Ministry of High Education and Scientific Research
Al-Furat Al-Awsat Technical University
Al-Najaf Technical Institute

PHYSIOLOGY OF EYE

Optometry Department
By
Asst.Lec.Noor Ayed Manney
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Noor.ayed.inj@atu.edu.iq

week	Topics Covered
1	**Retina: Structure and General Functions: Introduction to retinal anatomy, major retinal regions, and its role in converting light into neural signals.**
2	**Photoreceptors: Rods vs. Cones: Differences between rods and cones in structure, distribution, sensitivity, and visual function.**
3	**The Sensory Foundation of Vision: Mechanism of phototransduction and how visual stimuli are processed by retinal cells.**
4	**Comparative Anatomy of Rods and Cones: Detailed comparison of outer segments, pigments, synaptic structures, and neural connections.**
5	**The Cones (Photopic Vision): Function of cones in daylight vision, color perception, and high visual acuity.**
6	**The Rods (Scotopic Vision): Function of rods in dim-light vision, night adaptation, and peripheral vision.**

week	Topics Covered
7	**Central Vision Anatomy: Organization of the central retina and importance in fine visual discrimination.**
8	**The Macula Lutea: Structure, pigmentation, and clinical importance of the macula in detailed vision.**
9	**The Fovea: Anatomy of the fovea, cone concentration, and role in maximum visual acuity.**
10	**Clinical Impact of Macular and Foveal Disorders: Common diseases affecting central vision such as macular degeneration and edema.**

week	Topics Covered
11	**Peripheral Retina Anatomy and Boundaries: Peripheral retinal structure and its role in motion detection and visual field expansion.**
12	**The Ora Serrata and Physiological Boundaries: Anatomical transition zone between retina and ciliary body and its physiological significance.**
13	**Retinal Attachment, Retinal Layers, and Pigment Epithelium: Retinal layer organization and functions of retinal pigment epithelium (RPE).**
14	**Sensory Layers and Mechanics of Retinal Detachment: Mechanisms, causes, and clinical features of retinal detachment and related pathology.**

References

- ►Hall, J. E. (2021). *Guyton and Hall Textbook of Medical Physiology* (14th ed.). Elsevier.

- ► Remington, L. A. (2021). *Clinical Anatomy and Physiology of the Visual System* (4th ed.). Elsevier.

- ►Levin, L. A., Nilsson, S. F. E., Ver Hoeve, J., Wu, S. M., Kaufman, P. L., & Alm, A. (2011). *Adler's Physiology of the Eye* (11th ed.). Elsevier.

PHYSIOLOGY OF EYE

UNIT 1

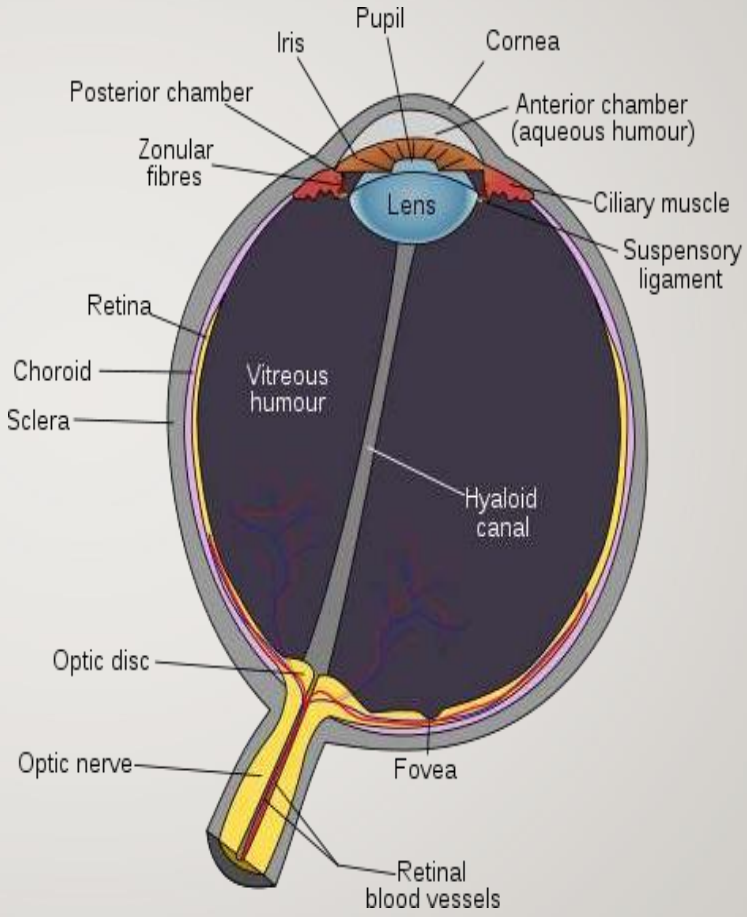
- This lecture provides a comprehensive overview of the retina, including its anatomical structure and functional organization. It explains how the retina converts light into neural signals that are transmitted to the brain for visual interpretation.
- The discusses the structural and functional differences between rods and cones. Special emphasis is placed on their distribution in the retina and their roles in dim-light vision, color perception, and visual acuity.

PRE TEST : SELECT THE CORRECT ANSWER :-

- Which photoreceptor is mainly responsible for night vision?
  a) Cones
  b) Rods
  c) Macula
  d) Fovea
- Which part of the retina is responsible for the highest visual acuity?
  a) Ora serrata
  b) Optic disc
  c) Fovea
  d) Choroid

PHYSIOLOGY OF EYE

- cornea
- pupil
- iris
- anterior chamber
- aqueous humor
- lens
- vitreous humor
- retina
- fovea
- choroid
- sclera
- optic nerve



THE EYE

- The eyes are the organs of the special sense of sight. They sit in the orbit of the skull which provides them with positional protection.
- Humans have two eyes which work together, this is known as binocular vision.

- The human eye is one of the important sensory organs of the human body.
- It is very sensitive and exposed to various diseases, thus **protection** and **prevention** is necessary to keep the eye safe and healthy.

THREE LAYERS OF **HUMAN EYE**

1) **outer layer** which is fibrous and protective
2) **middle layer** which contains many blood vessels
3) **inner layer** known as the optic part of the eye

THE OUTER LAYER OF THE EYEBALL:

Five-sixths of the eye is known as the **sclera** which is the white of the eye you can see.

At the front of the eye the sclera becomes the cornea which is transparent and allows light to enter the eye.

THE MIDDLE LAYER:

The middle layer contains many **blood vessels** such as arteries and veins. Within this layer there are also muscles (**ciliary muscles**) and at the front of the eyeball the **iris**.

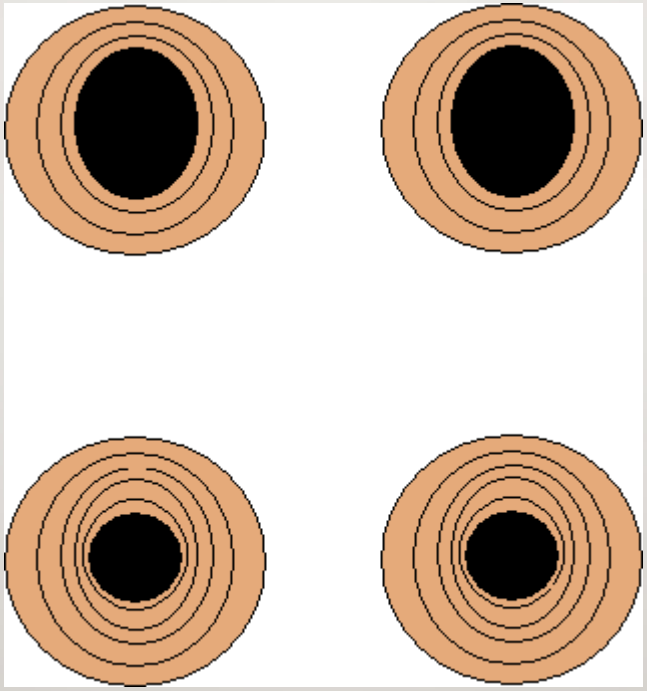
The **iris** is a circular, coloured structure which has a central opening called the **pupil**. **Muscles** within the iris are responsible for changing the size of the pupil in different conditions.

PUPIL SIZE

- Can you think of any times when your pupils have changed size?
- In order to control the amount of light entering the eye, the pupil can become smaller or larger.
- Muscles in the iris are arranged in differing ways to allow this to happen.

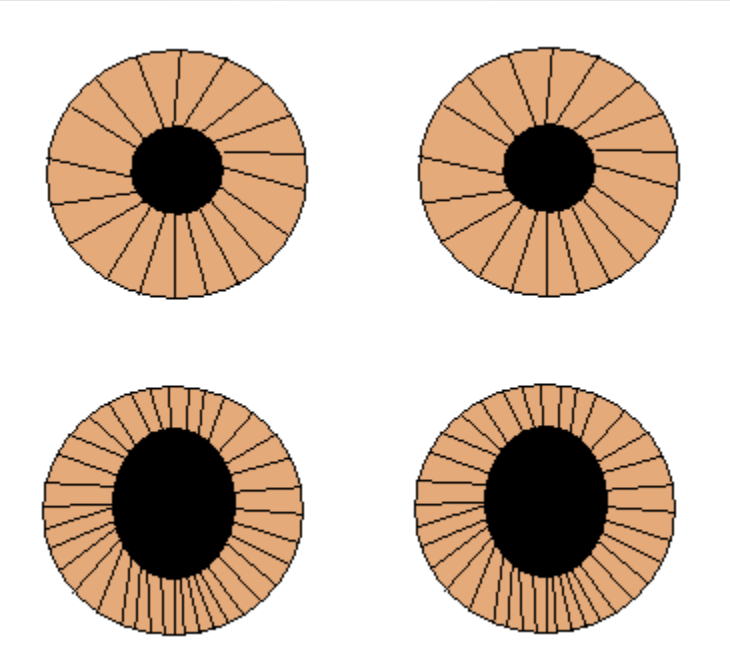
CONSTRICTION

- A circular pattern of muscle (the **sphincter pupillae muscle**) when contracted decreases the size of the pupil. This is constriction. This happens in light situations.



DILATIO

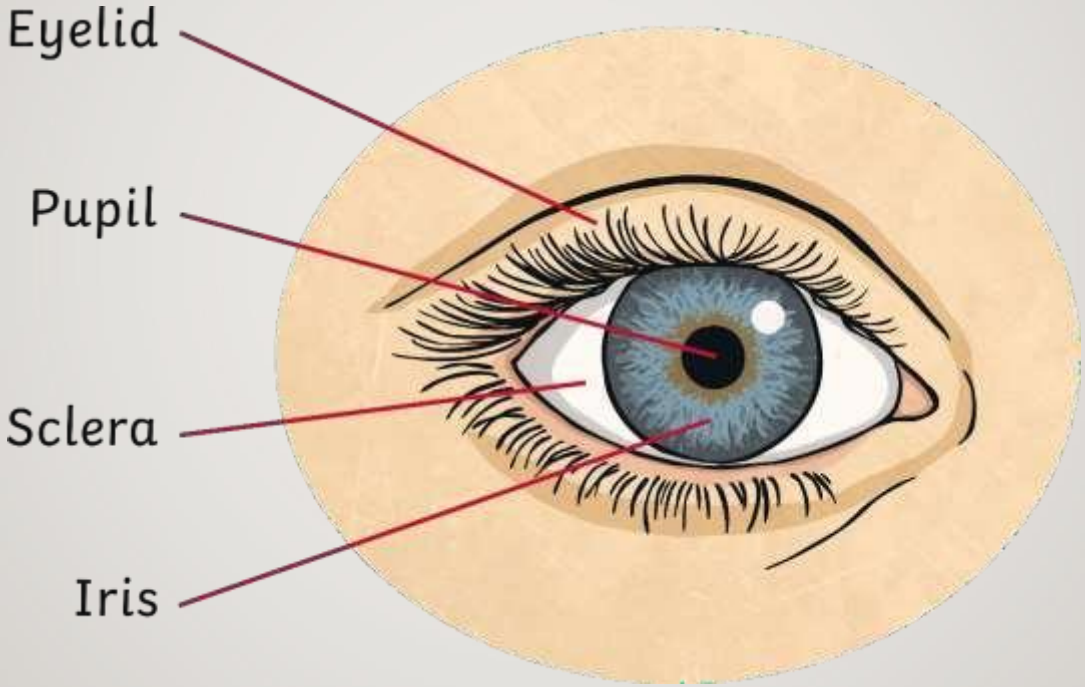
- A radial pattern of muscle (the **dilator pupillae muscle**) when contracted increase the size of the pupil. This is dilation. This happens in **dark situations.**



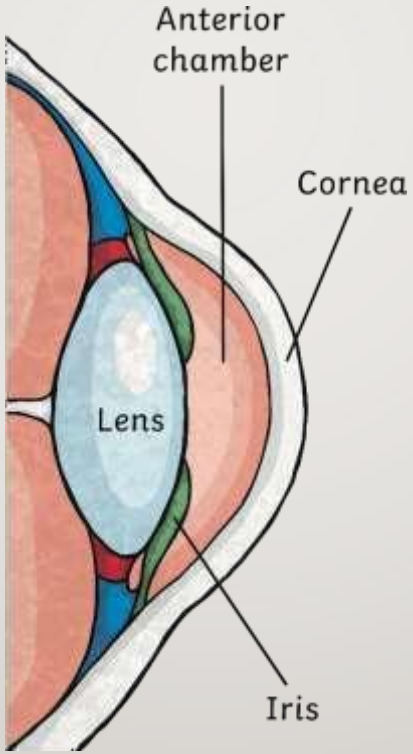
THE INNER LAYER OF EYEBALL

- is known as the
  - **retina** which is **sensitive to light.**
- On the retina there are some obvious features:
- The **optic disc** is where the optic nerve leaves the retina to carry information to the brain. This is **not sensitive** to light and is sometimes referred to as the **blind spot.**
- The **fovea** is the thinnest area of the retina and is the **most sensitive** part of the eye.

