

The Human Eye

Introduction

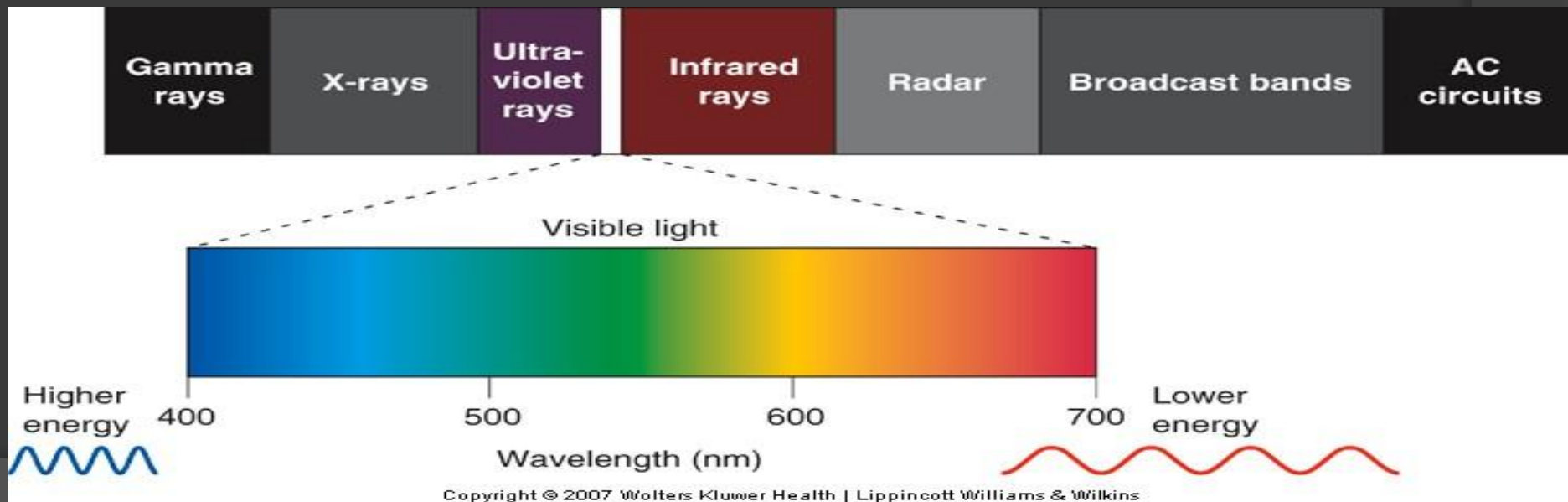
- Half the human cerebral cortex is involved with vision
- Distance from refractive surface to the point where parallel light rays converge is called the *focal point*
- Vision is 20/20 when you can recognize a letter that subtends an angle of $0.083^\circ = 5$ minutes of arc
 - newborn's visual acuity is approximately 20/400
 - 20/120 @ one month,
20/60 @ four, 20/30 @ eight month
- Rods are 1000 times more sensitive to light than cones

Introduction (continued)

- The center-surround organization of retinal ganglion cell receptive fields emphasizes contrast at light-dark edges
- There are three types of ganglion cells in mammals:
 - M-type (magno) respond with burst, constitute 5% of the total and have relatively large receptive fields
 - P-type (parvo) respond with a sustained activation, constitute 90% of total, have smaller receptive fields
 - nonM-nonP cells constitute the remaining 5% and along with the P-type cells tend to be color sensitive
- **There are approximately 125 million photoreceptors in the retinal that are funnelled into 1 million ganglion cells**
- **Clearly there is compression of the incoming information**

Properties of Light

- Light
 - Energy is proportional to frequency
 - *e.g.*, gamma radiation and cool colors — high energy
 - *e.g.*, radio waves and hot colors — low energy



Properties of Light

Properties of Light

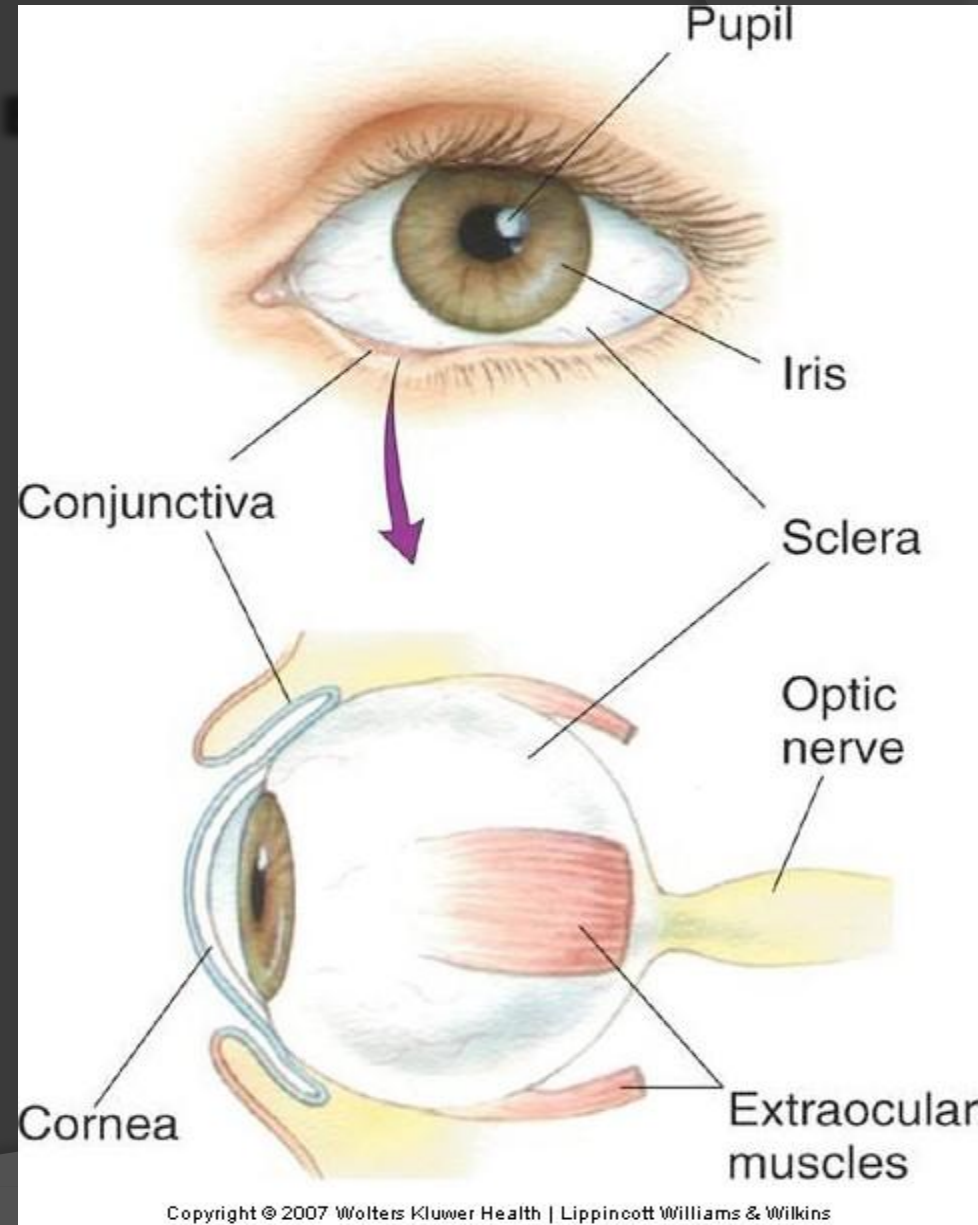
- **Optics**
 - **Study of light rays and their interactions**
 - **Reflection**
 - **Bouncing of light rays off a surface**
 - **Absorption**
 - **Transfer of light energy to a particle or surface**
 - **Refraction**
 - **Bending of light rays from one medium to another**

