بسم الله الرحمن الرحيم

Vision (Pt.1)

MID | Lecture 5

﴿إِنِّي تَوَكَّلْتُ عَلَى اللَّهِ رَبِّي وَرَبِّكُمْ ۚ مَّا مِن دَابَّةٍ إِلَّا هُوَ آخِذٌ بِنَاصِيَتِهَا ۚ إِنَّ رَبِّي عَلَىٰ صِرَاطٍ مُّسْتَقِيمٍ﴾

Written by: Nour Elzogheir

Reviewed by: Lubna Alhourani

PHYSIOLOGY

رحلة اليقين مع سورة يس

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

وَجَآءَ مِنْ أَقْصَا ٱلْمَدِينَةِ رَجُلٌ يَسْعَىٰ قَالَ يَٰقَوْمِ ٱتَّبِعُوا۟ ٱلْمُرْسَلِينَ (٢٠) ٱتَّبِعُوا۟ مَن لَّا يَسْـَٔلُكُمْ أَجْرًا وَهُم مُّهْتَدُونَ (٢١)

{وَجَآءَ مِنْ أَقْصَا ٱلْمَدِينَةِ رَجُلٌ يَسْعَىٰ قَالَ يَٰقَوْمِ ٱتَّبِعُوا۟ ٱلْمُرْسَلِينَ } وجاء من مكان بعيد في المدينة رجل مسرع (وذلك حين علم أن أهل القرية هَمُّوا بقتل الرسل أو تعذيبهم) ، قال: يا قوم اتبعوا المرسلين إليكم من الله، اتبعوا الذين لا يطلبون منكم أموالا على إبلاغ الرسالة، وهم مهتدون فيما يدعونكم إليه من عبادة الله وحده. وفي هذا بيان فضل مَن سعى إلى الأمر بالمعروف والنهي عن المنكر.

ثم ذكر تأييدا لما شهد به ودعا إليه، فقال:{ اتَّبِعُوا مَنْ لَا يَسْأَلُكُمْ أَجْرًا } أي: اتبعوا من نصحكم نصحا يعود إليكم بالخير، وليس [يريد منكم أموالكم ولا أجرا على نصحه لكم وإرشاده إياكم، فهذا موجب لاتباع من هذا وصفه. بقي] أن يقال: فلعله يدعو ولا يأخذ أجرة، ولكنه ليس على الحق، فدفع هذا الاحتراز بقوله: { وَهُمْ مُهْتَدُونَ } لأنهم لا يدعون إلا لما يشهد العقل الصحيح بحسنه، ولا ينهون إلا بما يشهد العقل الصحيح بقبحه.

Neurophysiology

Vision I

Fatima Ryalat, MD, PhD

Assistant Professor, Department of Physiology and Biochemistry
School of Medicine, The University of Jordan

Eyes are the organs responsible for vision, which results from the electromagnetic stimulation (light). Sensory receptors (photoreceptors) are located in the retina. This means that light has to travel all the way until it reaches the photoreceptor layer in the posterior retina for phototransduction to occur.

When looking at the structure of the eye, we notice that the eye is mostly spherical (the cornea distorts this structure).

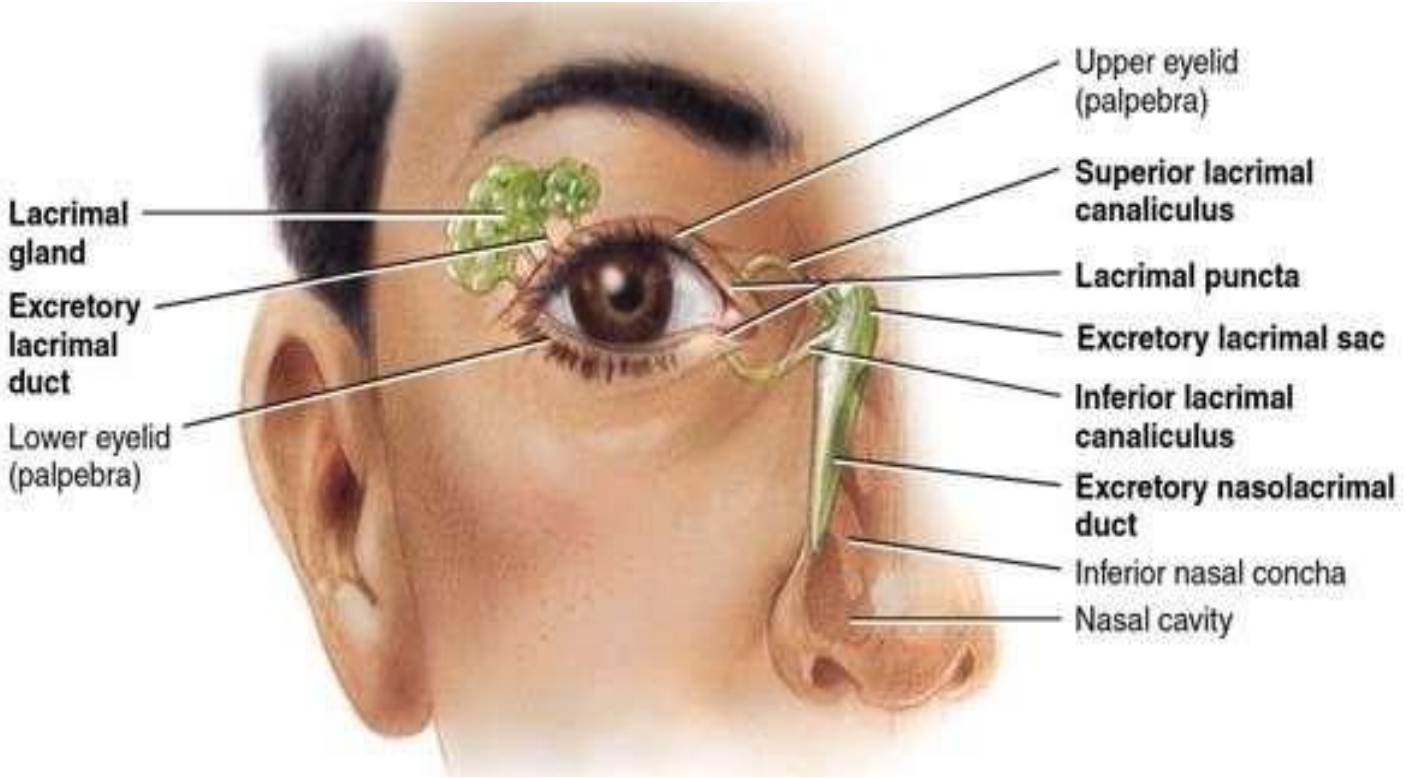
Eyes are protected by many mechanisms:
1. Bony skull covering it posteriorly.
2. Fat in the extraocular muscles.
3. Tears produced by the lacrimal gland and act lubricant and antimicrobial fluid.
4. Anteriorly by the eyelashes, eyebrows, and eyelids closing reflexively in case of danger.

Protective mechanisms in the eye

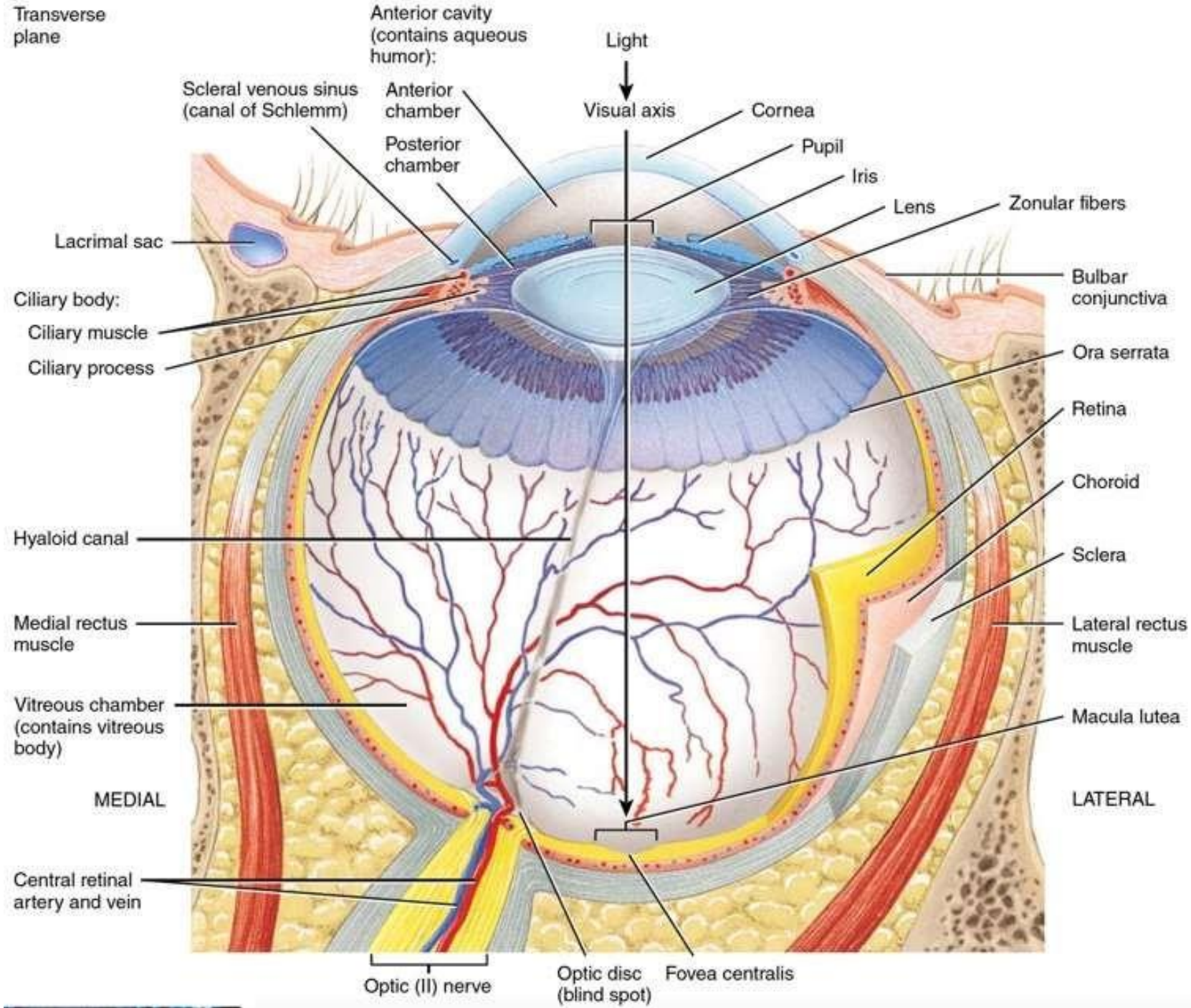
- Several mechanisms help protect the eyes from injury:
- Except for its anterior portion, the eyeball is sheltered by the bony socket in which it is positioned.
- The eyelids act like shutters to protect the exposed part of the eye from environmental insults. They close reflexly to cover the eye under threatening circumstances
- 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 tiny canals in the medial corner of each eye, eventually emptying into the back of the nasal passageway.
- This drainage system cannot handle the profuse tear production during crying, so the tears overflow from the eyes.



