Vision

1-Physiology of the eye & Refraction

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OBJECTIVES:-

At the end of this lecture, the student should be able to:-

- **Describe different components of the eye and function of each and -understand the eye protection media**
- **Describe the refraction of light as it passes through the eye to the retina, identifying the refractive media of the eye**
- **Know glocuma and binocular vision**
- **Know layers of retina, blind spot, and fovea centralis**
- **explain the different light sensitivities of the fovea, peripheral retina and optic disk**
- **Know principles of optics and errors of refraction**
- Light pathway in the eye-

-*Textbook/Guyton & Hall*

Reference book/Ganong review of medical physiology

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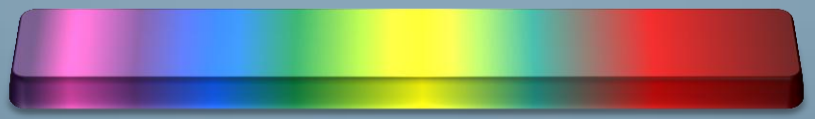
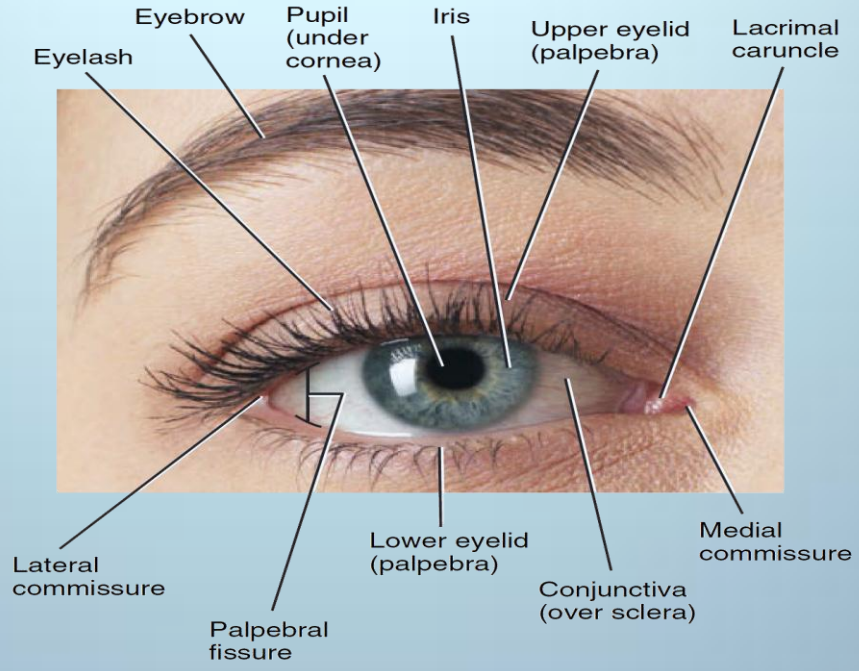
FUNCTIONS OF VISION

DISCRIMINATION – LIGHT VS. DARK

DETECTION OF MOVEMENT

DETECT COLOUR (ADAPTIVE VALUE OF COLOUR VISION)





EYE HAS:-

1-Refracting Media

2- Coats (Sclera, Choroid and Retina)

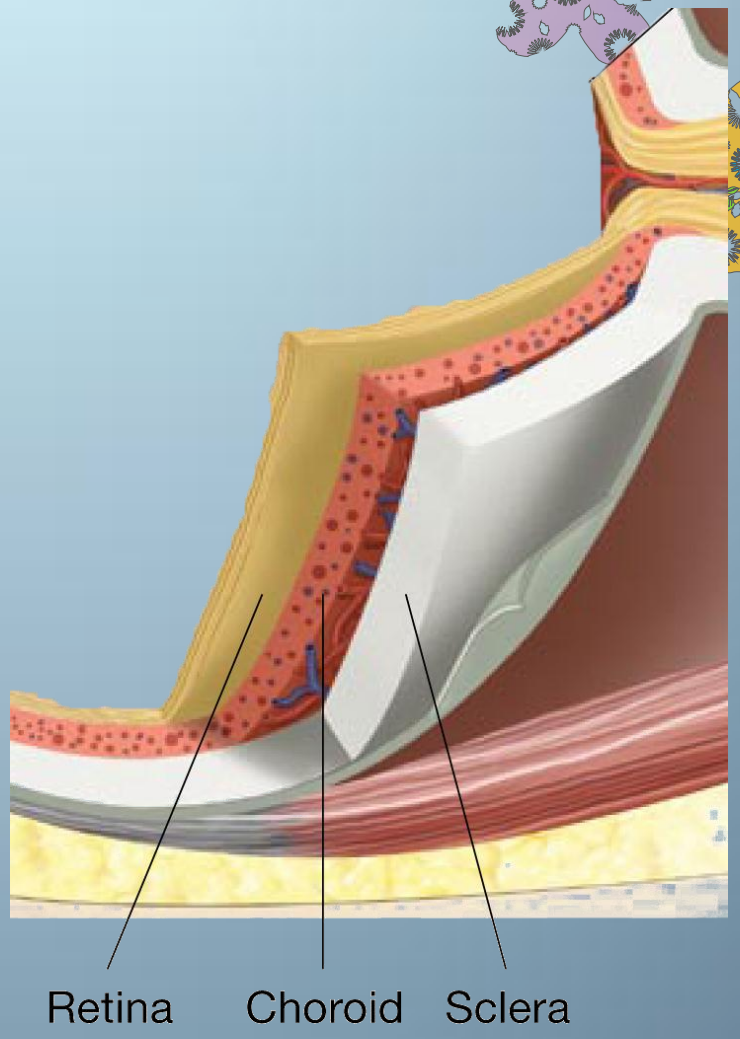
-Post 2/3 Retina, Ant1/6 Cornea

The eye is a fluid-filled sphere enclosed by three specialized tissue layers.

1-the sclera is a tough outer covering of connective tissue.

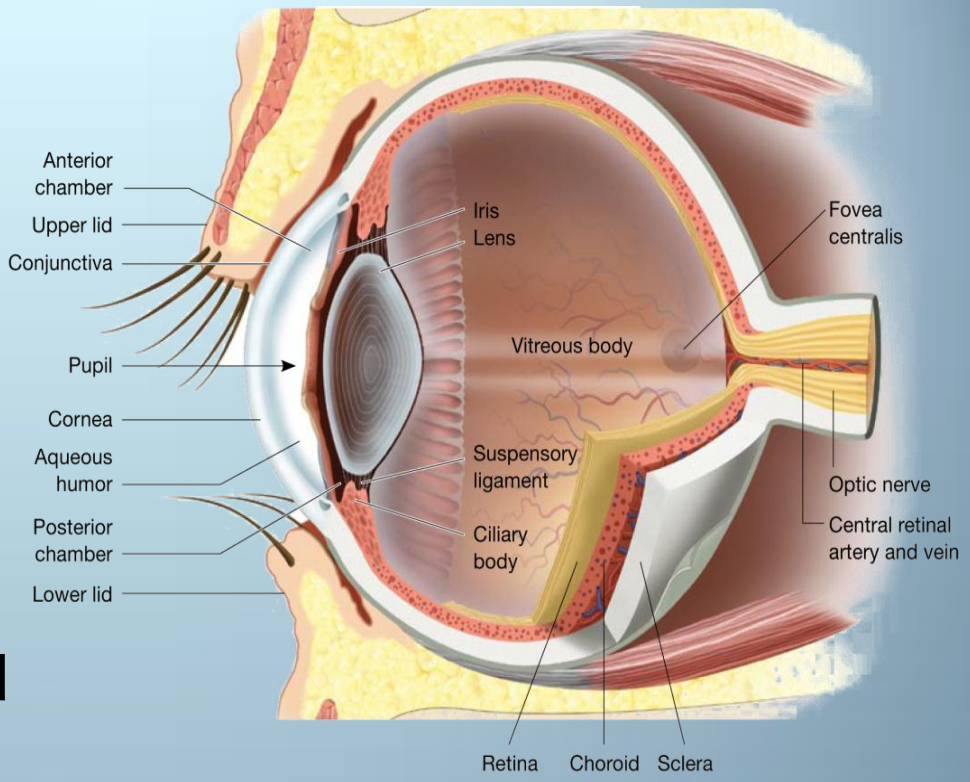
2-the middle layer is the choroid containing blood vessels.

3-the retina is the innermost layer which contains light sensitive cells



Anatomy of the eye:

1- Sclera (thick ,white fibrous tissue for protection- spherical appearance)

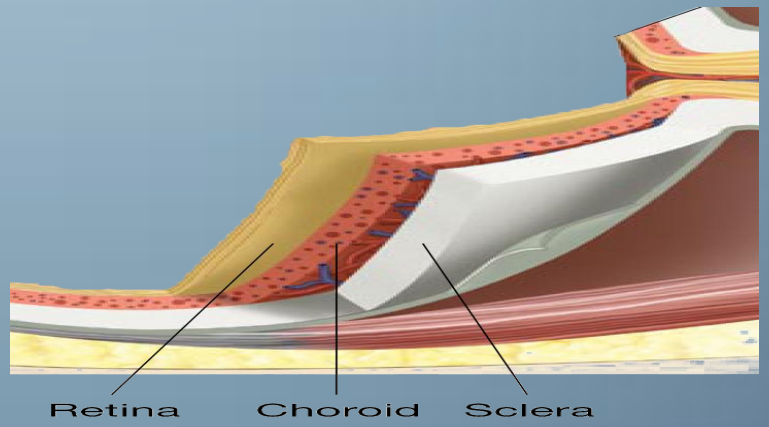


-Choroids

-inside sclera , highly vascular

-the capillaries in the choroid are the primary source of nourishment for retinal photoreceptors & oxygen to rods and cones

- post 2/3 of choroid has retina (innermost layer lining)



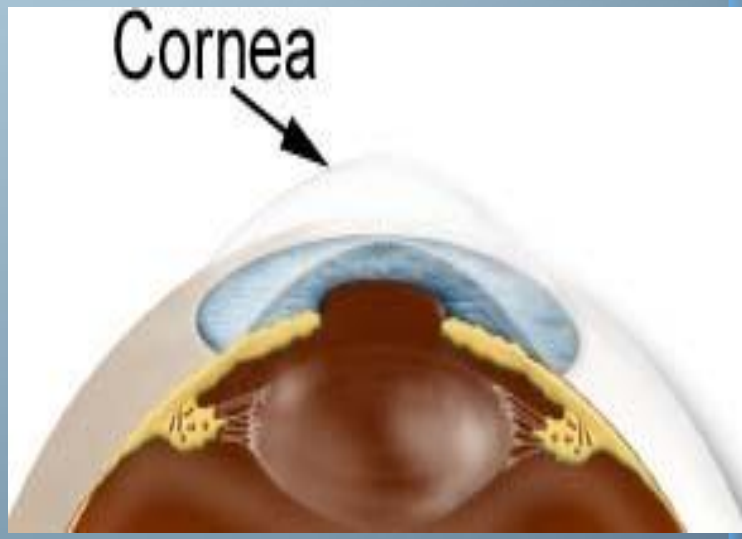
2- cornea （modified ant 1/6 of sclera ）to allow light to enter the eyes, transparent , avascular.

Q.From where it gets its nutrition?

-A/ Tears& aquous humor

- Refractive or diopteric power

40-45 D at its anterior surface.

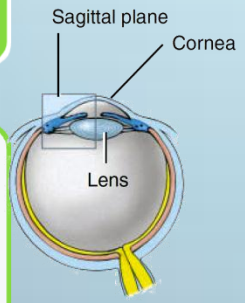


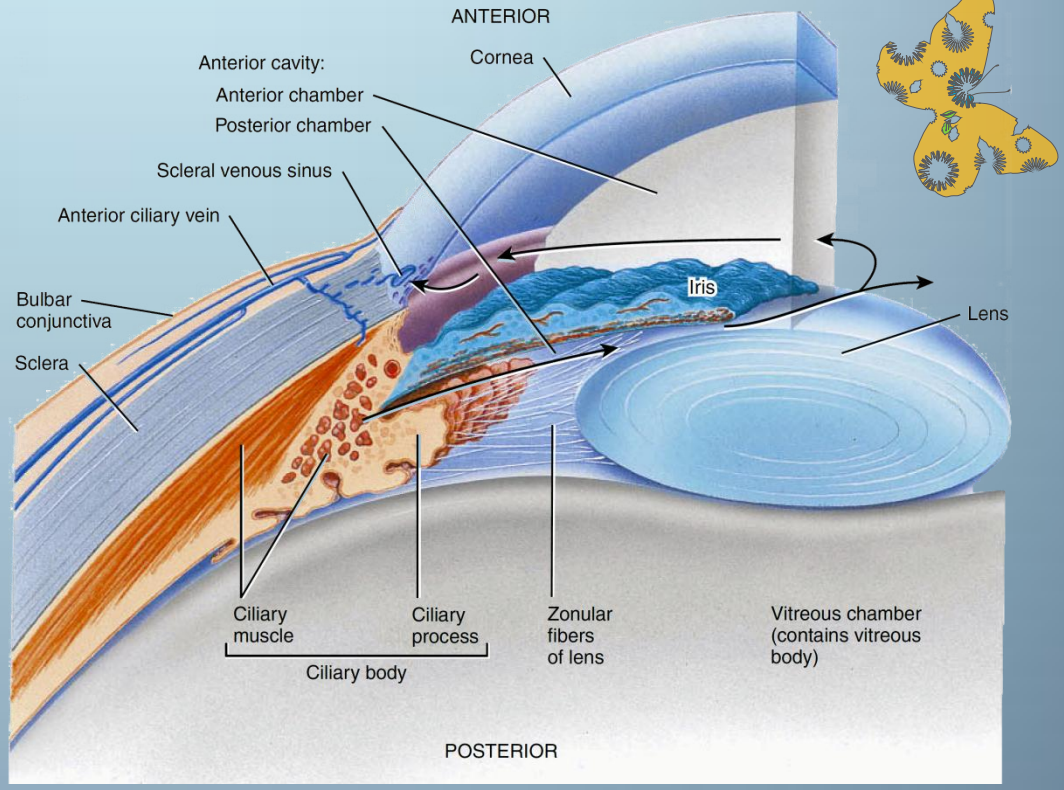
THE CORNEA HAS NO BLOOD SUPPLY; IT GETS OXYGEN DIRECTLY THROUGH THE AIR.

OXYGEN FIRST DISSOLVES IN THE TEARS AND THEN DIFFUSES THROUGHOUT THE CORNEA

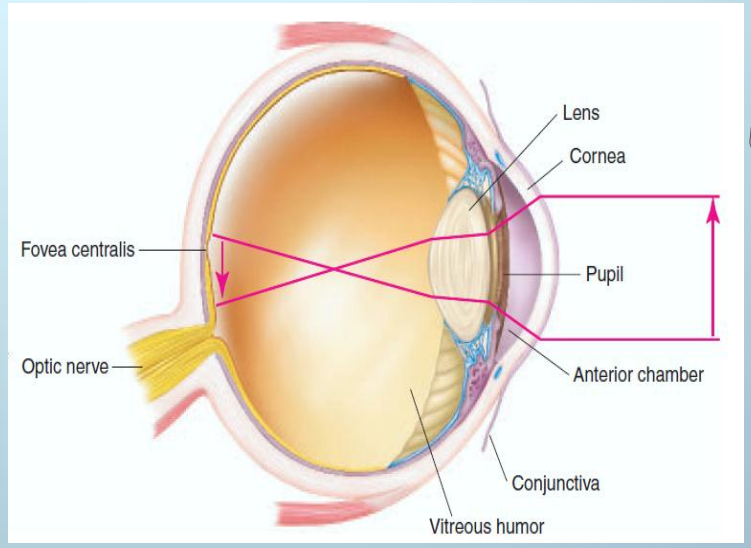
THE ENVIRONMENT SUPPLIES ALMOST ALL OXYGEN NEEDED FOR TISSUE RESPIRATION IN THE OPEN EYE.