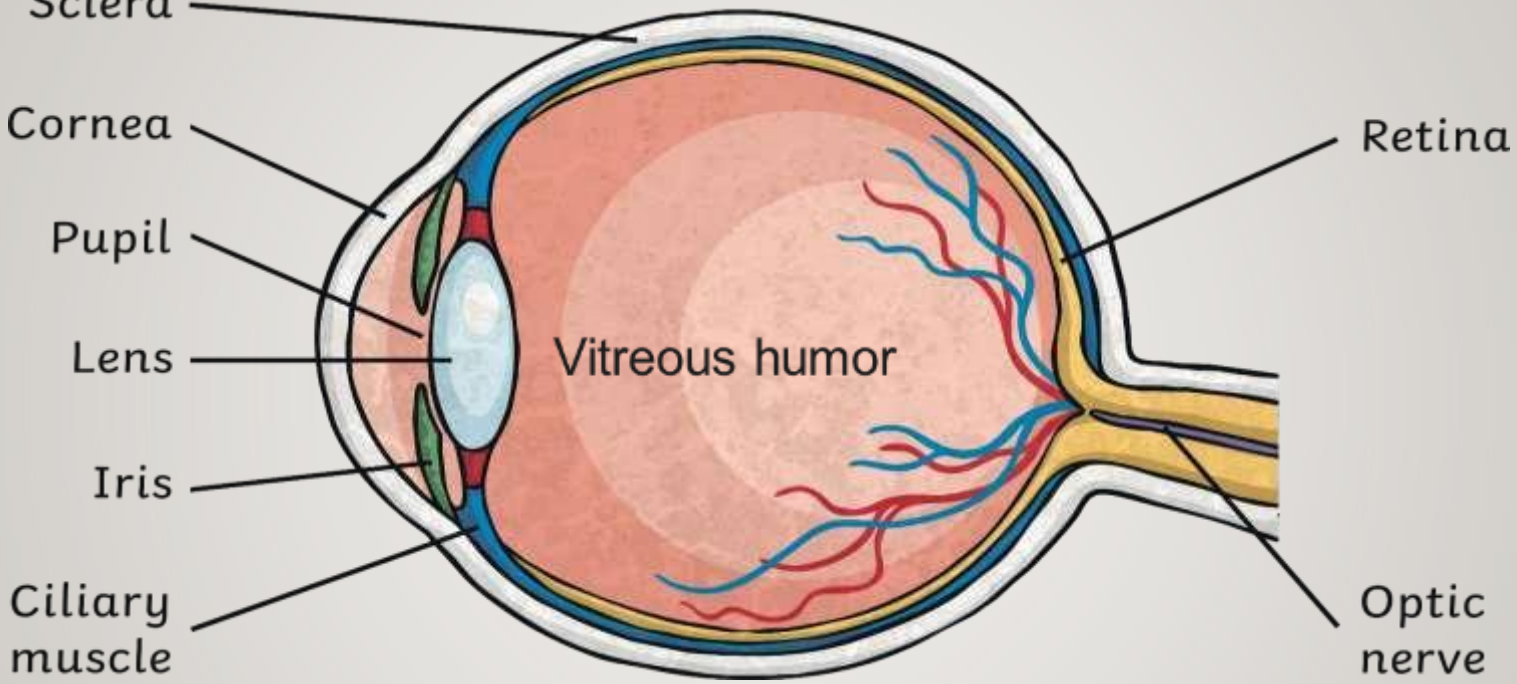
THE **SCLERA** IS THE WHITE PART OF THE EYE. IT PROVIDES A PROTECTIVE COATING, WHICH COVERS MOST OF THE EYE.



- The **anterior chamber** is the space between the cornea and the iris. This space is filled with a special fluid that helps keep the eye healthy.

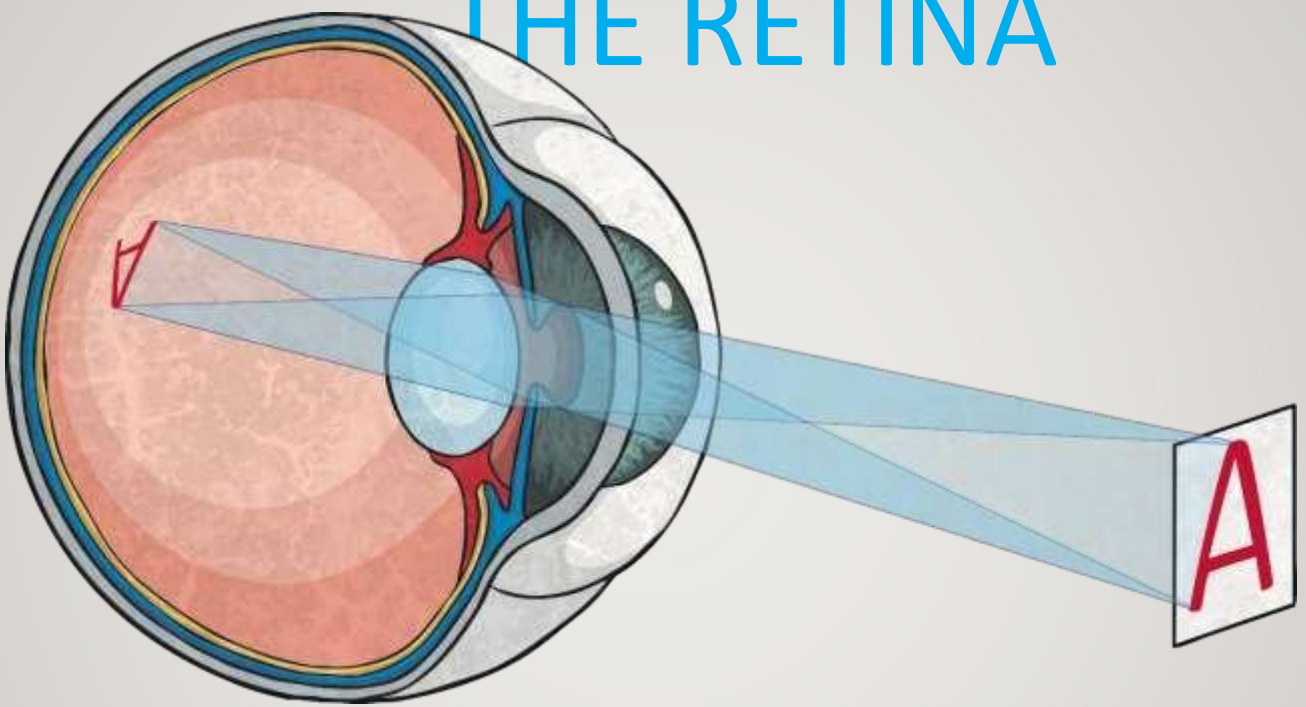


THE VITREOUS BODY



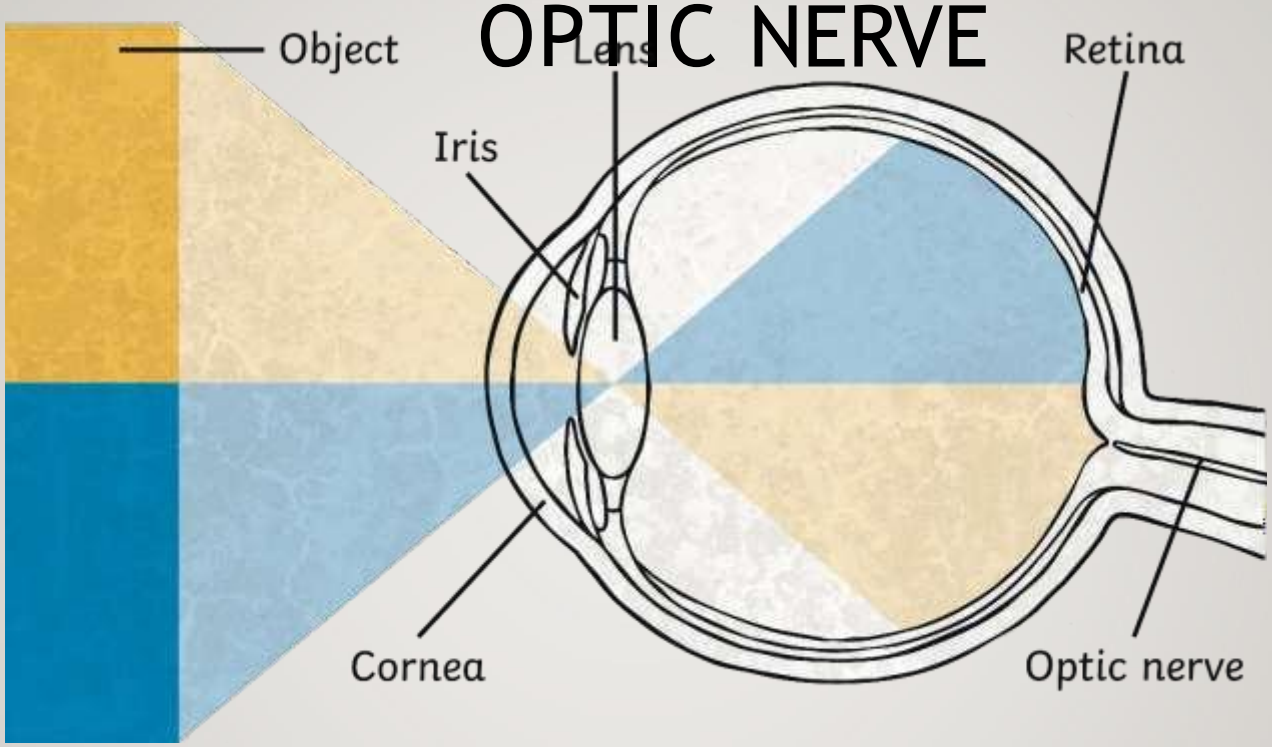
The **vitreous body** is the biggest part of the eye and gives the eye it shape. It is filled with a clear, jelly like material called the vitreous humor.

THE RETINA



The **retina** is in the very back of the eye. The retina takes the light the eye receives and changes it into nerve signals so the brain can understand what the eye is seeing. When the image hits the retina, it is actually upside down!

OPTIC NERVE



The **optic nerve** carries the messages from the eye to the brain. The messages it sends to the brain are still upside down but amazingly the brain knows how to flip this image up the right way!

POST TEST :-

- **Select the correct answer:**
  The macula lutea is mainly responsible for:
  a) Peripheral vision
  b) Color blindness
  c) Central vision
  d) Tear production
- **Short note:**
  Explain the functional differences between rods and cones in the retina.

PHYSIOLOGY OF THE EYE

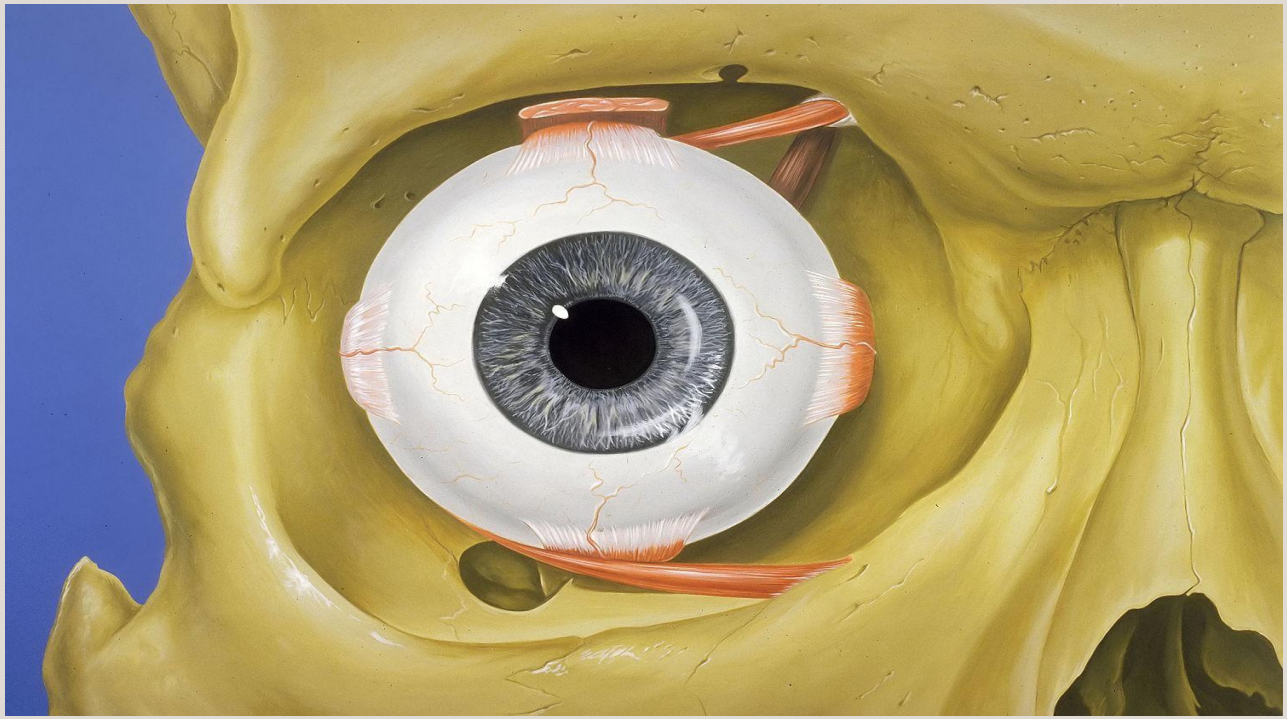
UNIT 1

- This lecture provides a comprehensive overview of the accessory visual structures that protect and support the human eye. It explains the anatomy and functions of structures such as the eyelids, eyelashes, conjunctiva, lacrimal apparatus, eyebrows, and orbital cavity.
- The lecture also discusses the physiological importance of these structures in maintaining eye lubrication, protection from foreign particles, tear production, and overall visual health.

PRE TEST : SELECT THE CORRECT ANSWER :-

- **Select the correct answer:**
  1. Which structure is primarily responsible for producing tears?
  a) Retina
  b) Lacrimal gland
  c) Cornea
  d) Optic nerve
- 2. The main function of the eyelids is to:
  a) Detect light
  b) Produce visual signals
  c) Protect and lubricate the eye
  d) Control color vision

ACCESSORY VISUAL STRUCTURES



EYEBROW

- The eyebrow is an area of thick, short hairs above the eye. The **main function** is to prevent sweat, water, and other debris falling into the eye, but they are also important to human communication and facial expressions.