- The lacrimal gland continuously produces fluid (tears) that spreads across the anterior part of the eye. This fluid then drains through the lacrimal canaliculi into the lacrimal sac, then down the nasolacrimal duct.
- Crying happens when we have too much of this fluid being produced, causing it to spill over as tears and drain into the nasal cavity and the pharynx (we taste it).


Transverse plane
Anterior cavity (contains aqueous humor):
Light
Scleral venous sinus (canal of Schlemm)
Anterior chamber
Visual axis
Cornea
Posterior chamber
Pupil
Iris
Lens
Zonular fibers
Lacrimal sac
Bulbar conjunctiva
Ciliary body:
Ciliary muscle
Ciliary process
Ora serrata
Retina
Choroid
Hyaloid canal
Sclera
Medial rectus muscle
Lateral rectus muscle
Vitreous chamber (contains vitreous body)
Macula lutea
MEDIAL
LATERAL
Central retinal artery and vein
Optic (II) nerve
Optic disc (blind spot)
Fovea centralis

Layers

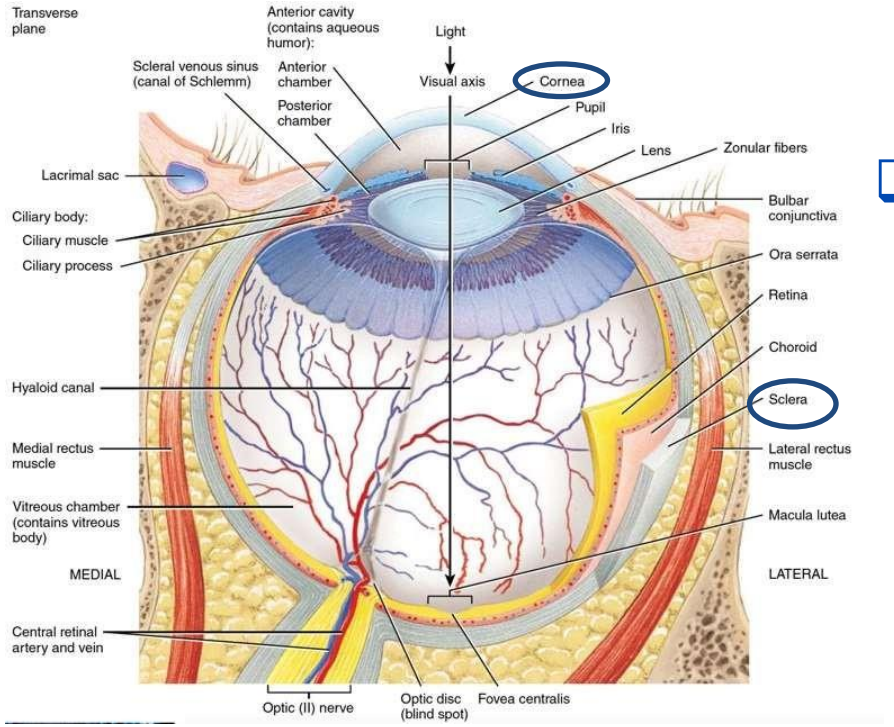
Eye is a spherical, fluid-filled structure enclosed by three layers (From outermost to innermost):

- (1) the sclera/cornea.
- (2) the choroid/ciliary body/iris. Called the uvea
- (3) the retina.

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.



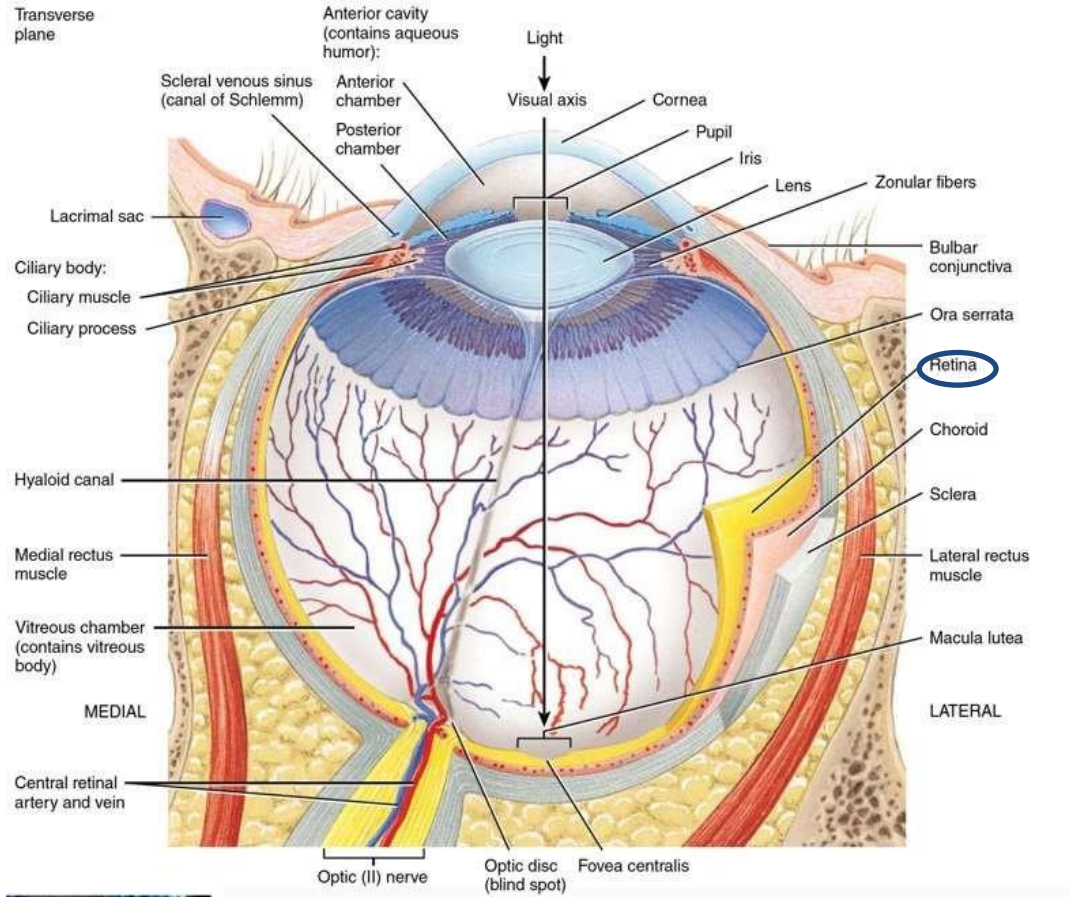
- Cornea is a transparent layer at the front of the eye, allows light to enter, and continues posteriorly as the sclera (the whitish part). Together, they form the fibrous outer layer, which gives the eye its strength and structure.

Retina

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

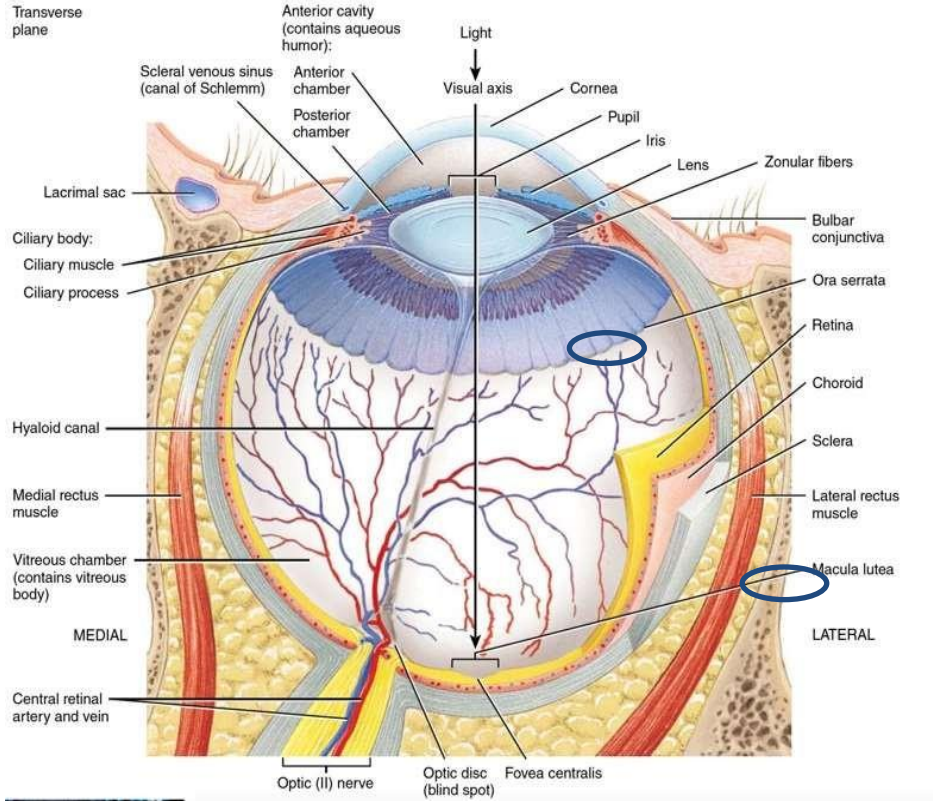
- The nervous layer contains the rods and cones, the photoreceptors that convert light energy into nerve impulses.