IN THE CLOSED EYE, ABOUT TWO THIRDS OF THE OXYGEN DEMAND IS MET BY DIFFUSION FROM THE CAPILLARIES AND THE REST FROM THE ANTERIOR CHAMBER





IN HUMANS, THE CORNEA HAS RESIDENT IMMUNE CELLS



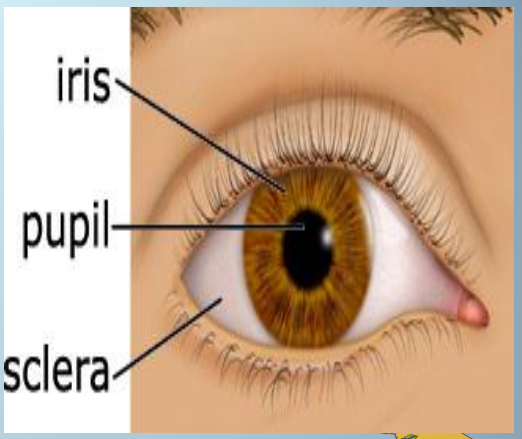
3- conjuctiva

- Transparent membrane cover anterior surface of eye,reflected on inner surface of eye lids

- Covered with thin film of tears for protection,wetness, cleaning

4- pupil /

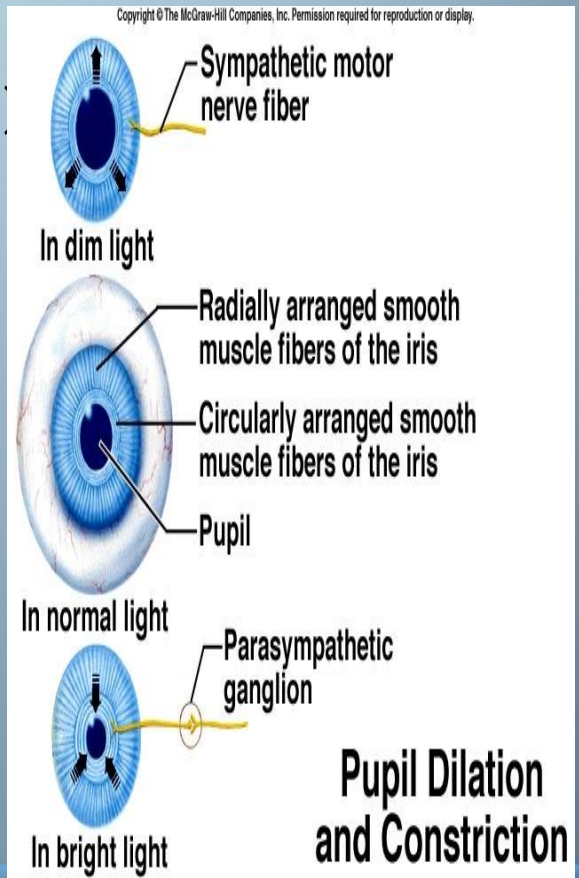
behind center of cornea, control & allow light to enter the eye,appears black because, as you look through the lens, you see the heavily pigmented back of the eye (choroid and retina)

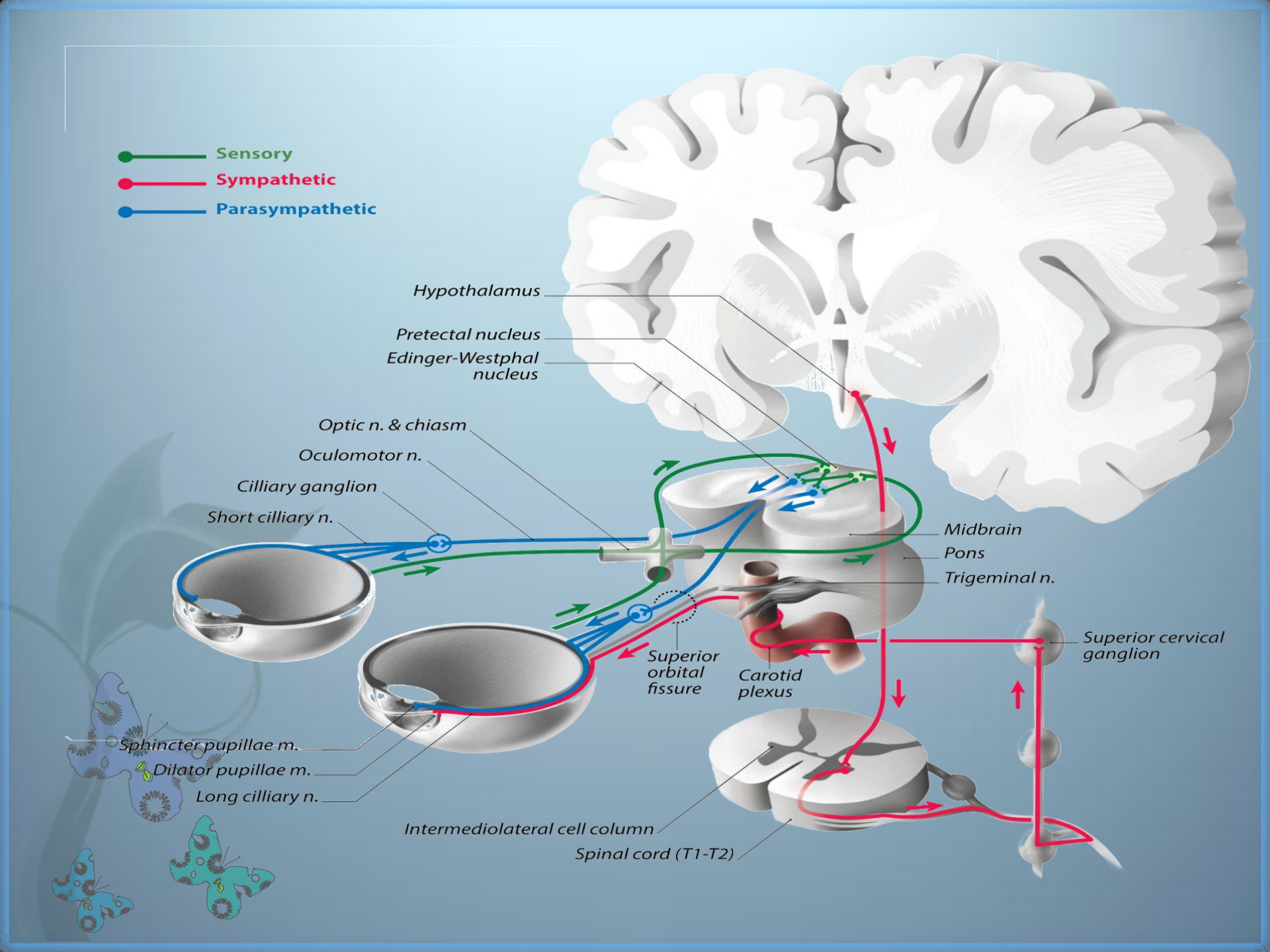


5- Iris

colored part (has radial muscle dilates the pupil as in dimlight (supplied by sympathetic) + circular muscles constrict the pupil (by parasympathetic), as in bright light

-the eyes appear brown to black when the iris contains a large amount of melanin, and blue due to low melanin.




Sensory
Sympathetic
Parasympathetic
Hypothalamus
Pretectal nucleus
Edinger-Westphal nucleus
Optic n. & chiasm
Oculomotor n.
Cilliary ganglion
Short cilliary n.
Midbrain
Pons
Trigeminal n.
Superior cervical ganglion
Superior orbital fissure
Carotid plexus
Sphincter pupillae m.
Dilator pupillae m.
Long cilliary n.
Intermediolateral cell column
Spinal cord (T1-T2)

6-Cilliary muscles (body)

thick ant part of choroid to which attached suspensory ligaments (zonule)

7- lens

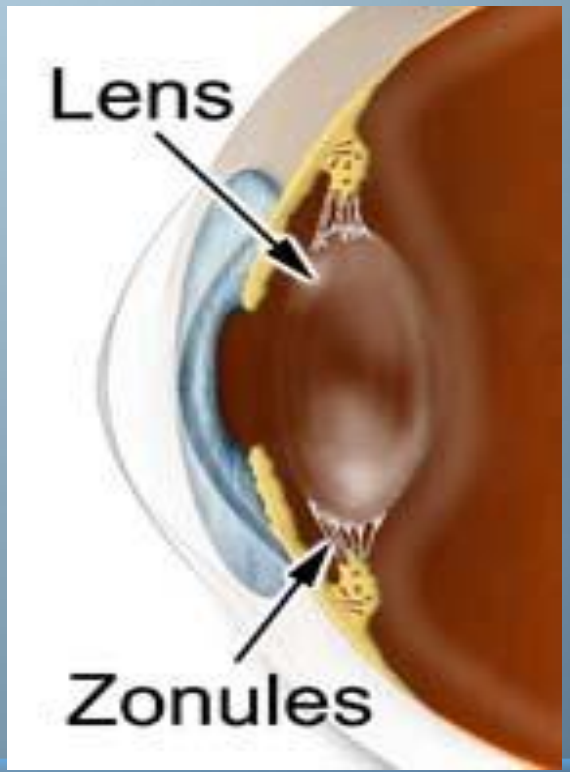
transparent, biconvex, semisolid, diopteric power 15-20 D,
held in place by zonule
(lens ligament= suspensory ligament)
attached to ant part of cilliary body

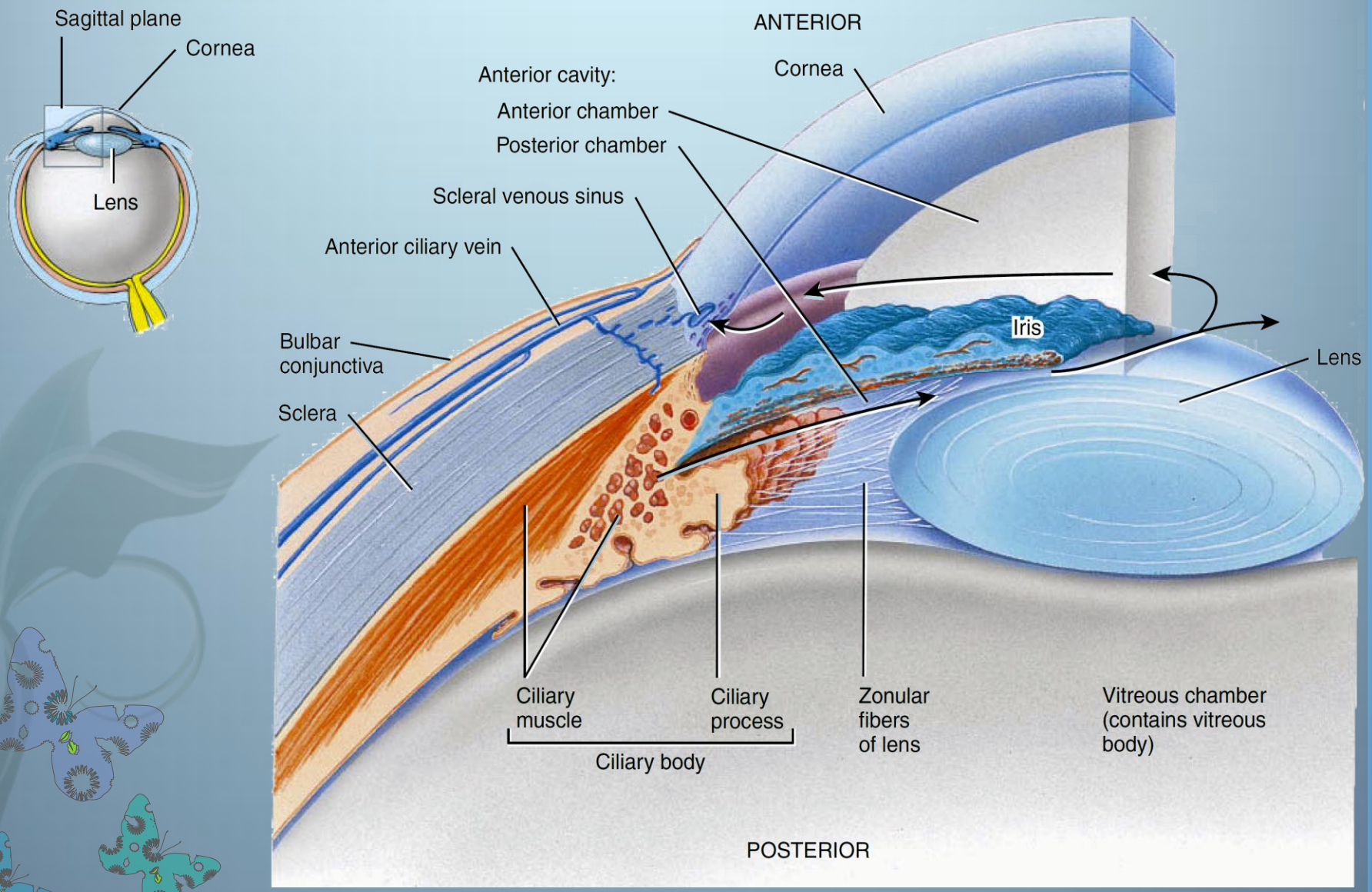
within the cells of the lens, proteins called crystallins are arranged like the layers of an onion,this makes up the refractive media of the lens

-the lens helps focus images on the retina to facilitate clear vision.

q.what is cataract?

8- Uvea = choroid + iris + cilliary muscles

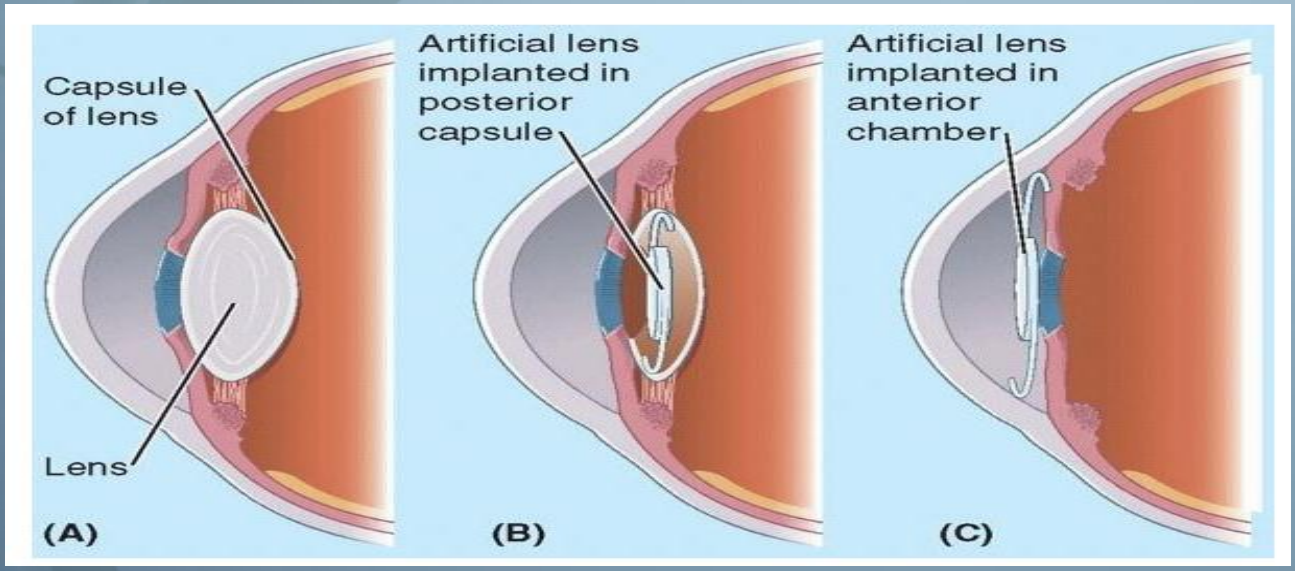



Sagittal plane
Cornea
Lens
ANTERIOR
Anterior cavity:
Anterior chamber
Posterior chamber
Cornea
Scleral venous sinus
Anterior ciliary vein
Bulbar conjunctiva
Sclera
Iris
Lens
Ciliary muscle
Ciliary process
Ciliary body
Zonular fibers of lens
Vitreous chamber (contains vitreous body)
POSTERIOR

Cataracts" occurs in older people. is a cloudy or opaque area or areas in the lens

- the proteins in some lens fibers become denatured and coagulate to form opaque areas .

- When a cataract has obscured light transmission so greatly that it impairs vision



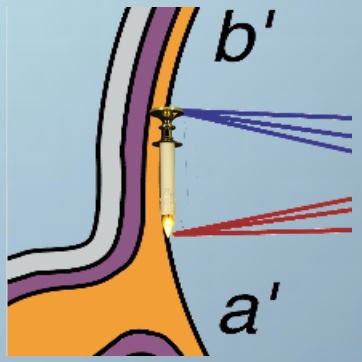
-An extracapsular cataract extraction involves removing the lens but leaving the capsule to put synthetic lens .

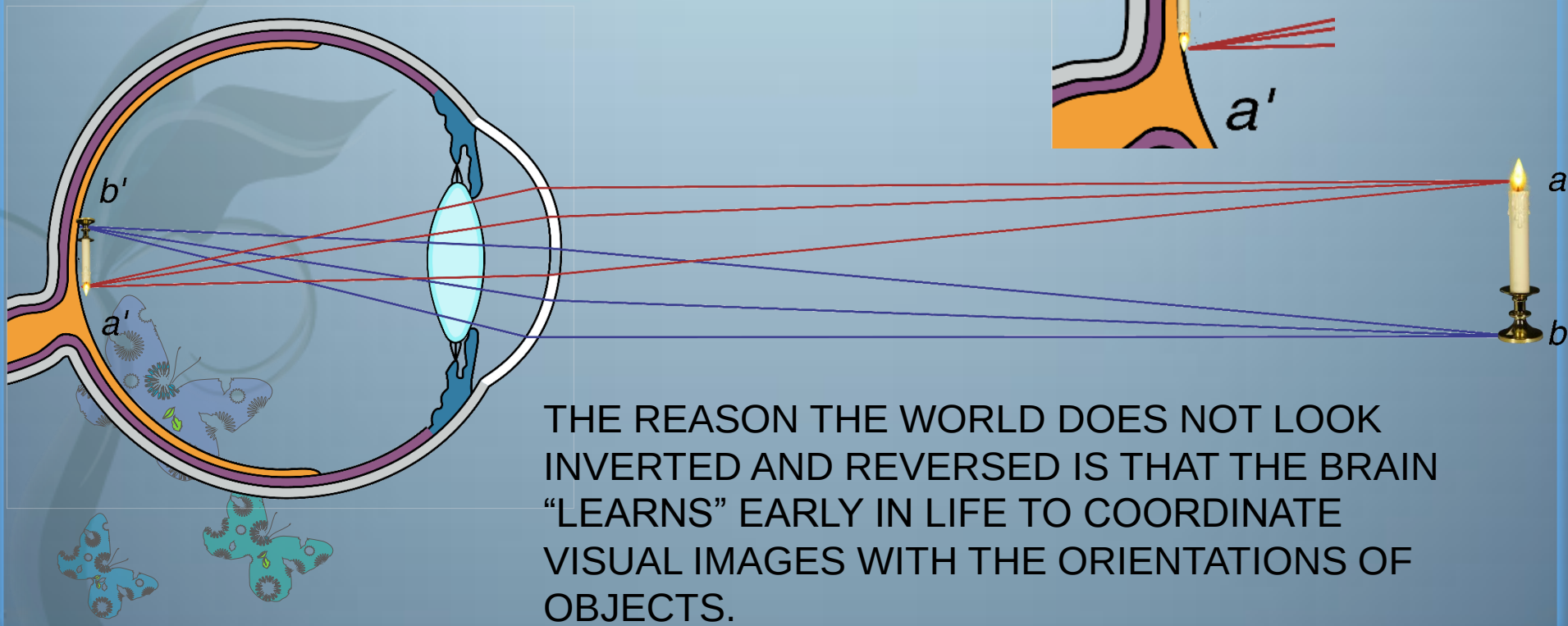
- Intracapsular lens extraction removing the lens and capsule, and implanting a synthetic lens in the anterior chamber