EYEBROW

EYELID

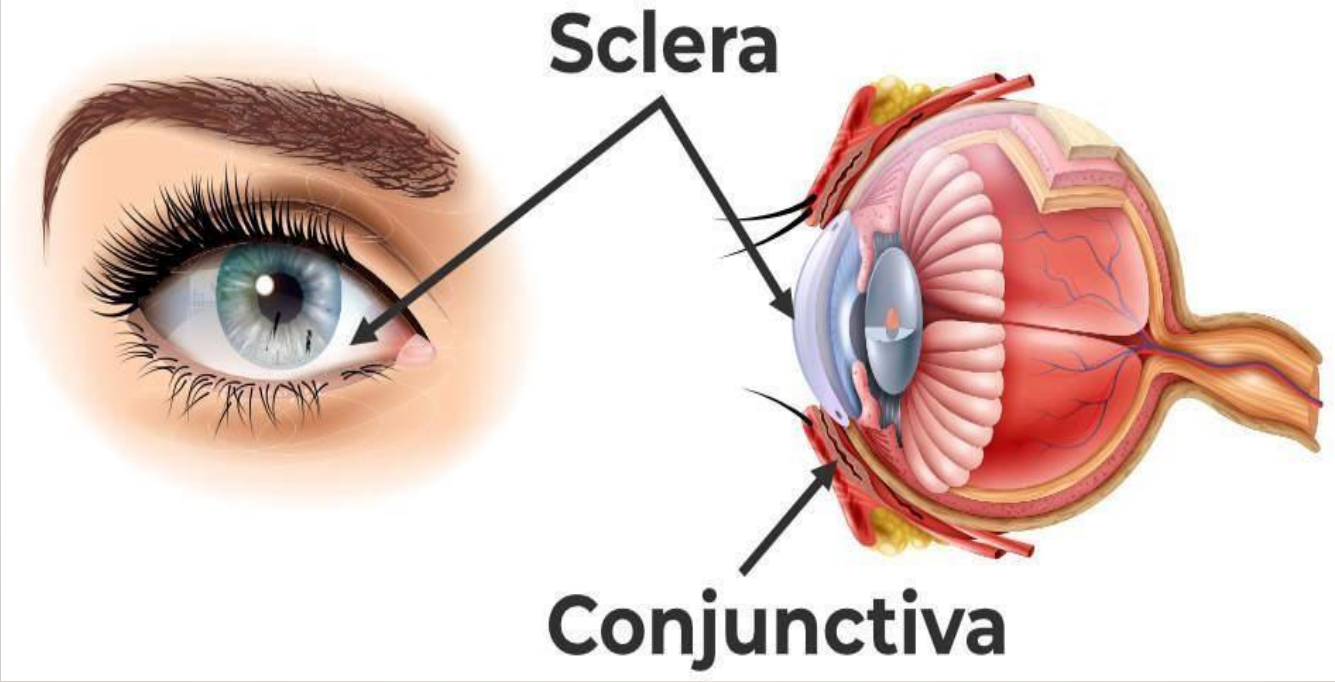
- An eyelid is a thin fold of skin that covers and protects the eye. The levator palpebrae superioris muscle helps in the movement of eyelid. The human eyelid features a row of eyelashes along the eyelid margin, which helps in protection of the eye from dust and foreign debris. **The main function** of eyelid is to keep the cornea moist and clean.

EYELID

CONJUNCTIVA

- The conjunctiva is a tissue that lines the inside of the eyelids and covers the sclera. It is composed of unkeratinized, stratified squamous epithelium with goblet cells, and stratified columnar epithelium. The conjunctiva is **basically** transparent, and the white colour we see is actually sclera.

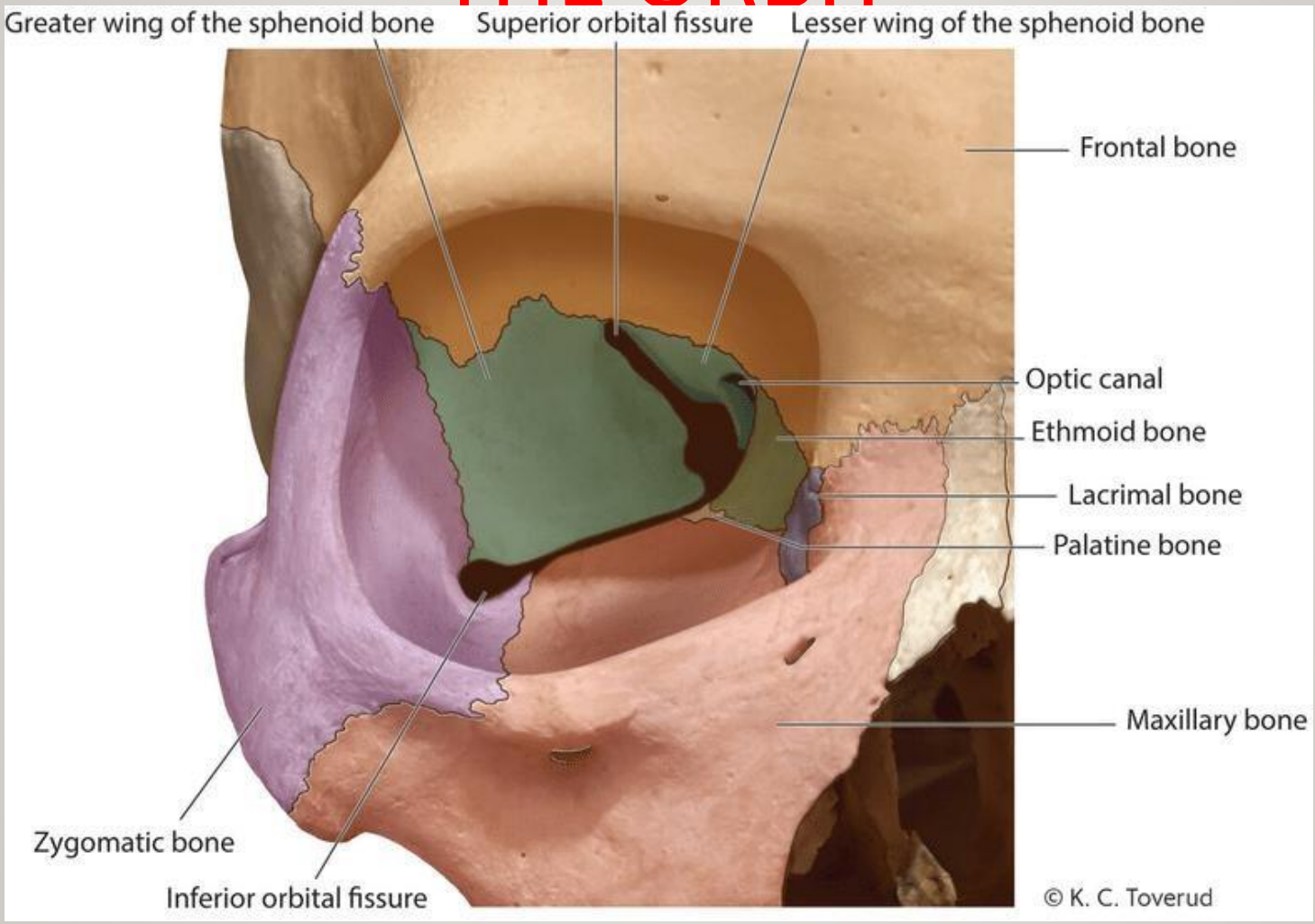
CONJUNCTIVA



THE ORBIT

- The orbit is the cavity or socket of the skull in which the eye and its appendages are situated. In the adult human, the volume of the orbit is 30 millilitres (1.06 imp fl oz; 1.01 US fl oz), of which the eye occupies 6.5 ml (0.23 imp fl oz; 0.22 US fl oz). **The orbit helps in smooth rotation of the eyeball**

THE ORBIT


Greater wing of the sphenoid bone
Superior orbital fissure
Lesser wing of the sphenoid bone
Frontal bone
Optic canal
Ethmoid bone
Lacrimal bone
Palatine bone
Maxillary bone
Zygomatic bone
Inferior orbital fissure
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POST TEST :-

- **Select the correct answer:**
  Which accessory structure helps prevent dust and foreign particles from entering the eye?
  a) Fovea
  b) Eyelashes
  c) Retina
  d) Choroid
- **Short note:**
  Explain the functions of the conjunctiva and lacrimal apparatus in maintaining eye health.

PHYSIOLOGY OF THE EYE

UNIT 1

- This lecture provides a detailed explanation of the physiological processes involved in image formation within the human eye. It discusses how light rays are refracted by the cornea and lens to produce a focused image on the retina.
- The lecture also explains the mechanisms of accommodation, pupil constriction, and lens adjustment for near and distant vision. In addition, it highlights the importance of retinal focusing and the optical principles required for clear visual perception.

PRE TEST : SELECT THE CORRECT ANSWER :-

- **Select the correct answer:**
  1. Which structure is responsible for most of the light refraction in the eye?
  a) Retina
  b) Cornea
  c) Optic nerve
  d) Iris **Select the correct answer:**
  2. Accommodation occurs when the lens changes its shape for:
  a) Tear production
  b) Color vision
  c) Focusing on near objects
  d) Peripheral vision

PHYSIOLOGY OF VISION

IMAGE FORMATION

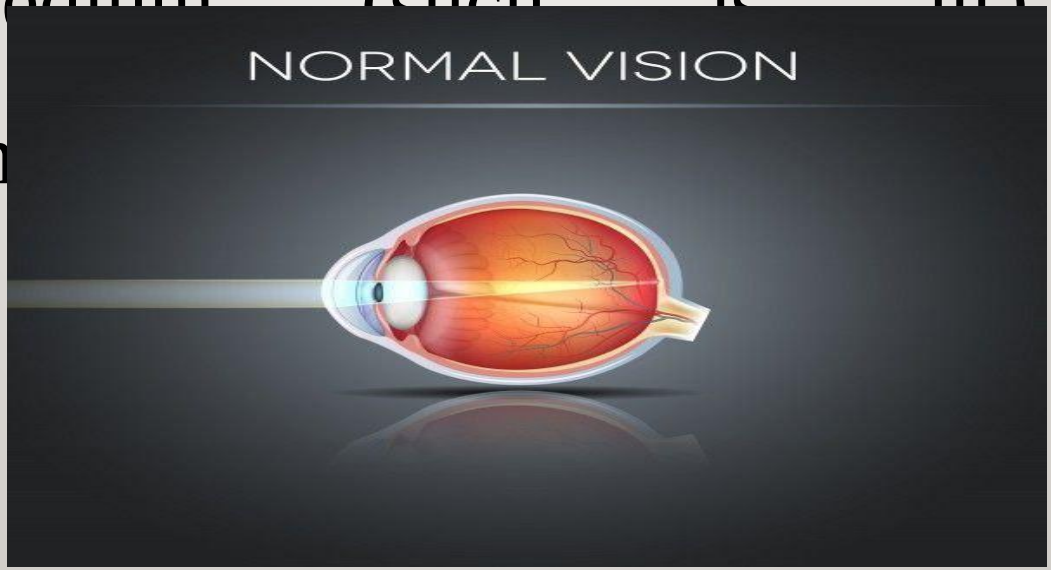
PROCESSES FOR IMAGE FORMATION

- refraction of light rays by cornea and lens
- accommodation of the lens
- constriction of the pupil

accommodation and pupil size are controlled by smooth muscle fibers of ciliary muscle and iris (intrinsic eye muscles)

REFRACTION

- the bending of light as it passes at an oblique angle from one medium (such as air) to an



REFRACTION (CONT.)

- anterior and posterior surfaces of cornea refract light
- both surfaces of lens further refract light into exact focus on retina
- images are inverted (upside down) and reversed right to left brain learns early in life to coordinate visual images with location of object

REFRACTION (CONT.)

- 3/4 of the focusing occurs on the cornea
- lens is responsible for fine-tuning of image
- convex surface of the lens causes light waves to converge (come to a point)
- concave surface of lens causes light waves to diverge (fan out)
- normal eye shape causes light waves to be sharply focused upon retina

LIGHT REFRACTION

- light waves of distant objects travel at almost parallel angles - focused on retina by cornea and flatter lens

- light waves of nearer objects reach eye in a more divergent line - the closer the object, the more divergent the lines

ACCOMMODATION

- process by which the curvature or thickness of the lens is increased for near vision

- divergent waves tend to focus behind the retina unless accommodation increases refracting power of the eye

FAR VISION

- lens is fairly flat, held under tension by suspensory ligaments
- light entering from distant objects strikes eye as parallel rays
- refractory power of eye is sufficient to focus light rays on retina, producing sharp image

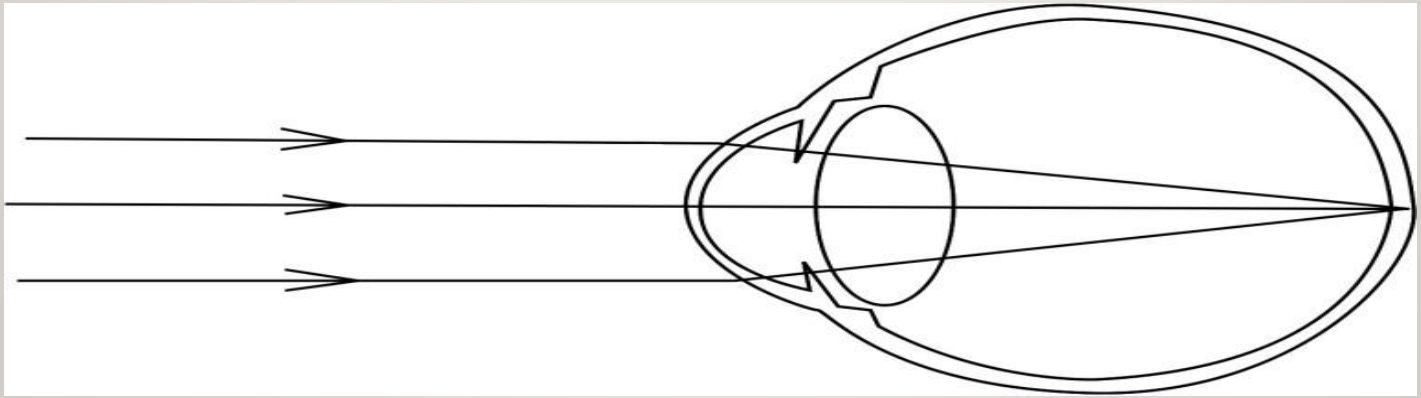
NEAR POINT

- minimum distance at which an object can be brought into clear focus
- 4 inches in young adult
- increasing distance at which an object can be brought into clear focus is primarily due to loss of elasticity and hardening of the lens, therefore its ability to accommodate