- The retina consists of two layers: an outer pigmented layer and an inner neural layer. The neural layer contains the photoreceptors, which transmit visual information to the brain via the optic nerve.



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.



- The iris is the colored part of the eye and it contains smooth muscles that attach to the ciliary body. It continues posteriorly as the choroid, which is a highly vascular and pigmented layer. The pigmented layers in both the retina and the choroid are very important in preventing the scattering of light during vision.

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.
- Not all light rays that pass the cornea will reach the retina, as some rays will face with the iris and won't reach the retina. Only the light rays that pass the pupil will get into the retina.

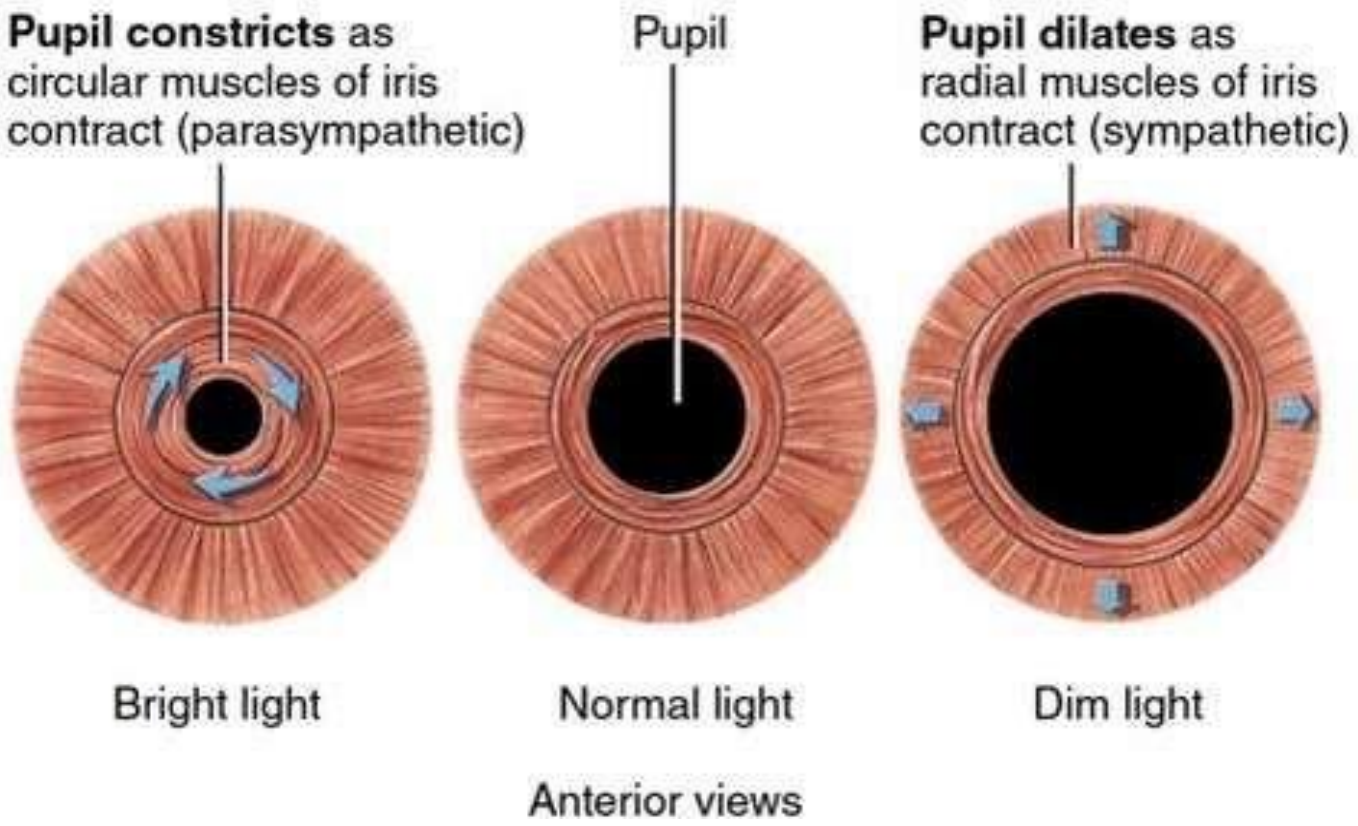
Iris

- 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).

Case 1: Parasympathetic stimulation (relaxed) causes the circular muscle to contract, constricting the pupil, and decreasing it's diameter.



Case 2: In a threatening situation (the classical example of being chased by a lion); the sympathetic nervous system will be activated, leading to the contraction of the radial muscle and the dilatation of the pupil, so you see very clearly in a fight/flight situation.

Pupil is the opening surrounded by two types of muscles: circular and radial muscles, which can contract to change the size of the pupil.

Lens

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

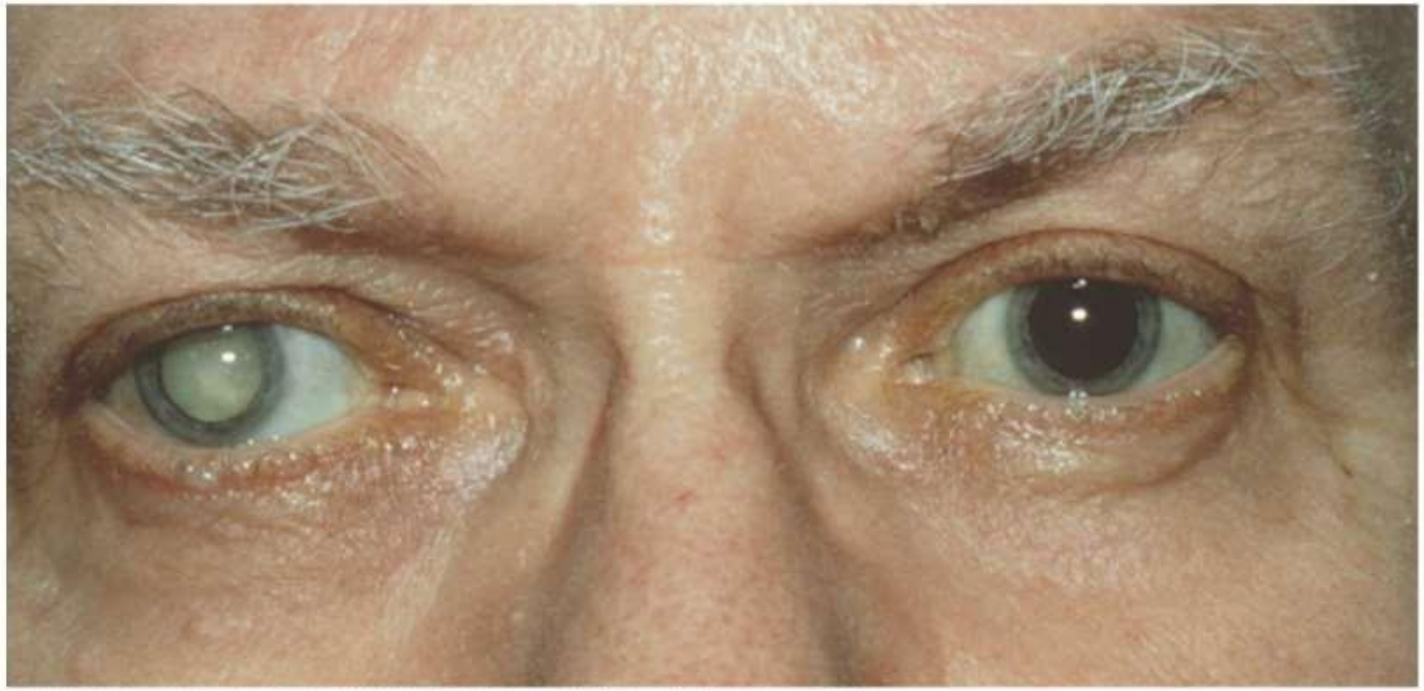
- The lens is a transparent structure made of proteins and fluid part. It is suspended by about 70 ligaments attached to the periphery of the eye, called the **suspensory ligaments**. Tension in these ligaments can change so that the curvature of the lens changes.

Lens

- 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.

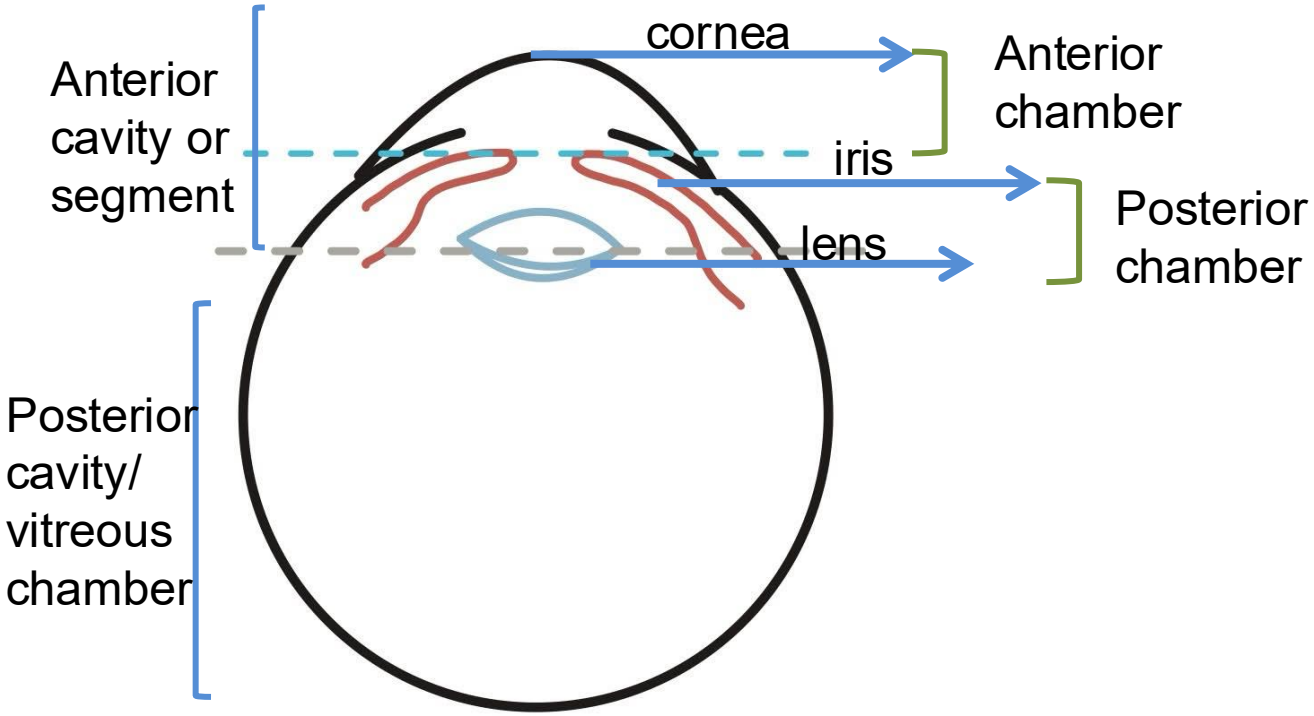
Cataract

- “Cataracts” are an especially common eye abnormality that occurs mainly in older people.
- 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.
- Cataract (results in blurred vision) is associated with aging, diabetes mellitus or even hypertension.