The Structure of the Eye

The Structure of the Eye

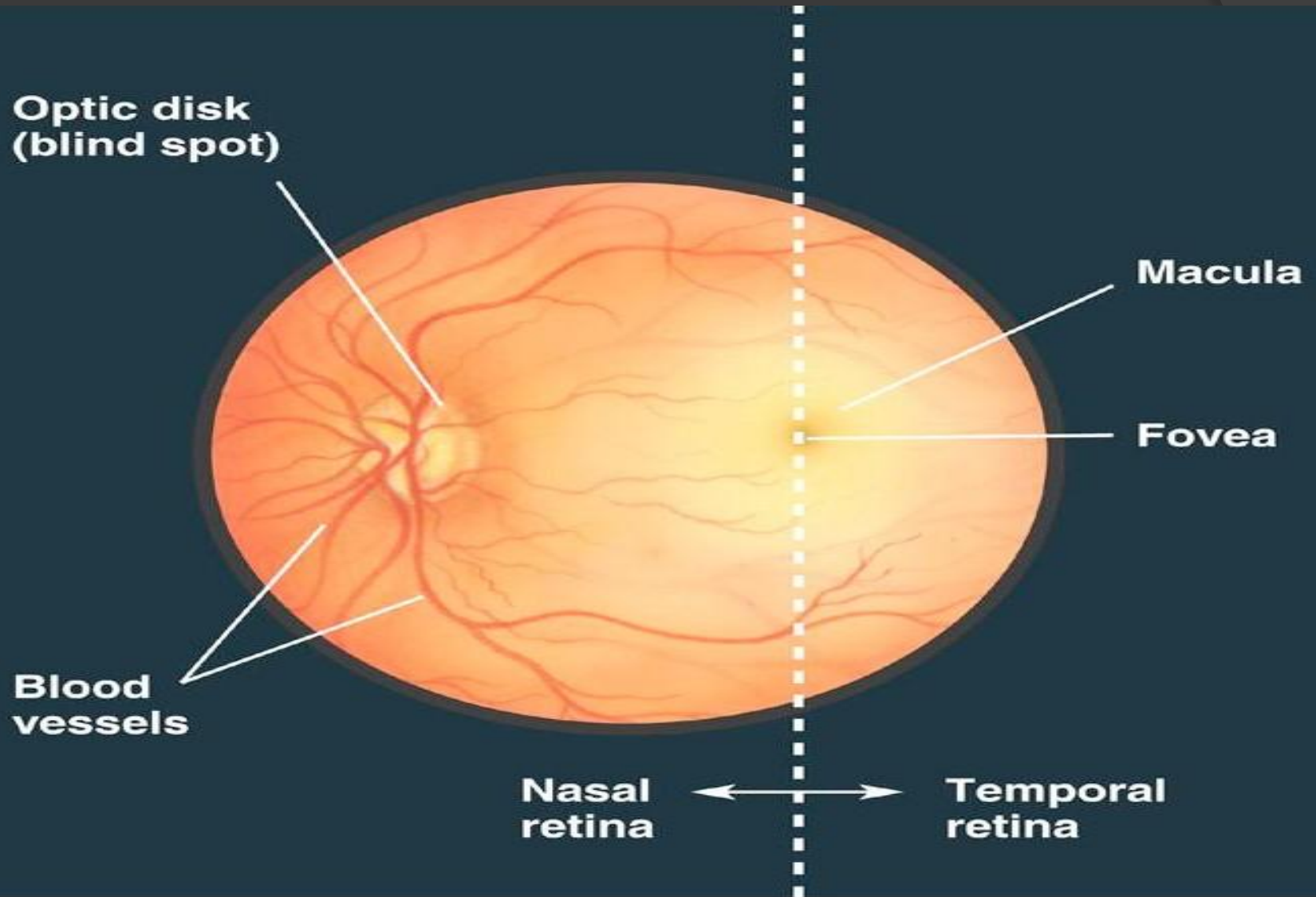
Gross Anatomy of the Eye

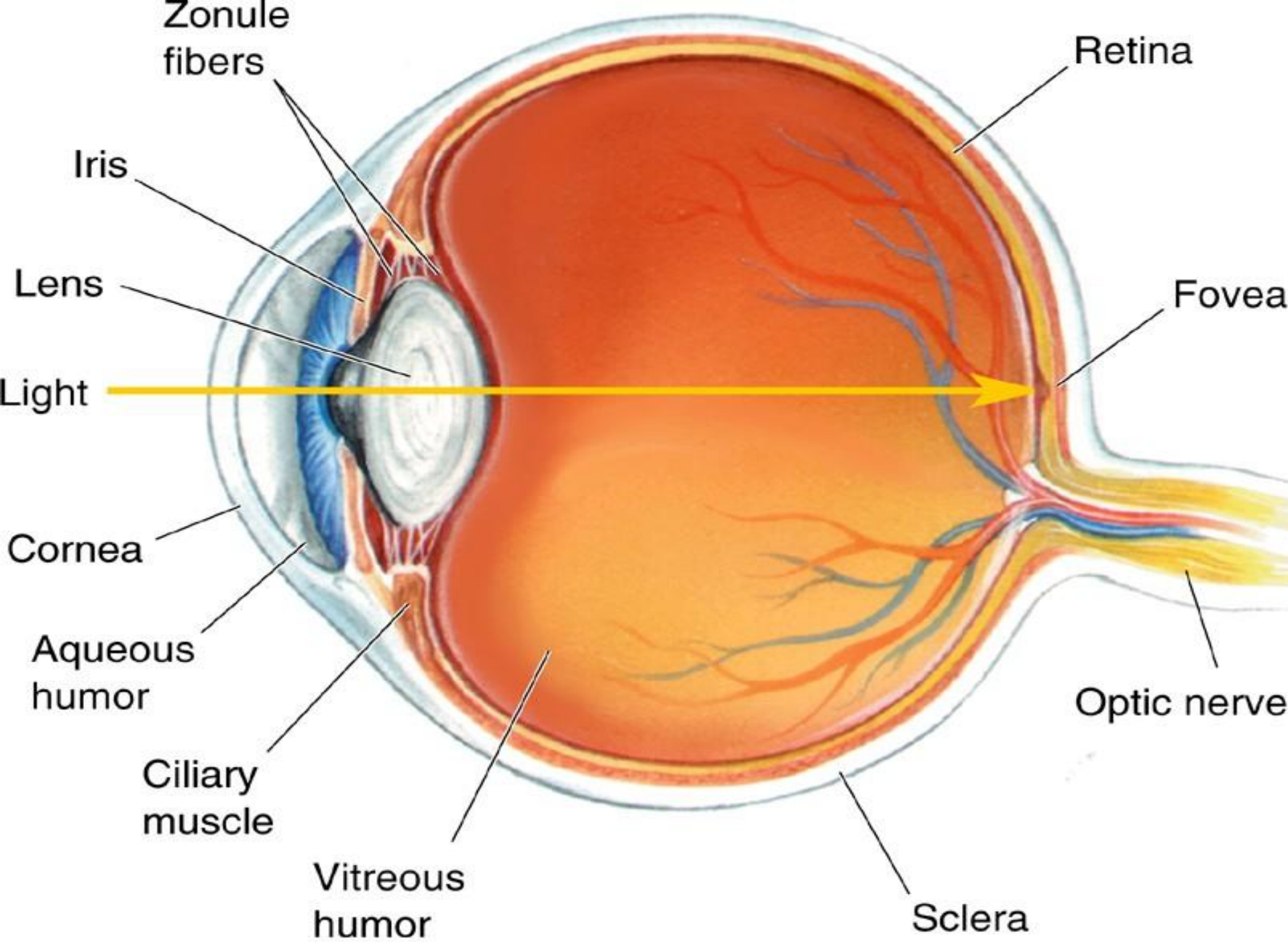
- **Pupil:** Opening where light enters the eye
- **Sclera:** White of the eye
- **Iris:** Gives color to eyes
- **Cornea:** Glassy transparent external surface of the eye
- **Optic nerve:** Bundle of axons from the retina