The lens system of the eye will focus an image on <u>the retina upside down</u>

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

however, the brain perceives objects in the upright position despite the upside-down orientation on the retina

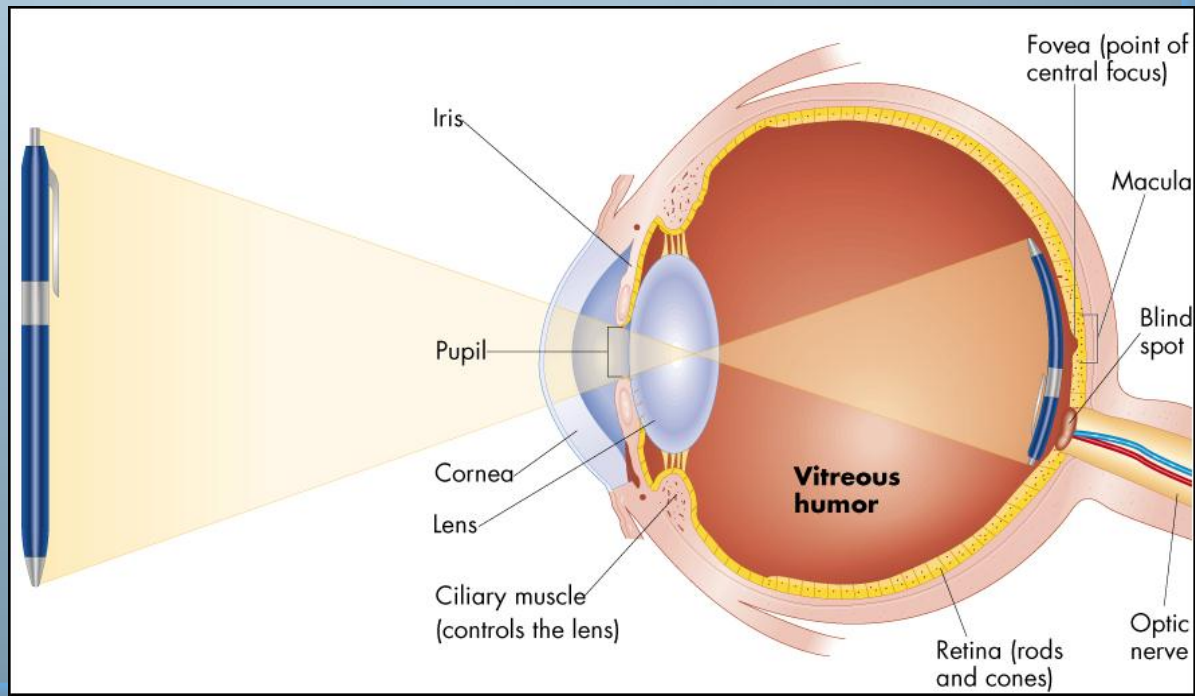




THE REASON THE WORLD DOES NOT LOOK INVERTED AND REVERSED IS THAT THE BRAIN "LEARNS" EARLY IN LIFE TO COORDINATE VISUAL IMAGES WITH THE ORIENTATIONS OF OBJECTS.

Anterior chamber of the eye ✹
/Between iris & cornea.

-posterior chamber of the eye /
Between iris & cilliary muscles
- Iris between both



Refractive media of the eye:-

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 t*he vitreous humor*.

- *A total refractive power of 59 diopters when the lens is accommodated for distant vision*

Refractive media of the eye:-

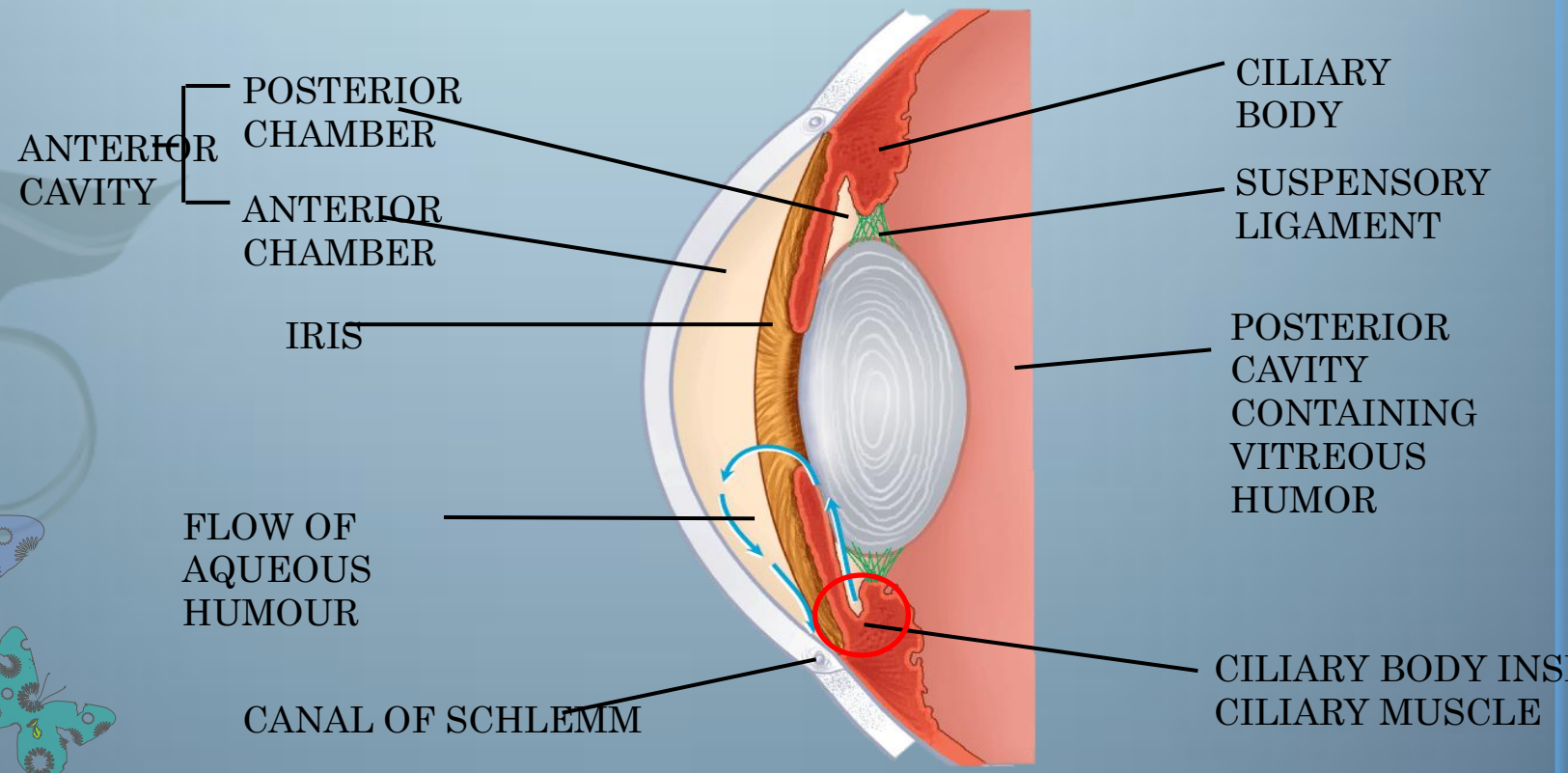
1-Cornea

- Its diopteric power is 40-45 diopter at its anterior surface.
- About two thirds of the 59 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,
- (whereas the refractive index of the eye lens is not greatly different from the indices of the aqueous humor and vitreous humor)

- 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.

2-THE AQUEOUS HUMOUR

-the aqueous humour is a transparent, slightly gelatinous (gel-like) fluid similar to plasma



-The aqueous humor

- is continually being formed and reab- sorbed.

-The balance between its formation and reabsorption regulates the total volume and pressure of the intraocular fluid

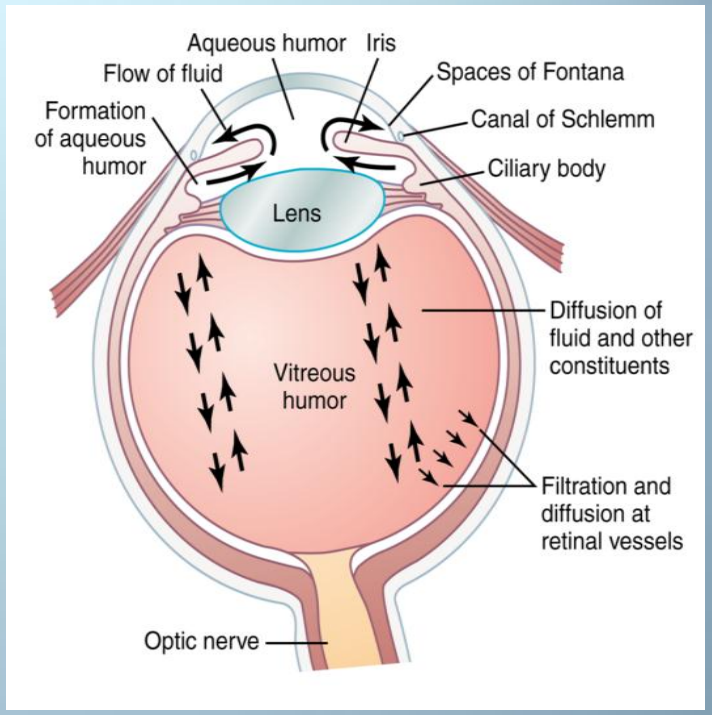
- nourishes the cornea and iris

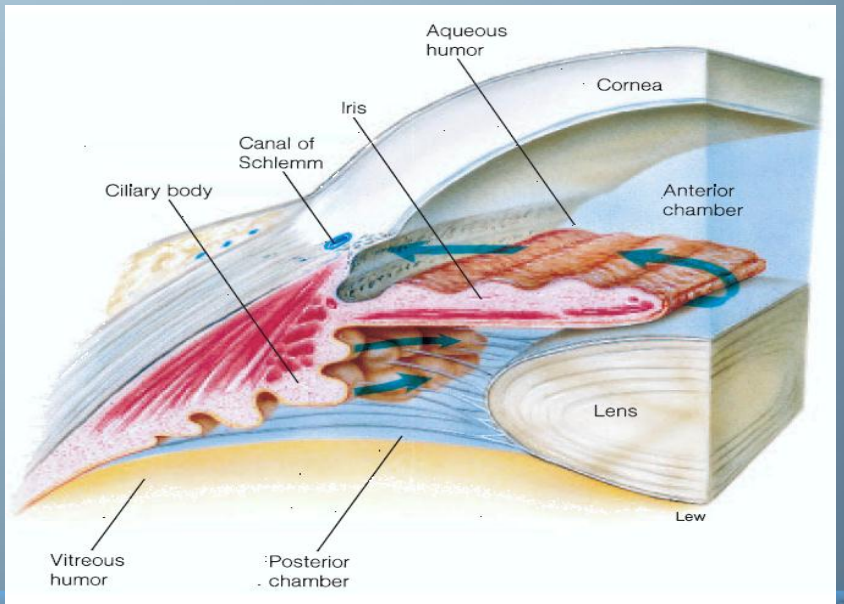
- produced in the ciliary body by an active secretion by ciliary processes..

GO TO ➔ **posterior chamber>>> to pupil >>>> ant chamber >>>>drained into canal of Schlemm in anterior chamber angle, which is a venous channel at the junction between the iris and the cornea (anterior chamber angle).**

-It causes intra-ocular pressure 10-20 mmhg

- Obstruction of this outlet leads to increased intraocular pressure , a critical risk factor for glaucoma



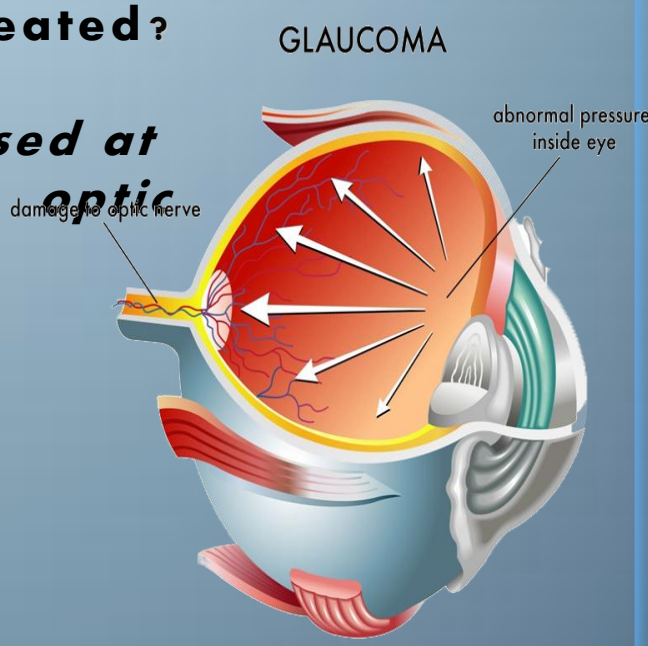


What is glucoma ?

(intraocular pressure more than 20mm Hg)

-Why it causes damage of optic nerve?
obstruction of AQ H outlet leads to increased intraocular pressure.
-excessive aqueous humour pushes the lens backwards into vitreous, which pushes against the retina.
this compression causes retinal and optic nerve damage that can cause blindness if not treated?

the axons of the optic nerve are compressed at the optic disc. This lack of nutrition of the optic nerve fibers, which causes death of the involved fibers& blindness



3-lens:-

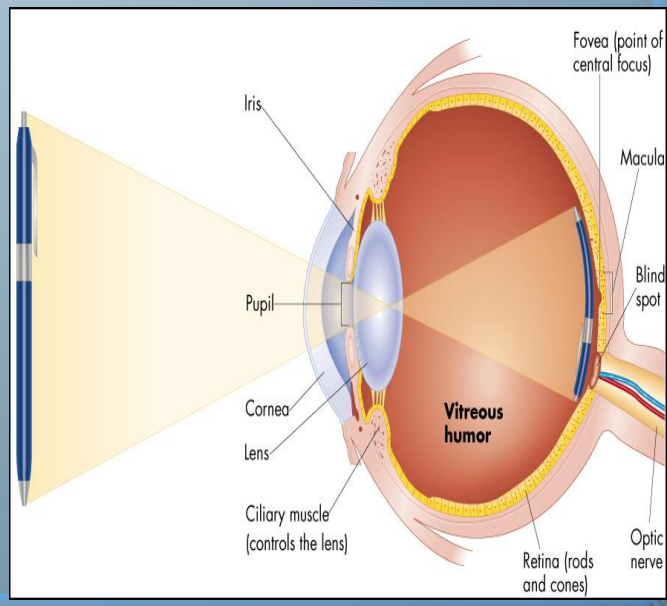
- Has diopteric power 15-20 D

-(1/3 refractive power of eye) , more important than cornea.

why?

-in response to nervous signals from the brain, *its curvature can be increased* markedly to provide "accommodation,

"



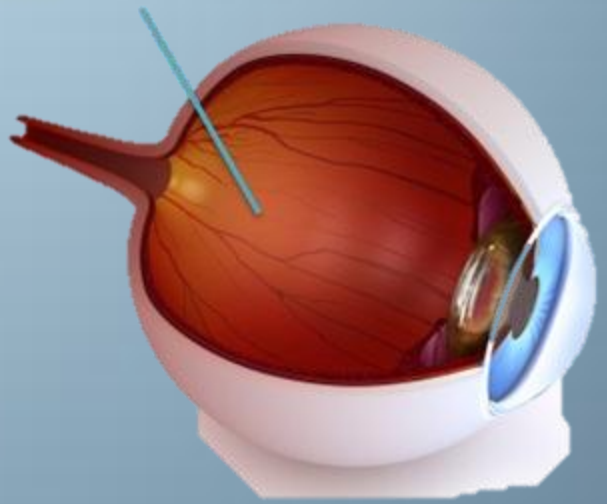
4-THE VITREOUS HUMOUR

-is the transparent, colourless, gelatinous mass .fills the vitreous chamber between the posterior surface of lens and the retina

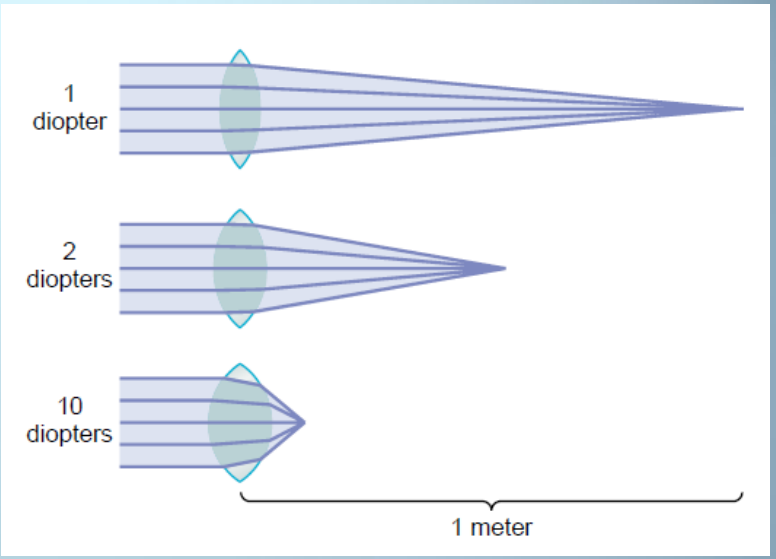
(for nourishing retina & keep spheroid shape of the eye)