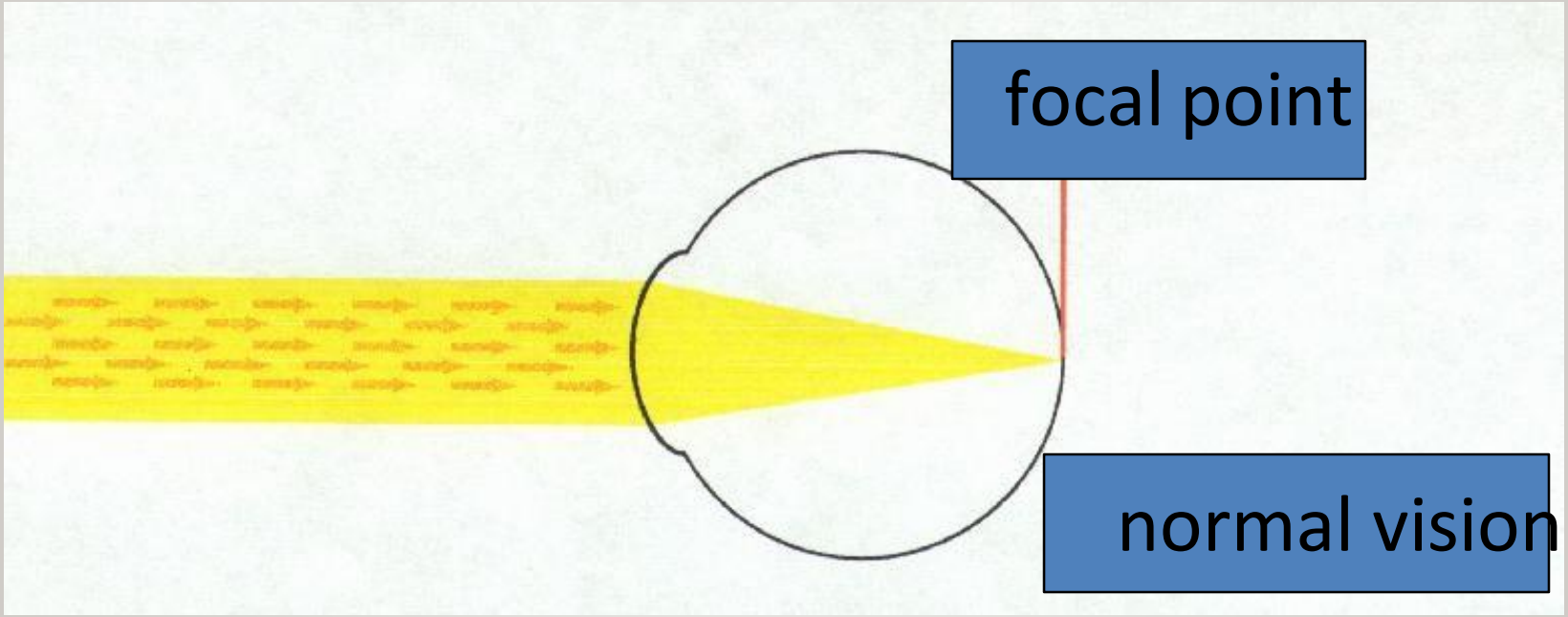
  - this condition is called presbyopia

EMMETROPIC

- normal eye
- can sufficiently refract rays from an object 6 feet away to focus a clear image on the retina



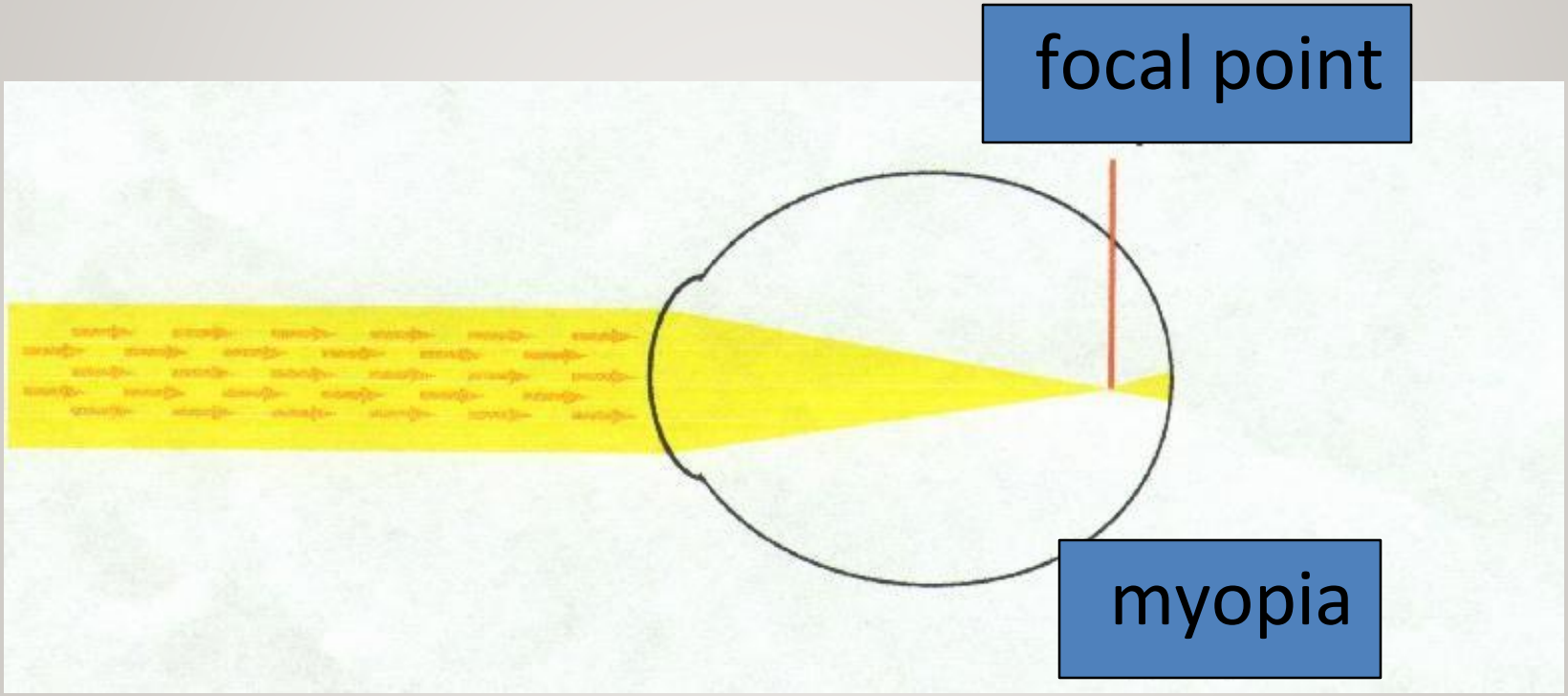
EMMETROPIC



MYOPIA

- nearsightedness
- condition may result from too long an eyeball or a thickened lens
- light waves' point of focus is in front of the retina
- concave lens corrects focus to a point further through the eyeball directly on the retina

MYOPIA

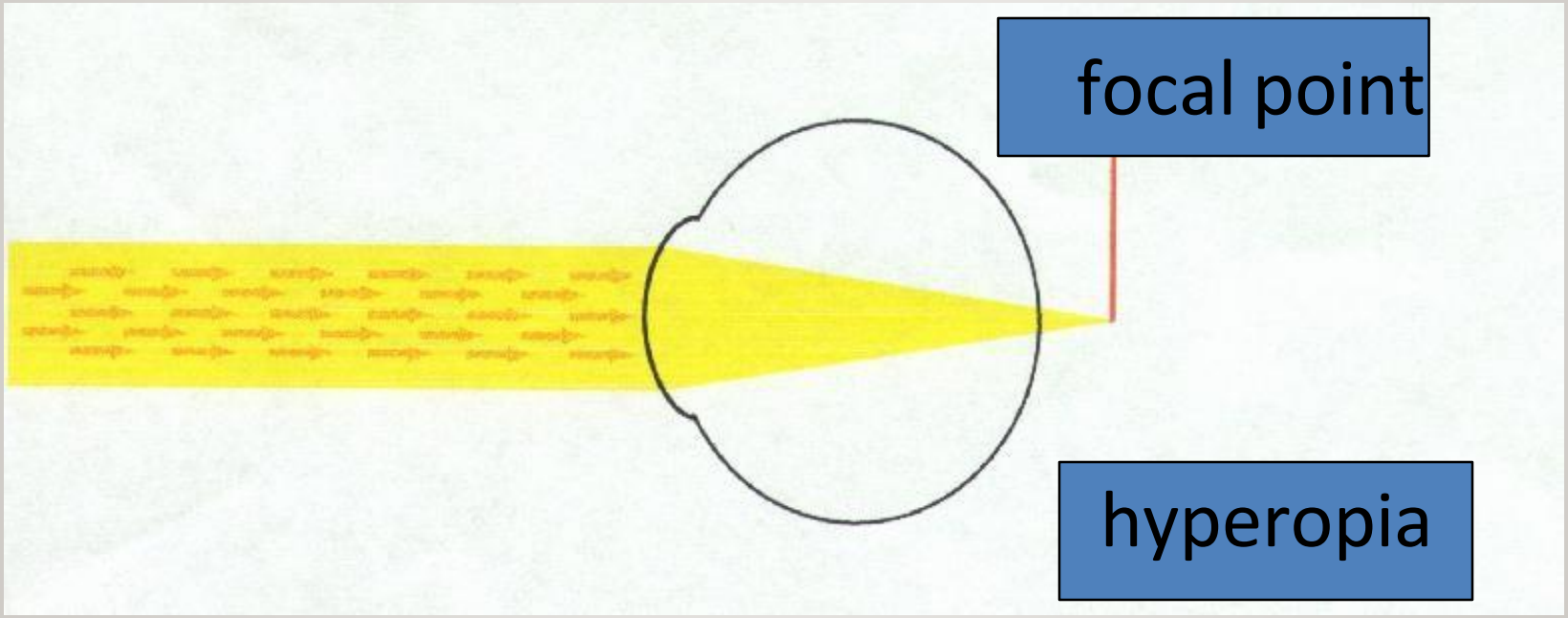


inability to see far objects

HYPEROPIA

- farsightedness
- also known as hypermetropia
- condition may result from too short a eyeball or a thin lens
- light waves point of focus is behind the retina
- convex lens corrects by focusing images directly on the retina

HYPEROPIA



inability to see near objects

ASTIGMATISM

- irregularities or defects in curvature of the surface of lens or cornea
- cornea is elliptical
- some portions of an image are in focus on the retina while other portions are not and therefore image is blurred

POST TEST :-

- **Select the correct answer:**
  In myopia, the image is focused:
  a) Behind the retina
  b) Directly on the retina
  c) In front of the retina
  d) On the optic nerve
- **Short note:**
  Explain the role of accommodation and pupil constriction in clear image formation.

PHYSIOLOGY OF THE EYE

UNIT 1

- This lecture provides a comprehensive overview of the visual pathway and the transmission of visual information from the retina to the brain. It explains the roles of photoreceptors, optic nerves, optic chiasma, optic tracts, lateral geniculate nucleus, and visual cortex in visual processing.
- The lecture also discusses how neural impulses generated in the retina are interpreted by the brain to produce visual perception. In addition, it highlights the physiological importance of visual signal integration and coordination within the central nervous system.

PRE TEST : SELECT THE CORRECT ANSWER :-

- **Select the correct answer:**

  1. The optic nerve carries visual information from the retina to the:
  a) Cornea
  b) Brain
  c) Lens
  d) Iris **Select the correct answer:**
  2. Where does partial crossing of optic nerve fibers occur?
  a) Retina
  b) Optic tract
  c) Optic chiasma
  d) Visual cortex

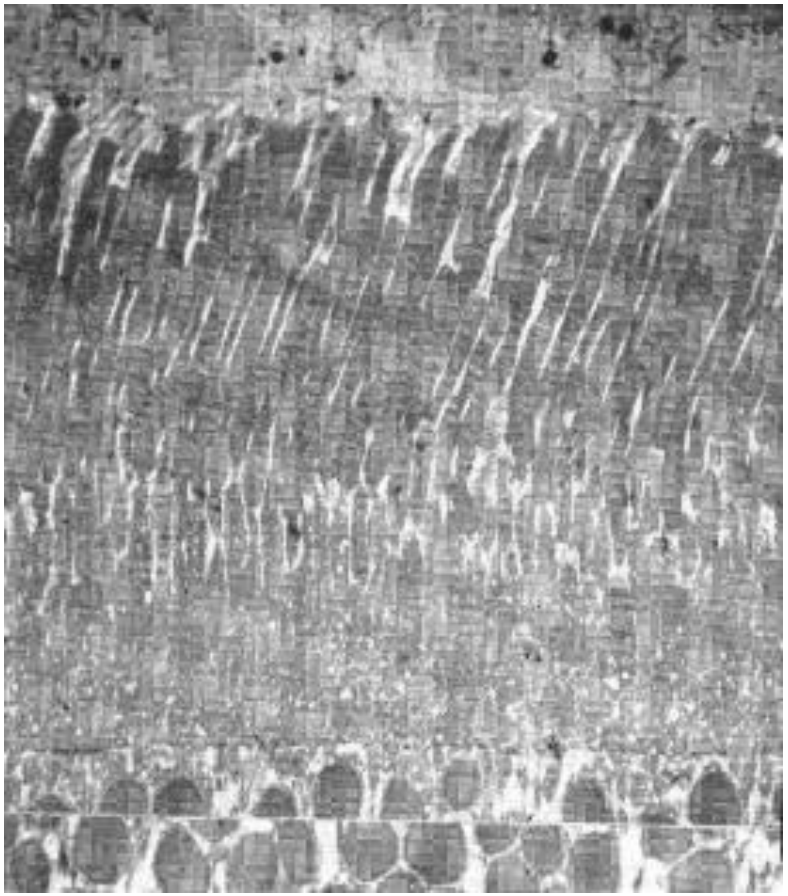
VISUAL PATHWAY

* begins in photoreceptors of retina
- - stimulated by image focused on retina
* receptor potentials travel via optic nerve to lateral geniculate nucleus in thalamus then on to visual cortex on occipital lobe
* processing of visual information occurs along entire pathway

PHOTORECEPTORS

* rods - 20 million
  - stimulated by low intensity light
* cones - 6 million
  - stimulated by high intensity light of color
  - three types of cones
  - named for different appearance of their outer segment
  - divided into outer and inner segment

PHOTORECEPTORS



layer of rods and cones

RODS

CYLINDRICAL OR ROD-SHAPED

* **Outer segment contains:**

  - many flattened , arranged

  - photosensitive pigment, part of lamellar membrane

RODS (CONT.)

* **Inner segment contains:**

  - many mitochondria

  - cell nucleus

  - synaptic base which contains neurotransmitter glutamate

RODS **(cont.)**

* predominant type of photoreceptors
* found in all areas of retina except fovea centralis
* extremely sensitive to light
* in dim light rods are the only photoreceptor stimulated
* do not distinguish color
* all night images are black and white
* image produced is not sharp

CONES

tapered or cone-shaped

* **Outer segment contains:**

  - pigment-containing saccules

* **Inner segment contains:**

  - many mitochondria

  - cell nucleus

  - large synaptic base which most likely contains neurotransmitter glutamate

CONES (CONT.)

* fovea centralis contains a high concentration of cones
* depression on fovea centralis increases exposure of cones to light waves (sharpest image)

CONES (CONT.)