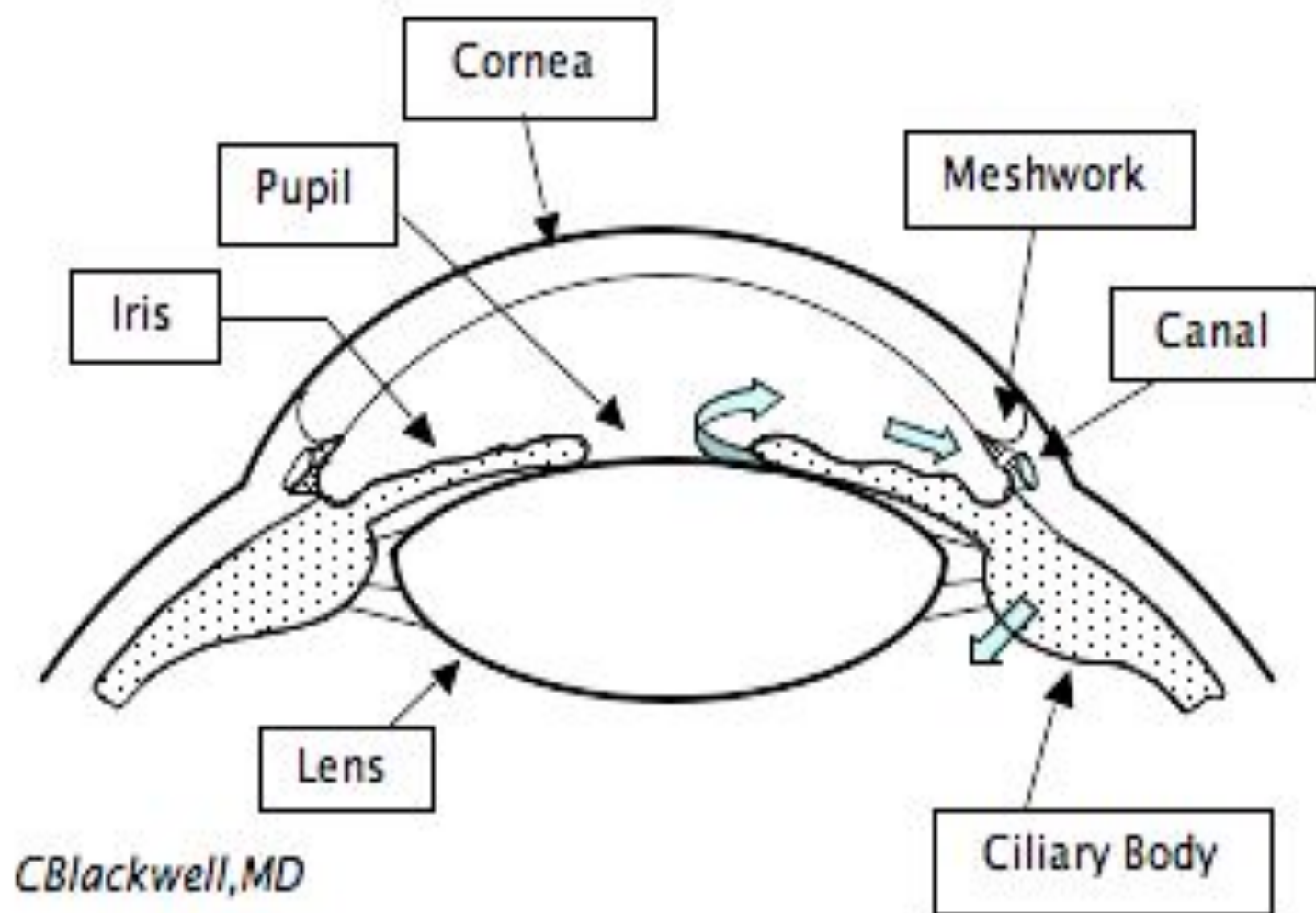
The Structure of the Eye

- Ophthalmoscopic Appearance of the Eye





Front of the Eye



Canal of Schlemm

Aqueous humor

Lens

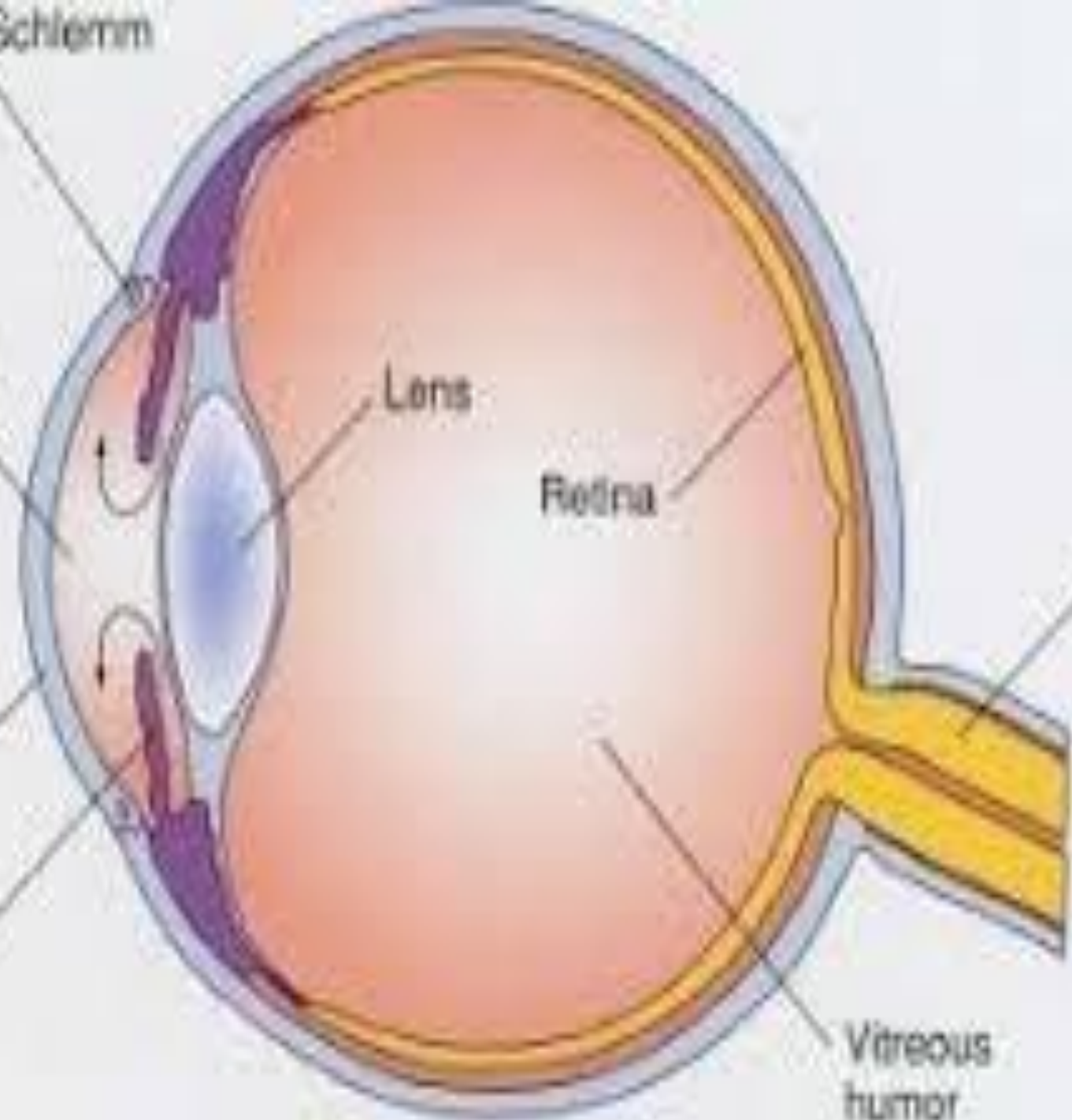
Retina

Optic nerve