-the vitreous humour is clear and allows light to pass through

THE VITREOUS HUMOUR



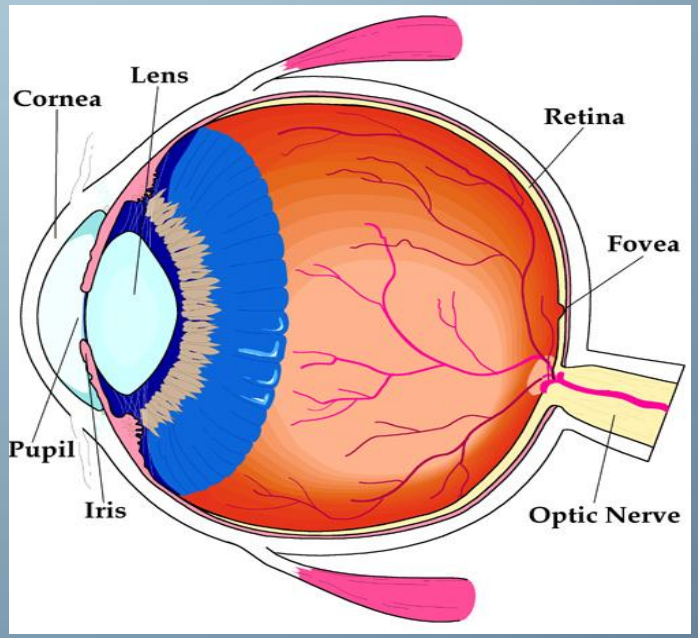
- VITREOUS HUMOUR REMAINS FROM BIRTH

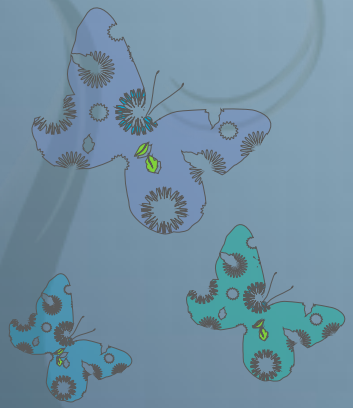


Lens-retina distance =15mm

Dioptre (s) = 1 / Focal length (in meters)

<u>Diopteric power of the eye:</u>
Cornea ……40-45 D (max refraction)
Lens …… 15-20 D
Accomodation by lens …. +12 D





External protection of the eye

1- Bony orbit

2- lids blinking keep cornea moist

3 -Conjuctiva

4-Tears from lacrimal gland has antibacterial, lubricating effect ,keep cornea moist & clear & provide nutrition to the cornea)

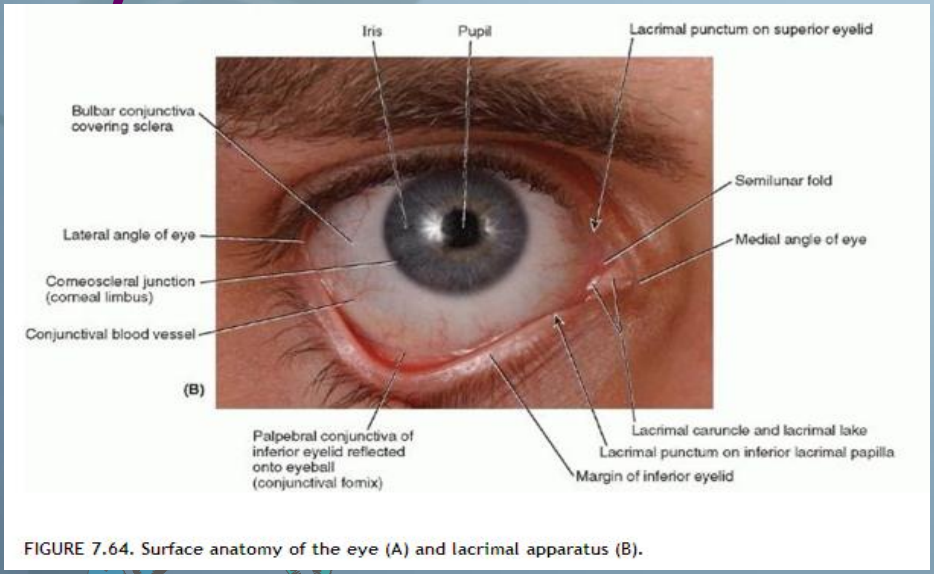
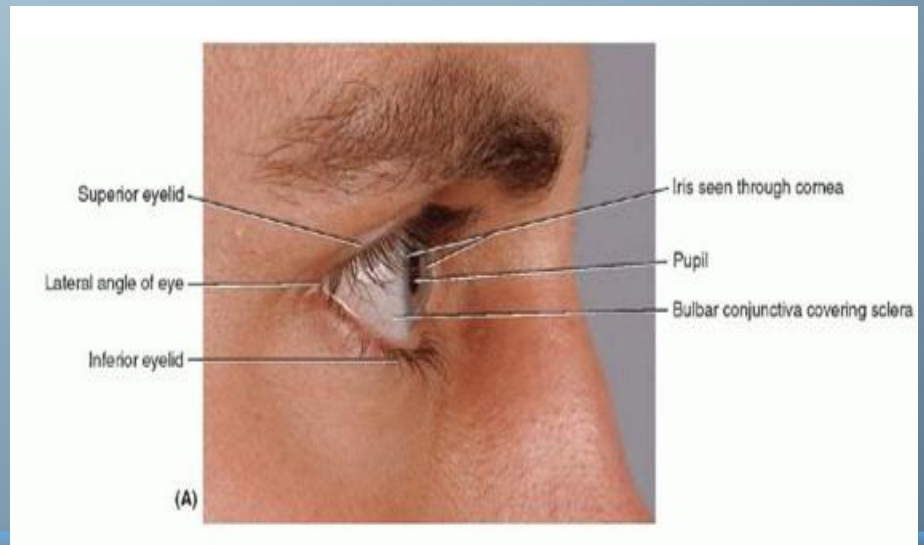
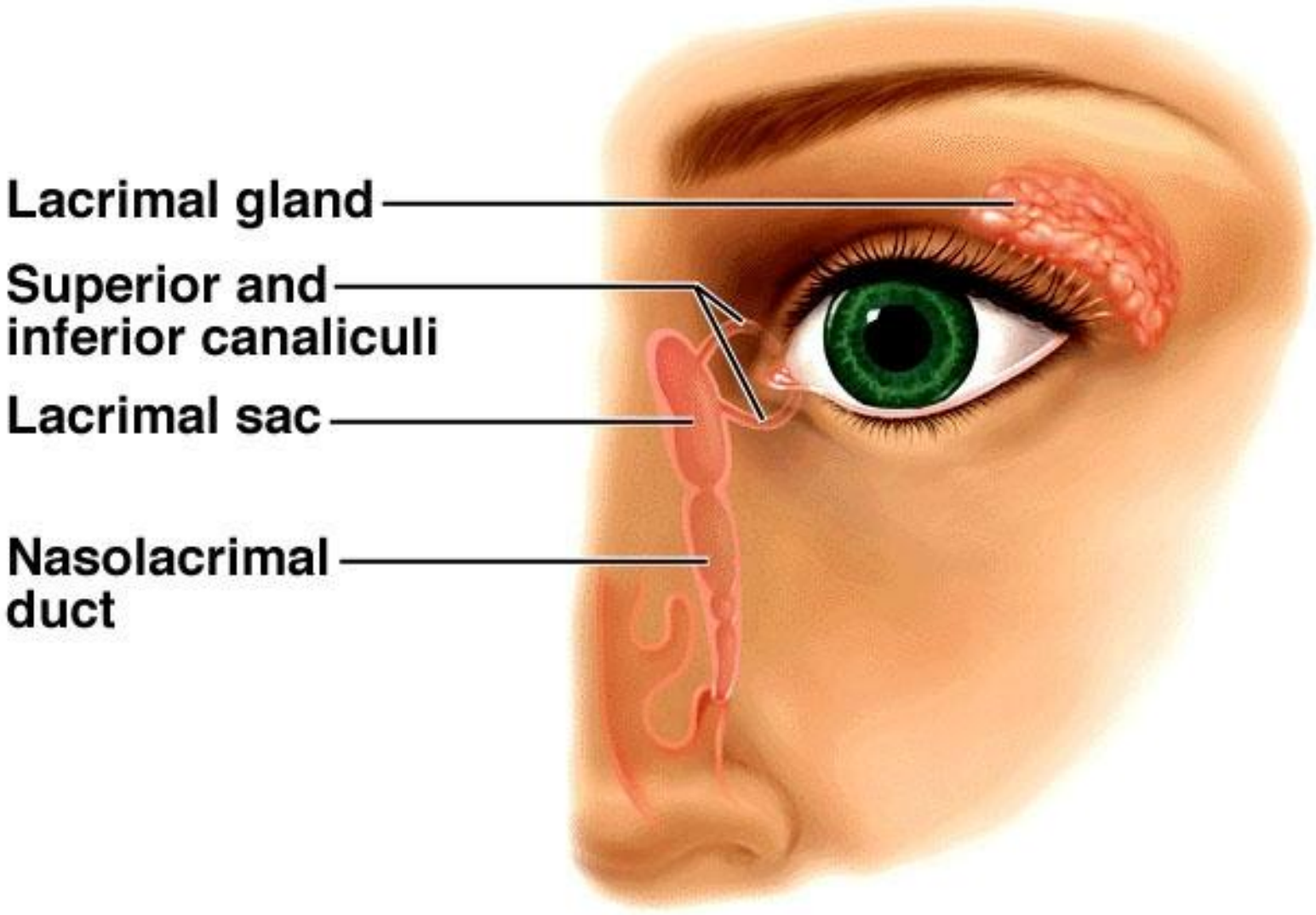


FIGURE 7.64. Surface anatomy of the eye (A) and lacrimal apparatus (B).



Lacrimal Apparatus



RETINA

1-Photoreceptors （ RODS + CONES ）

2-OPTIC DISC （ blind spot. Why?)
- 3mm medial & above post pole of eye
- optic nerve leave & retinal bld vessles enter

- no photoreceptors so it is blind)

3-FOVEA CENTRALIS :-

-depression in macula lutea

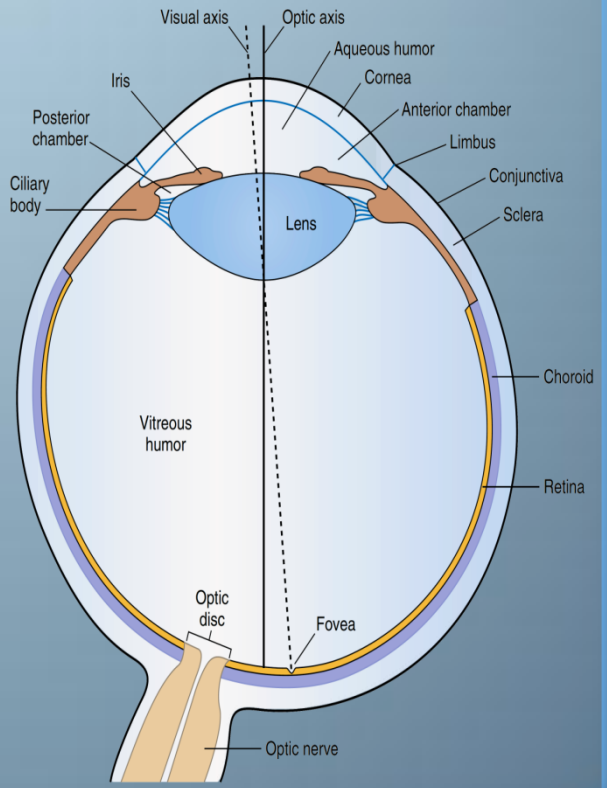
yellow pigmented spot at post pole of eye -

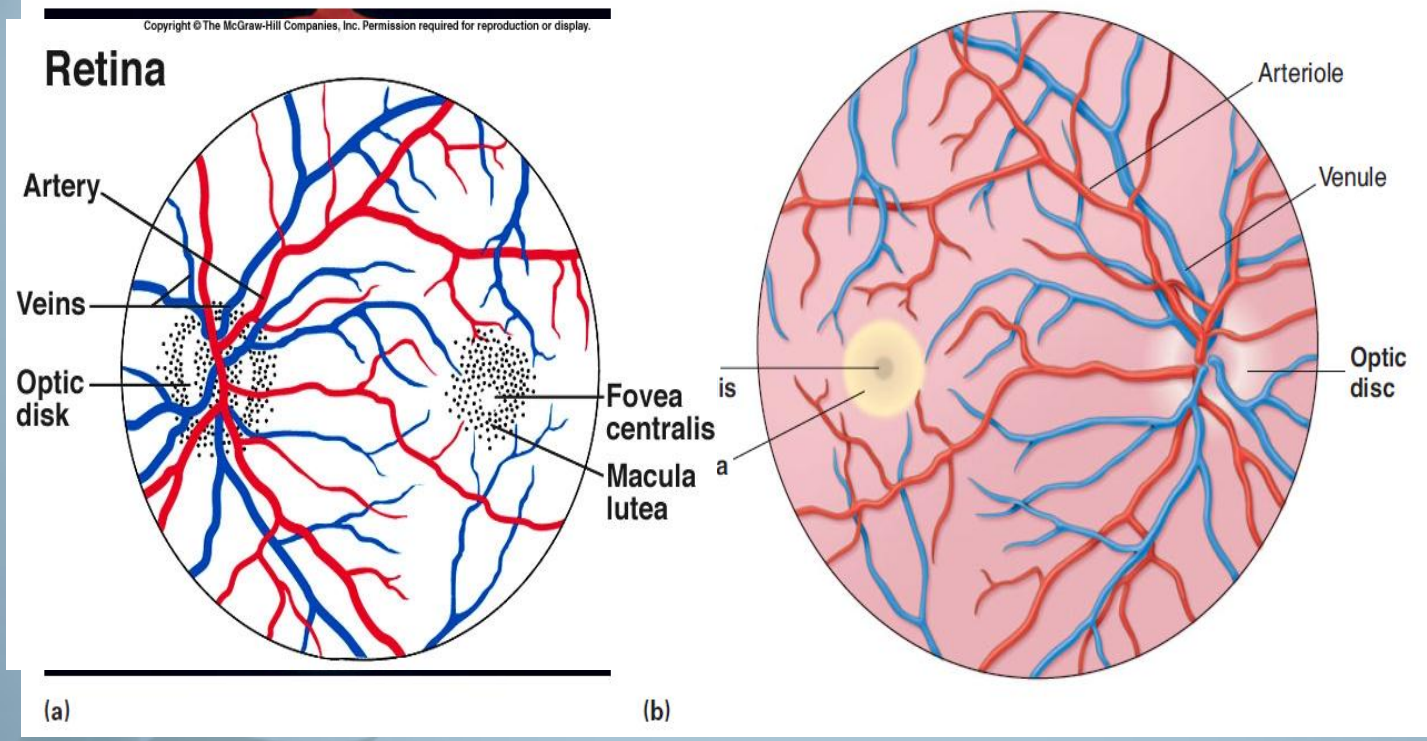
-only cones -

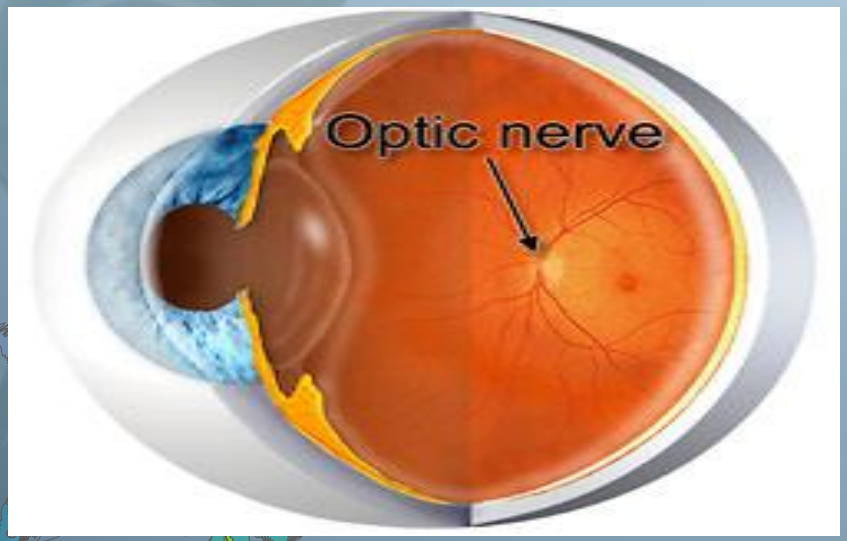
-high visual acuity -

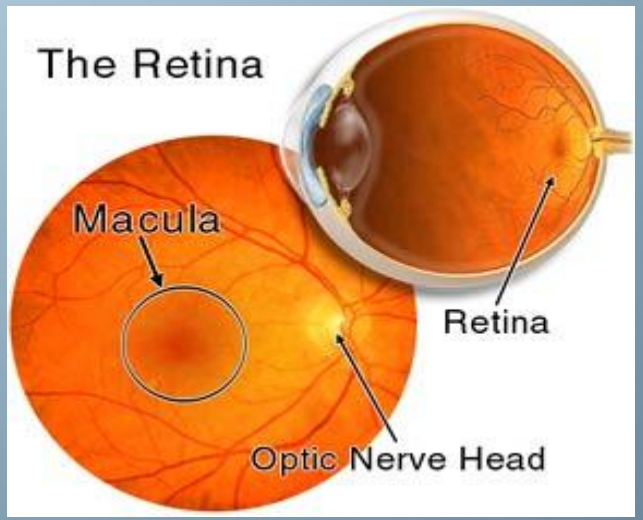
=for colors vision & details detection -

when attention is attracted to or fixed on an object, the eyes are normally moved so that light rays coming from the object fall on the fovea









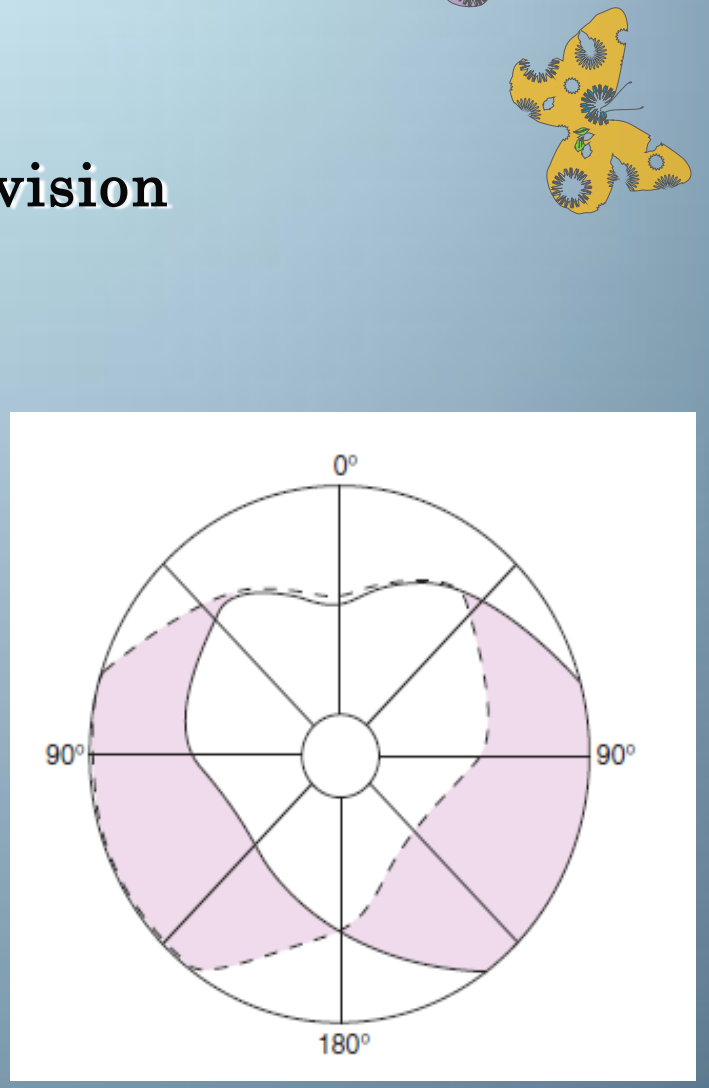
BINOCULAR VISION for :-

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.

