Physiology Team 439

MED439
KING SAUD UNIVERSITY

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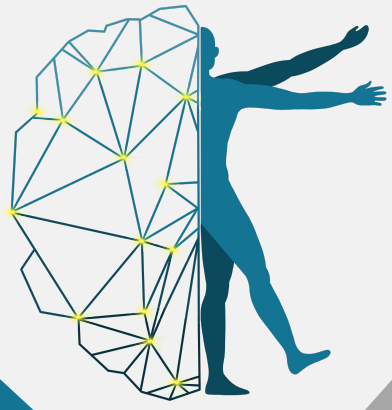


Physiology of the eye & Refraction

Objectives:

- Describe different components of the eye and functions of each
- Describe the refraction of light as it passes through the eye to the retina
- Identifying the refractive media of the eye
- Know fluid system of eye & glaucoma.
- Binocular vision.
- Know the layers of retina, blind spot, and fovea
- Know principles of optics and errors of refraction

Color index:

- Important.
- Girls slide only.
- Boys slide only.
- Dr's note.
- Extra information.

Editing File

1 The Eye

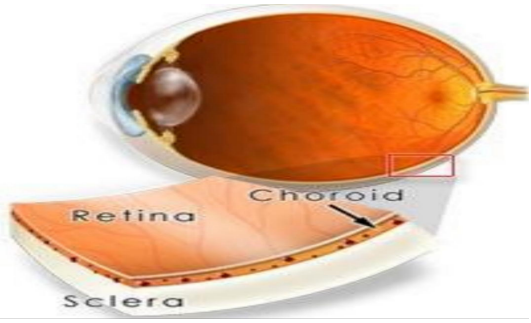
Eye

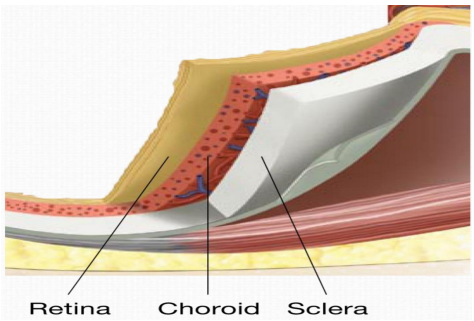
Human vision is one of the most complex visual systems among animals. The eye is a complex sensory organ, which capable of transduction physical stimuli of light rays into electrical and chemical signals that can be interpreted by the brain to construct physical images.

Male slides

Female slides

It is a fluid-filled sphere enclosed by three specialized tissue layers.
1-the sclera is a tough outer covering of connective tissue.
2-the middle layer is the choroid containing blood vessels.
3-the retina is the innermost layer which contains light sensitive cells.



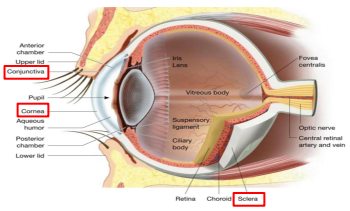


2 Structure of The Eye

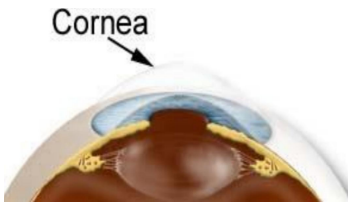
A outermost fibrous layer:

protective layer

1 sclera: thick ,white fibrous tissue for protection- spherical appearance.



2 cornea: modified anterior 1/6 of sclera to allow light to enter the eyes. It is transparent and avascular.
Q. From where it gets its nutrition?
A. Tears & aqueous humor (Diffusion).



3 conjunctiva: Transparent membrane (epithelium) cover anterior surface of eye, reflected on inner surface of eyelids (lines it and covers the sclera) and Covered with thin film of mucus tears for protection (prevent entrance of microbes and dust), wetness and cleaning.

B middle vascular layer:

1- CONSIST OF:

Iris

Colored part of the eye. Has aperture (pupil) control & allow light to enter the eye. Has the papillary muscles

Pupil

Behind center of cornea, control & allow light to enter the eye,appears black because, as you look through the lens, you see the heavily pigmented back of the eye (choroid and retina) *

Choroids

Inside sclera, highly vascular structure.
Posterior ⅔ of it has retina (the innermost layer lining) not present in the anterior part .
The outermost layer of retina (the photoreceptor) Rods and Cones) depends mostly on diffusion from choroid capillaries for nutrition specially oxygen supply. **