* **Photopigments:**

  - blue-green

  - green-sensitive

  - red-sensitive

COLORBLINDNESS

* most forms result from the absence or deficiency of one of the three photopigments
* inherited condition
* most common type is red-green

  - deficiency of either red or green cones

  - red and green are seen as same color

RED-GREEN COLOR BLINDNESS

* gene for red-green color blindness is recessive, designated (c)
* normal color vision, designated (C) dominant
* C/c genes located on X chromosome
* Y chromosome does not contain DNA that programs color vision
* X chromosome dictates color blindness

RED-GREEN COLOR BLINDNESS (CONT.)

* only females who have two (Xc) genes are red-green color blind
* in (XCXc) females trait is masked by the normal dominate (C)
* males do not have the second (X) chromosome to mask the trait
* all males with(Xc) will be red-green color blind

POST TEST :-

- **Select the correct answer:**
  The primary visual cortex is located in the:
  a) Frontal lobe
  b) Temporal lobe
  c) Occipital lobe
  d) Parietal lobe
- **Short note:**
  Explain the sequence of structures involved in transmitting visual impulses from the retina to the visual cortex.

PHYSIOLOGY OF THE EYE

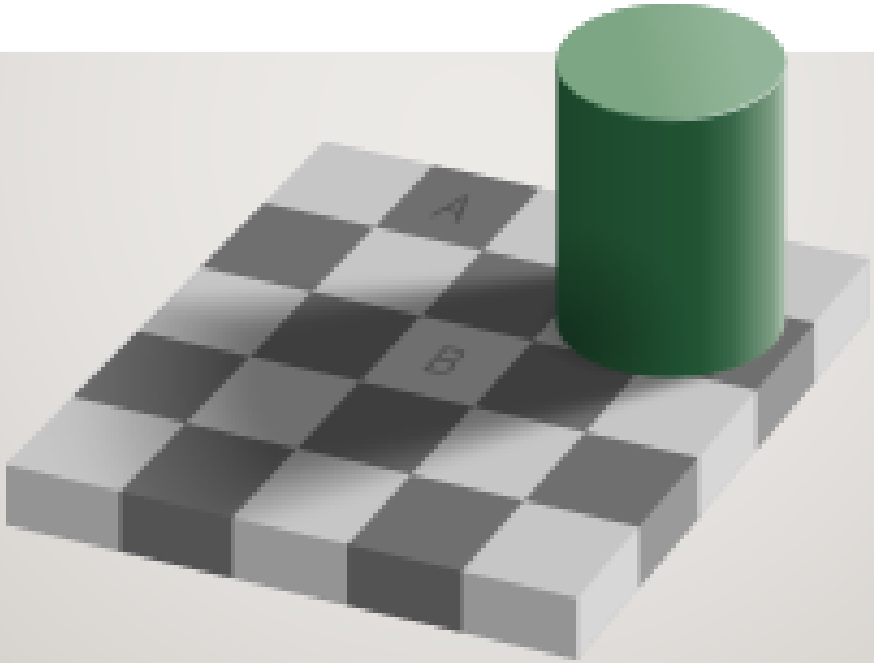
UNIT 1

- This lecture provides an overview of optical illusions and their relationship to visual perception. It explains how the brain interprets visual information and why certain images can produce misleading or altered perceptions of reality.
- The lecture also discusses the major types of optical illusions, including physical, physiological, and cognitive illusions. In addition, it highlights the role of the visual cortex and neural processing in creating perceptual distortions and visual misinterpretations.

PRE TEST : SELECT THE CORRECT ANSWER :-

- **Select the correct answer:**
  1. An optical illusion occurs when:
  a) The eye cannot detect light
  b) Visual perception differs from reality
  c) The retina is detached
  d) The lens loses elasticity
- 2. Which type of illusion is caused by the physical properties of light?
  a) Cognitive illusion
  b) Physiological illusion
  c) Physical illusion
  d) Retinal illusion

OPTICAL ILLUSION



DEFINITION

* **optical illusion (also called a visual illusion):**

is an illusion caused by the visual system and characterized by a visual percept that arguably appears to differ from reality.

CLASSIFICATION

* According to that, there are three main classes:
* Physical
* Physiological
* cognitive illusions
* in each class there are four kinds: **Ambiguities, distortions, paradoxes, and fictions.**

PHYSICAL VISUAL

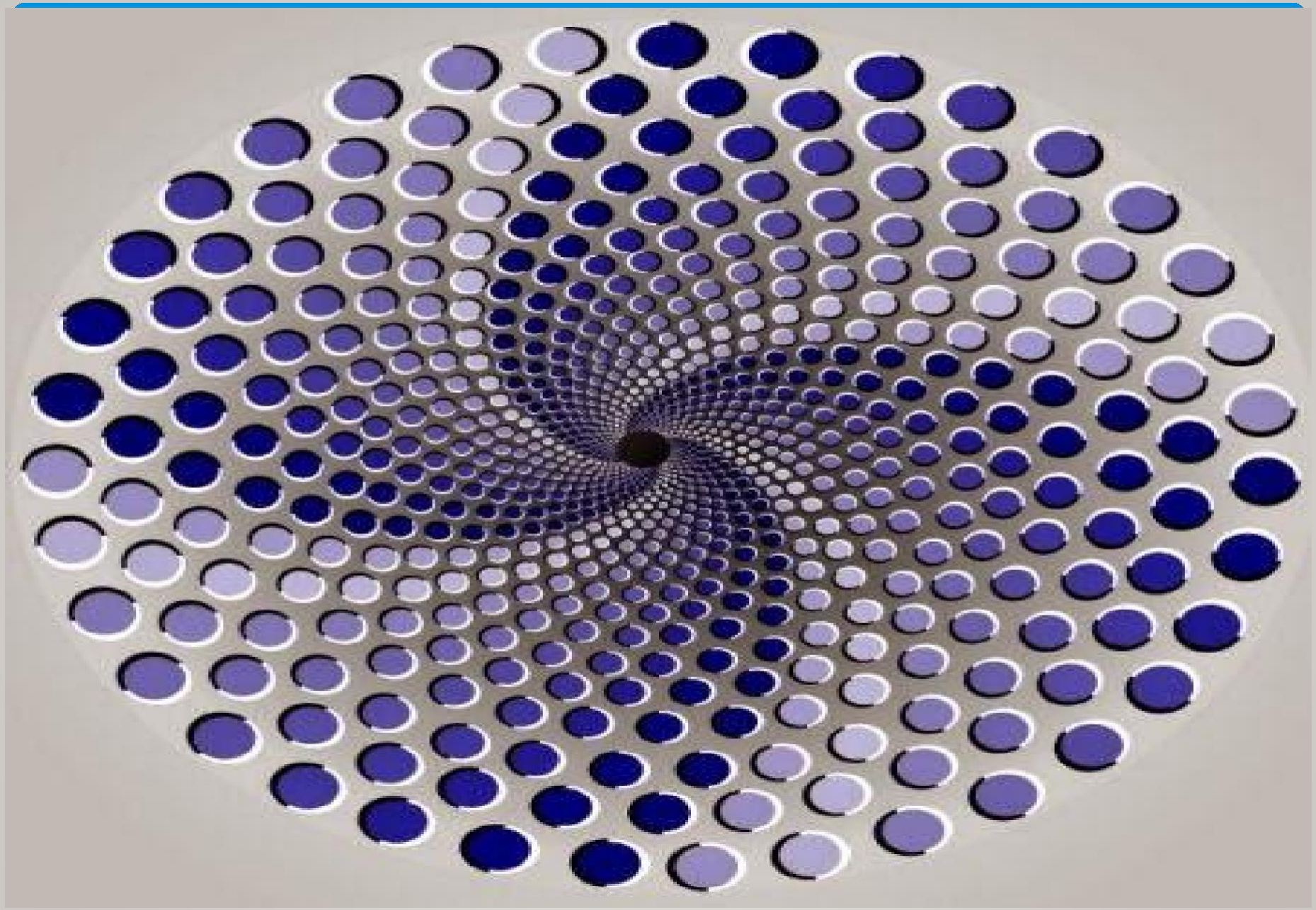
* Physical illusions are optical illusions in which the illusion has occurred due to the physical properties of the environment and their effects on the behavior of light, essentially occurring before light hits the retina of the eye.

SOME EXAMPLES FOR PHYSICAL ILLUSIONS

* The mirage phenomena : caused by the reflection of light off a thin layer of hot air near heated ground (known as a temperature inversion).

PHYSIOLOGICAL VISUAL ILLUSIONS

* are presumed to be the effects on the eyes or brain of excessive stimulation or interaction with contextual or competing stimuli of a specific type—brightness, color, position, tile, size, movement, etc.

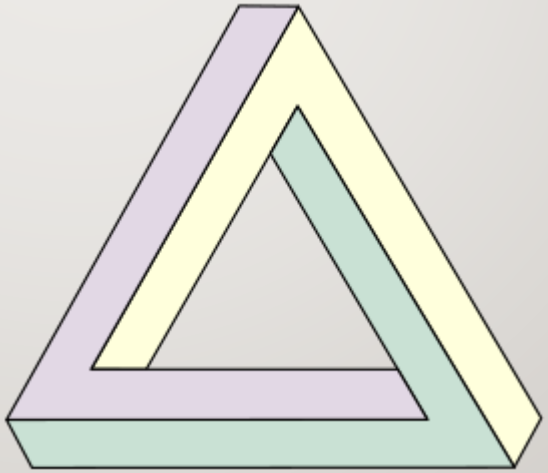


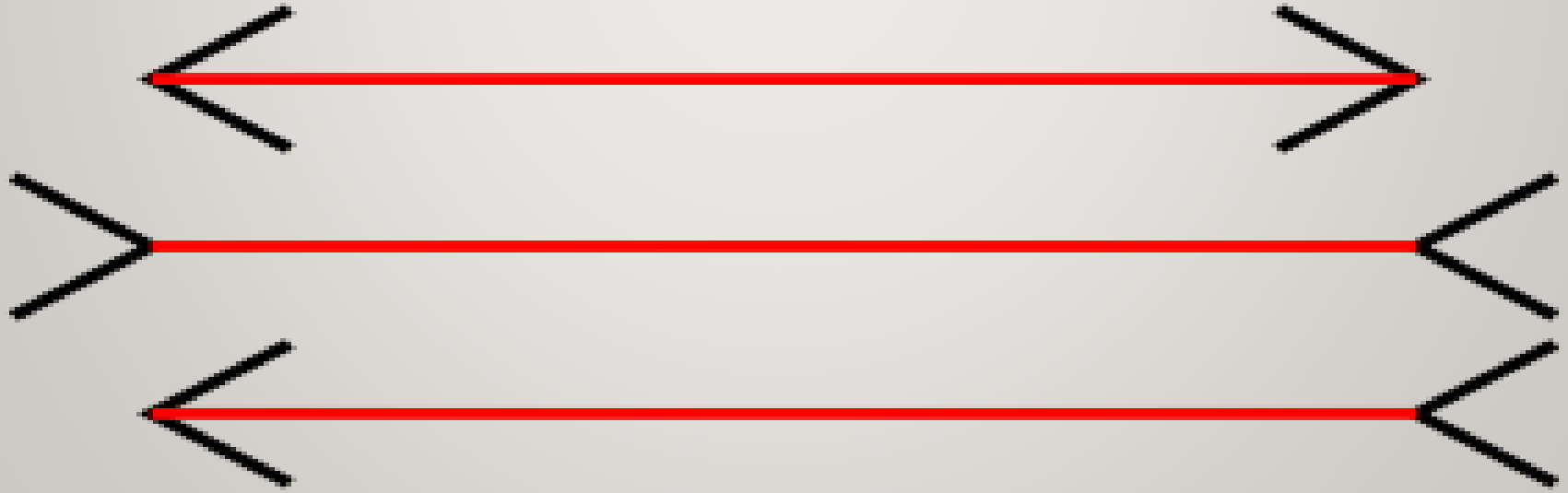
COUNT……

* The explanation of these effects is that stimuli have individual dedicated neural paths or channels in the visual cortex, the repetitive stimulating of which can mislead the visual system

COGNITIVE ILLUSIONS

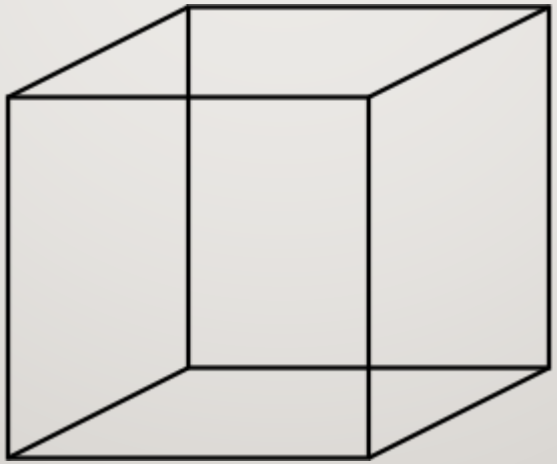
* Cognitive illusions are assumed to arise by interaction with assumptions about the world, leading to "unconscious inferences"





COUNT……

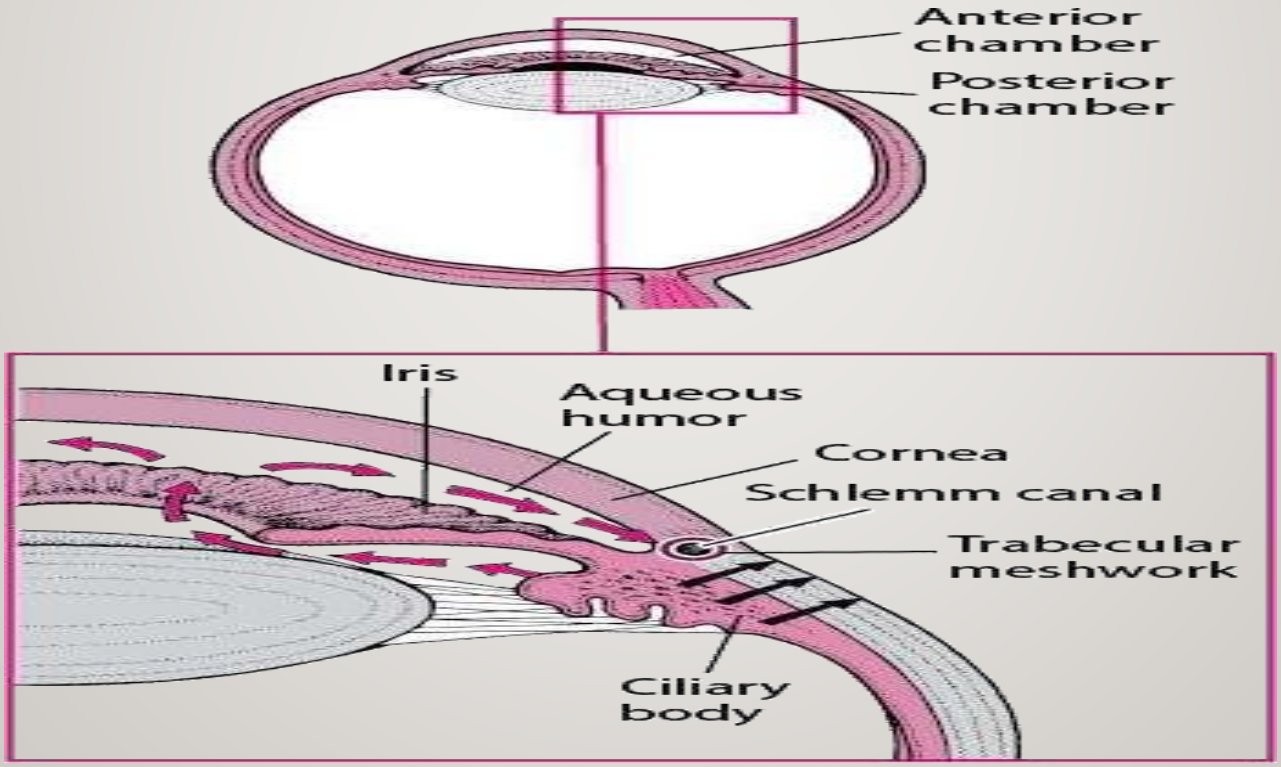
* These images can be meant to confuse the senses or to require the mind to refocus attention to see both images.