- The pupil normally looks dark due to the pigmented layers of the retina behind it. In case of cataract, the lens becomes opaque, turning the pupil white and blocking light from entering the eye.

The eye is divided into two segments: anterior segment and posterior segment, separated from each other by the lens. The anterior segment is filled with a fluid called aqueous humor, while the posterior segment is filled with vitreous humor.
The anterior segment is further divided into two chambers, where the anterior chamber is in front of the iris and the posterior chamber behind the iris.



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.

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.

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,”.

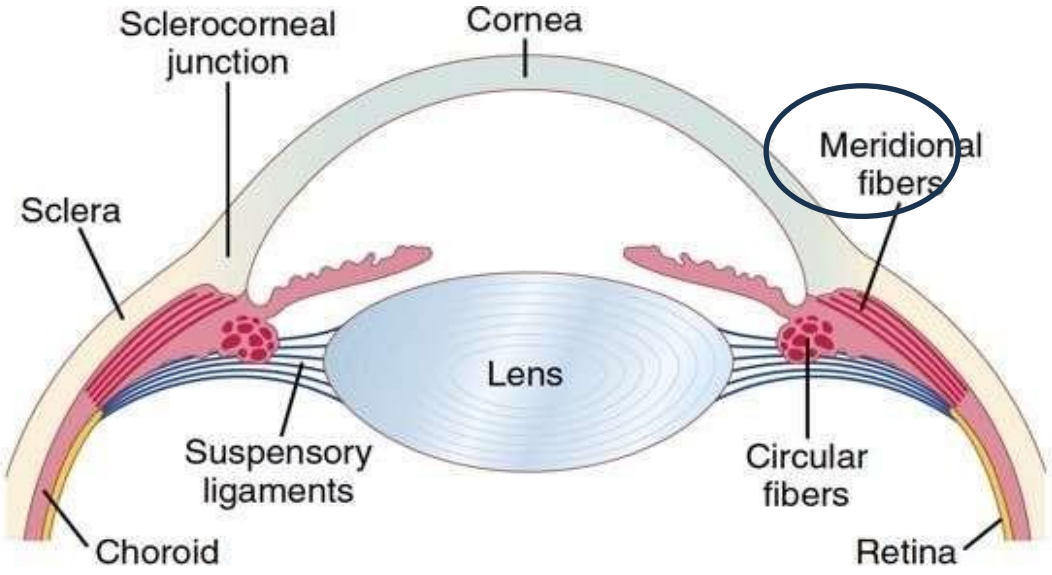
- However, on the surfaces of the trabecular plates are large numbers of phagocytic cells

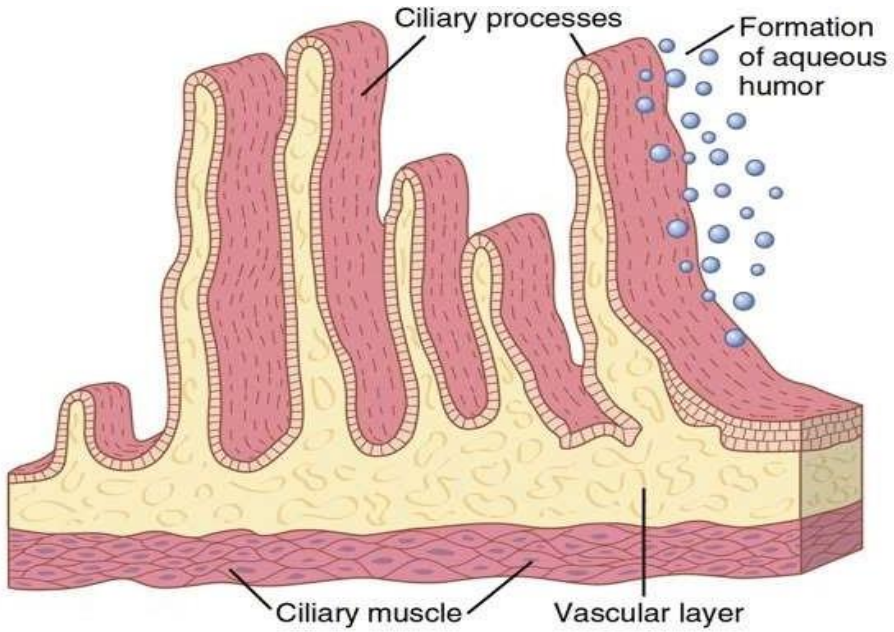
Intraocular fluid

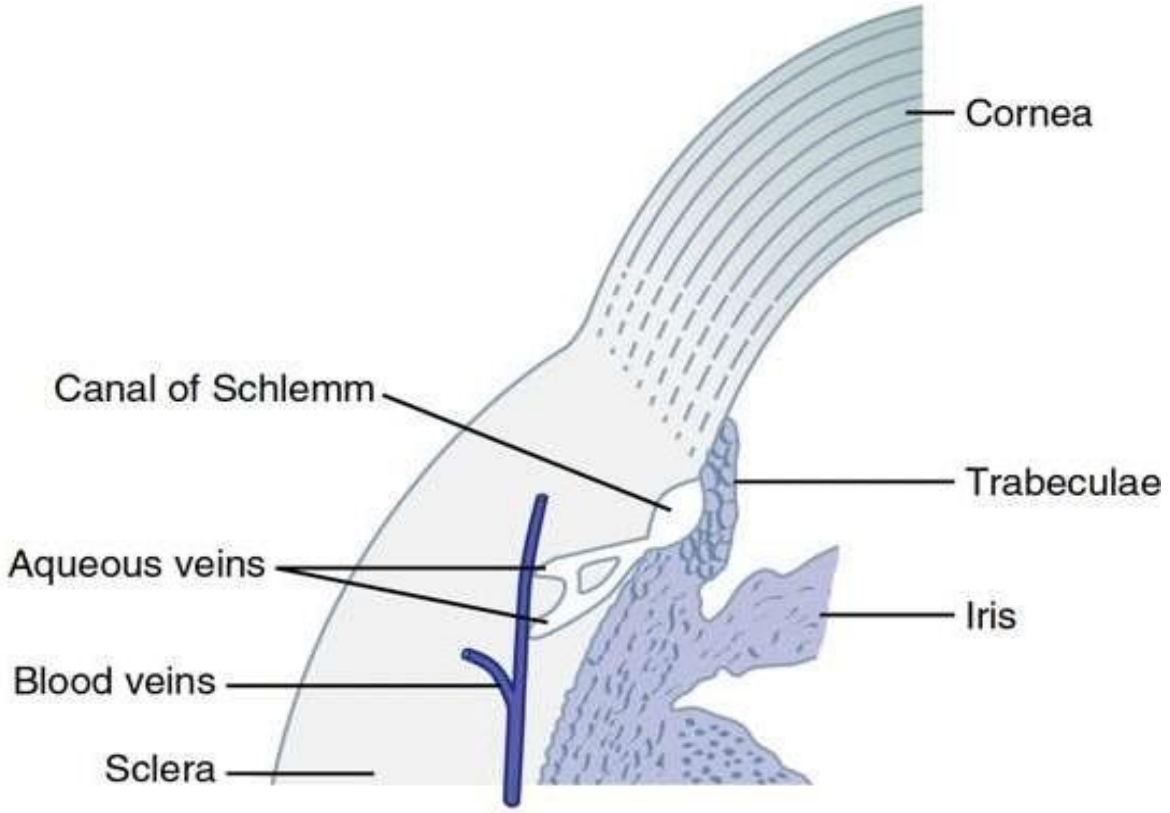
- The aqueous humor is a freely flowing fluid, whereas the vitreous humor, sometimes called the vitreous body, is a gelatinous mass held together by a fine fibrillar network composed primarily of greatly elongated proteoglycan molecules.
- Aqueous humor is continually being formed and reabsorbed.
- Aqueous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

- The aqueous fluid is renewed continuously (formed and reabsorbed). The cornea and the lens are avascular structures (they need to stay transparent), so they get the nutrients they need from this fluid and release their byproducts.

- Looking at the anterior segment of the eye that is divided by the iris into an anterior chamber and a posterior chamber, the production of aqueous humor occurs in the posterior chamber by the ciliary processes (the finger-like projections) of the ciliary body. This production mechanism involves many enzymes, such as Na+/K+ ATPase and carbonic anhydrase.