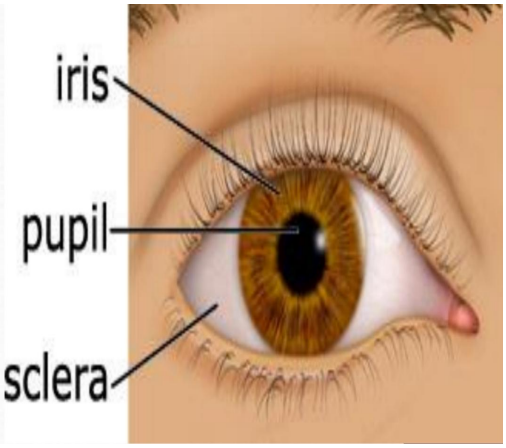
Ciliary body

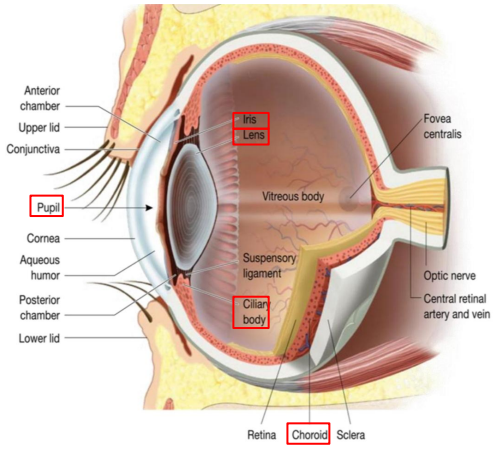
Thick anterior part of choroid consists of Ciliary muscles, Ciliary glands and Suspensory ligaments (zonules) which are attached to the lens.**

Lens

Transparent, biconvex, semisolid. Dioptric (unit of refractive power) power 15-20 D.
held in place by zonule (lens ligament = suspensory ligament) attached to anterior part of ciliary body. Within the cells of the lens, proteins called crystallins are arranged like the layers of an onion, this makes up the refractive media of the lens. Lens helps focus images on the retina to facilitate clear vision.*

❖ Uvea is: choroid + iris + ciliary body fleshy parts in the eye

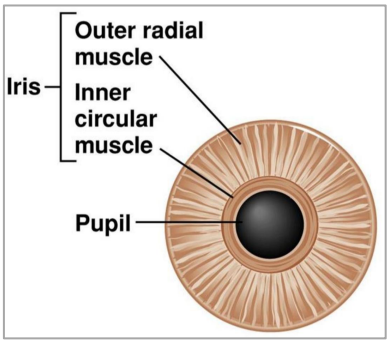




* Girls slides. * Boys slides ** Mixed.

2- **The pupillary muscle** consists of:

1- radial muscle dilates the pupil as in dim light supplied by sympathetic mydriasis
2- constrictor pupillae (circular muscles) constrict the pupil by parasympathetic as in bright light. Myosis



2- **The Anterior & Posterior Cavities:**

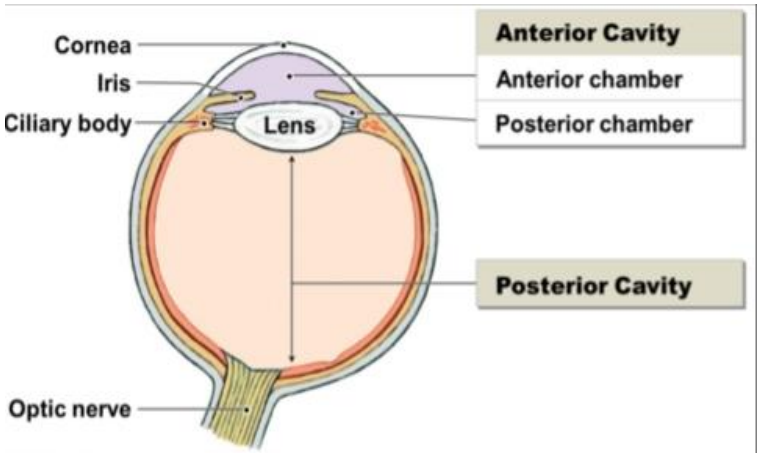
The Ciliary Body (& its suspensory ligament) and lens divide the eye into :

1 Anterior cavity

which contains a fluid called aqueous Humor.
The Iris further divides the anterior cavity into:
a- Anterior Chamber (between cornea and iris).
b- Posterior Chamber (behind the iris; between the iris and lens).

2 Posterior cavity:

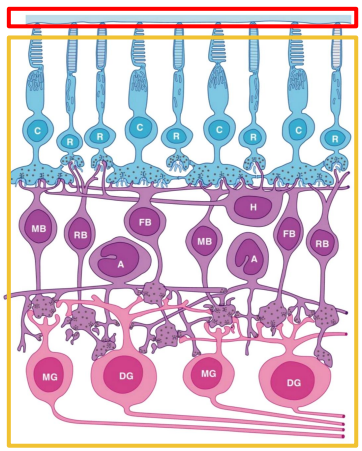
which contains fluid called Vitreous Humor.



C innermost layer (retina) Most important layer

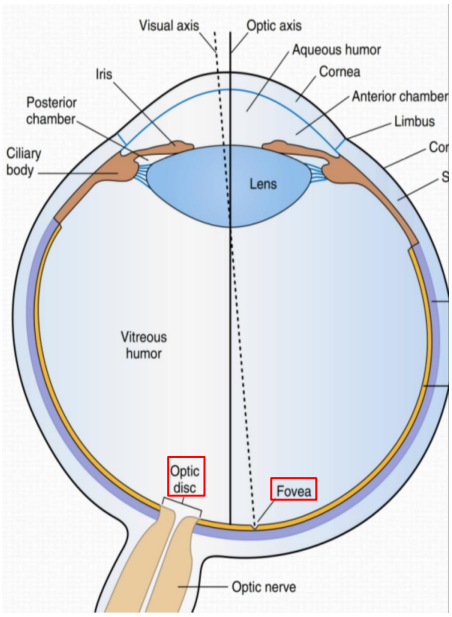
Consists of Outer pigmented part and Inner neural part containing:

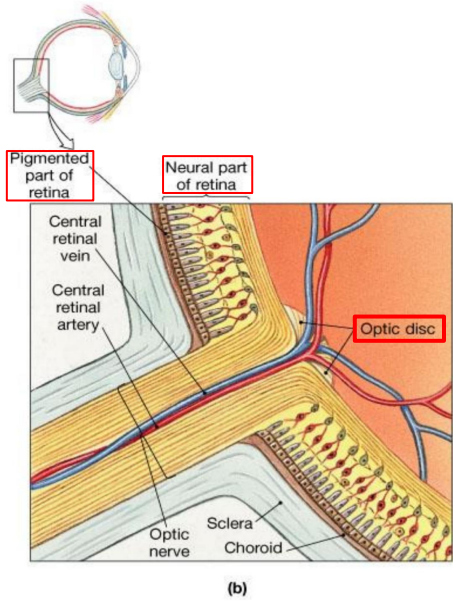
photoreceptors	Called Rodes & Cones. **A) Rods:** are best for vision in dim light (*scotopic vision*). **B) Cones:** are best for vision in daylight or bright light (*photopic vision*), color vision (color perception) & perception of detail (acuity of vision).
optic disc (blind spot)	3mm medial & above post pole of eye where optic nerve leaves & retinal blood vessels enter (NO photoreceptors so it is blind spot). ما تستقبل الضوء + ما نحس فيها لأن عندنا double vision Find **your** blind spot
fovea centralis	Depression or spot at the center of macula lutea (An important part of the retina)* . Yellow pigmented at post pole of eye. Contains only Cones and has the maximum concentration of it*. Consequently, the fovea centralis is the point of maximal visual activity in the retina and high visual activity for colors vision & details detection. When you turn your eye to look at an object, you tend to place its image in the fovea *.

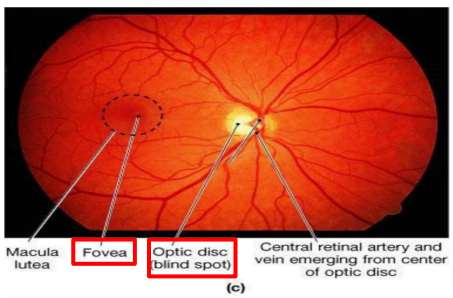


outer pigmented part

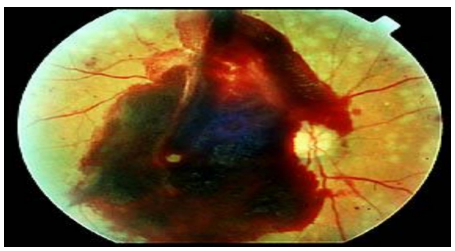
Inner Neural part







Normal ophthalmoscopy view



Retinopathy in diabetes:
Vessels have weak walls causes hemorrhaging and blindness.

3 Layers of Retina & Retinal Cells

There are five basic classes of neurons in the retina:

- Photoreceptors
- Bipolar cells
- Horizontal cells
- Amacrine cells
- Ganglion cells

❖ **Layers of retina (10 layers), the most important are**

Layer	Type of Cells & features
1- Pigment cell layer (Vit A)	Outermost layer (absorb light & prevent its reflection back). The pigment layer also stores large quantities of vitamin A an important precursor of the photosensitive chemicals of the rods and cones.
2- Rods & Cones	Their outer & inner segments, but not cell bodies. (Rodes 90-120 million & cones 4.5- 6 million) (Cones concentrated in fovea centralis and rods concentrated on the peripheries) photoreceptor cells are responsible for capturing light and transforming this into generator potential.
3-Outer nuclear layer	Cell bodies of Rods & Cones.
4-Outer plexiform layer	mainly of Horizontal cells.
5-Inner nuclear layer	Bipolar cells.
6-Inner plexiform layer	Amacrine cells. Interposed between the inner nuclear and ganglion cell layers.
7-Ganglion cell layer	The axons of ganglion cells form the optic nerve
8-Optic nerve fibers	1.2 million fibers. Horizontal cells (outer plexiform layer) make synaptic connections with receptors. Amacrine cells (inner plexiform layer) make synaptic connections with ganglion cells.