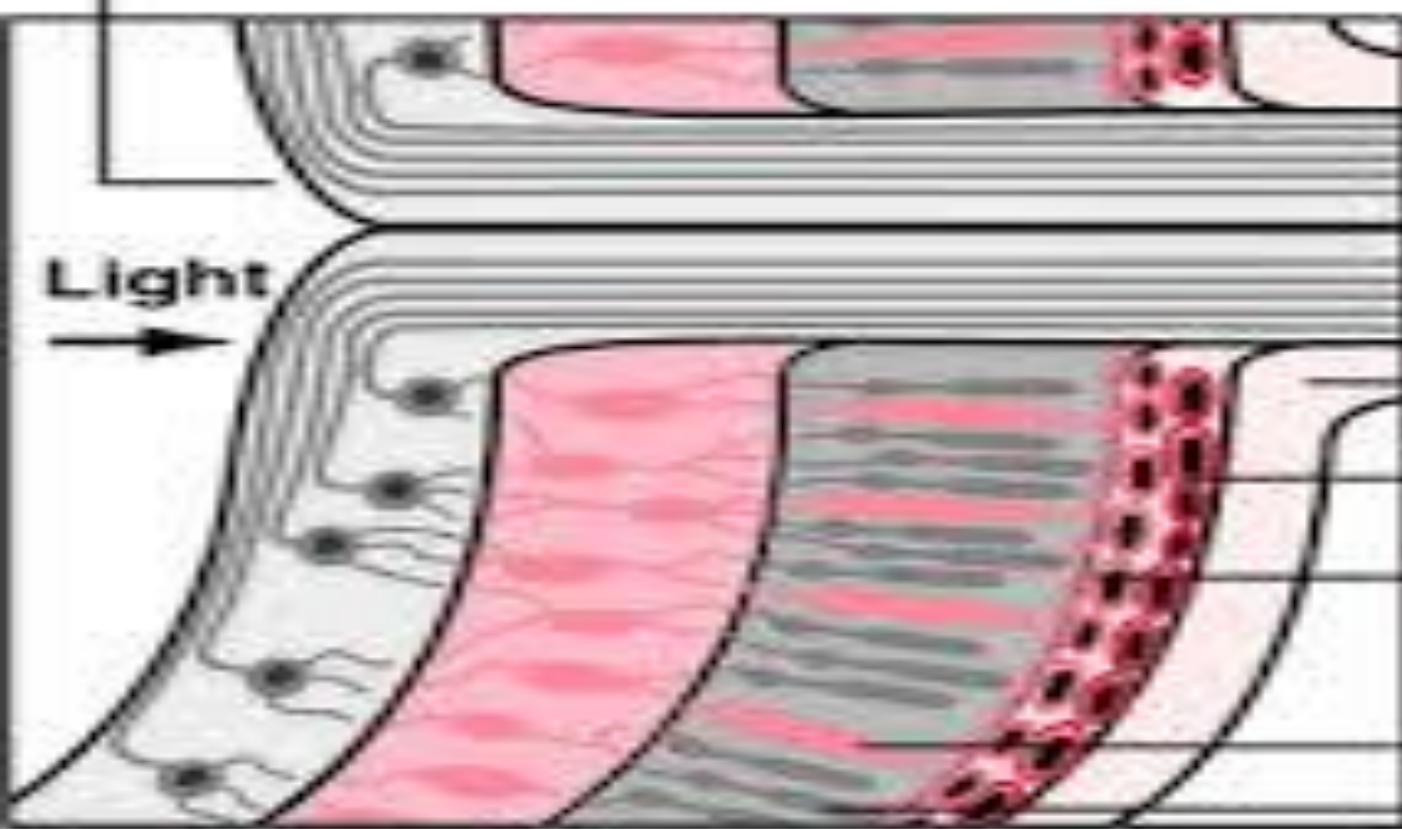
Cornea

Iris

Vitreous humor



Optic disc



Light

Optic nerve

Sclera

Choroid

Pigmented epithelium of retina

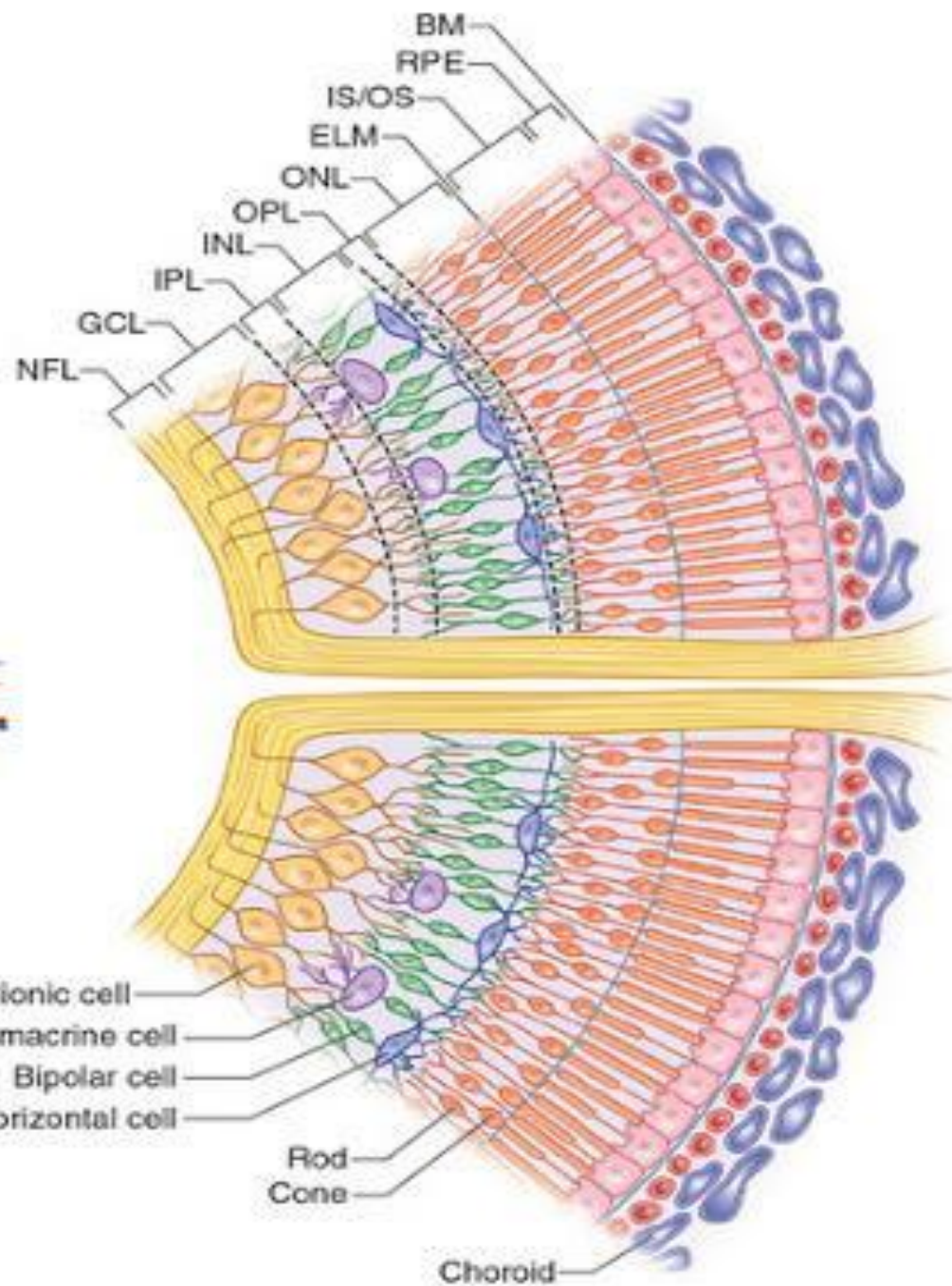
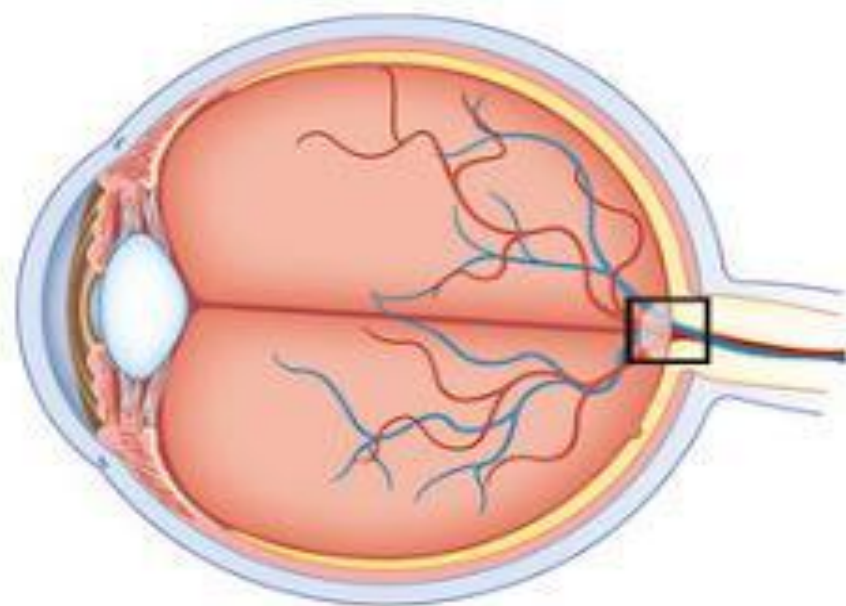
Cone