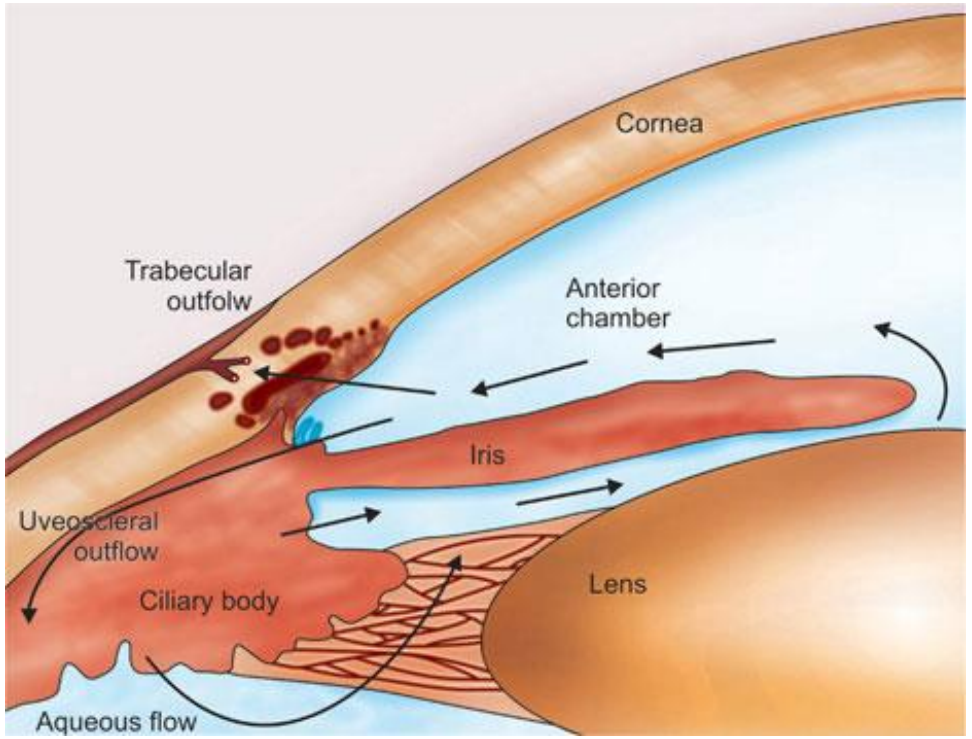


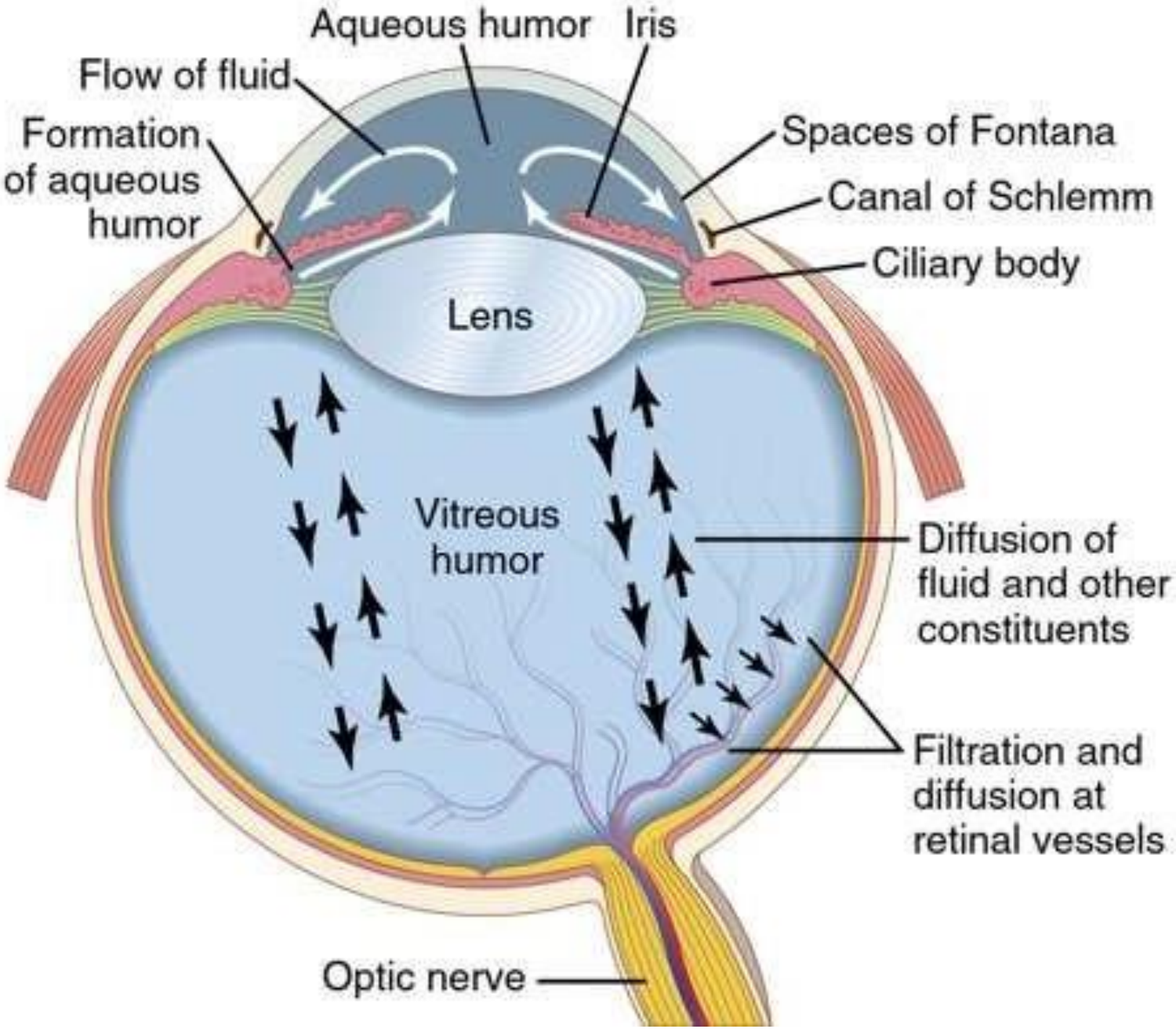




- After it is produced, the aqueous humor flows from the posterior chamber to the anterior chamber. From there, it gets reabsorbed at an angle present between the cornea and the iris called **trabeculae.**

- The trabeculae (trabecular meshwork) is a specialized structure that forms some sort of a network. This meshwork has openings that allow the aqueous humor to enter, getting absorbed to the canal of Schlemm, and then to the venous circulation.




Aqueous humor
Iris
Flow of fluid
Formation of aqueous humor
Spaces of Fontana
Canal of Schlemm
Ciliary body
Lens
Vitreous humor
Diffusion of fluid and other constituents
Filtration and diffusion at retinal vessels
Optic nerve

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.

- It is important to maintain the intraocular pressure (IOP) in the normal range, by balancing the production and the reabsorption of aqueous humor. Normal IOP ranges between 15–20 mmHg, where any increase is pathological.

- To measure the intraocular pressure, you need (local anesthesia) and a (tonometry), which touches the eye and measures the pressure. Diabetic and older patient populations get routine checkups to prevent such visual field defects.

Glaucoma المياه الزرقاء

- 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.

- When there is an increase in the secretion or decrease in the reabsorption; the volume of aqueous humor in the anterior chamber rises; thus increasing the pressure against the vitreous fluid and pressing on the weakest point, the optic nerve disc, leading to a condition called **glaucoma**, which is actually a spectrum of disorders.

More on Glaucoma

Pathological Changes include:

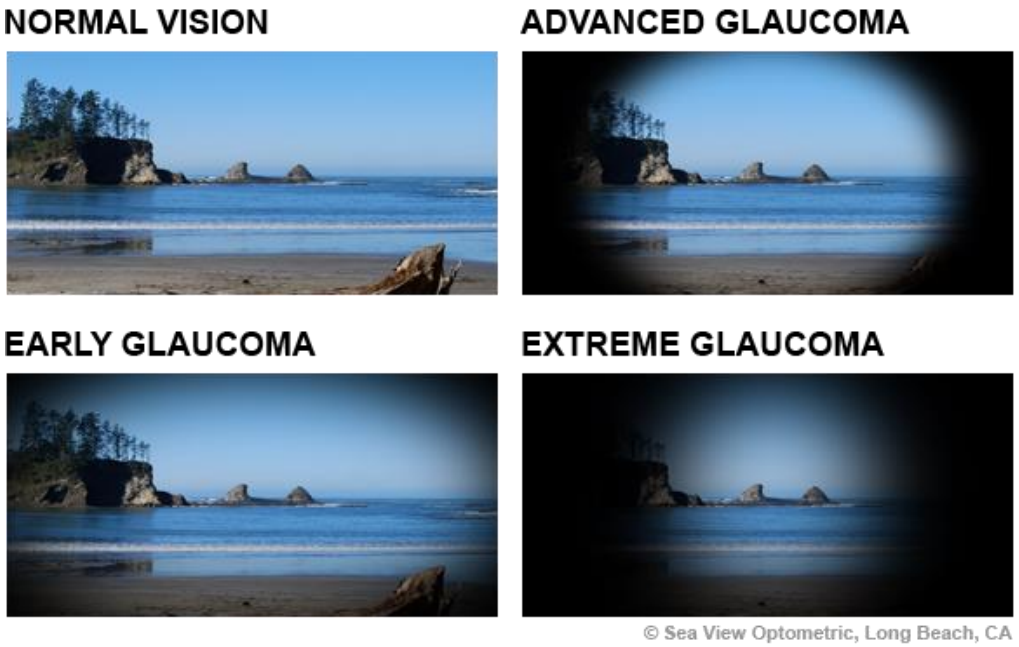
- Damage to the optic nerve (observed by using an ophthalmoscope).
- Vascular changes.
- The patient's visual field is affected, with the peripheral fields being affected first.

Normal optic nerve head

Glaucomatous cupping

Clinical Presentation:

- In the early stages, the patient experiences blurry or dark areas in their peripheral vision.
- If left untreated, this darkness progresses centrally, narrowing the visual field.
- Another presentation is a fixed black spot (scotoma) in the field of vision where the patient cannot see through.



Treatment of Glaucoma

Glaucoma can be treated either by increasing the reabsorption of aqueous humor or decreasing its secretion. In most cases, glaucoma is caused by decreased reabsorption.

Aging, chronic diseases, intraocular infections, and trauma can all produce debris. These debris get trapped at the trabecular meshwork, blocking the drainage pathway and preventing fluid from reaching the canal of Schlemm to be removed. The body attempts to adapt by employing phagocytes at the trabeculae, but in cases of chronic inflammation or infection; debris accumulation occurs over time, leading to increased intraocular pressure.

Treatment Options:

1. Laser Surgery
2. Drug Therapy:
   - Carbonic anhydrase inhibitors which decrease the production of aqueous humor.
   - Parasympathomimetics that decrease the diameter of the pupil (miosis), pulling the iris away from the drainage angle and increasing the angle size, facilitating the fluid outflow.