Priciples of optics:-

-Biconvex lens(converge) & biconcave -lens(diverge)

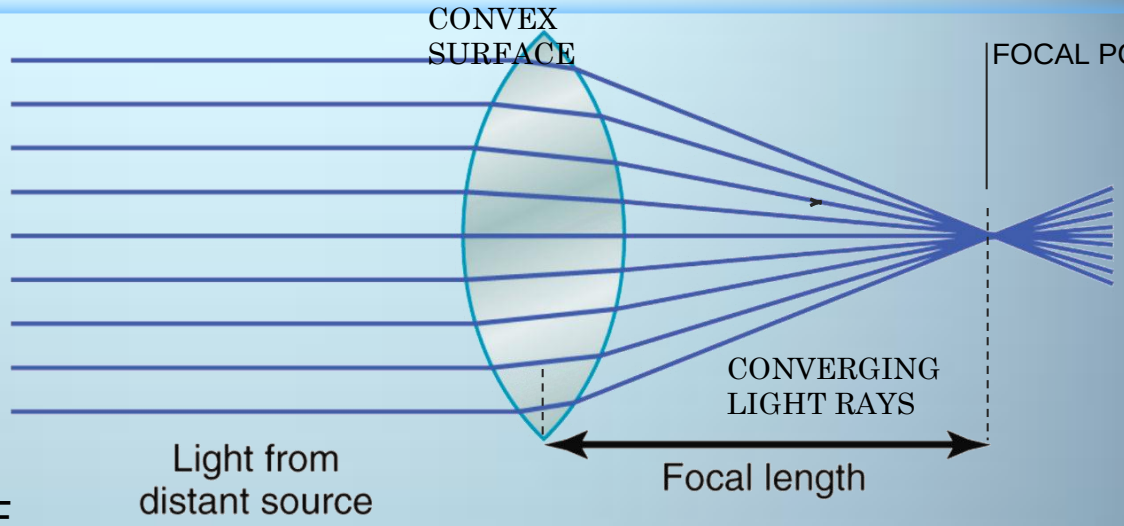
-Diopter (measure of refractive power
R.P = 1 / Principal focal distance in meters(*The distance beyond a convex lens at which parallel rays converge to a common focal point*)

Exp/if Principal focal distance of a lens is 25cm, so its R.P=1/ 0.25 meter = 4D

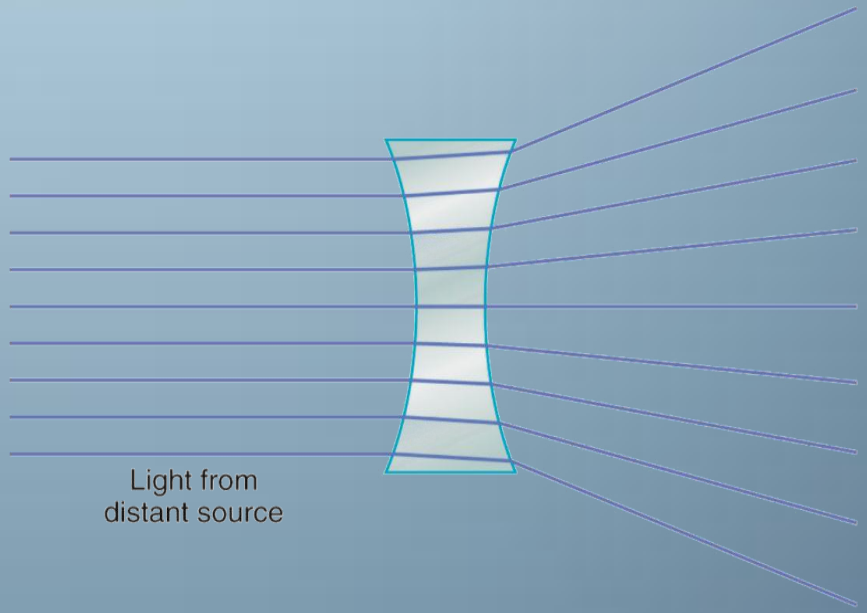
-

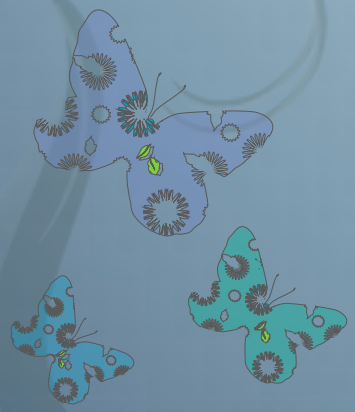
--The greater the curvature of the lens, the greater the refractive power of the eye

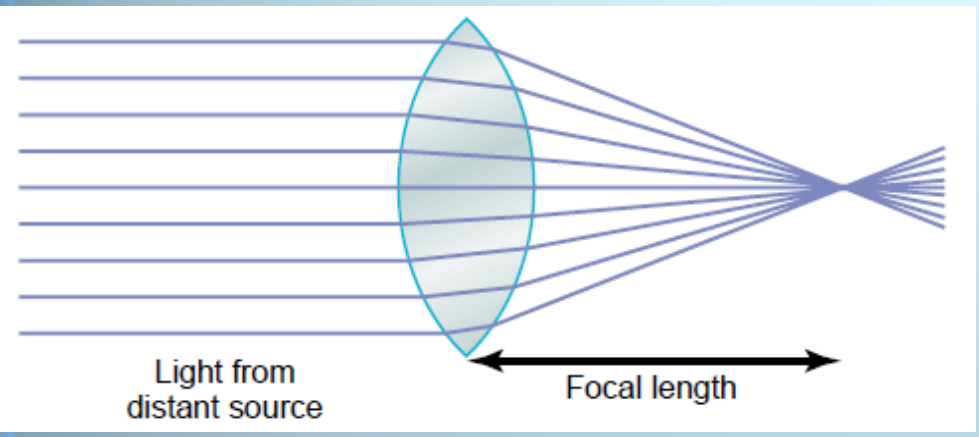
Emmetropic eye;- is thenormal eye has image on retina, has diopteric power 59-60D



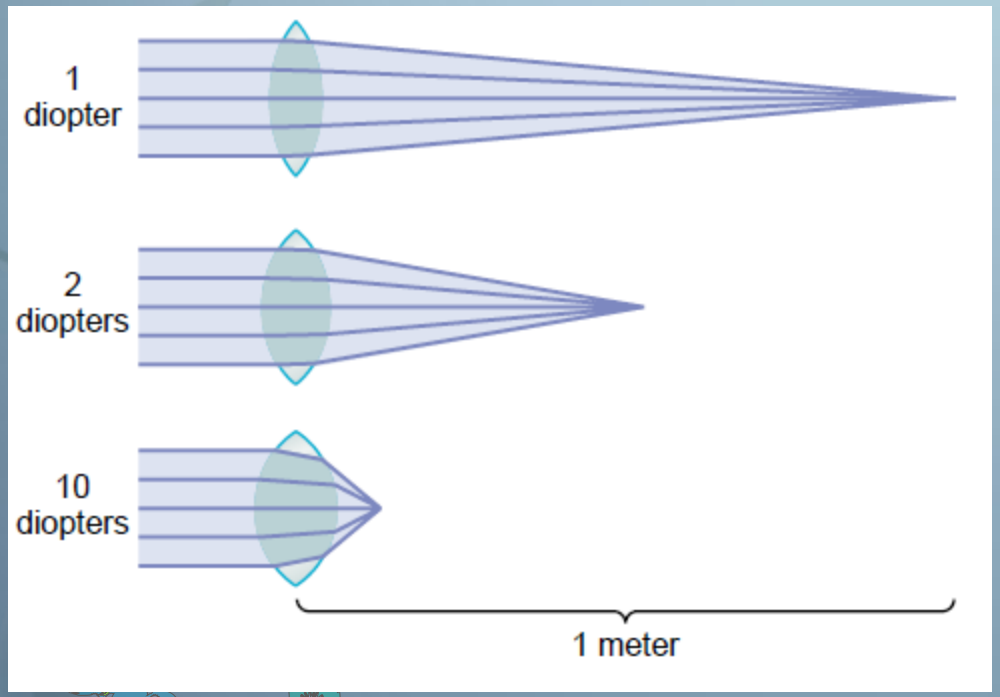
IF THE LENS HAS EXACTLY THE PROPER CURVATURE, PARALLEL LIGHT RAYS PASSING THROUGH EACH PART OF THE LENS WILL BE BENT EXACTLY ENOUGH SO THAT ALL THE RAYS WILL PASS THROUGH A SINGLE POINT, WHICH IS CALLED THE FOCAL POINT

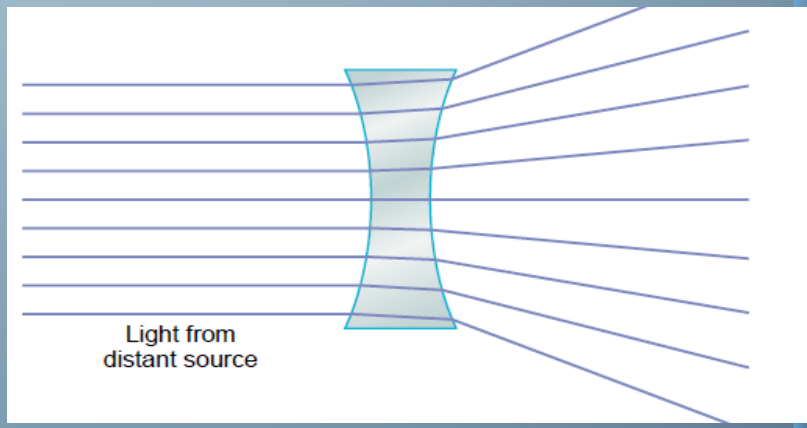






Concave lenses "neutralize" the refractive power of convex lenses. Thus, placing a 1-diopter concave lens immediately in front of a 1-diopter convex lens results in a lens system with zero refractive power





DIOPTERS AND CONCAVE LENSES

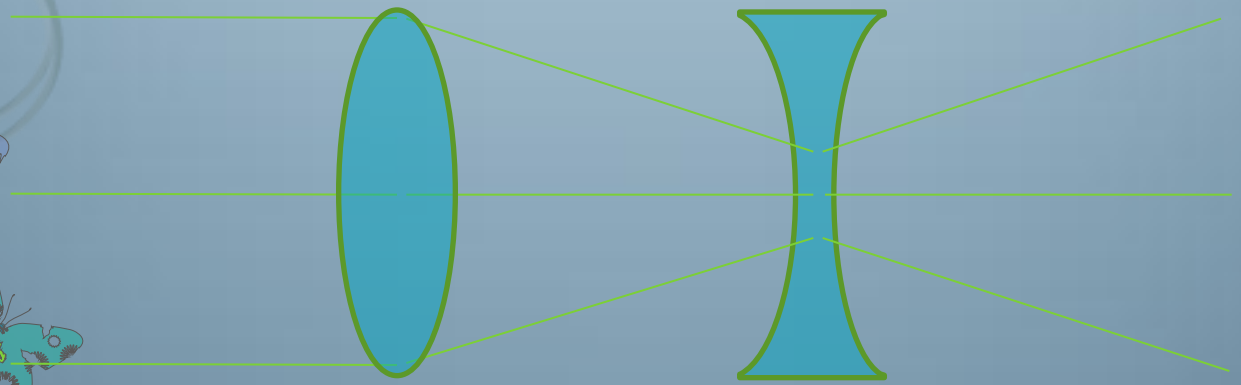
CONCAVE LENSES "NEUTRALIZE" THE REFRACTIVE POWER OF CONVEX LENSES.

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.

THE REFRACTIVE POWER OF CONCAVE LENSES CANNOT BE STATED IN TERMS OF THE FOCAL DISTANCE BEYOND THE LENS BECAUSE THE LIGHT RAYS DIVERGE RATHER THAN FOCUS TO A POINT.

DIOPTERS FOR A CONCAVE LENS ARE MEASURED BY HOW MUCH IT NEUTRALISES THE REFRACTIVE POWER OF A CONVEX LENS

FOR EXAMPLE WHERE A CONCAVE LENS DIVERGES LIGHT RAYS AT THE SAME RATE THAT A 1-DIOPTER CONVEX LENS CONVERGES THEM, THE CONCAVE LENS IS SAID TO HAVE A DIOPTRIC STRENGTH OF −1.



FOCAL LENGTH OF A LENS

THERE IS A DIFFERENCE IN FOCAL LENGTH BETWEEN THESE TWO LENSES – DUE TO THE CURVATURE OF THE LENS

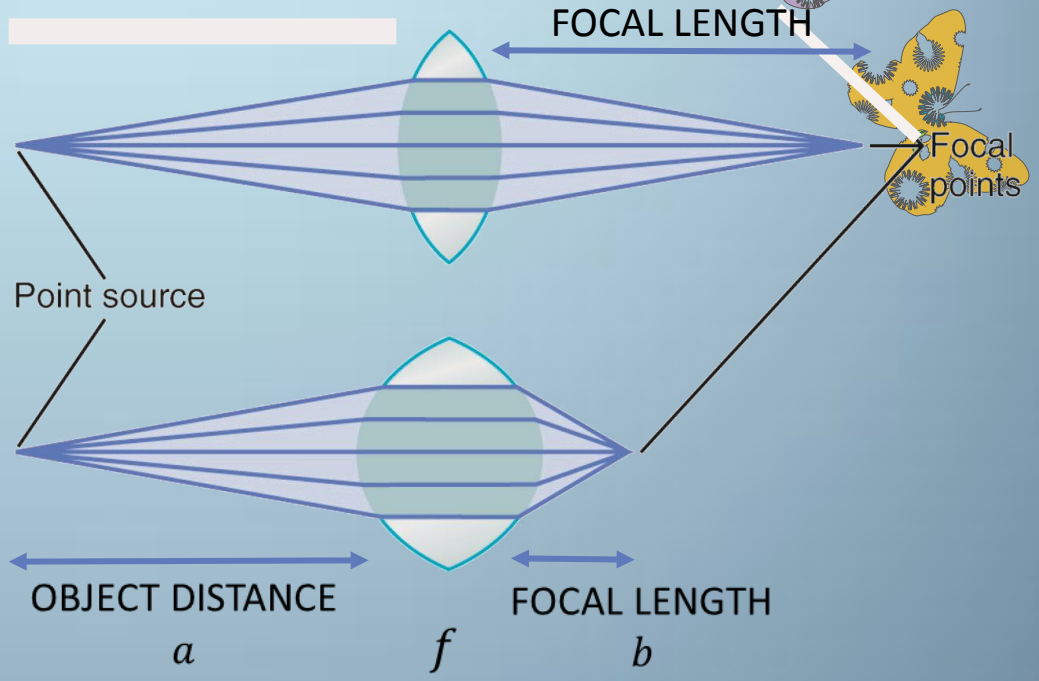
THE FOCAL LENGTH OF THE LENS IS EXPRESSED IN THE FOLLOWING

FORMULA: $\frac{1}{f} = \frac{1}{a} + \frac{1}{b}$

f is the focal length of the lens for parallel rays,

a is the distance from the point source of light to the lens

b is the focal length on the other side of the lens.