Rod

Ganglion neuron layer

Bipolar neuron layer

Rod and cone layer



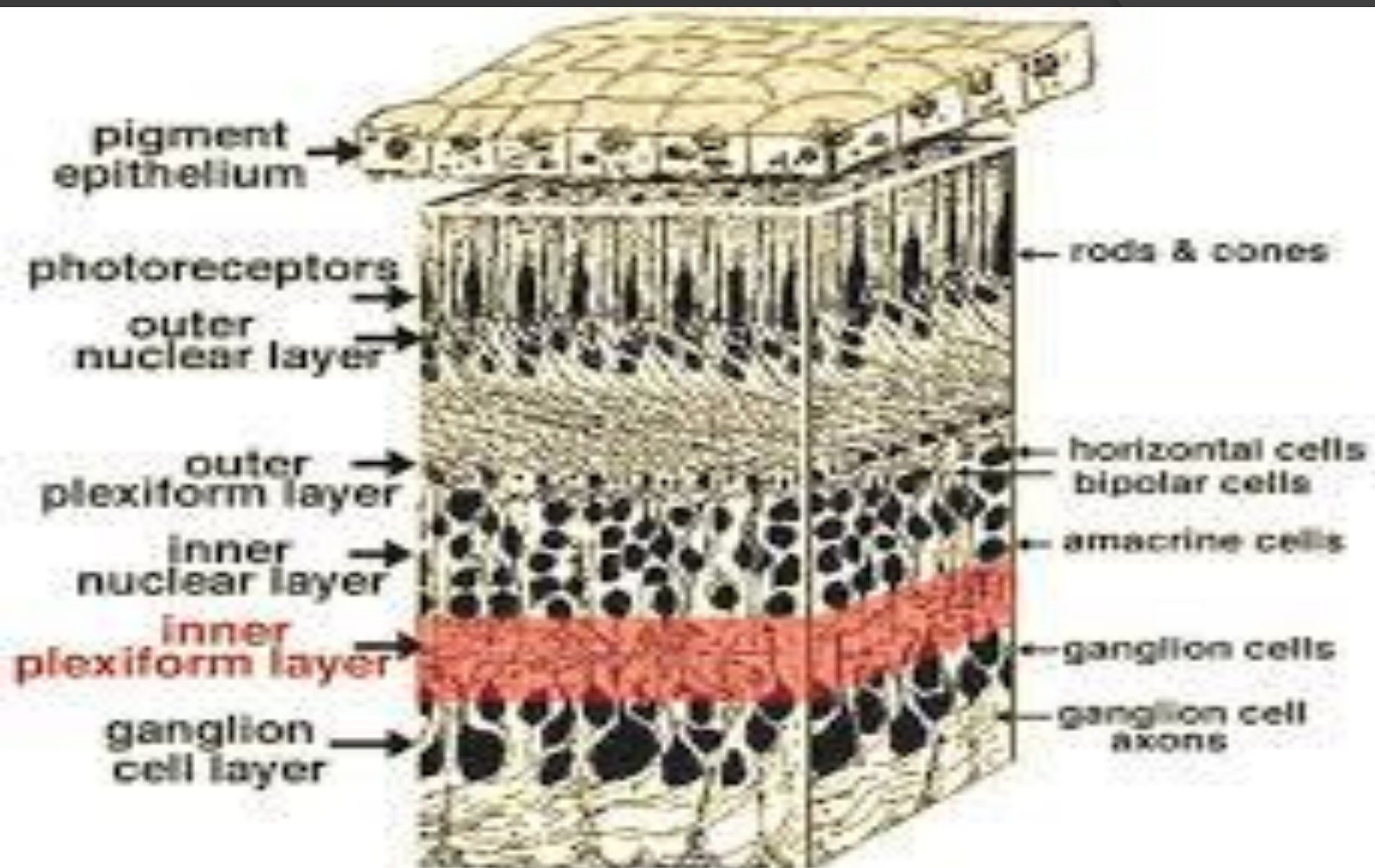


Fig. 7. 3-D block of retina with the inner plexiform layer highlighted (red).

The optic nerve is formed by the convergence of axons from the retinal ganglion cells. These cells in turn receive impulses from the photoreceptors of the eye (the rods and cones). After its formation, the nerve leaves the bony orbit via the optic canal, a passageway through the sphenoid bone.

Image Formation by the Eye

Image Formation by the Eye

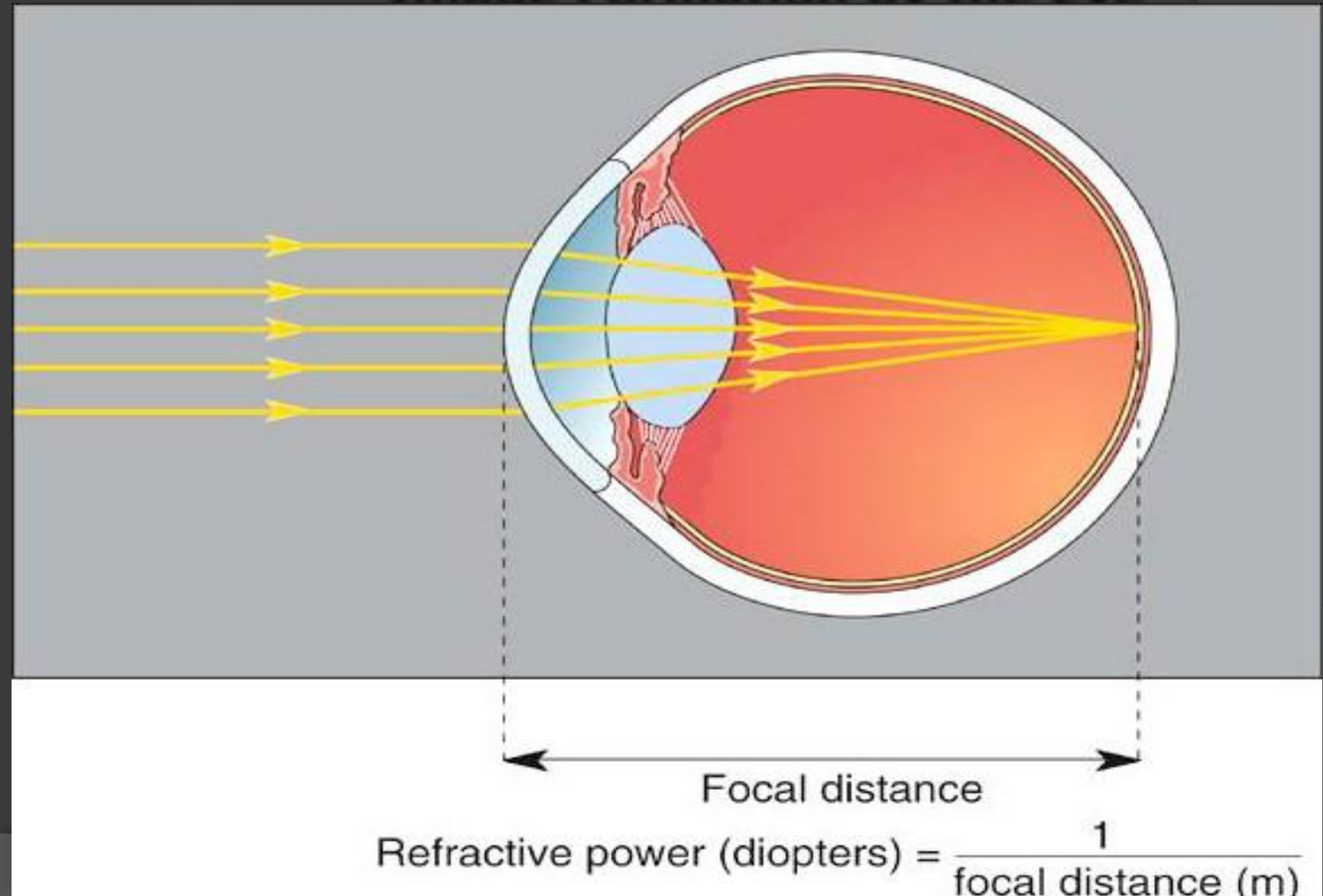


Image Formation by the Eye

- **Accommodation by the Lens**
 - **Changing shape of lens allows extra focusing**