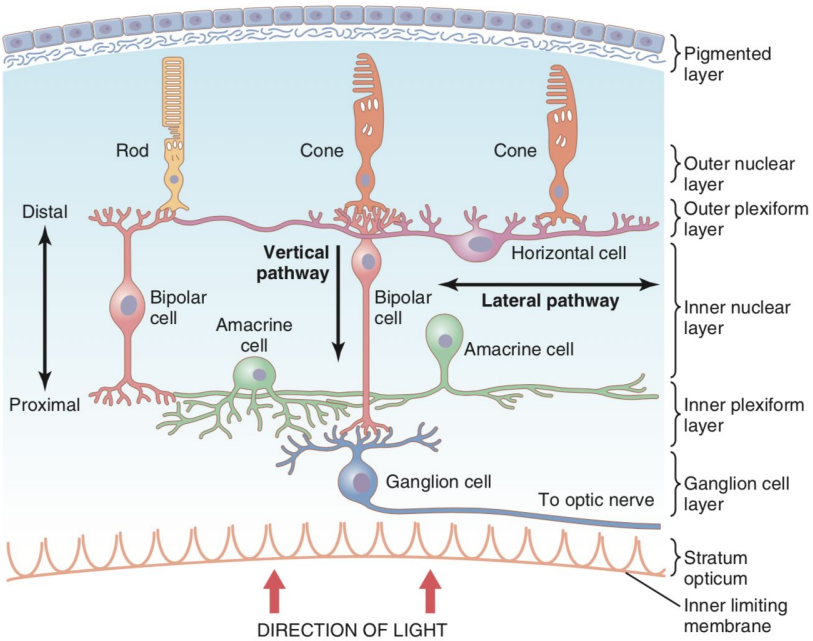
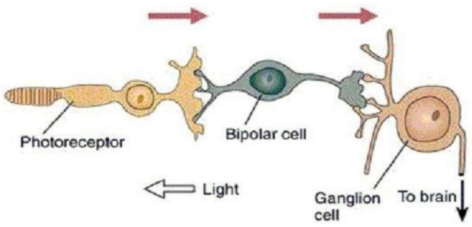


Figure 51-1. Layers of the retina.

4 Retinal neural circuitry & Light pathway

Light hits photoreceptors, sends signal to the bipolar cells then to ganglion cells.



Muller cells: are the major glial element of the retina

- located in the inner nuclear layer
- providing metabolic support to retina
- maintaining synaptic levels of neurotransmitters. act as light conductor.

Light pathway

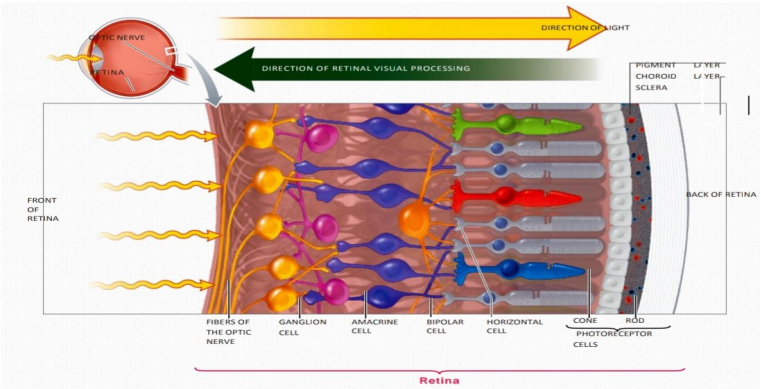
light passes through the lens system of the eye and then through the vitreous humor

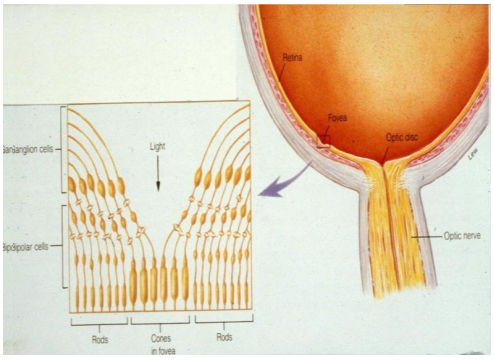
it enters retina & passes first through the ganglion cells and then through the plexiform and nuclear layers.

before it finally reaches the layer of rods and cones located on the outer edge of the retina

Light absorbed by pigment cell layer contain melanin pigment, then to rodes & cons, then impulses pass from them to rest of layers.

finally to ganglion cell layer to optic nerve





Nerve fibers and ganglion axons go two both side away from the center to allow direct striking of the light to the cones of the fovea centralis to give the best color vision and the best details detection

5 External Protection of the Eye

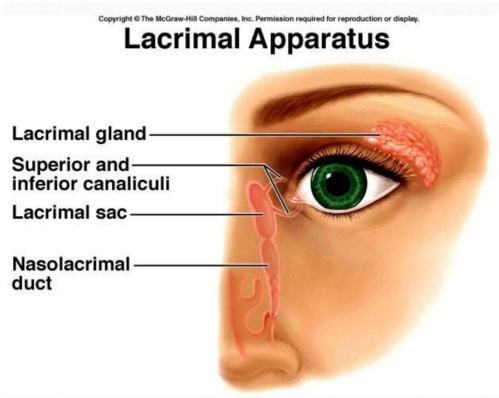
A Bony orbit

B Eyelids with their lashes (Eyelids blinking keep cornea moist)

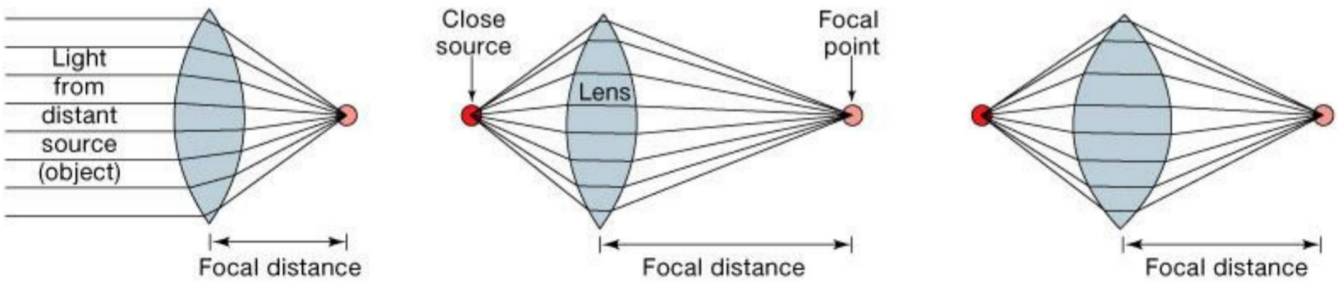
C Conjunctiva

D Tears from lacrimal gland:

- has antibacterial, lubricating effect
- keep cornea moist & clear
- provide nutrition to the cornea



6 Lenses: Image Formation



(a) The closer the light source, the longer the focal distance

(b) The rounder the lens, the shorter the focal distance

Make sure you understand image formation very well since the concept is used in treating errors in refraction
(Also accommodation uses this, Details are found in the accommodation lecture)

7 Lenses: Principles of Optics

L9

A

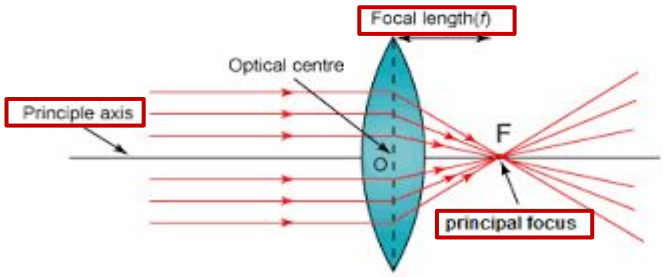
principle focus:-
parallel rays strike biconvex lens refracted in a point is PF.

B

principal axis:-
PF lies on line pass through centers of lens curvatures

C

Principal focal distance:
distance between lens & PF.
Lens ---- Retina distance = 17mm, 15mm.
Biconvex Lens (converge) & biconcave lens(diverge)



Diopter

Diopters are a measure of refractive power = $\frac{1}{\text{Principle focal distance in meters}}$

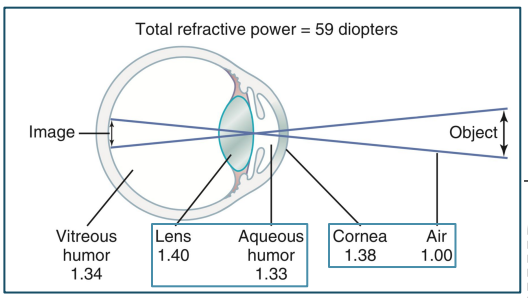
Example: If Principal focal distance of a lens is 25cm, how much refractive power would it have?

$$\frac{1}{0.25\text{m}} = 4 \text{ Diopters}$$

The greater the curvature of the lens the greater the refractive power of the eye (in accommodation, We increase the curvature of the lens)
Concave lenses "neutralize" the refractive power of convex lenses.
Thus, placing a 1-diopter concave lens immediately in front of a 1-diopter convex lens results in a lens system with zero refractive power *

Emmetropic eye

Emmetropic is the Normal eye. It has image exactly on the retina, and has a dioptric power of 59-60D



Cornea: 40-45D
Lens: 15-20D
Accomodation by Lens: +12

Explanation: If you remember from high school or prep year, Snell's law:the refractive index (Velocity of light in vacuum C / Velocity of light in medium V). So, the higher the difference in refractive indices the higher the refraction. In the case of of the cornea the difference is 0.38 which produces 40-45Ds. And the lens has a difference of 0.07 which produces 15-20 D and with accommodation the refractive index of the lens increases further which can add 12Ds

8 Refractive Media of The Eye

L9

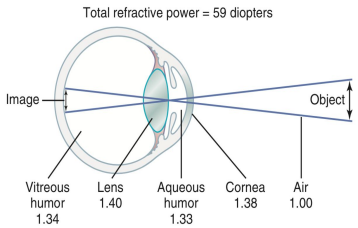
1. The interface between air and the anterior surface of **the cornea,**
2. The interface between the posterior surface of the cornea and **the aqueous humor**,
3. The interface between the aqueous humor and the anterior surface of **the lens of the eye,**
4. The interface between the posterior surface of the lens and **the vitreous humor.**

- a total refractive power of 59 diopters when the lens is accommodated for distant vision.

The Cornea

It's dioptric power is 40-45 diopter at its anterior surface. About two thirds of the 59-60 diopters of refractive power of the eye is provided by the anterior surface of the cornea.