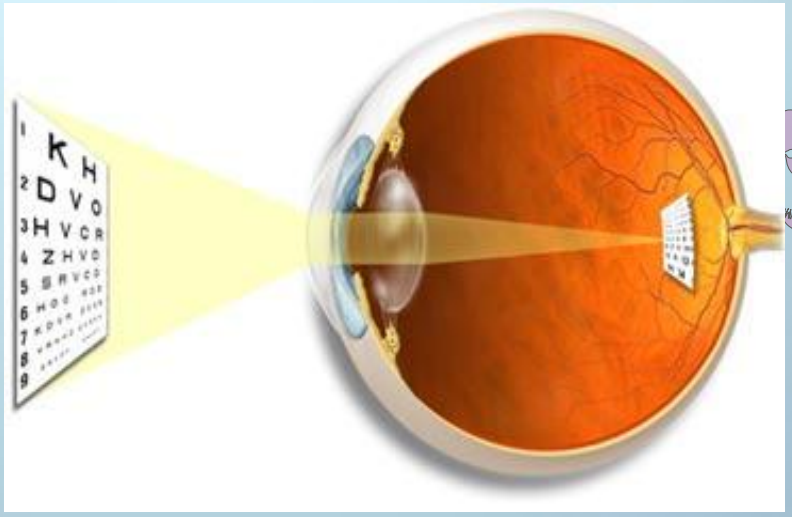


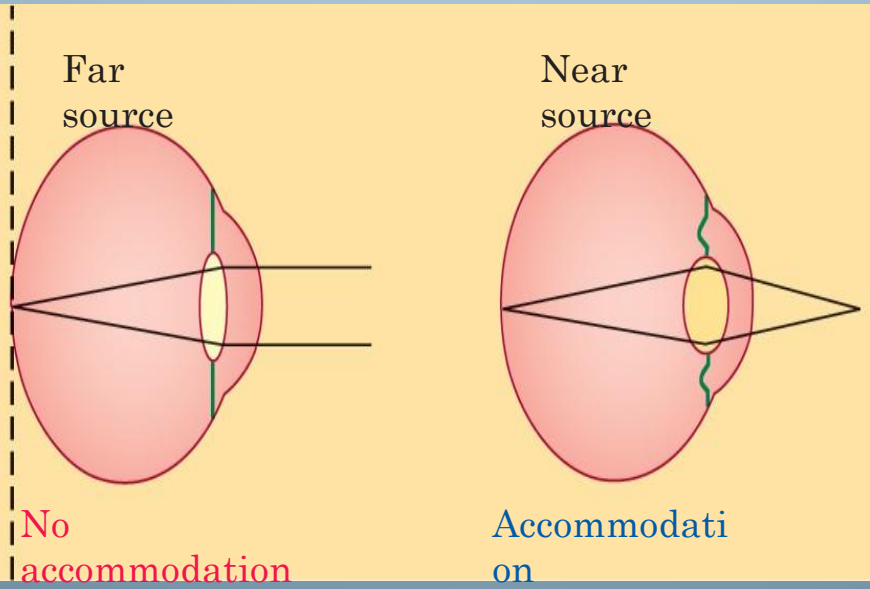
$$\frac{1}{f} = \frac{1}{a} + \frac{1}{b}$$

Emmetropic eye

can see all distant objects clearly with its ciliary muscle relaxed & see close objects clearly with ciliary muscles contracted

Normal eye = Emmetropia





Far source focused on retina without accommodation

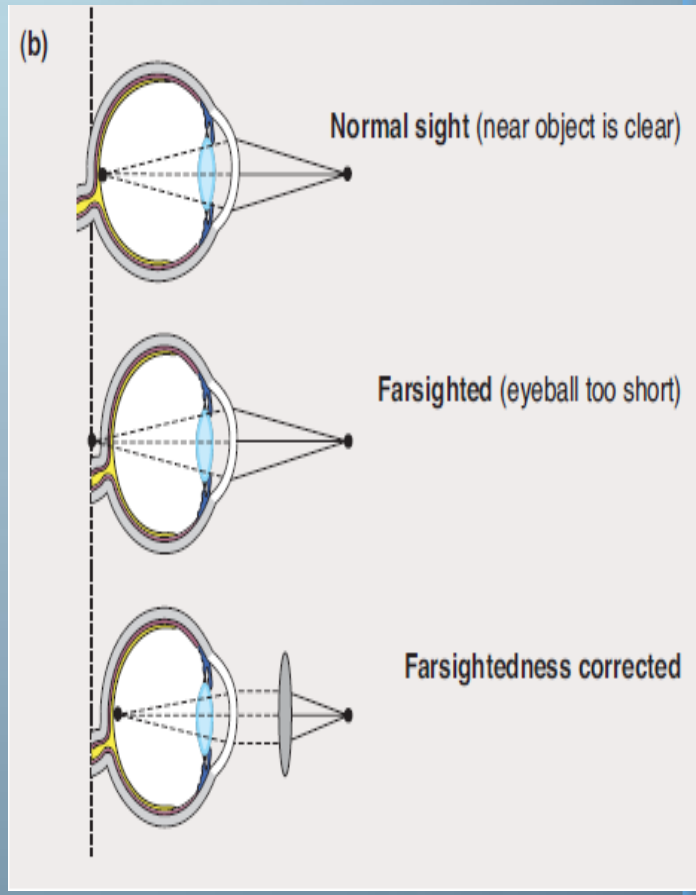
Near source focused on retina with accommodation

1-Errors of refraction

1/Hyperopia(hypermetropia-farsightedness)

-Small eye ball- weak lens system
-Focus behind retina
-Causes headache & blurred vision
-Continuous accomodation to bring image on retina causes muscular effort on cilliary muscle & prolonged convergence , this leads to headache & finally squint

- Correction by biconvex lens



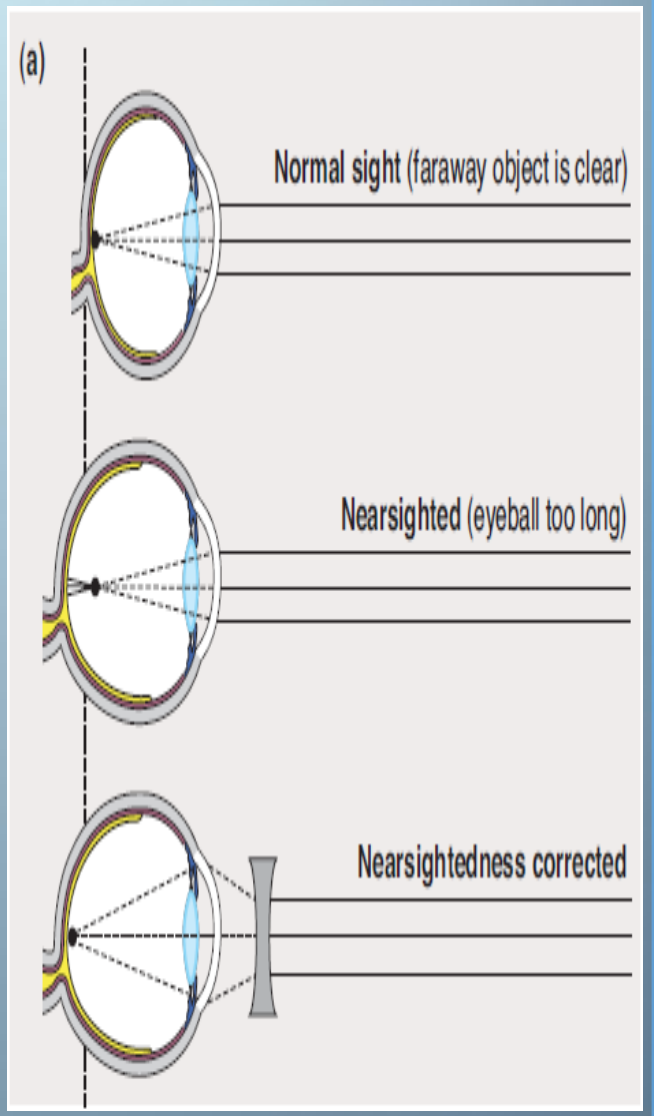
2- Myopia(near sightedness)

-Genetic large eye ball or too much refractive power of lens system or cornea due to its too curved surface- or due to long antero-posterior diameter of the eye

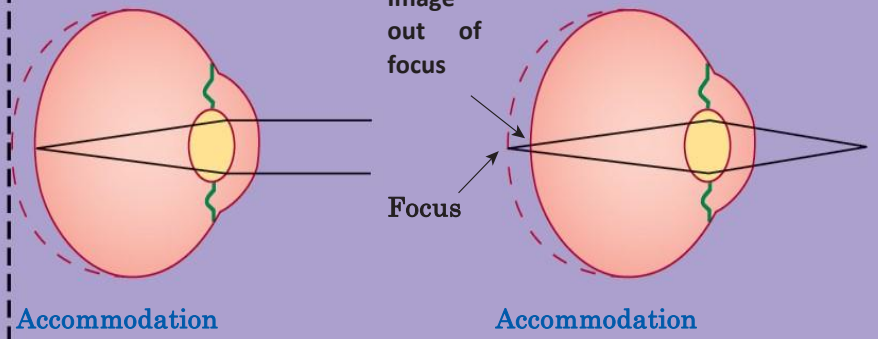
-Extensive close work as in studying

-Focus in front the retina

-Correction by biconcave lens to diverge rays before strike the lens

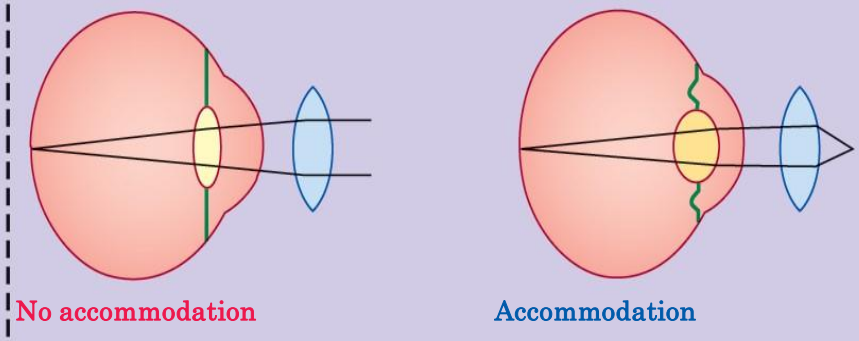


(c) Farsightedness (Hyperopia)



Eyeball too short or lens too weak

1. **Uncorrected**

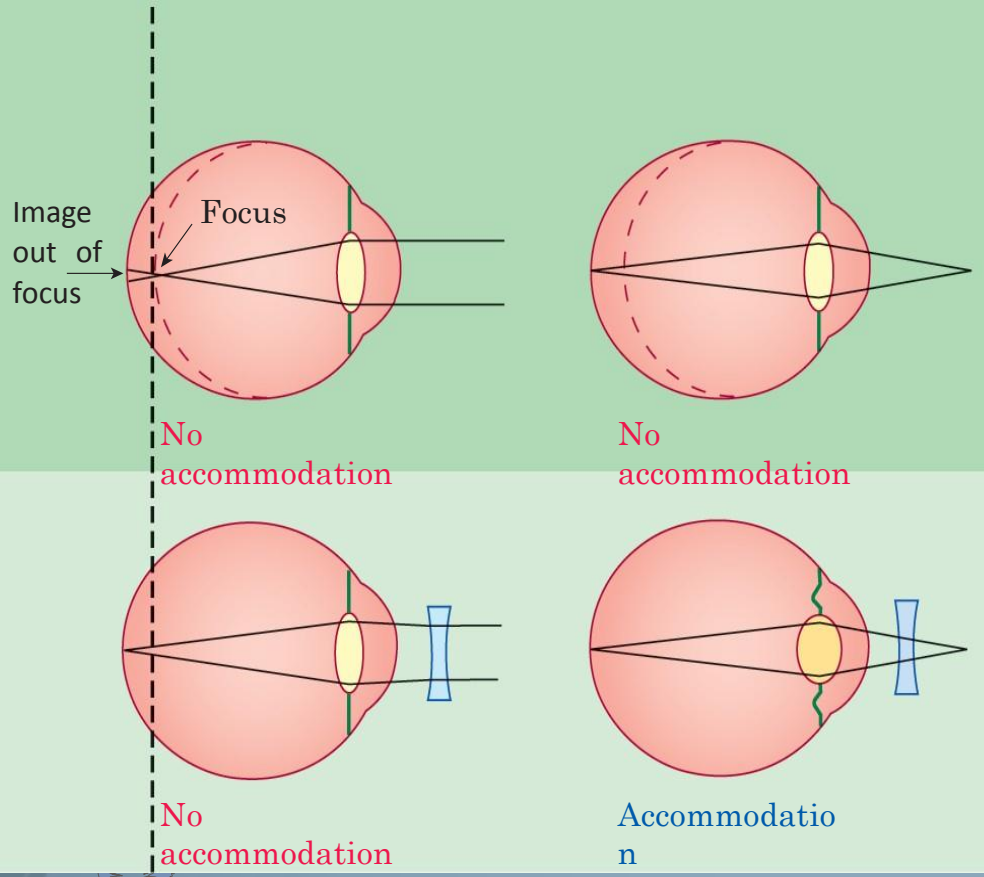


2. **Corrected with convex lens, which converges light rays before they reach the eye**

Far source focused on retina without accommodation

Near source focused on retina with accommodation

- Nearsightedness (Myopia)



Eyeball too long or lens too strong

1. Uncorrected

Far source focused in front of retina (where retina would be in eye of normal length)

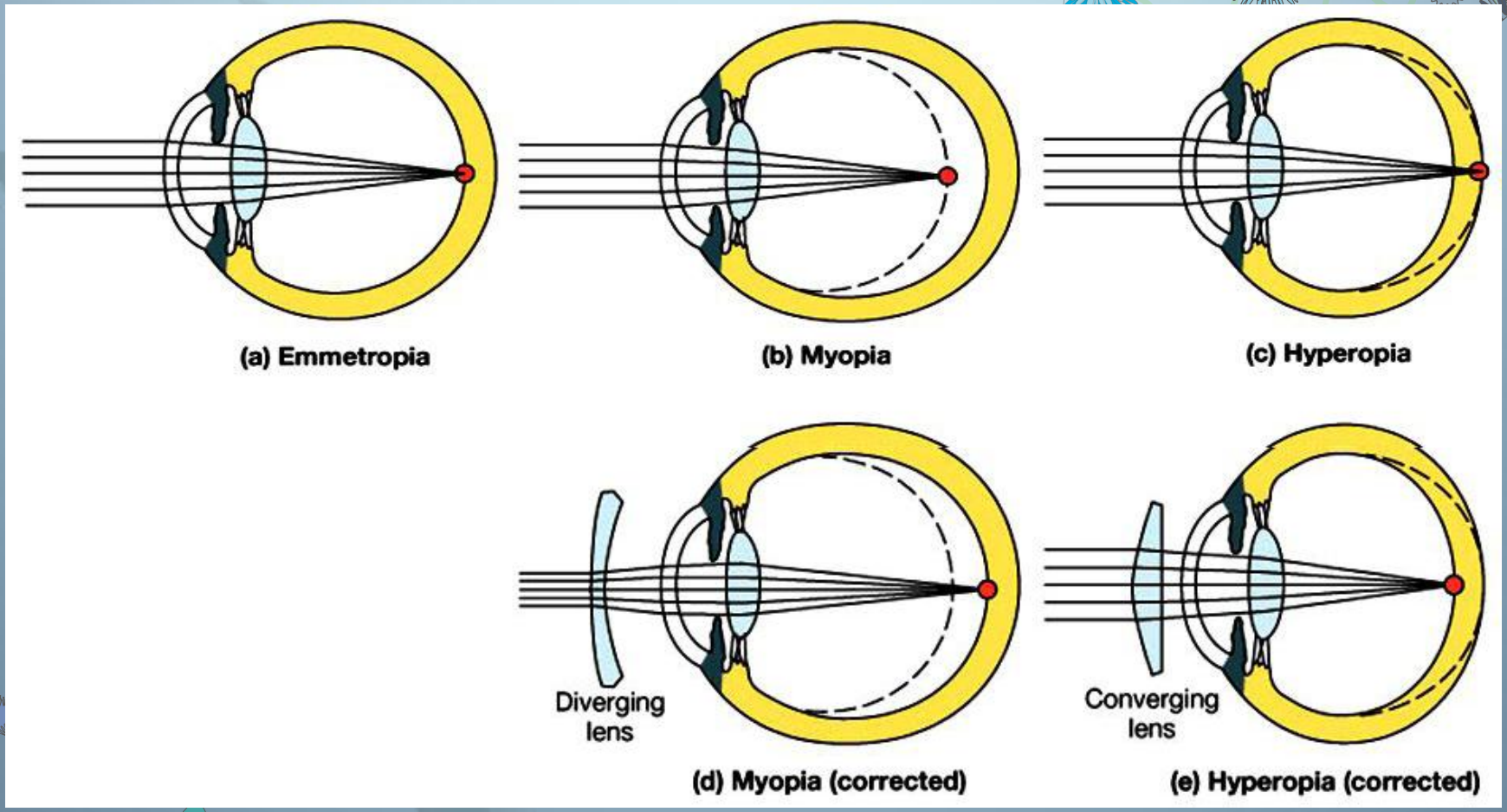
Near source focused on retina without accommodation

2. Corrected with concave lens, which diverges light rays before they reach the eye

Far source focused on retina without accommodation

Near source focused on retina with accommodation

THE CONCAVE LENS BENDS THE IMAGE OUTWARDS SLIGHTLY – THEN THE EYE LENS CAN REFRACT THE IMAGE INWARDS TO FOCUS ON THE FOCAL POINT OF THE RETINA


(a) Emmetropia
(b) Myopia
(c) Hyperopia
Diverging lens
(d) Myopia (corrected)
Converging lens
(e) Hyperopia (corrected)

3-Presbyopia

(eye near point receeds by age due to loss of accomodation

-Focus behind retina -

-correction by biconvex lens -

4-Astigmatism

(mainly uneven & ununiform corneal curvature and very little due to uneven lens curvature