POST TEST :-

- **Select the correct answer:**
  Cognitive illusions mainly result from:
  a) Damage to the retina
  b) Changes in tear production
  c) Brain interpretation and assumptions
  d) Corneal opacity
- **Short note:**
  Briefly explain the differences between physical, physiological, and cognitive optical illusions.

AQUEOUS HUMOUR



UNIT 1

- This lecture provides a comprehensive overview of the aqueous humour, its formation, circulation, and physiological functions within the eye. It explains how the aqueous humour is produced by the ciliary body and circulates through the anterior and posterior chambers to maintain intraocular pressure and nourish avascular ocular structures.

PRE TEST : SELECT THE CORRECT ANSWER :-

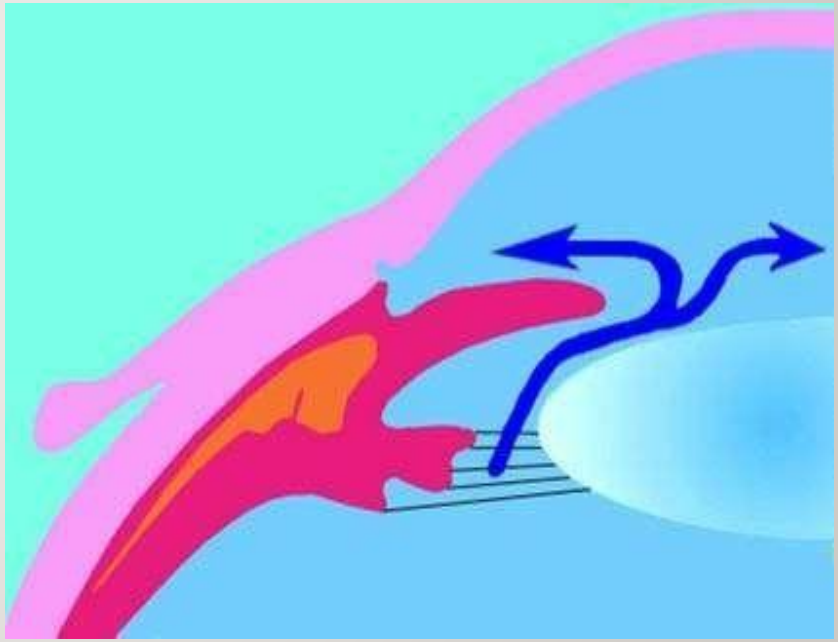
- **Select the correct answer:**

  1. The aqueous humour is produced by the:
  a) Retina
  b) Ciliary body
  c) Optic nerve
  d) Cornea

- 2. The main function of aqueous humour is to:
  a) Detect color vision
  b) Maintain intraocular pressure
  c) Form visual impulses
  d) Control retinal detachment

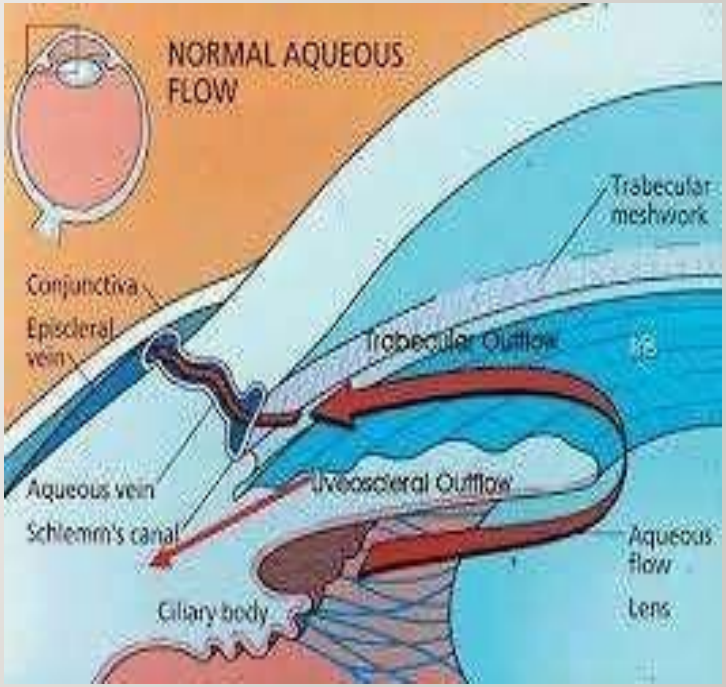
DEFINITION

* Aqueous humor is the fluid produced by the eye. It provides nutrition to the eye, as well as maintains the eye in a pressurized state.



COUNT….

* Aqueous humor flows from the ciliary body into the anterior chamber, out through a spongy tissue at the front of the eye called the trabecular meshwork and into a drainage canal.



AQUEOUS HUMOUR

* The aqueous humour is a transparent water-like fluid similar to plasma, but containing low protein concentrations. It is secreted from the ciliary body, a structure supporting the lens of the eyeball.

COUNT…..

* It fills both the anterior and the posterior chambers of the eye, and is not to be confused with the vitreous humour, which is located in the space between the lens and the retina, also known as the posterior cavity or vitreous chamber.

FUNCTION

- important for early ocular development & maintaining global integrity throughout life.
- Serves as a vascular system for the avascular structures of the eye: cornea, lens.
- by providing substrates & nutrients & removing metabolites.

COUNT…

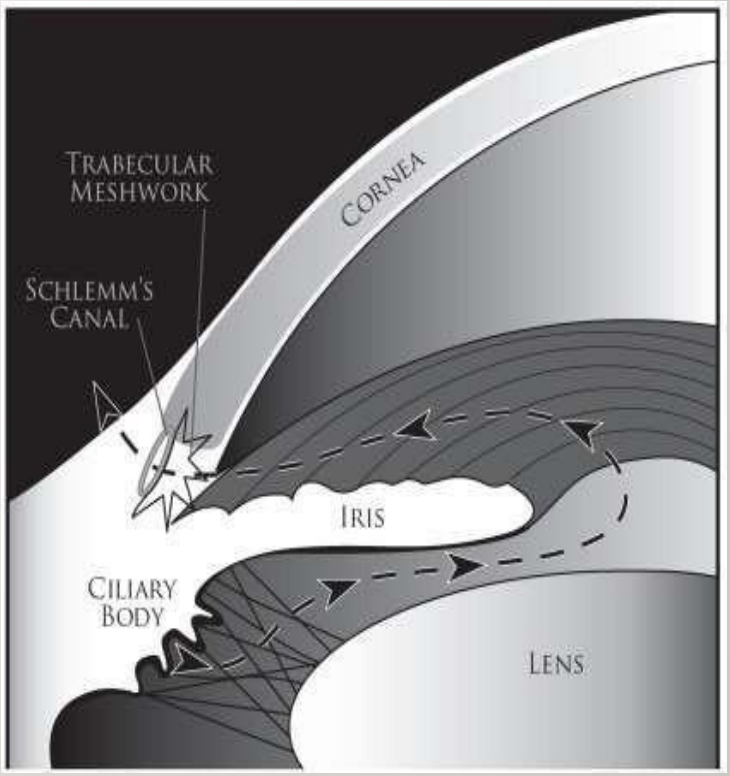
- Delivering high concentration of Ascorbate:
  - scavenges free radicals & protects against UV rays & other radiations.
- Local paracrine signaling & immune responses.
- Colourless & transparent medium as part of eye's optical system.

COUNT…..

- Presence of immunoglobulins indicates a role in immune response to defend against pathogens.
- Provides inflation for expansion of the cornea and thus increased protection against dust, wind, pollen grains, and some pathogens.
- For refractive index.
- Prevents eye dryness.

PRODUCTION

* Aqueous humour is secreted into the posterior chamber by the ciliary body, specifically the non-pigmented epithelium of the ciliary body
* Blood cannot normally enter the eyeball.

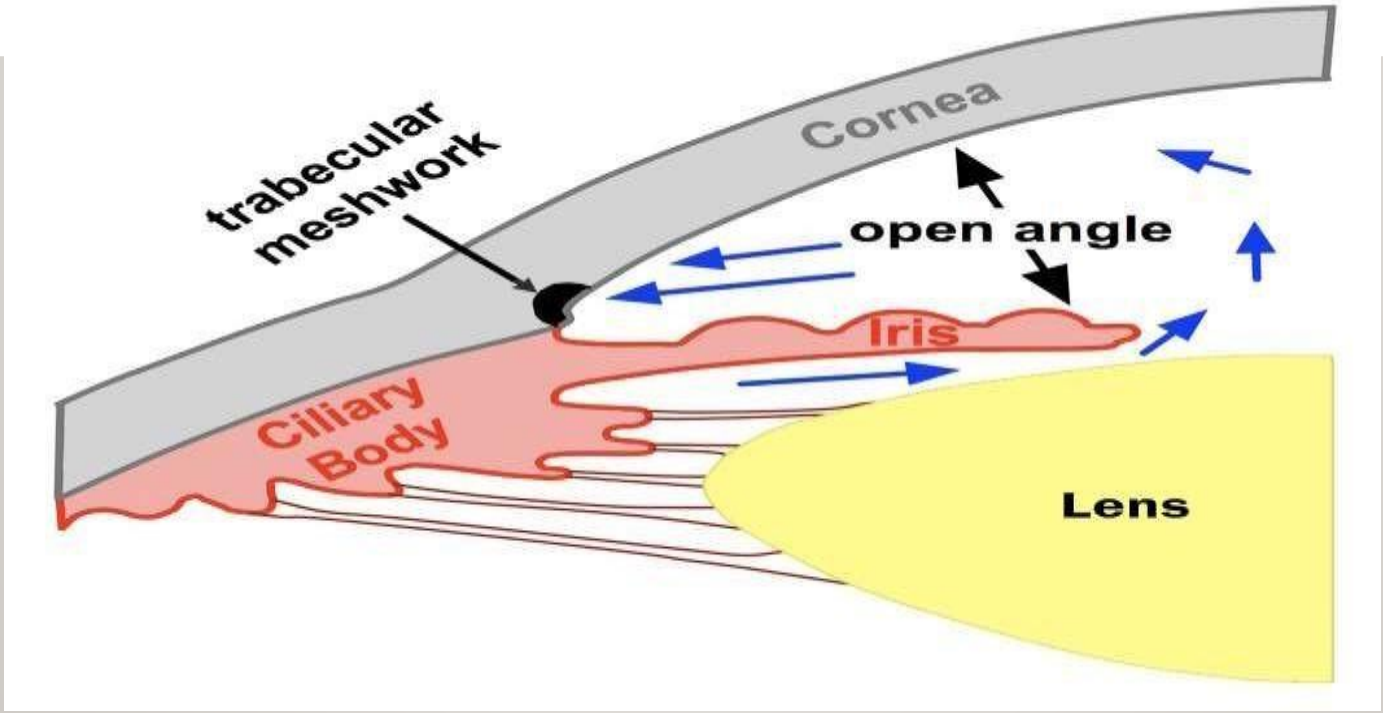


DRAINAGE

* Aqueous humor is continually produced by the ciliary processes and this rate of production must be balanced by an equal rate of aqueous humor drainage.
* Small variations in the production or outflow of aqueous humor will have a large influence on the intraocular pressure.

DRAINAGE PROCESS

- * Water, solutes and small particulate material such as cell fragments are drained from the anterior chamber with a bulk flow of aqueous humor into the iridocorneal angle. the fluid passes through the uveal, corneo-scleral and endothelial meshwork into the **canal of Schlemm** to be drained through collector channels into intrascleral, episcleral and conjunctival veins.


trabecular
meshwork
Cornea
open angle
Iris
Ciliary
Body
Lens

POST TEST :-

- **Select the correct answer:**
  The aqueous humour drains mainly through the:
  a) Fovea
  b) Canal of Schlemm
  c) Optic disc
  d) Vitreous body
- **Short note:**
  Explain the circulation and physiological importance of aqueous humour in maintaining eye health.