Note: Pupil dilators are avoided as they can narrow the angle and worsen glaucoma.

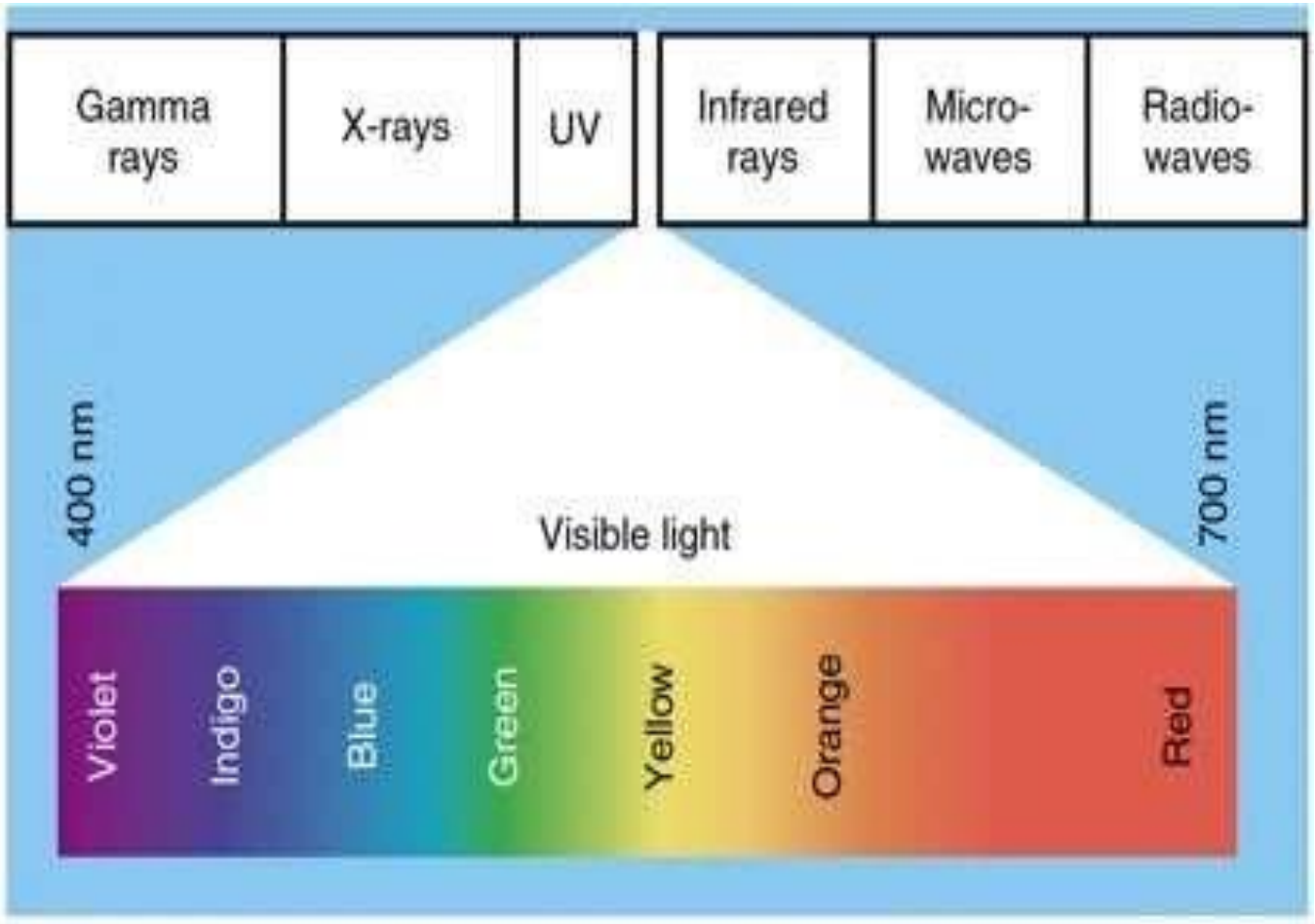
Vitreous humor

- 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.

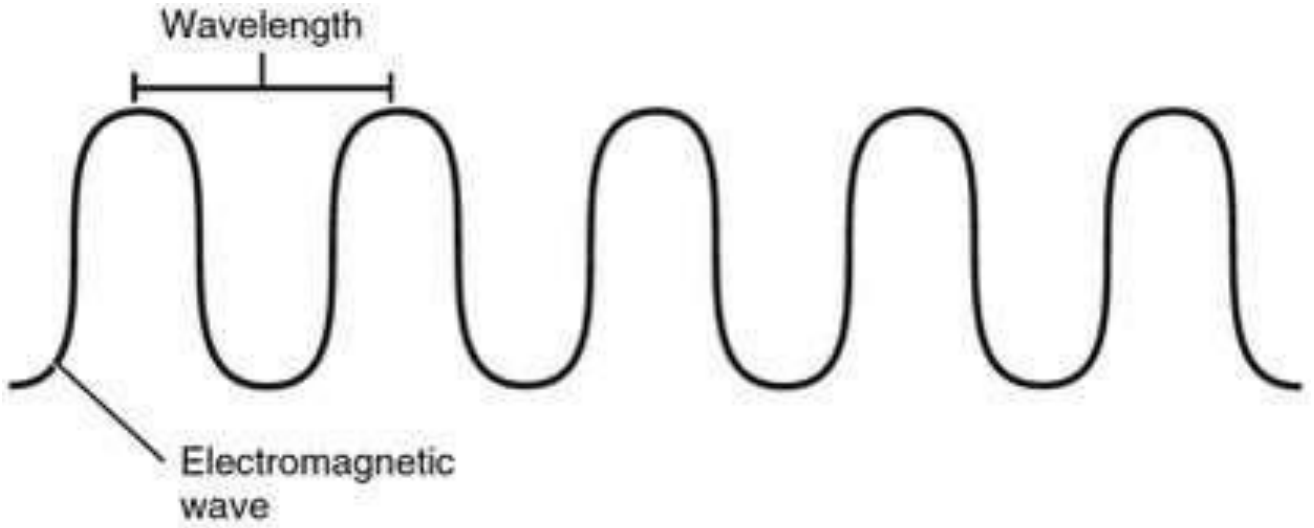
- Posteriorly, we will have the vitreous fluid, which is a jelly-like thick fluid responsible for maintaining the structure of the eye.
- Unlike the aqueous fluid, it is constant and doesn't get renewed.

- Light is an electromagnetic wave (consisting of perpendicular electrical and magnetic waves)
- We can only see a very small range of wave lengths which falls between (400 nm-700 nm).



Light waves

- In addition to having variable wavelengths, light energy varies in intensity—that is, the amplitude of the wave (intensity or brightness).



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 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.

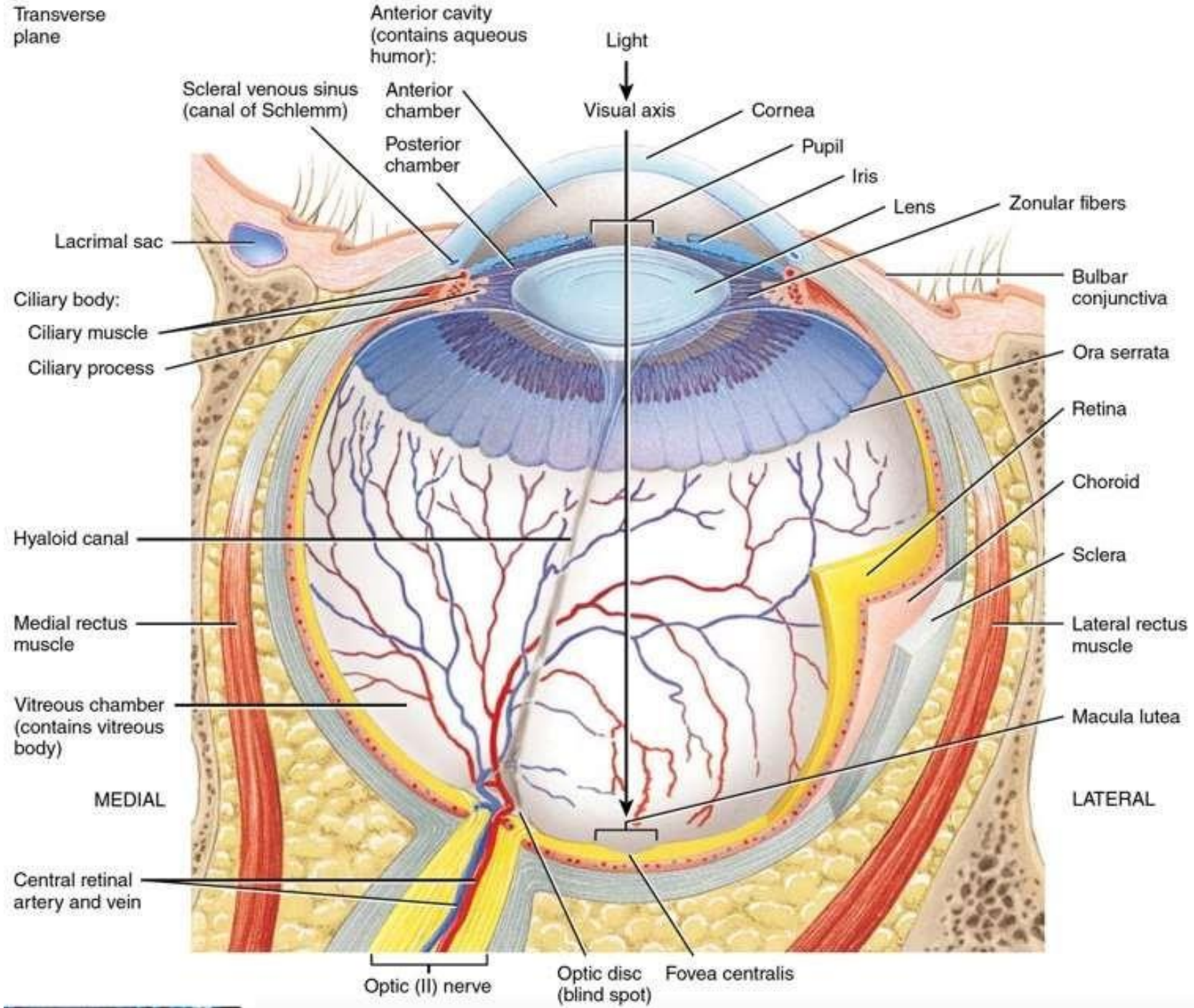
- Light waves can either get absorbed, reflected, refracted, or pass through. When light waves pass through two different substances, they get refracted. Refraction is the bending of light. The degree of this bending is determined by the light's angle of incidence and the varying densities of the eye's internal structures.