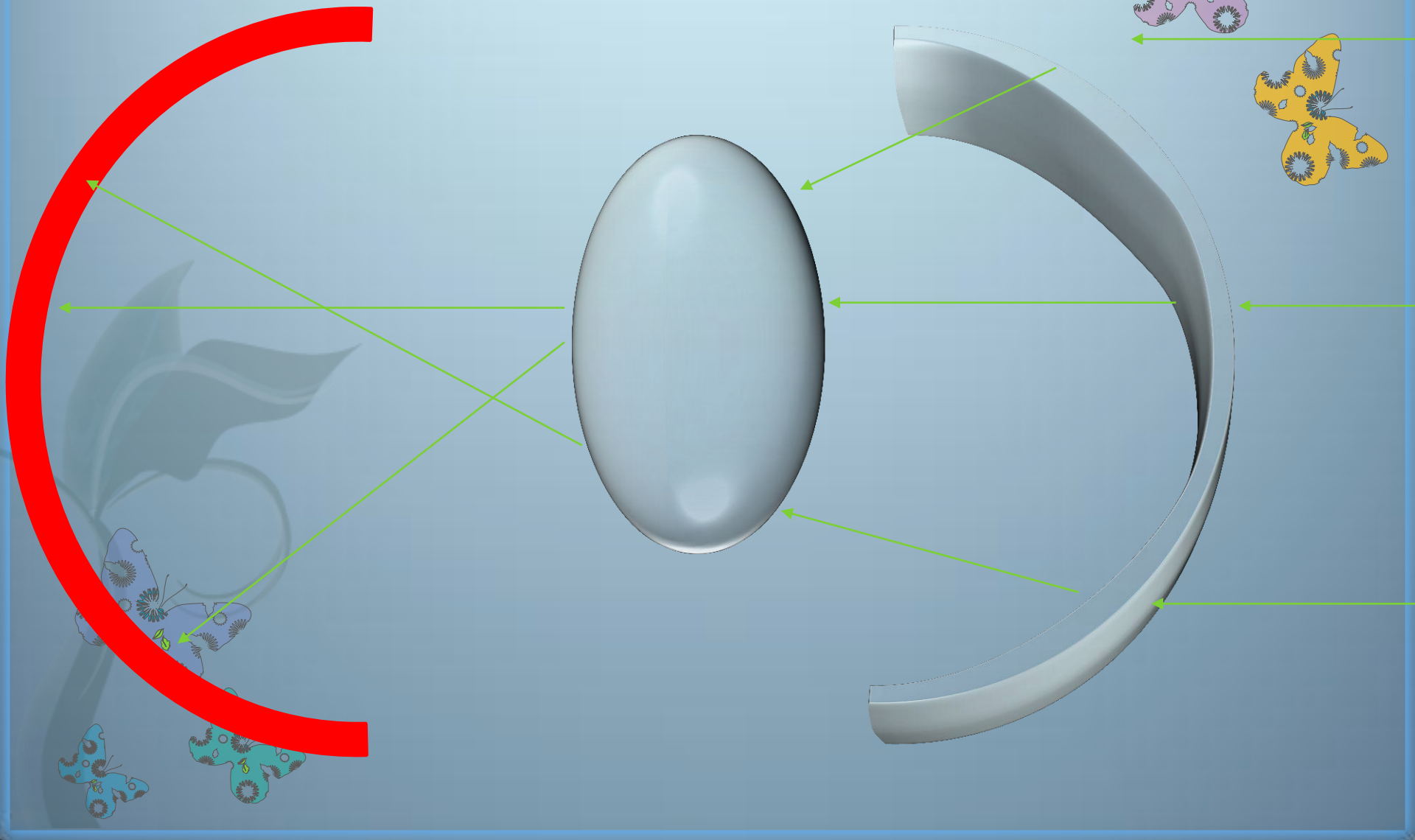
-rays refracted to different foci >>>>>>> blurred vision

-correction by cylindrical lens which bends light rays in only one plane (a focal line)

ASTIGMATISM

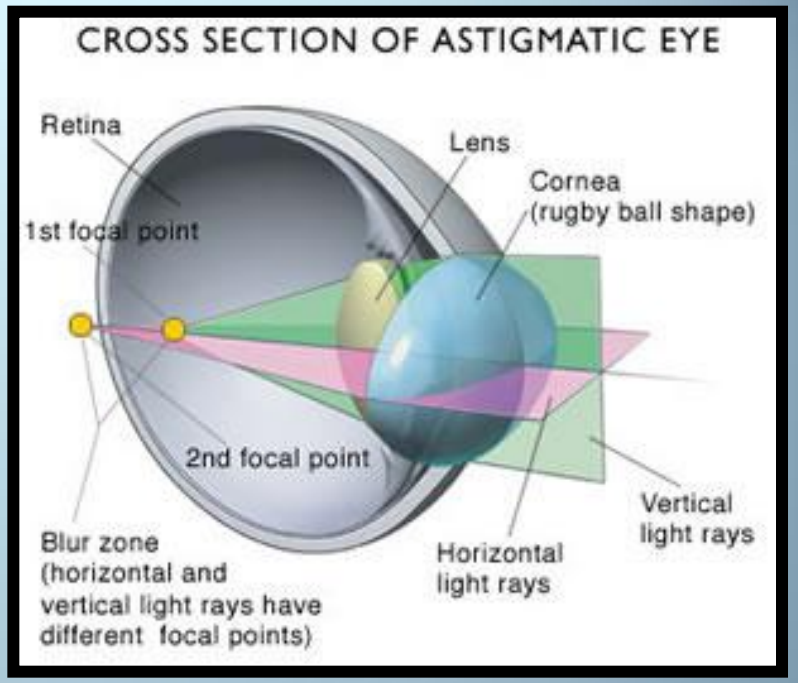
DISTORTED CORNEA

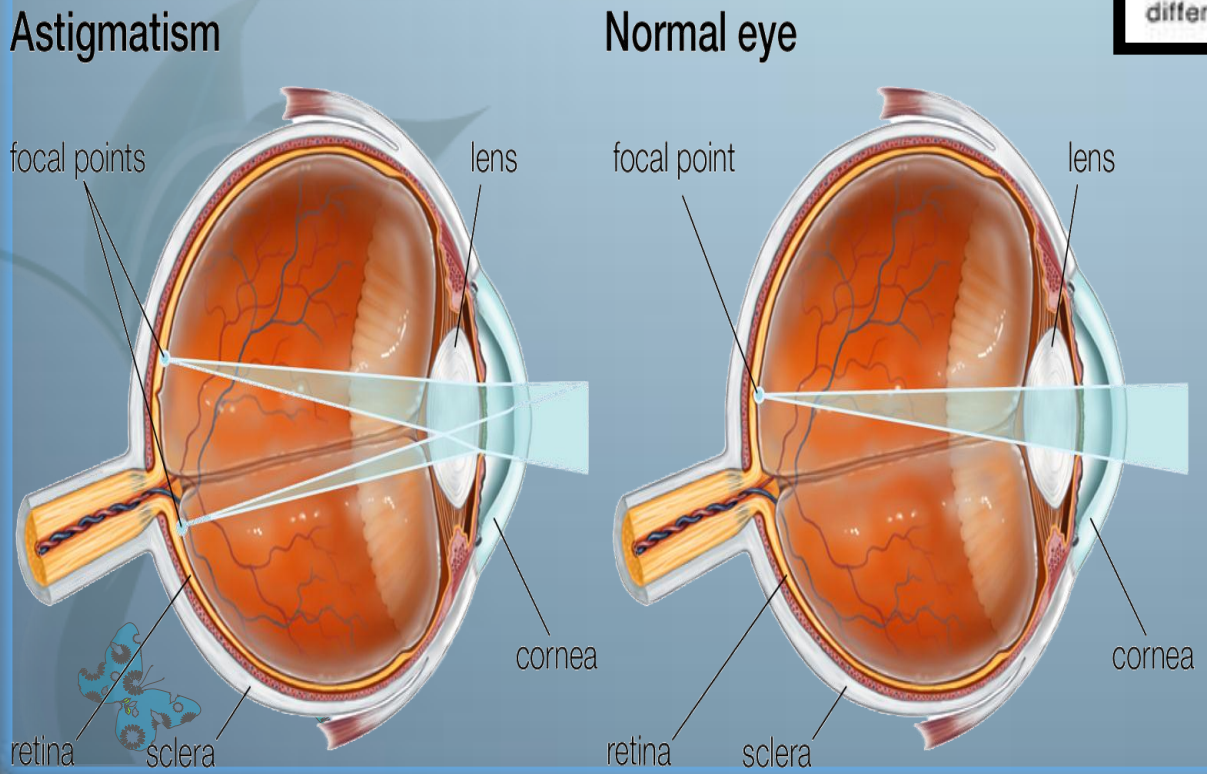
RETINA

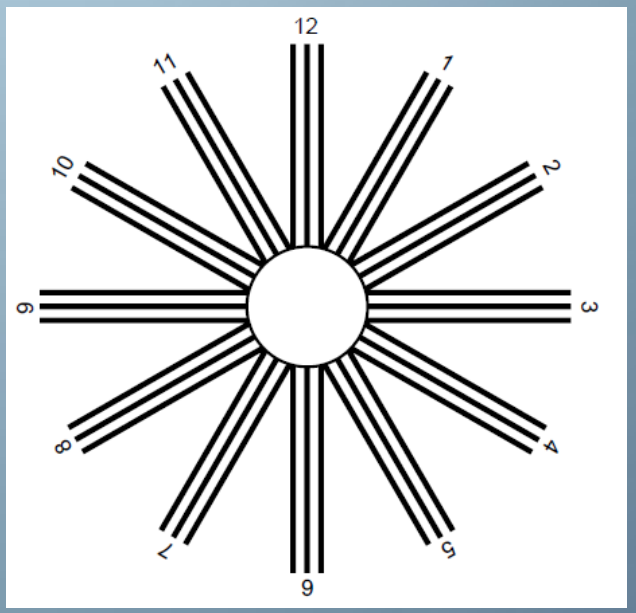


Astigmatism

light rays focus at one focal distance in more than one focal point







LAYERS OF RETINA (10 layers), the most important are :-

1-Pigment cell layer (vit A) (outermost layer) .what is its value?

(absorb light & prevent its reflection back)

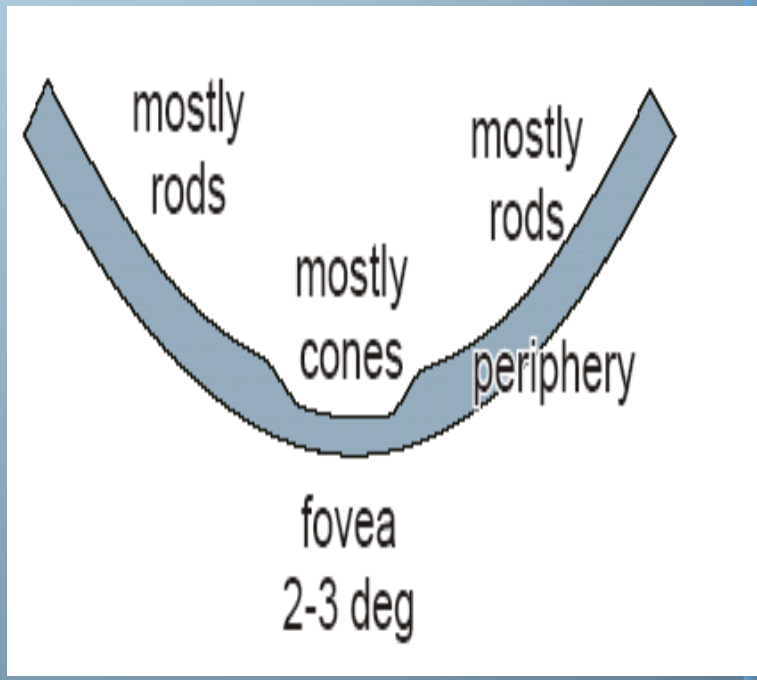
-The pigment layer also stores large quantities of *vitamin A*. This vitamin A is an important precursor of the photosensitive chemicals of the rods and cones.

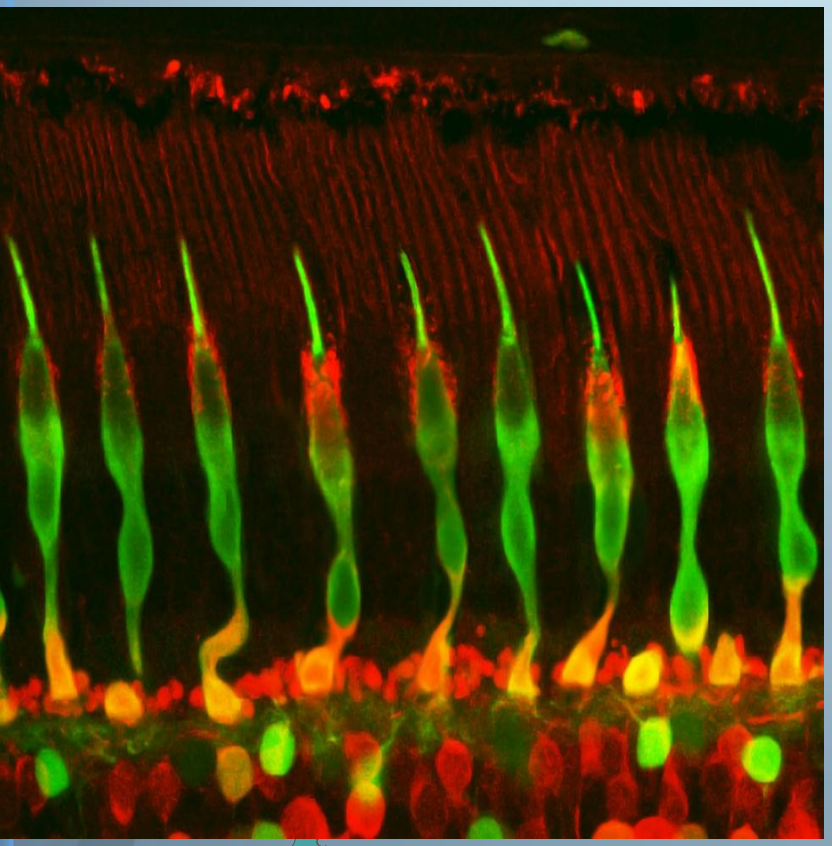
2- rodes & cones

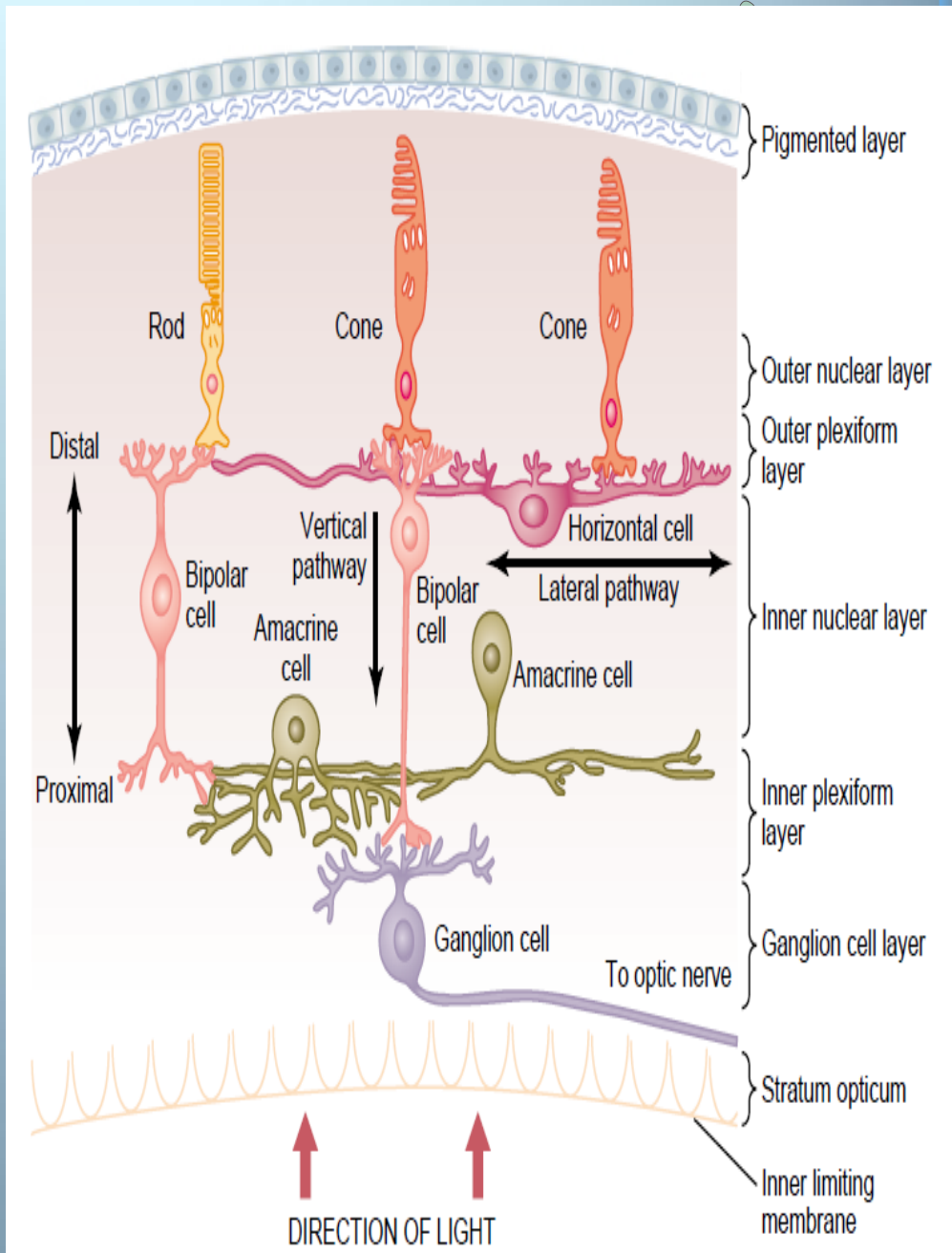
(their outer& inner segments), but not cell bodies(rodes 90-120 million & cones 4.5- 6 million) - describe their distribution.