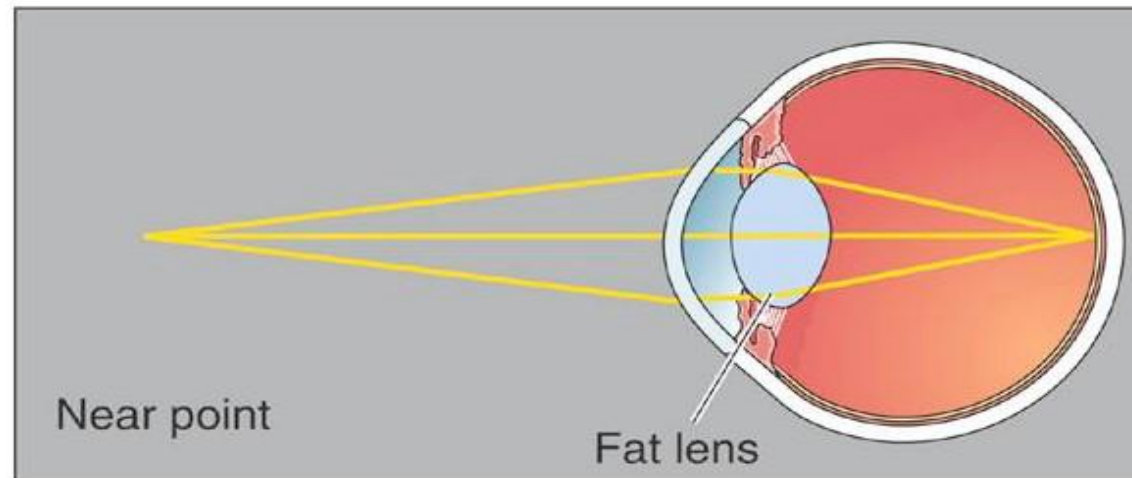
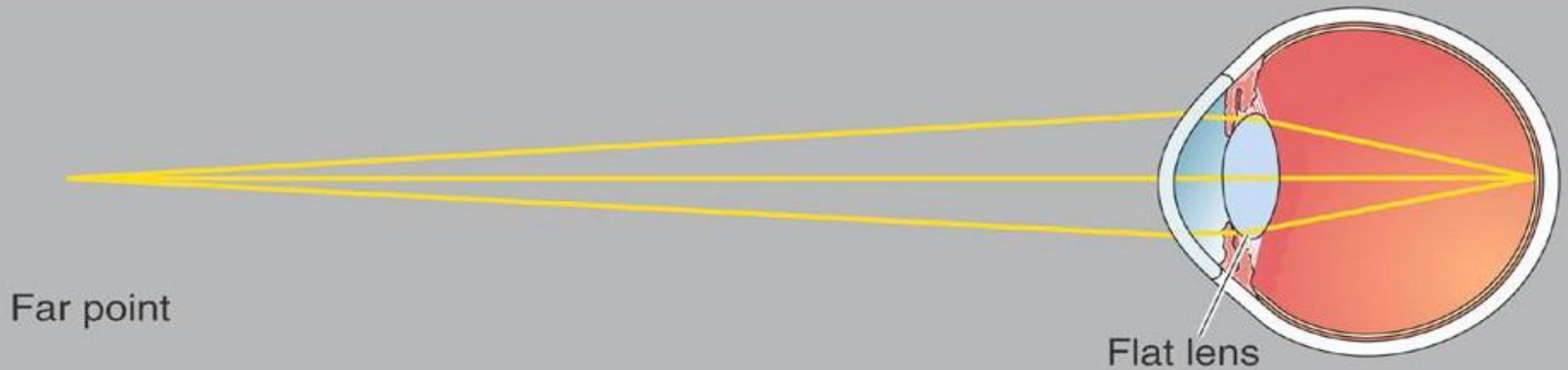


Image Formation by the Eye

Image Formation by the Eye

- **Visual Acuity**
 - Ability to distinguish two nearby points
 - Visual angle: distances across the retina described in degrees

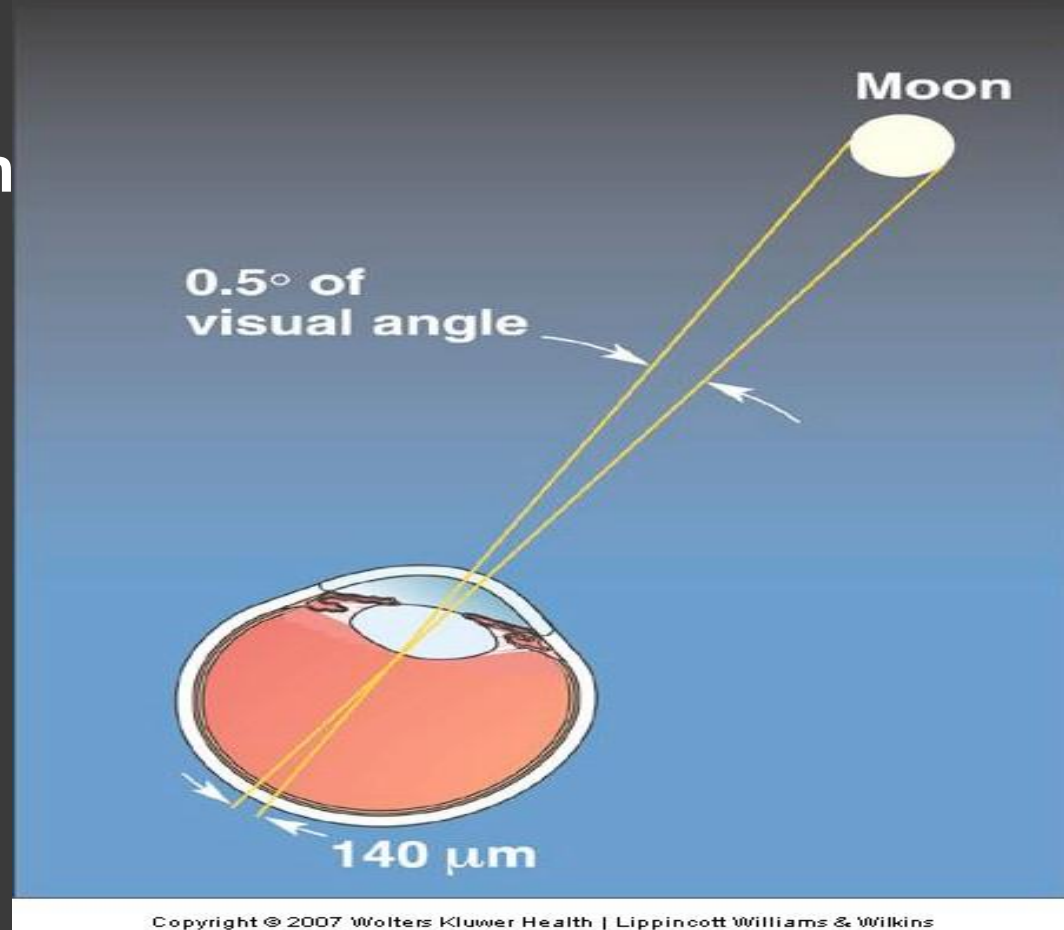
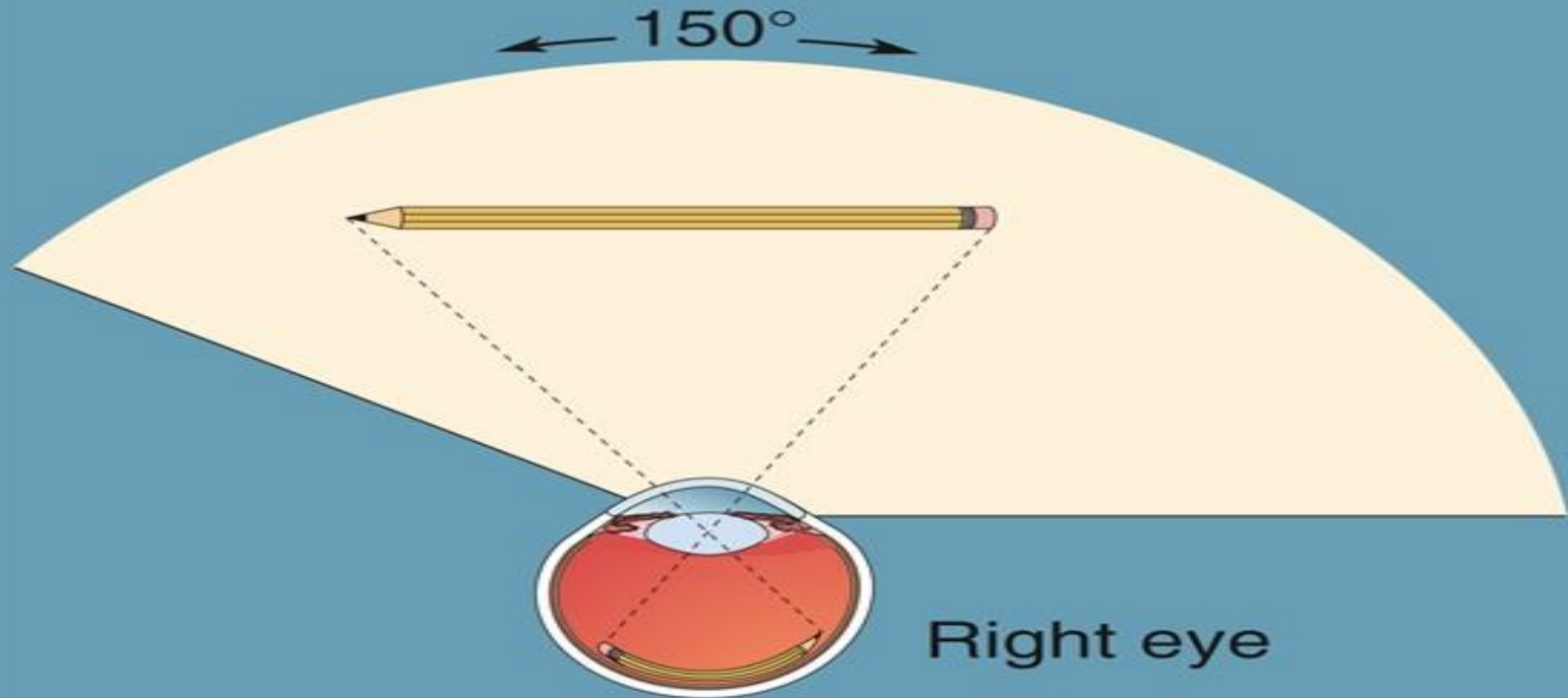