Refraction

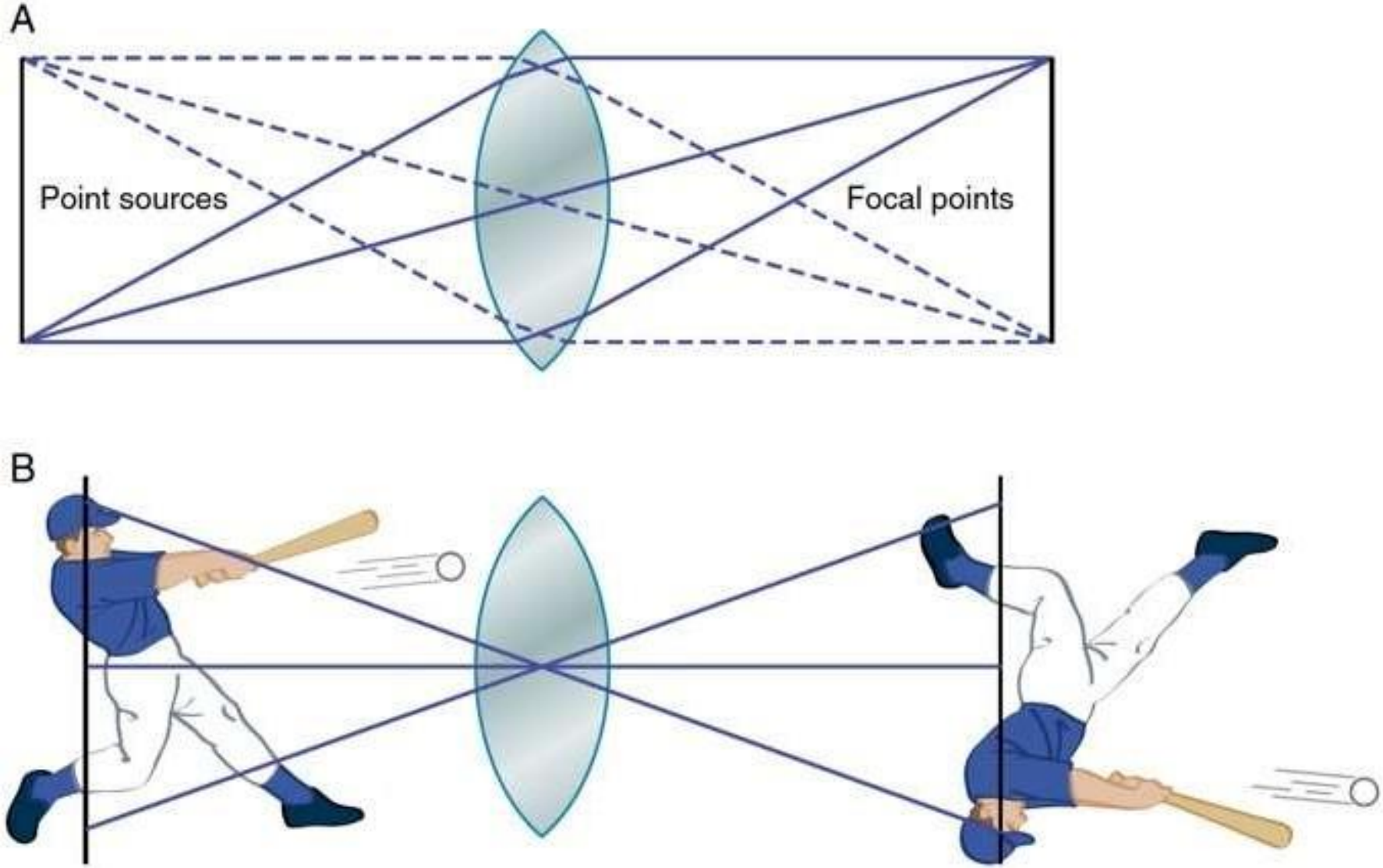
- Light travels faster through air than through other transparent media such as water and glass.
- When a light ray enters a medium of greater density, it is slowed down.
- The course of direction of the ray changes if it strikes the surface of the new medium at any angle other than perpendicular.
-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

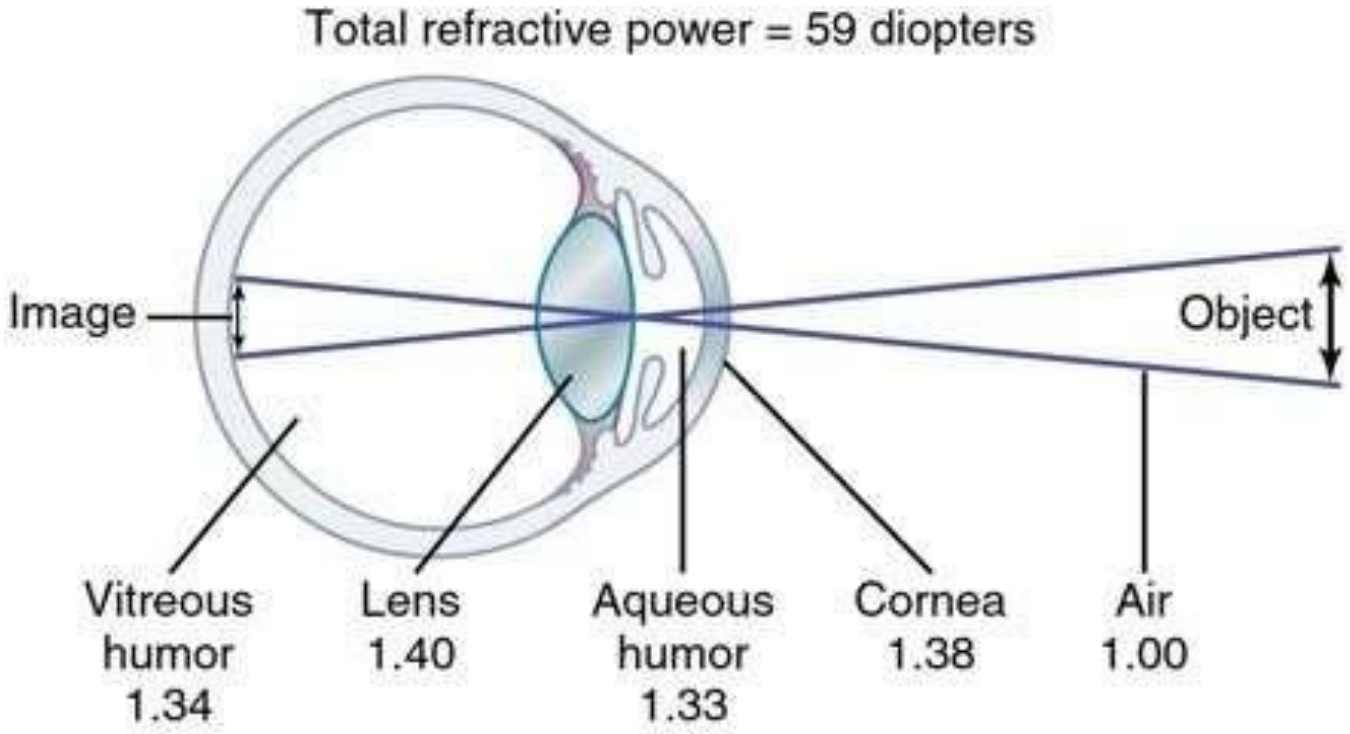

A
Point sources
Focal points
B

- 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 lens of the eye is a convex structure. It converges all the light rays that pass through the pupil into one point at the retina. The point where all the light rays are joined is called the focal point, and it must be exactly on the retina for us to see clearly.

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.



- In the eye, 75% of the refraction is achieved by the cornea, and the remaining 25% is achieved by the lens. The lens is important due to its ability to change its curvature at different visual stimulations, a property called accommodation (discussed in the next lecture).

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 refractive index of any substance other than the air is larger than one.
- 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.

  - The more curved the lens, the shorter the focal length becomes, and the higher the refractive power.
  - When we say the refractive power is 1 diopter, this means that the lens can converge light at a point 1 meter away from its center.

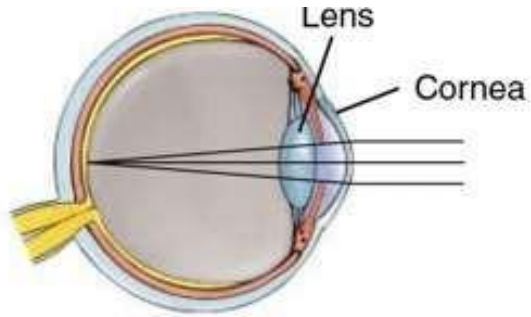
Refraction

- In the reduced eye, a single refractive surface is considered to exist, with a total refractive power of 59 diopters when the lens is accommodated for distant vision.

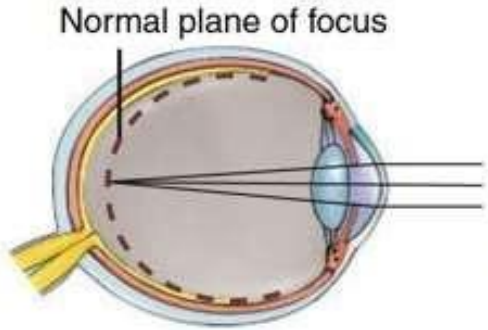
- About two-thirds of the 59 diopters of refractive power of the eye is provided by the anterior surface of the cornea (not the lens).

- The principal reason for this phenomenon is that the refractive index of the cornea is markedly different from that of air.