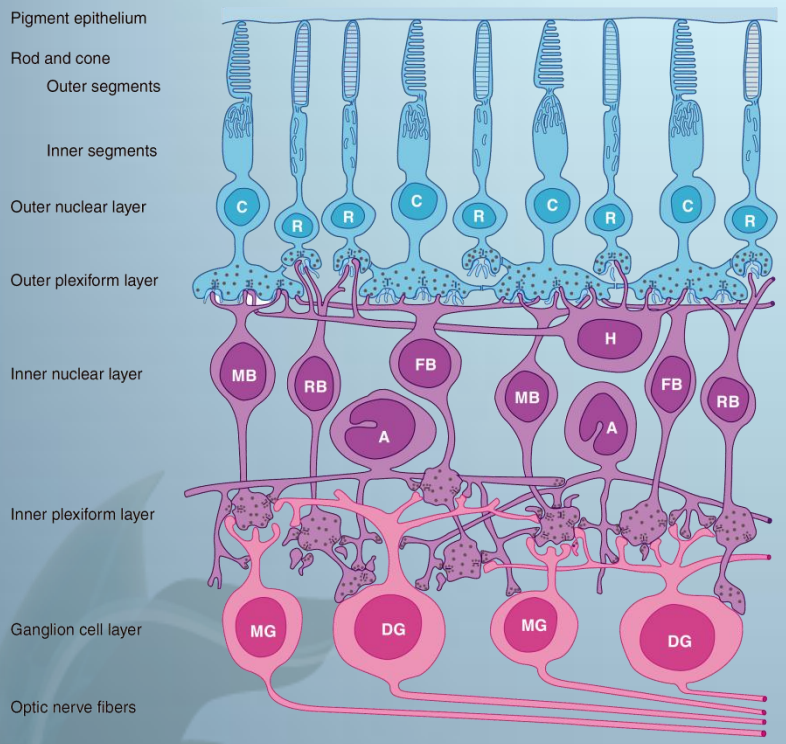
photoreceptor cells are responsible for capturing light and transforming this into generator potential to be used by the nervous system

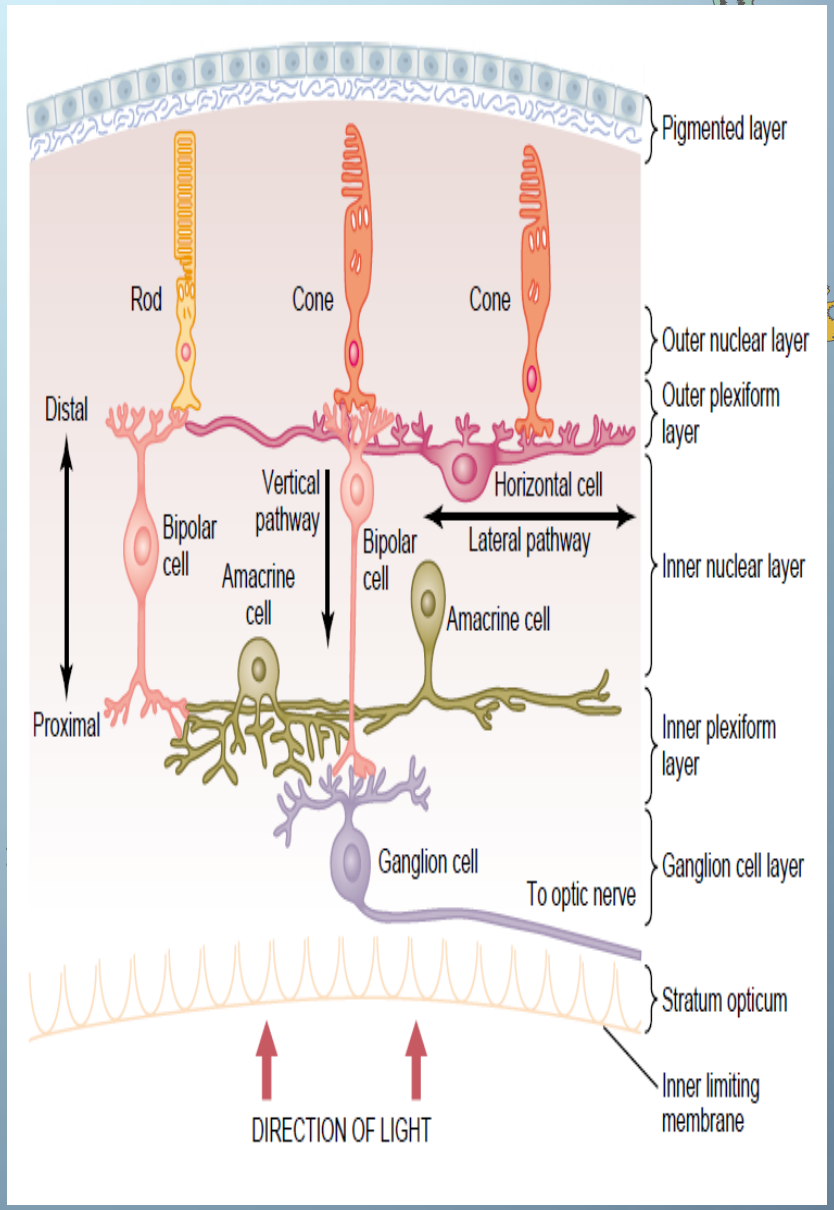
)






Pigmented layer
Rod
Cone
Cone
Outer nuclear layer
Outer plexiform layer
Distal
Vertical pathway
Horizontal cell
Bipolar cell
Lateral pathway
Bipolar cell
Amacrine cell
Amacrine cell
Inner nuclear layer
Proximal
Inner plexiform layer
Ganglion cell
To optic nerve
Ganglion cell layer
Stratum opticum
Inner limiting membrane
DIRECTION OF LIGHT





RETINAL CELLS

THE CELL BODIES AND PROCESSES OF THESE NEURONS ARE STACKED IN ALTERNATING LAYERS

there are five basic classes of neurones in the

photoreceptors,

bipolar cells,

ganglion cells,

horizontal cells,

amacrine cells.

3-Outer nuclear layer(cell bodies of rodes & cones)

4-Outer plexiform layer

mainly of Horizontal cells.

5-Inner nuclear layer (bipolar cells)

6-Inner plexiform layer.

(amacrine cells) the inner plexiform layer is interposed between the inner nuclear and ganglion cell layers.)

7-Ganglion cell layer

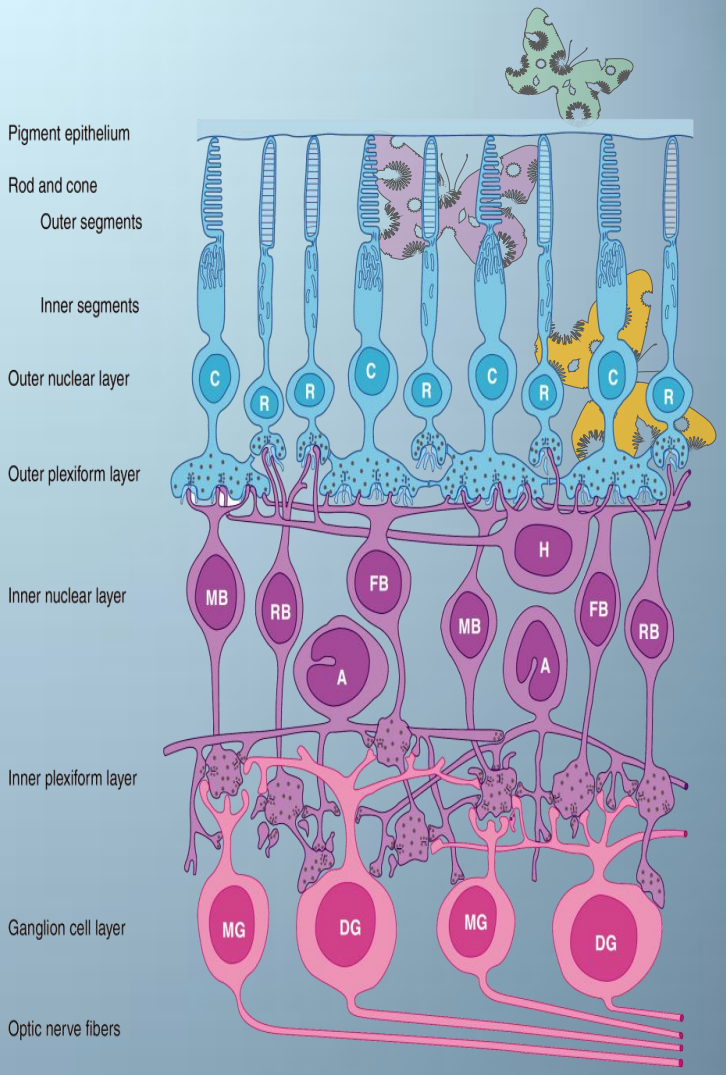
8-Optic nerve fibers (1.2 million fibers)

-# Horizontal cells (outer plexiform layer)

(Make synaptic connections with receptors

Amacrine cells (inner plexiform layer)

(make synaptic connections with ganglion cells)



Müller cells are the major glial element of the retina.

-located in the inner nuclear layer

-form architectural support structure

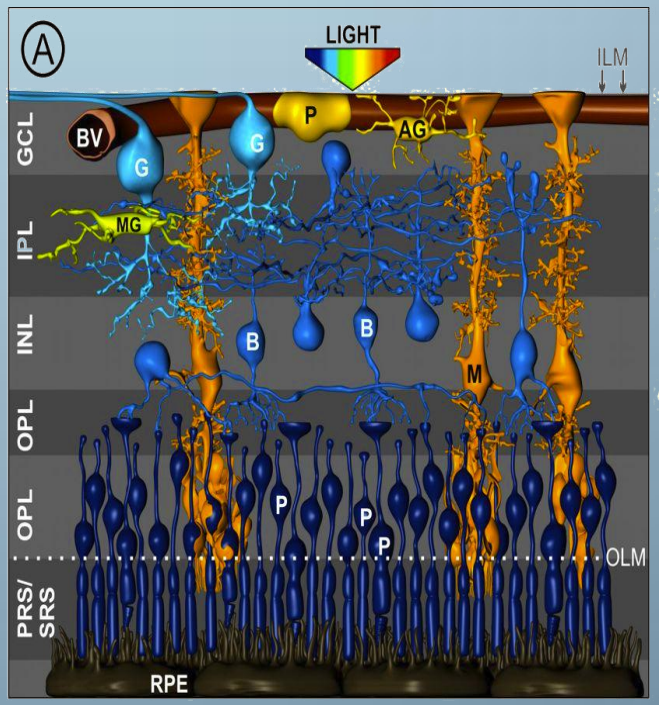
providing metabolic support to retina

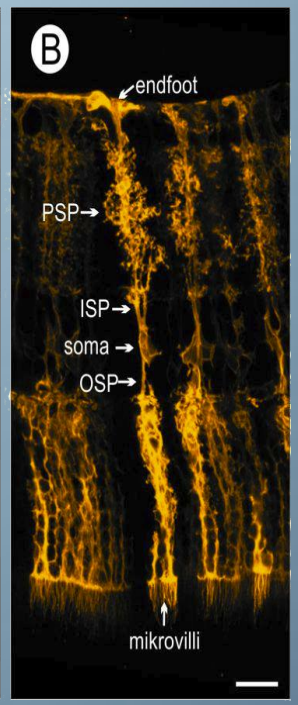
-maintaining synaptic levels of neurotransmitters.

-they can be - differentiate into a neural progenitor following injury to the retina,

-act as light conductor which funnels light to the rods and cone CELLS.

MÜLLER CELLS ARE SHOWN IN ORANGE





Light pathway in the eye:

After light passes through the lens system of the eye and then through the vitreous humor, it *enters the retina from the inside of the eye*

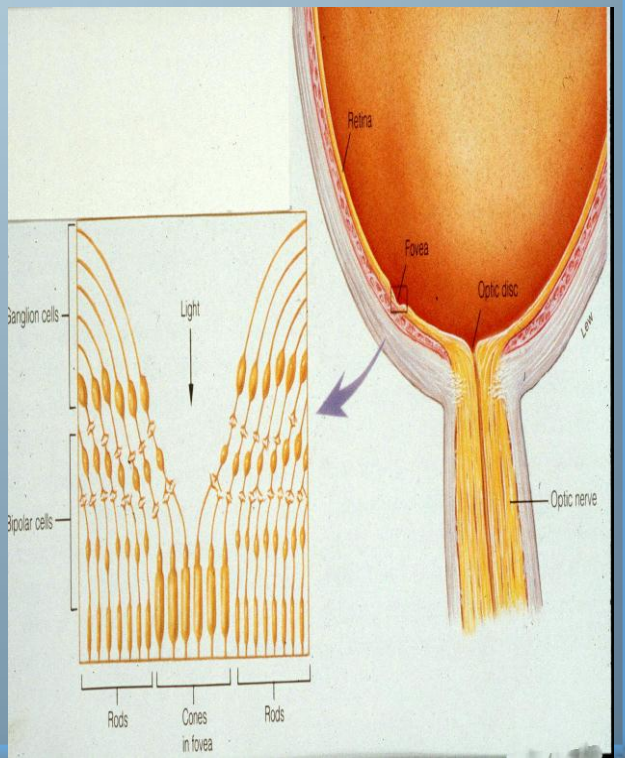
-it passes first through the ganglion cells and then through the plexiform and nuclear layers before it finally reaches the layer of rods and cones located all the way on the outer edge of the retina

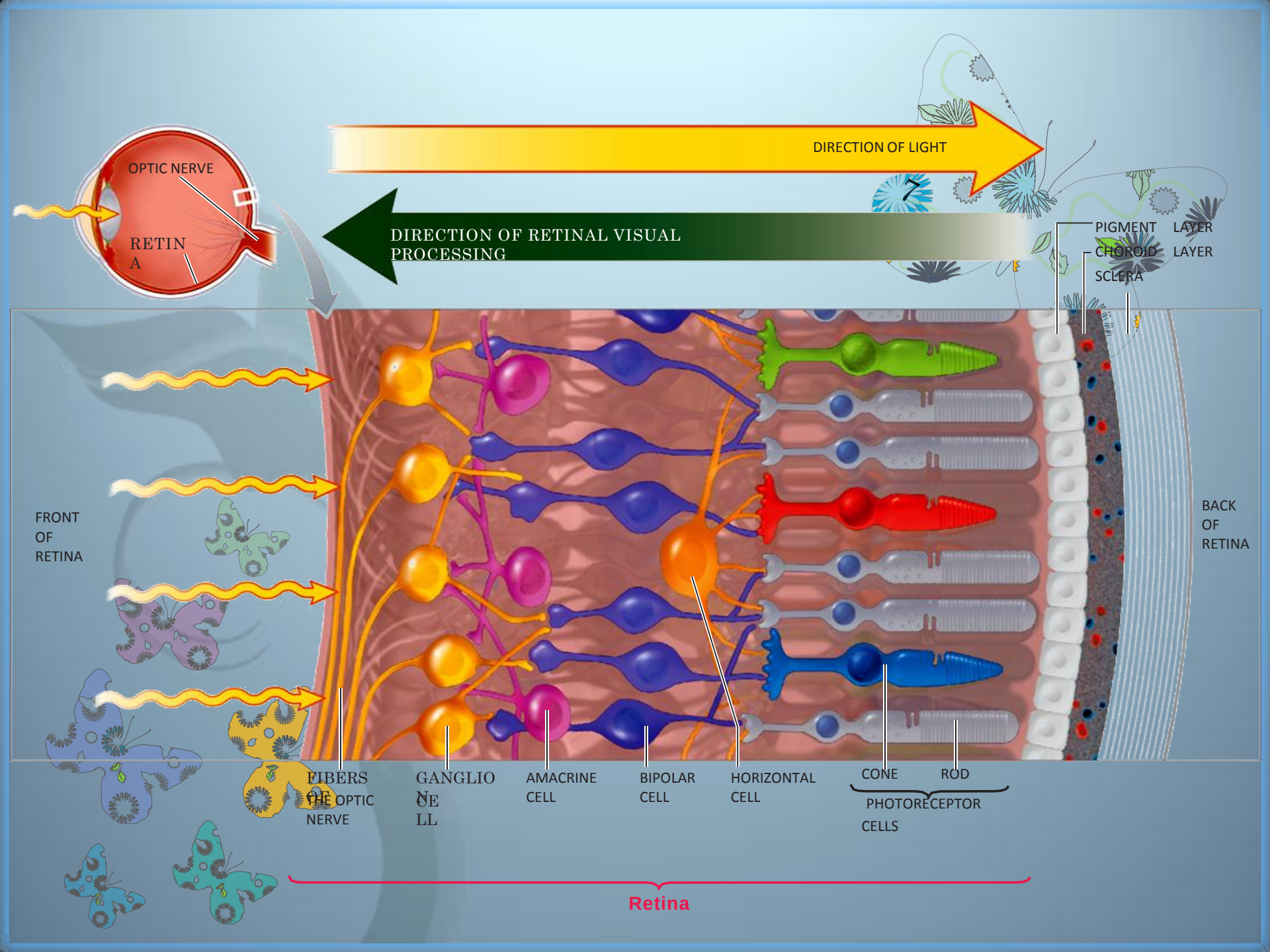
--Light absorbed by pigment cell layer that contain melanin pigment
- then impulses pass from rodes & cones to rest of layers finally to ganglion cell layer -to optic nerve

.

The visual acuity is decreased by this passage through such non- homogeneous tissue.

-However, in the *central foveal region of the retina,* the inside layers are pulled aside to decrease this loss of acuity.This allows light to pass unimpeded to the cones.




OPTIC NERVE
RETINA
DIRECTION OF LIGHT
DIRECTION OF RETINAL VISUAL PROCESSING
PIGMENT LAYER
CHOROID LAYER
SCLERA
FRONT OF RETINA
BACK OF RETINA
FIBERS OF THE OPTIC NERVE
GANGLION CELL
AMACRINE CELL
BIPOLAR CELL
HORIZONTAL CELL
CONE
ROD
PHOTORECEPTOR CELLS
Retina

Thank you for listening