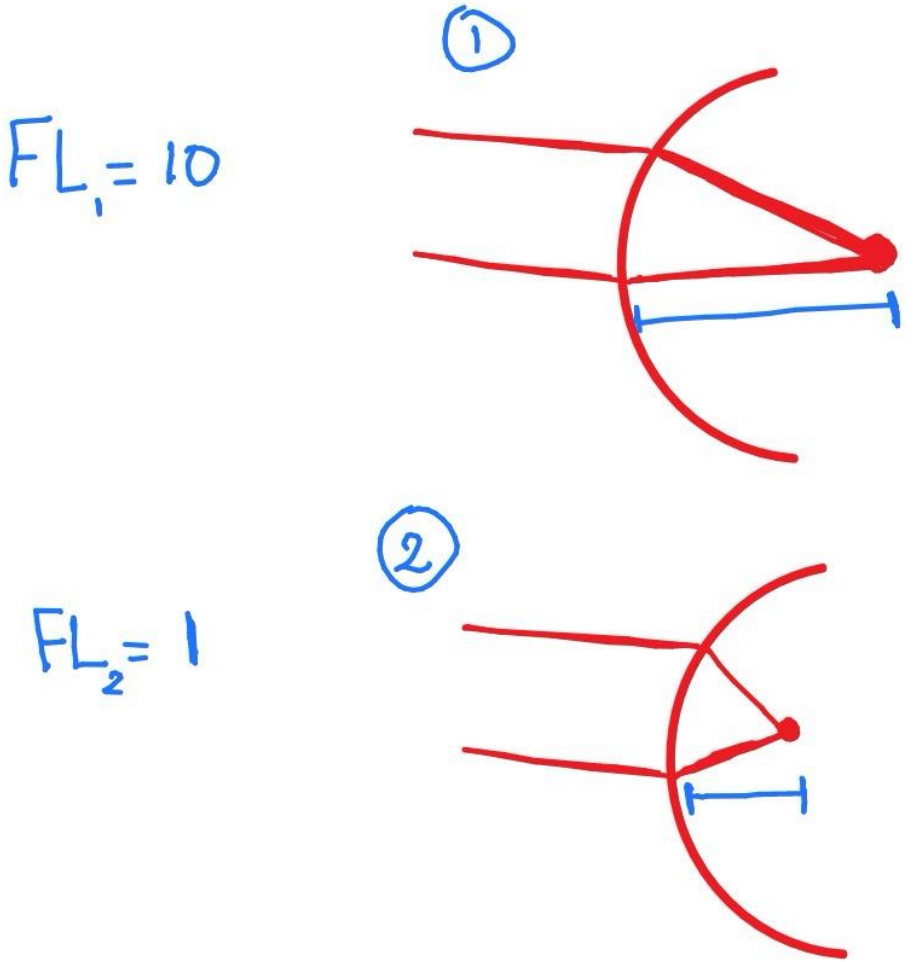
Refractive power

- The more a lens bends light rays, the greater is its “refractive power.” This refractive power is measured in terms of diopters.

- The refractive power in diopters of a convex lens is equal to 1 meter divided by its focal length.

- Thus, a spherical lens that converges parallel light rays to a focal point 1 meter beyond the lens has a refractive power of **+**1 diopter.

- Focal length (FL) is the distance between the focal point and the lens (as in the convex lens).
- **Refractive power** = 1/FL.
- As shown in the image, we have two convex lenses. Based on the law, the second lens is more powerful since 1/1 is greater than 1/10.
- The more powerful the lens, the more bending of the light at a shorter distance (the same concept applies to concave lenses in diverging).
- Refractive power is measured in **diopters**: 1/1 diopter. For convex lenses, we add + → +1 diopter. For concave lenses, we add - → -1 diopter.

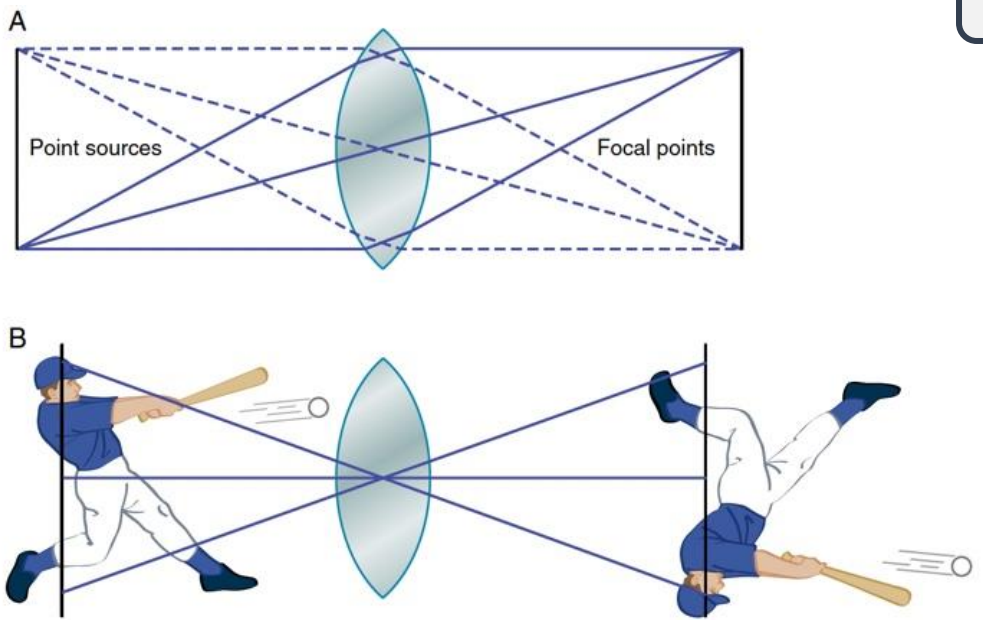


- The lens system of the eye can focus an image on the retina.

- The image is inverted and reversed with respect to the object.

- However, the mind perceives objects in the upright position despite the upside-down orientation on the retina because the brain is trained to consider an inverted image as normal.

- The doctor didn't explain them



Refractive errors

- In astigmatism, the curvature of the cornea is uneven, so light rays are unequally refracted.

- The doctor didn't explain them

Additional sources

1. MSS anatomy (Dr. Hiba👑)

- "من أكثر من ذكر الموت رضيَ من الدنيا باليسير.. ومن عدَّ كلامه من عمله قلَّ كلامه إلا في ما ينفعه.. "
-التابعيّ عمر بن عبد العزيز-
- "ما من شيء يتكلّم به ابن آدم إلا أحصيَ عليه.. حتى أنينه في مرضه.." {أحصاه الله ونسوه}
-التابعيّ طاووس بن كيسان-
- قيل: يا رسول الله ما النجاة؟ قال: "أمسِك عليك لسانك"

أمسك عليك لسانك في أيام فضيلة كهذه.. وإن يكنْ هذا وحده ما خرجت به من الشهر فقد غنمت ونجوت..

VERSIONS	SLIDE #	BEFORE CORRECTION	AFTER CORRECTION
V1→ V2	44 + 45		They have been added
V2→V3	9		Highlighted

امسح الرمز و شاركنا بأفكارك لتحسين أدائنا !!