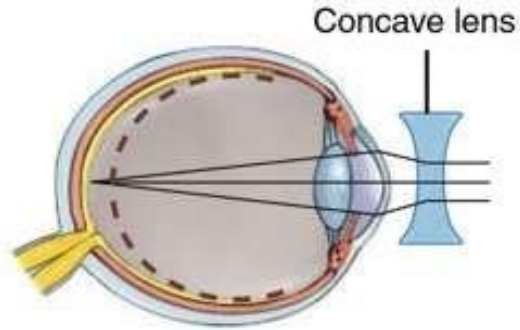
- There are two main refraction structures: the cornea and the lens. The one with the largest refractive power (meaning the highest ability to bend light) is the cornea, as the difference between its refractive index and that of air is the highest.



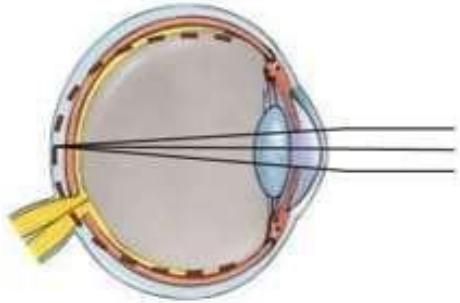
(a) Normal (emmetropic) eye



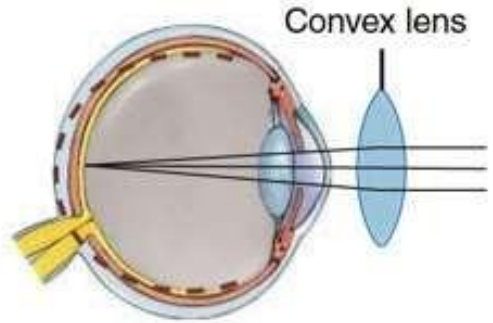
(b) Nearsighted (myopic) eye, uncorrected



(c) Nearsighted (myopic) eye, corrected



(d) Farsighted (hyperopic) eye, uncorrected

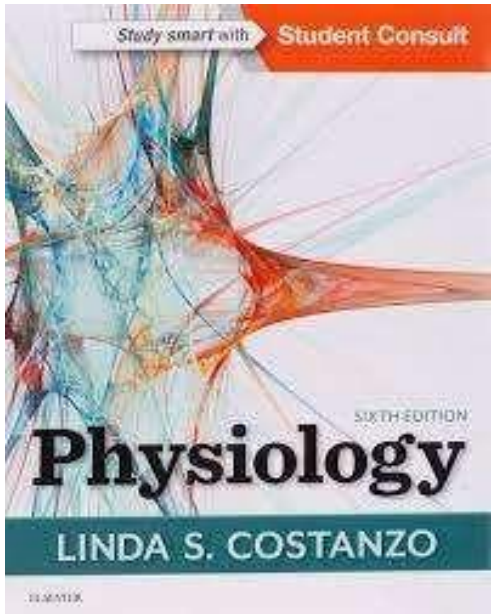


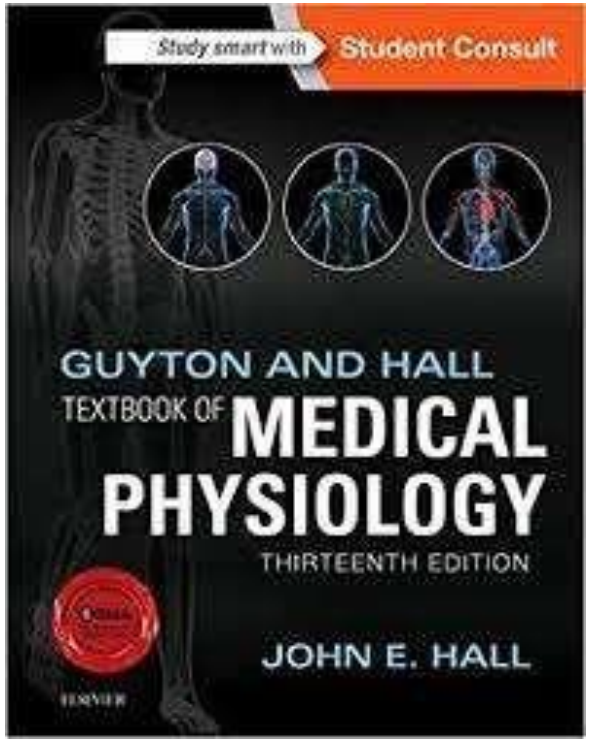
(e) Farsighted (hyperopic) eye, corrected

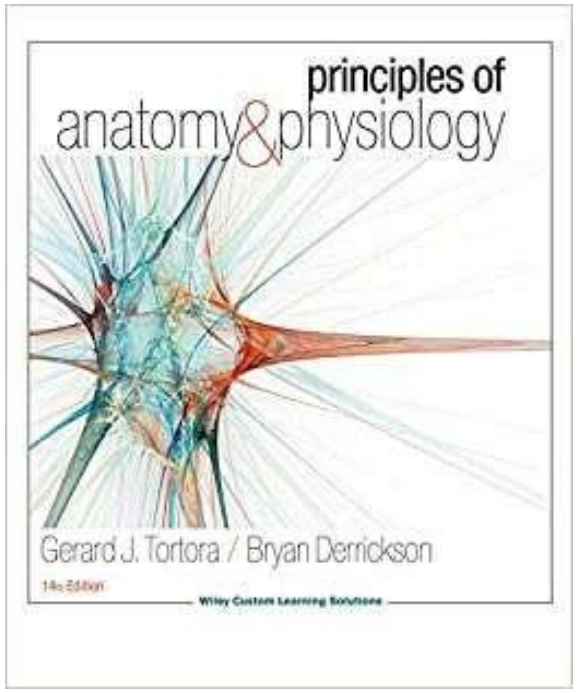
Refractive errors

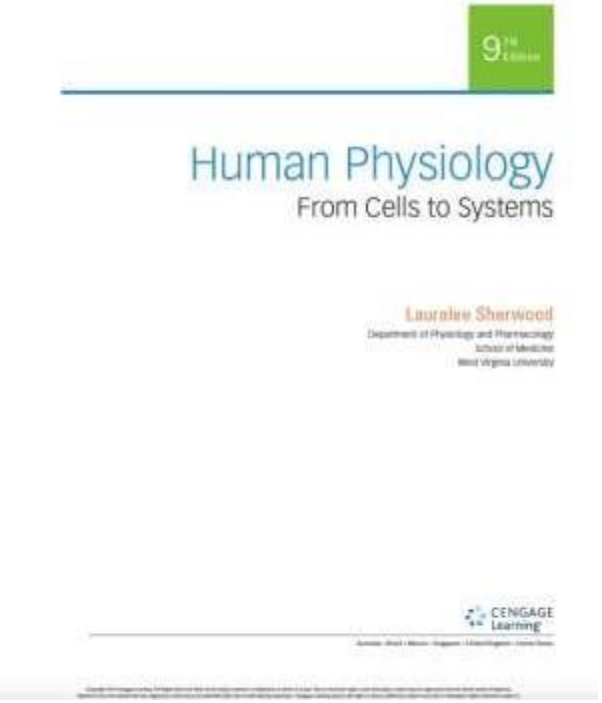
- In astigmatism, the curvature of the cornea is uneven, so light rays are unequally refracted.

References

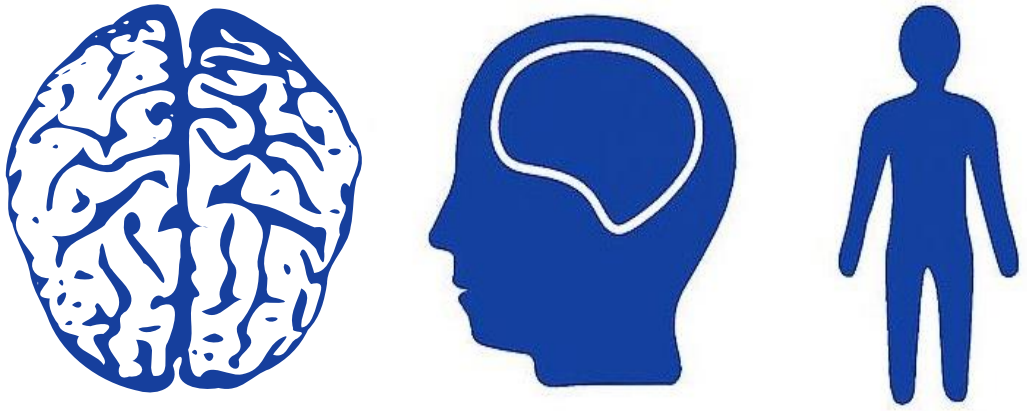

Study smart with
Student Consult
SIXTH EDITION
Physiology
LINDA S. COSTANZO


Study smart with
Student Consult
GUYTON AND HALL
TEXTBOOK OF MEDICAL
PHYSIOLOGY
THIRTEENTH EDITION
JOHN E. HALL


principles of
anatomy&physiology
Gerard J. Tortora / Bryan Derrickson
14th Edition
Wiley Custom Learning Solutions


9th Edition
Human Physiology
From Cells to Systems
Lauralee Sherwood
CENGAGE Learning

Thank you



PHYSIOLOGY QUIZ LECTURE 5

External Resources

رسالة من الفريق العلمي

اللهم إن عمر عطية في ذمتك وحبل جوارك، فقِه من فتنة القبر وعذاب النار،
أنت أهل الوفاء والحق، فاغفر له وارحمه إنك أنت الغفور الرحيم.

عن أبي هريرة رضي الله عنه أن رسول الله صلى الله عليه وسلم قال: (قال الله عزوجل: كل عمل بن آدم له إلا الصيام؛ فإنه لي وأنا أجزي به، والصيام جنّة، وإذا كان يوم صوم أحدكم فلا يرفث، ولا يصخب، فإن سابّه أحد أو قاتله فليقل: إني امرؤ صائم، والذي نفس محمد بيده لخلوف فم الصائم أطيب عند الله من ريح المسك، للصائم فرحتان يفرحهما: إذا أفطر فرح، وإذا لقي ربه فرح بصومه) رواه البخاري ومسلم.

Scan the QR code or click it for FEEDBACK

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			