"LACRIMAL SYSTEM AND TEAR PHYSIOLOGY"

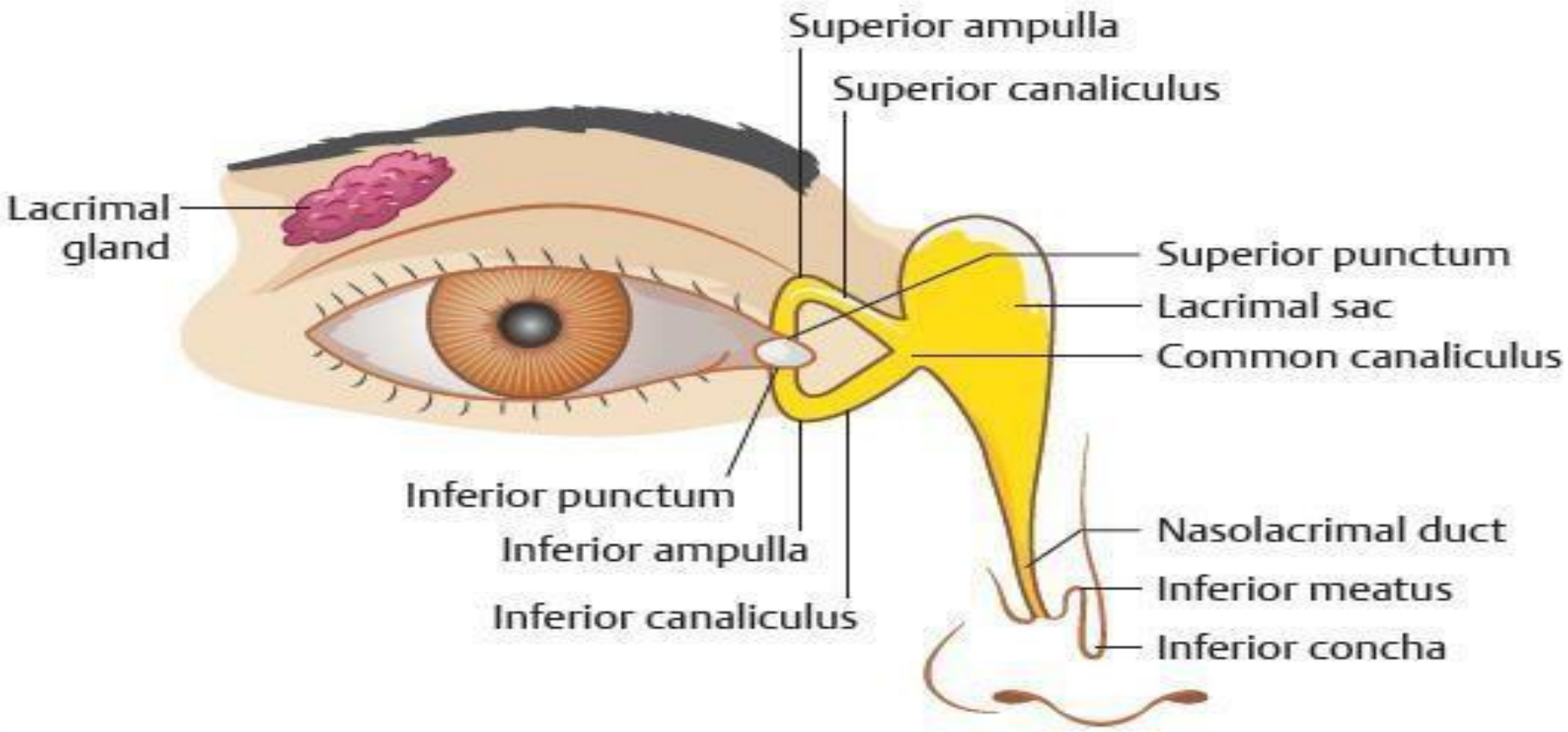
UNIT 1

- This lecture provides a detailed overview of the lacrimal system and the physiology of tear production and drainage. It explains the anatomical components of the lacrimal apparatus, including the lacrimal gland, lacrimal canals, lacrimal sac, and nasolacrimal duct.
- The lecture also discusses the composition and functions of tears in maintaining corneal lubrication, protection against infection, and preservation of ocular surface integrity. In addition, it highlights the mechanisms of tear secretion, drainage, and common disorders associated with tear dysfunction.

PRE TEST : SELECT THE CORRECT ANSWER :-

- **Select the correct answer:**

  The lacrimal gland is mainly responsible for:
  a) Producing tears
  b) Detecting light
  c) Controlling pupil size
  d) Forming visual impulses **Select the correct answer:**
  Tears normally drain into the nasal cavity through the:
  a) Optic canal
  b) Nasolacrimal duct
  c) Canal of Schlemm
  d) Vitreous chamber


Superior ampulla
Superior canaliculus
Lacrimal gland
Superior punctum
Lacrimal sac
Common canaliculus
Inferior punctum
Inferior ampulla
Inferior canaliculus
Nasolacrimal duct
Inferior meatus
Inferior concha

INTRODUCTION

The lacrimal system is the anatomical network responsible for tear production, maintenance, and drainage. It consist of the main lacrimal gland (and accessory lacrimal glands), which secrete the aqueous portion of tears; the meibomian glands, which produce the lipid layer of tears; the conjunctival goblet cells, which secrete mucins; and the nasolacrimal drainage apparatus (puncta, canaliculi, lacrimal sac, and nasolacrimal duct) that channels excess tears into the nasal cavity.

INTRODUCTION

Importance of tears in maintaining ocular health: lubrication, nutrition, antimicrobial defense, and optical clarity.

- **Production** of the three-layer tear film (lipid, aqueous, and mucin layers).
- **Distribution** and **stabilization** of tears via blinking and eyelid mechanics.
- **Protective**, **nutritional**, and **optical** functions (lubrication, antimicrobial defense, nutrient delivery, and clear refractive surface).
- **Drainage** of excess tears through the nasolacrimal pathway, maintaining tear film homeostasis.

COMPOSITION OF HUMAN TEARS:

- Water
- Electrolytes, the electrolytes are principally Na^+, K^+, Cl^-, and HCO^-, with lower levels of Mg^{2+} and Ca^{2+}
- Proteins – secreted from the lacrimal gland, (lysozyme, lactoferrin, lipocalin, and sIgA).
- Lipids - from the meibomian glands
- Mucins
  - lysozyme (an enzyme capable of destroying the cell walls of certain bacteria and thereby acting as a mild antiseptic).
  - Lactoferrinan (an iron-binding protein , by combining with iron, lactoferrin prevents microorganisms from combining with and using iron for their growth).

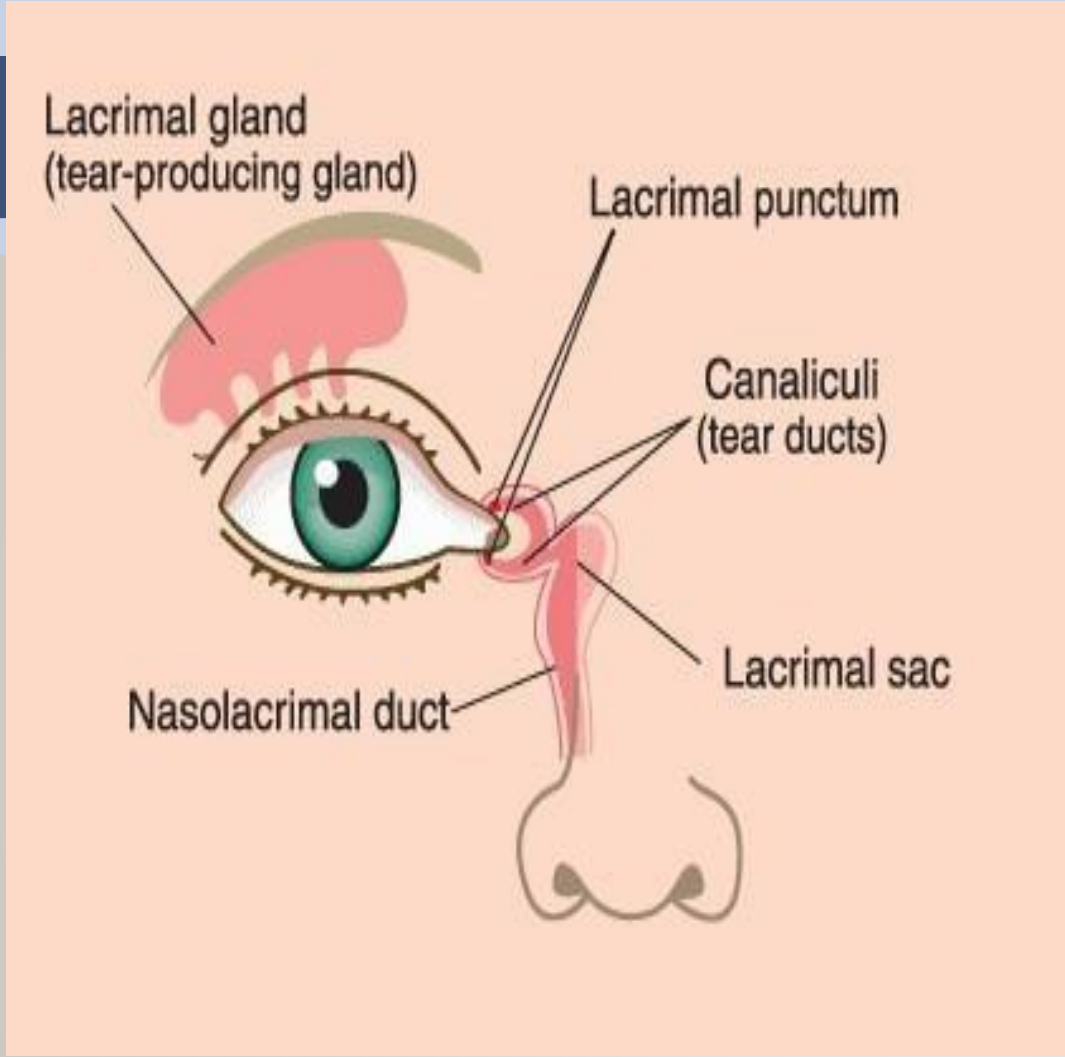
FUNCTION OF TEARS:

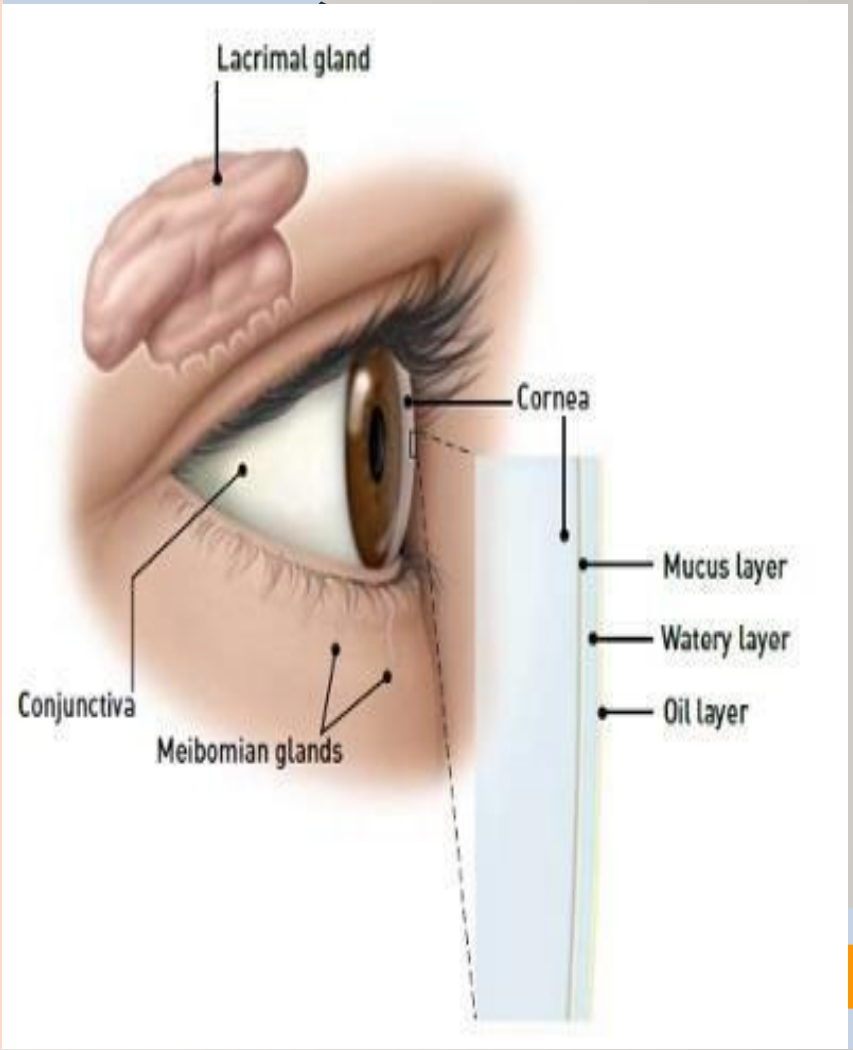
1) Tears act as both **a delivery and an excretory** route for nutrients and metabolic products of the corneal epithelium.

2) The presence of the tear film improves the quality of the retinal image by smoothing out irregularities of the cellular surfaces.

3) It acts as a lubricant **preventing eye dryness** which is provided by the tear film coating the cornea.

4) It plays a **protective role** against infection carried out mainly by its protein content of lysozymal enzymes, lactoferrin, secretory IgA


Lacrimal gland
(tear-producing gland)
Lacrimal punctum
Canaliculi
(tear ducts)
Lacrimal sac
Nasolacrimal duct


Lacrimal gland
Cornea
Mucus layer
Watery layer
Oil layer
Conjunctiva
Meibomian glands

2. ANATOMY OF THE LACRIMAL SYSTEM

- **1. Main Lacrimal Gland**
- **Location**: Superotemporal aspect of the orbit
- **Structure**:
  - Lobulated gland containing secretory acini
  - Divided into orbital and palpebral lobes by the levator aponeurosis
- **Function**: Responsible for the bulk of reflex and some basal tear secretion

2. Accessory Lacrimal Glands

- GLANDS OF KRAUSE: LOCATED IN THE SUPERIOR CONJUNCTIVAL FORNIX
- GLANDS OF WOLFRING: LOCATED ALONG THE UPPER AND LOWER EDGES OF THE tarsal plates
- **Function**: Provide continuous (basal) tears for ocular surface lubrication

3. Meibomian (Tarsal) Glands

- **Location**: Embedded in the tarsal plates of the upper and lower eyelids
- **Secretion**: Meibum (lipid) that forms the outer tear film layer, reducing evaporation

4. Goblet Cells

- **Distribution**: Conjunctival epithelium, especially near the fornix
- **Product**: Mucins (MUC5AC primarily) that anchor tears to the ocular surface

5. NASOLACRIMAL DRAINAGE SYSTEM

- **Components**: Puncta → Canaliculi → Lacrimal sac → Nasolacrimal duct → Inferior meatus in the nasal cavity
- **Physiology**: Blinking action facilitates tear flow through negative pressure created by the orbicularis oculi muscle

TEAR FILM PHYSIOLOGY

- **Traditional Three-Layer Model**:
  - Mucin Layer (inner): From goblet cells; ensures even spread.
  - Aqueous Layer (middle): From lacrimal glands; provides oxygen, nutrients.
  - Lipid Layer (outer): From Meibomian glands; reduces evaporation.