Image Formation by the Eye

Image Formation by the Eye

- The Visual Field
 - Amount of space viewed by the retina when the eye is fixated straight ahead



Concluding Remarks

- **Light emitted by or reflected off objects in space**
□
imaged onto the retina
- **Transduction**
 - **Light energy converted into membrane potentials**
 - **Phototransduction parallels olfactory transduction**
 - **Electrical-to-chemical-electrical signal**
- **Mapping of visual space onto retina cells not uniform**

**The human eye
focuses (refracts)
light to produce
clear images, similar
to the way a camera
does.**

- **Causes of refractive errors**

- **Eye length.** If the eye is too long, light is focused before it reaches the retina, causing nearsightedness. If the eye is too short, light is not focused by the time it reaches the retina. This causes farsightedness or hyperopia.
- **Curvature of the cornea.** If the cornea is not perfectly spherical, then the image is refracted or focused irregularly to create a condition called astigmatism. A person can be nearsighted or farsighted with or without astigmatism.
- **Curvature of the lens.** If the lens is too steeply curved in relation to the length of the eye and the curvature of the cornea, this causes nearsightedness. If the lens is too flat, the result is farsightedness.

THE HUMAN EYE: How Images Are Formed

13.6

- The human eye gathers light from objects.
- In a healthy eye, a smaller, inverted, real image of an object is created on the retina at the back of the eye.
- Electrical impulses from the eye travel through the optic nerve to the brain.

The brain

- Takes inverted image from the retina and flips it so that the image we "see" appears upright



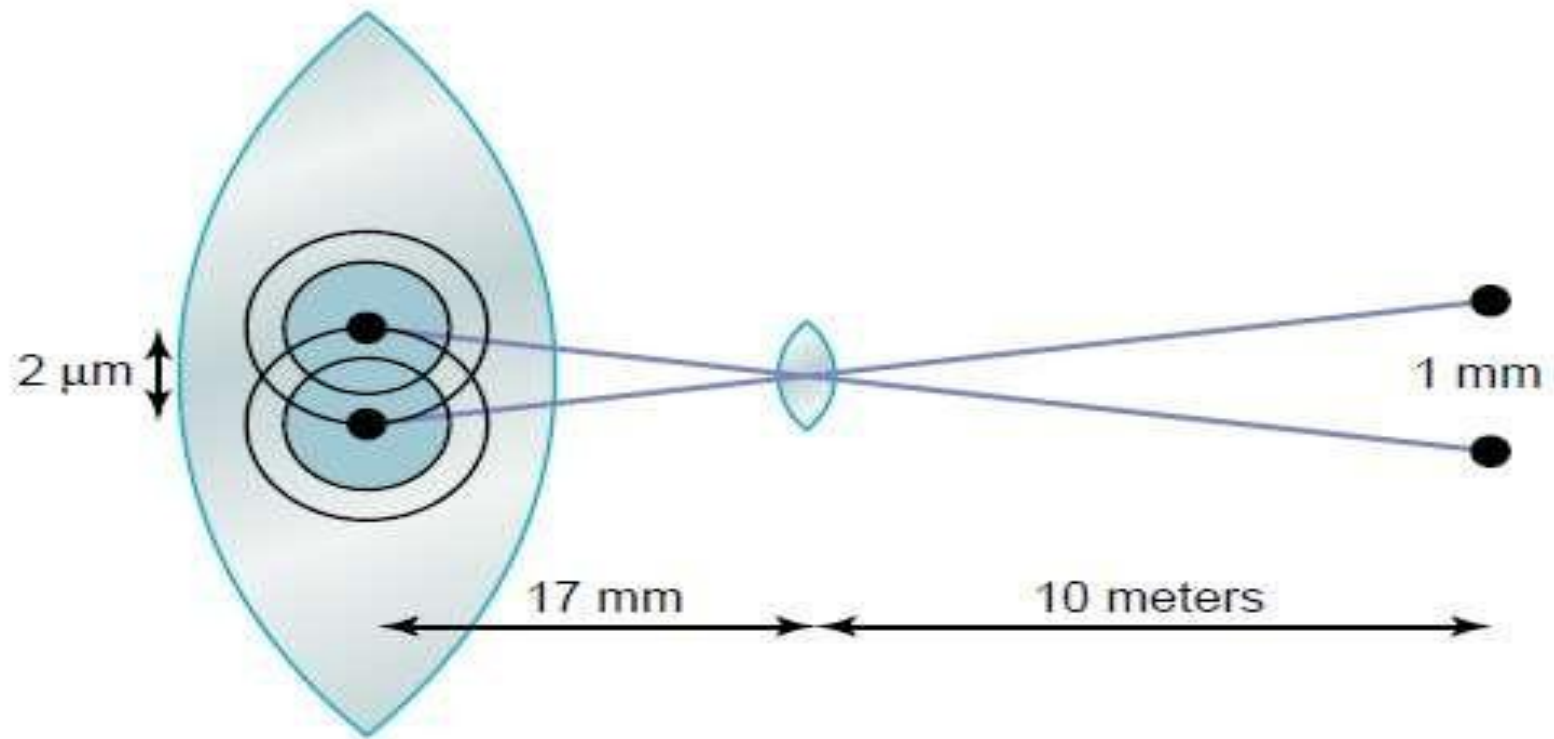
Myopia is the most common ocular disorder worldwide, it is the leading cause of visual impairment in children, and its incidence is increasing rapidly. In 2010, an estimated 1.9 billion people (27% of the world's population) were myopic,