- The principal reason for this is that the refractive index of the cornea is markedly different from that of air
- N.B/ The internal index of air is 1
  - the cornea 1.38
  - the aqueous humor 1.33
  - the crystalline lens 1.40
  - the vitreous humor 1.34

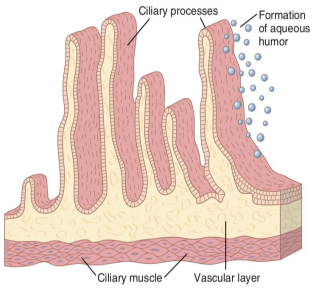


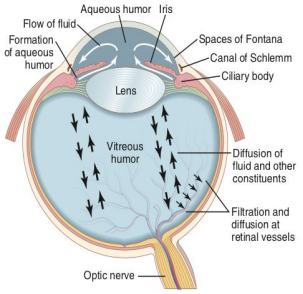
Aqueous Humor

Fluid produced by ciliary body (ciliary processes)>to post chamber > to pupil > to ant chamber > to canal of schlemm at angle of ant chamber > to veins

Function:

- Nourishing avascular structures (cornea ,lens)
- Causes intraocular pressure 10-20mm Hg
- Produced at a rate of 2-3 microliter/min by active transport of NA+, followed by Cl- and HCO3- and then osmosis of water
- Contains many nutrients like amino acids ascorbic acids and glucose
- is **continually being formed** and reabsorbed.
- nourishes the cornea and iris produced in the ciliary body by an active secretion by ciliary processes.
- the aqueous humour is a transparent, slightly gelatinous (gel-like) fluid similar to plasma
- It causes intraocular pressure 10-20 mmhg
- obstruction of this outlet leads to increased intraocular pressure , a critical risk factor for glaucoma





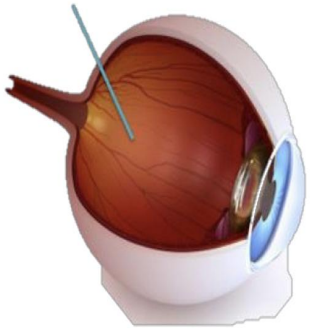
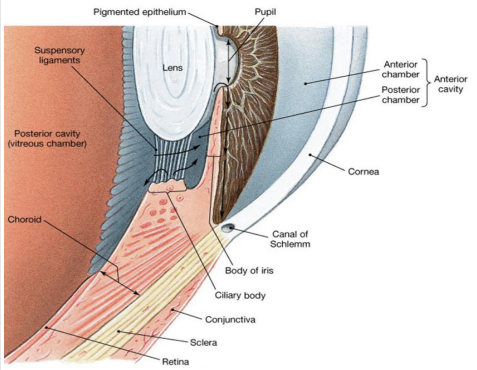
❖ Boys ❖ Girls

Glaucoma مياه زرقاء

- **Build up of Aqueous Humor Volume** > Increases pressure in eye > Damages nerve > Meds/surgery *.
- (intraocular pressure more than 20mm Hg) -obstruction of Aqueous humor outlet leads to increased intraocular pressure. - pushes the lens backwards into vitreous, which pushes against the retina. - compression causes retinal and optic nerve damage that can cause blindness*
- Glaucoma is an eye condition that develops when too much fluid pressure builds up inside of the eye. The increased internal pressure can damage the optic nerve, which transmits images to the brain. Without treatment, glaucoma can cause blindness within a few years. Glaucoma is most often inherited, meaning it is passed from parents to children. Less common causes of glaucoma include a blunt or chemical injury to the eye, severe eye infection, blockage of blood vessels in the eye and inflammatory conditions of the eye. Glaucoma usually occurs in both eyes, but it may involve each eye to a different extent.*

Normal vision

Glaucoma

The Vitreous Humor	Is the transparent,colorless, gelatinous mass ▪ It fills the vitreous chamber between the posterior surface of the lens and the retina ▪ The vitreous humour is clear and allows light to pass through ▪ For nourishing retina & keep spheroid shape of the eye ▪ Both water and dissolved substances can diffuse slowly in the vitreous humors ▪ VITREOUS HUMOUR REMAINS FROM BIRTH	
The Lens	Has dioptric power 15-20 D ▪ (1/3 refractive power of eye) , more important than cornea. why? ▪ Importance of the internal lens is that, in response to nervous signals from the brain, its curvature can be increased markedly to **provide "accommodation"**	

Cataracts الماء الأبيض

Lens clouds up > Must be removed > Typical to replace > lens with implant > Can get clouding repeated > Laser removal * can be caused by diabetes

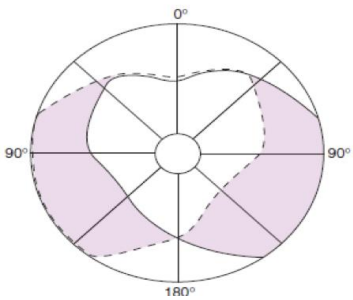
- Cataracts occurs in older people. It's a cloudy or opaque area or areas in the lens. *
- the proteins in some lens fibers coagulate to form opaque areas. *
- cataract impairs vision *

Binocular Vision

Are the areas in the centre of visual field of the two eyes in which any object in this area will be seen by both eyes. *

- BINOCULAR VISION for:

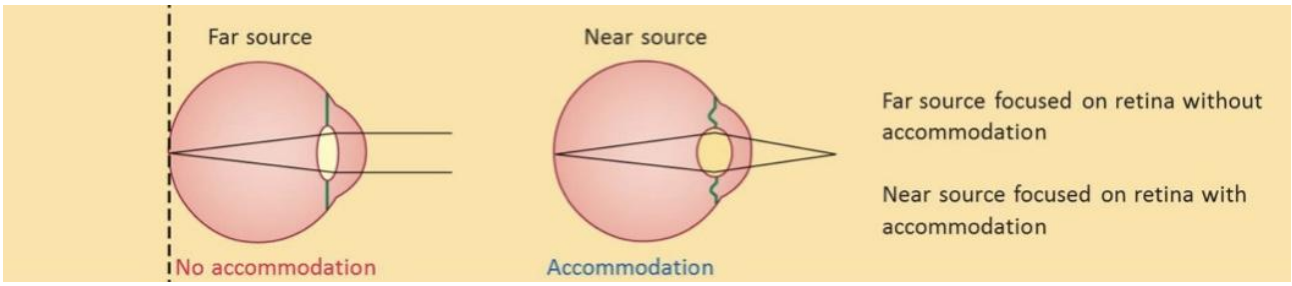
- 1- Large visual field
- 2- cancel the effect of blind spot
- 3- stereoscopic vision
- 4- one eye lesion does not affect vision