1. The **lipid layer** contains oils secreted by the meibomian glands (or tarsal glands). The outer-most layer of the tear film coats the aqueous layer to provide a hydrophobic barrier that retards evaporation and prevents tears spilling onto the cheek

2. THE AQUEOUS LAYER CONTAINS WATER AND OTHER SUBSTANCES SUCH AS PROTEINS (E.G. TEAR LIPOCALIN, lactoferrin, lysozyme and lacritin) secreted by the lacrimal gland. The aqueous layer serves to promote spreading of the tear film, control of infectious agents and osmotic regulation

3. THE MUCOUS LAYER CONTAINS MUCIN SECRETED BY THE CONJUNCTIVAL GOBLET CELLS. THE INNER-MOST LAYER OF THE TEAR FILM, IT COATS THE hydrophilic CORNEA. IT IS THE layer that allows TO PROVIDE AN even distribution of the tear film, as well as mucus covering of the cornea.

4. TEAR PRODUCTION AND TYPES

- **Basal Tears**: Continuous secretion for lubrication.
- **Reflex Tears**: Response to irritants (e.g., onions, dust).
- **Emotional Tears**: Linked to limbic system

Emotional tears contain more of the protein-based hormones prolactin, adrenocorticotropic hormone, and leucine enkephalin (a natural painkiller) than basal or reflex tears

4. REGULATION OF TEAR PRODUCTION

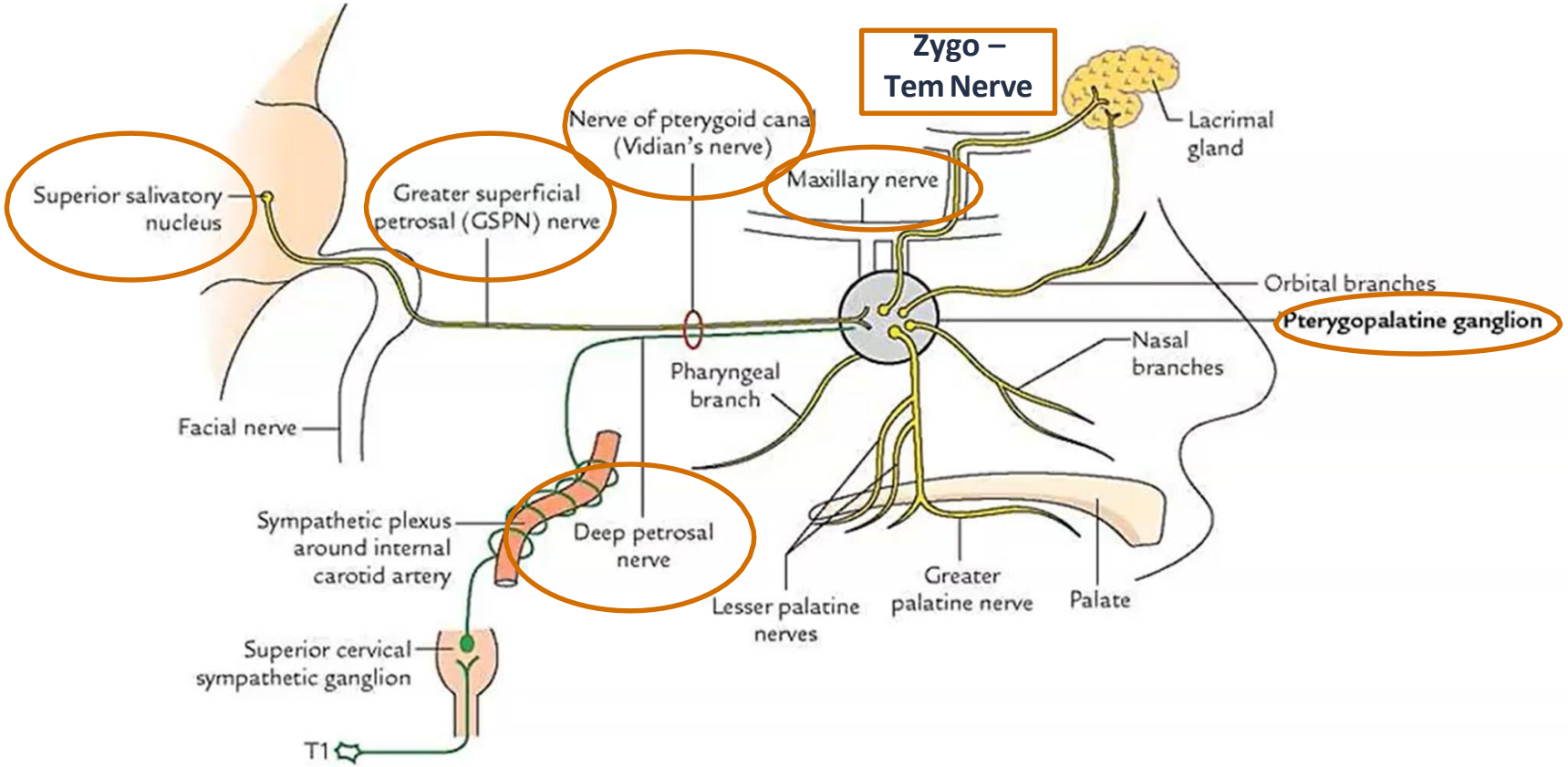
1. Neural Control

- **Parasympathetic Pathway** (major control):
  - Originates in the superior salivatory nucleus → travels with the facial nerve (VII) → synapses in the pterygopalatine ganglion → reaches lacrimal gland
  - Stimulation induces secretion of the aqueous component of tears (both basal and reflex tears)
- **Sympathetic Pathway**:
- Influences blood vessel constriction in the lacrimal gland and can modulate tear protein composition

- SENSORY PATHWAY:
- Afferent signals via the ophthalmic branch of the trigeminal nerve (V1) → dryness or irritation triggers reflex tear secretion

2. Hormonal and Local Factors

- **Androgens & Estrogens**: Imbalance can affect meibomian gland function and tear secretion
- **Inflammatory Cytokines**: Upregulated in conditions like dry eye disease, affecting glandular output


Zygo –
Tem Nerve
Nerve of pterygoid canal
(Vidian's nerve)
Lacrimal
gland
Superior salivatory
nucleus
Greater superficial
petrosal (GSPN) nerve
Maxillary nerve
Orbital branches
Pterygopalatine ganglion
Nasal
branches
Pharyngeal
branch
Facial nerve
Sympathetic plexus
around internal
carotid artery
Deep petrosal
nerve
Lesser palatine
nerves
Greater
palatine nerve
Palate
Superior cervical
sympathetic ganglion
T1

8. CLINICAL DISORDERS

- **Dry Eye Syndrome**:
  - Aqueous-deficient (e.g., Sjögren's syndrome).
  - Evaporative (Meibomian gland dysfunction).
- **Obstructive Disorders**: Congenital nasolacrimal duct obstruction, dacryocystitis.
- **Inflammatory/Autoimmune**: Sjögren's syndrome, blepharitis.

TI. DIAGNOSTIC TOOLS

- **Schirmer's Test**: Measures tear production (Types I and II).
- **Dye Tests**: Fluorescein to evaluate drainage.
- **Tear Break-Up Time (TBUT)**: Evaluates tear film stability and mucin-lipid interaction
- **Meibography**: Imaging of meibomian glands to assess structural changes
- **Lipid Layer Interferometry**: Observes lipid layer thickness/pattern
- **Slit Lamp Biomicroscopy**: Examination of tear meniscus, corneal staining patterns

TREATMENT STRATEGIES

- **Dry Eye**: Artificial tears, anti-inflammatory agents (cyclosporine)
- **Obstructions**: Probing (infants), dacryocystorhinostomy (DCR) for adults.
- **Innovations**: Autologous serum drops, thermal pulsation for Meibomian dysfunction.

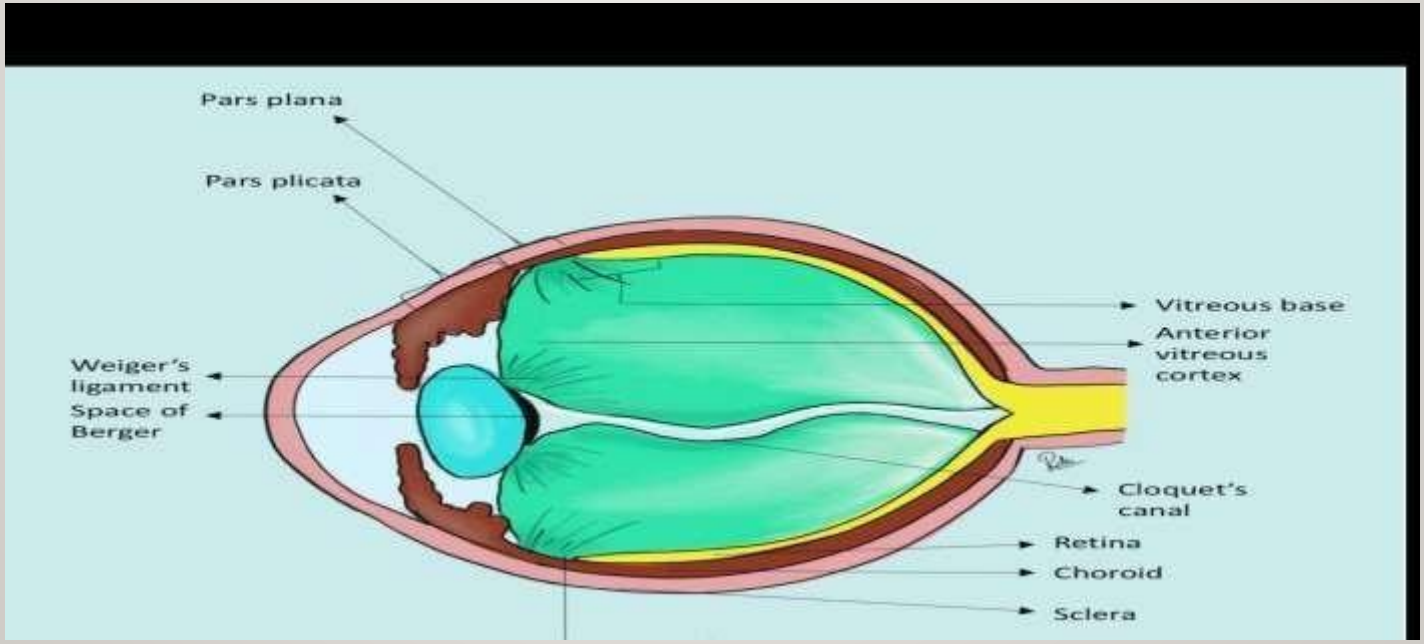
14TH EDITION

- Guyton and Hall
  - Textbook of Medical Physiology

POST TEST :-

- **Select the correct answer:**
  One important function of tears is to:
  a) Increase intraocular pressure
  b) Nourish and protect the cornea
  c) Form retinal images
  d) Control lens accommodation
- **Short note:**
  Explain the pathway of tear drainage from the lacrimal gland to the nasal cavity.

VITREOUS HUMOUR



UNIT 1

- This lecture provides a comprehensive overview of the vitreous humour, its anatomical structure, composition, and physiological functions within the eye. It explains how the vitreous humour fills the posterior cavity of the eyeball and helps maintain the spherical shape and internal support of the eye.

PRE TEST : SELECT THE CORRECT ANSWER :-

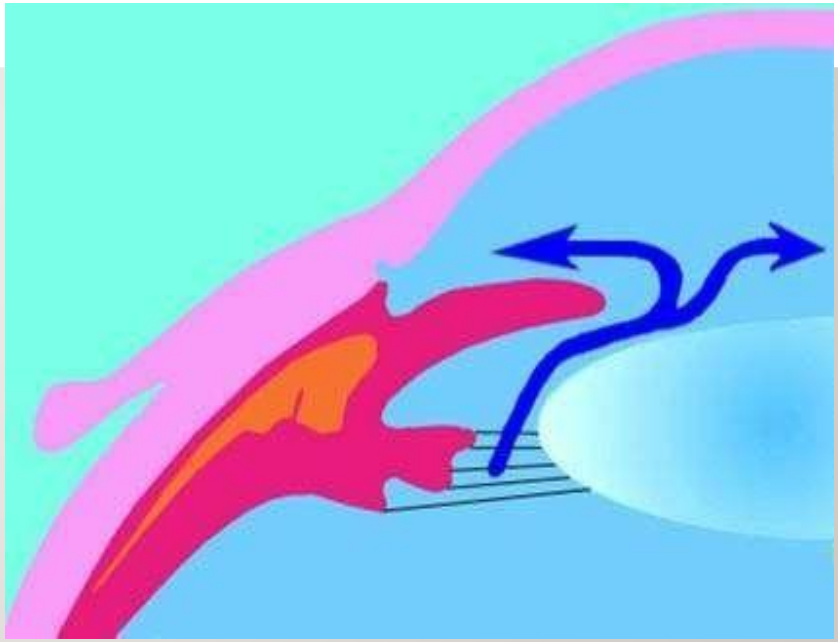
- **Select the correct answer:**

  1. The vitreous humour is located in the:
  a) Anterior chamber
  b) Posterior cavity
  c) Optic disc
  d) Lacrimal sac

- 2. One major function of the vitreous humour is to:
  a) Produce tears
  b) Maintain the shape of the eye
  c) Control pupil size
  d) Detect color vision

DEFINITION

* Viscous, gel — like fluid that is composed of 99 % water and mainly type II and some
* type IX collagen fibres, mucopolysaccharides and hyaluronic acid



FUNCTION

- Functions:
- ▪▪ Mechanical stabilisation of volume of globe
- ▪▪ Shock absorption
- ▪▪ Nutrition supply to lens and retina
- • As we age, syneresis (liquefaction) occurs

VITREOUS BASE

- • Portion of vitreous that is attached to peripheral retina and pars plana
- • It is 6 mm wide (straddling the ora serrata — 2 mm anterior and 4 mm posterior to it)
- • The vitreous base in tightly adherent to the ora serrata

VITREORETINAL JUNCTIONS

- • Firm attachment between vitreous and retina at level of foot plate of Muller's cells at internal limiting membrane.
- • Locations of vitreoretinal junctions
- ▪▪ Vitreous base — strongest
- ▪▪ Margin of optic disc

COUNT…..

* ▪▪ Fovea
* ▪▪ Back of lens
* ▪▪ Areas of chorioretinal scars
* ▪▪ Edges of lattice degeneration
* • Blunt trauma may cause avulsion of vitreous base which may lead to tearing of the retina along its posterior border
* • Posterior vitreous detachment is separation of cortical vitreous from the retina anywhere posterior to the vitreous base

POST TEST :-

- **Select the correct answer:**
  The vitreous humour mainly consists of:
  a) Blood vessels
  b) Jelly-like transparent material
  c) Dense muscle fibers
  d) Pigmented cells
- **Short note:**
  Explain the physiological functions of the vitreous humour in supporting retinal health and eye structure.