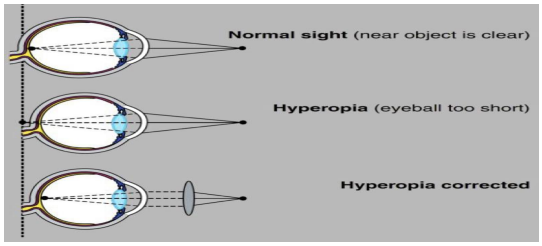
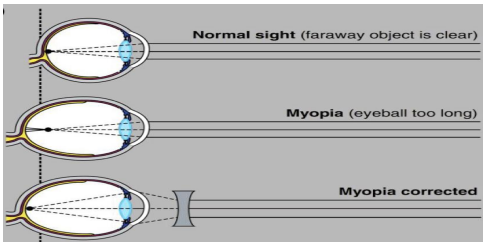
- Monocular and binocular visual fields:

-The **dashed** line- encloses the visual field of the left eye.
- the **solid** line, that of the right eye.
-The **common** area (heart-shaped in the center) is viewed with binocular vision.
-The **colored** areas are viewed with monocular vision.

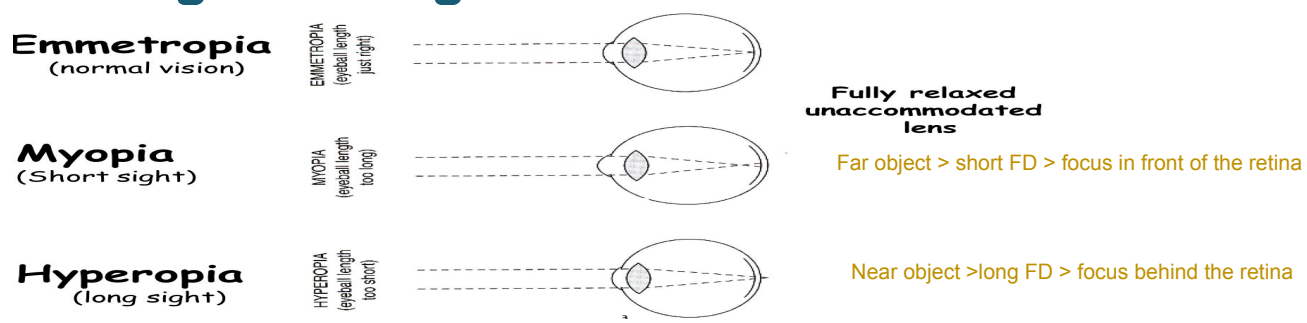
Normal eye (Emmetropia):



Errors of Refraction

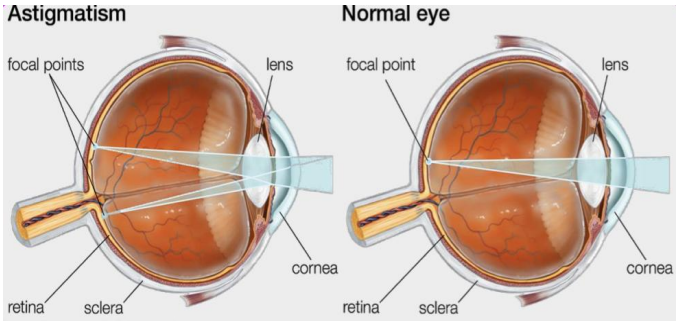
Abnormality	Hypermetropia (hyperopia = far-sightedness)	Myopia(nearsightedness)
cause	**Short (Small) eyeball + weak lens system**	▪ Myopia is thought to be partially genetic in origin However, there is a positive correlation between sleeping in a lighted room before the age of 2 and the subsequent development of myopia. * ▪ In young adults the extensive close work involved in activities such as studying accelerates the development of myopia *
features	An affected individual has to use accommodation even for distant objects. *	Genetic, **large eyeball,**long anteroposterior diameter of the eye,or too much refractive power of lens system or cornea due to its too curved surface
leads to	Continuous accomodation to bring image on retina causes muscular effort on ciliary muscle & prolonged convergence , this leads to headache & blurred vision & finally squint, **focus behind retina**	**focus in front of retina**
Correction by	correction by **biconvex** lens.	Correction by **biconcave** lens to diverge rays before strike lens
graphs		

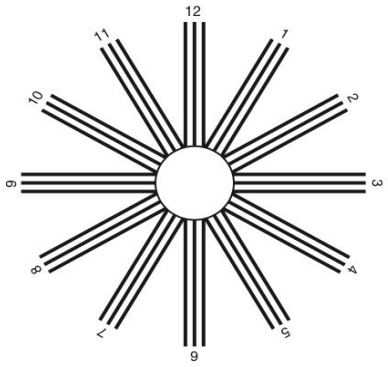
• Image Focusing

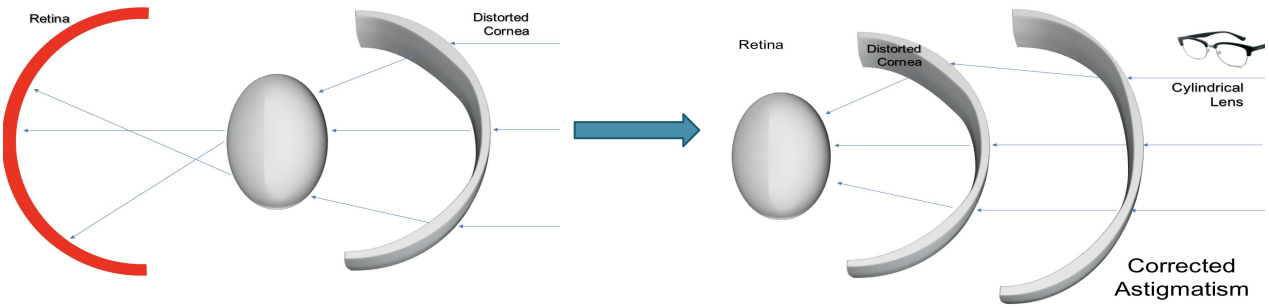


Astigmatism انحراف	Presbyopia
❖ Mainly Uneven & ununiformed corneal curvature, very rare ununiformed lens curvature ❖ Rays refracted to diff focus > blurred vision ❖ **Correction by cylindrical lens** which bends light rays in only one plane (a focal line)	Eye near point recedes by age due to loss of accommodation > Focus behind retina > correction by **biconvex** lens للي أعمارهم فوق الخمسين مثلاً يصيرو يلبسو نظارات قراءة لانه يصير لهم ciliary muscle weakness

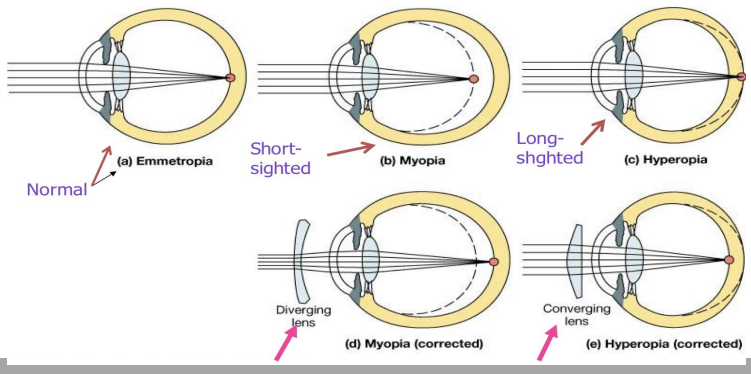
Astigmatism Pictures :

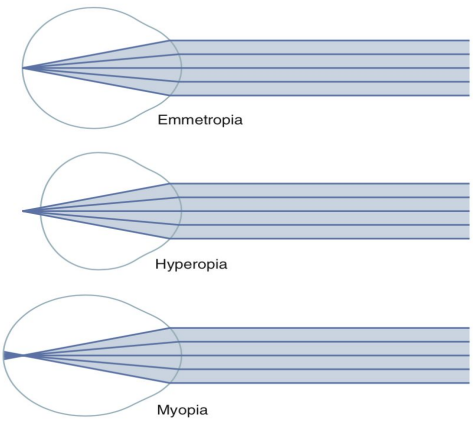






• Visual Abnormalities:





MCQ & SAQ:

Check out this week's Qbank which contains lovely practice questions including this lecture

Q1: colored part of the eye. Has pupil control & allow light to enter the eye. Has the pupillary muscles is the ...

A. Iris
B. Pupil
C. Ciliary muscle
D. Lens

Q2: Which of the following is the best photoreceptor for vision in dim light (scotopic vision)?

A. Pigmented epithelium
B. Rods
C. Cones
D. Optic nerve

Q3: Which of the following is an external structure for protection of the eye

A. Retina
B. Choroid
C. conjunctiva
D. Iris

Q4: the cause of Hypermetropia?

A. Short eyeball and weak lens system
B. Genetic
C. large eyeball
D. long anteroposterior diameter of the eye

Q5: The correction of Astigmatism?

A. I can't think of something here
B. Correction by biconvex lens
C. Correction by cylindrical lens
D. Correction by biconcave lens

Q6: The focus in Myopia.

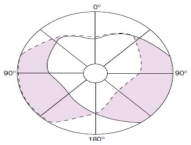
A. In front of retina
B. Behind the retina
C. Lateral to the retina
D. Medial to the retina

answer key:
1: A
2: B
3: C
4: A
5: C
6: A

1- Explain the light pathway.

2- Enumerate 8 of retinal layers and mention the retinal cell type for each.

3- describe the Monocular and binocular visual fields.



4- brief description for Refractive Media of The Eye.

A1: Slide #8

A2: Slide #7

A3: Slide #11

A4: Slide #13

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