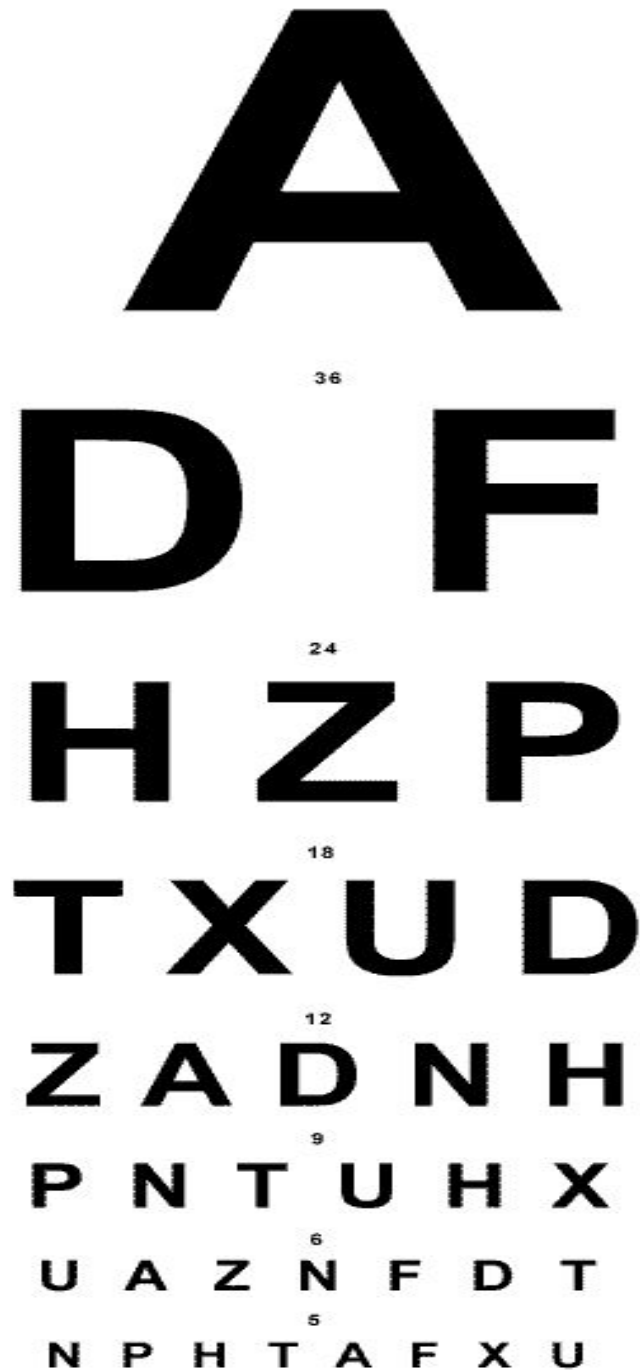
Vision impairment related to myopia has a significant economic impact and a significant effect on quality of life regarding patients' physical, emotional, and social functioning

Visual acuity

- It is the degree to which details and contours of the object are perceived,
- it is expressed in term of visual angle

- Normal visual acuity for discriminating between two point sources is 1 minute of an arc
- Fovea is 0.5mm
- Peripheral acuity is poor
- Snellen's chart and Jaeger's chart





Snellen's chart

Read from
a distance
of 6 mts

No. 7.
1.50M

able treaty, the restitution of the standards and prisoners which had been taken in the defeat of Crassus. His generals, in the early part of his reign, attempted the reduction of Ethiopia and Arabia Felix. They marched near a thou-

No. 8.
1.75M

sand miles to the south of the tropic; but the heat of the climate soon repelled the invaders, and protected the unwarlike natives of those sequestered regions

No. 9.
2.00M

The northern countries of Europe scarcely deserved the expense and labor of conquest. The forests and morasses of Germany were

No. 10.
2.25M

filled with a hardy race of barbarians who despised life when it was separated from freedom; and though, on the first

No. 11.
2.50M

attack, they seemed to yield to the weight of the Roman power, they soon, by a signal

Jaeger's chart

Read from
a distance
of 25 cms

Factors affecting visual acuity

1. **Optical factors-** state of image forming mechanisms of eye
2. **Retinal factors-** fovea has better acuity
3. **Stimulus factors-**
 - (i) Size of the object
 - (ii) Color of the object
 - (iii) Illumination
 - (iv) Contrast
 - (v) Brightness
 - (vi) Duration of exposure

Field of vision

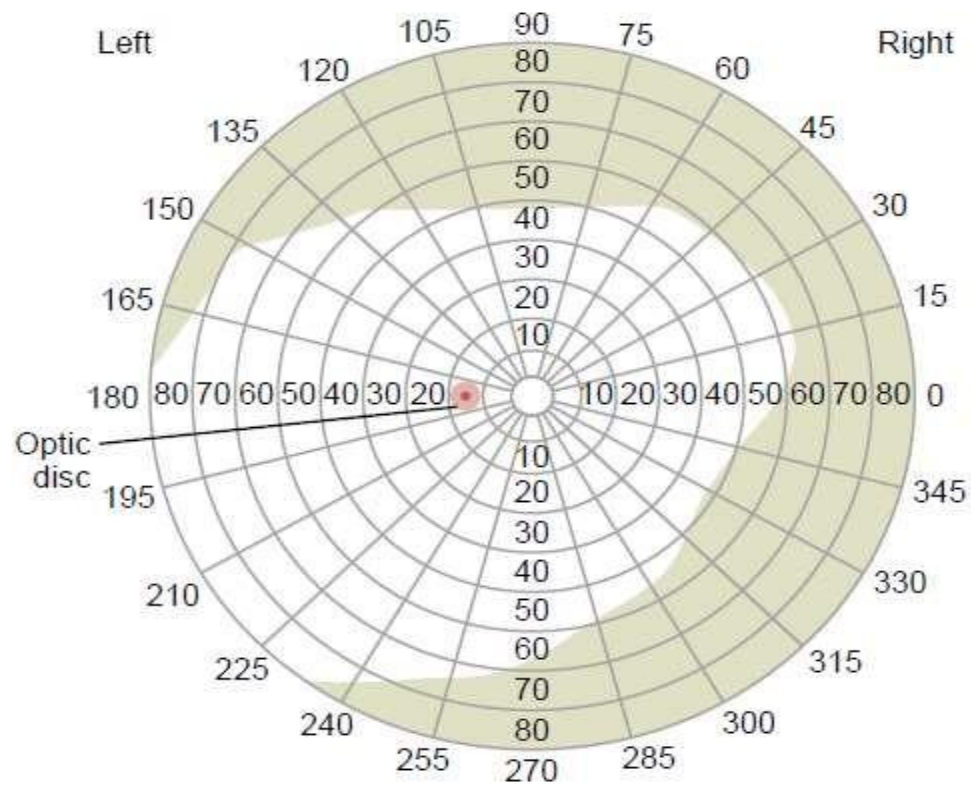
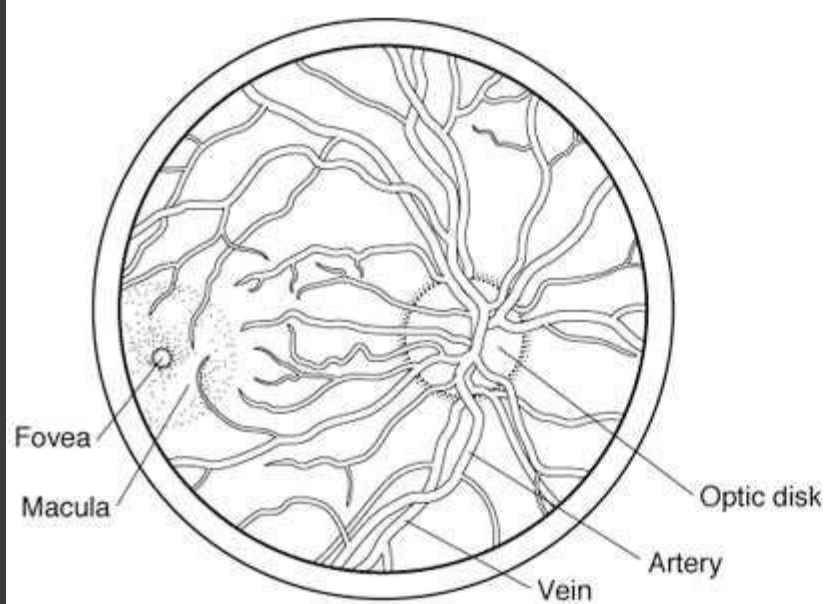
Def: All the surroundings visible when the vision is fixed

Methods of assessment:

- (i) Perimetry
- (ii) Confrontation method

Blind spot- 3mm medial to & slightly above posterior pole

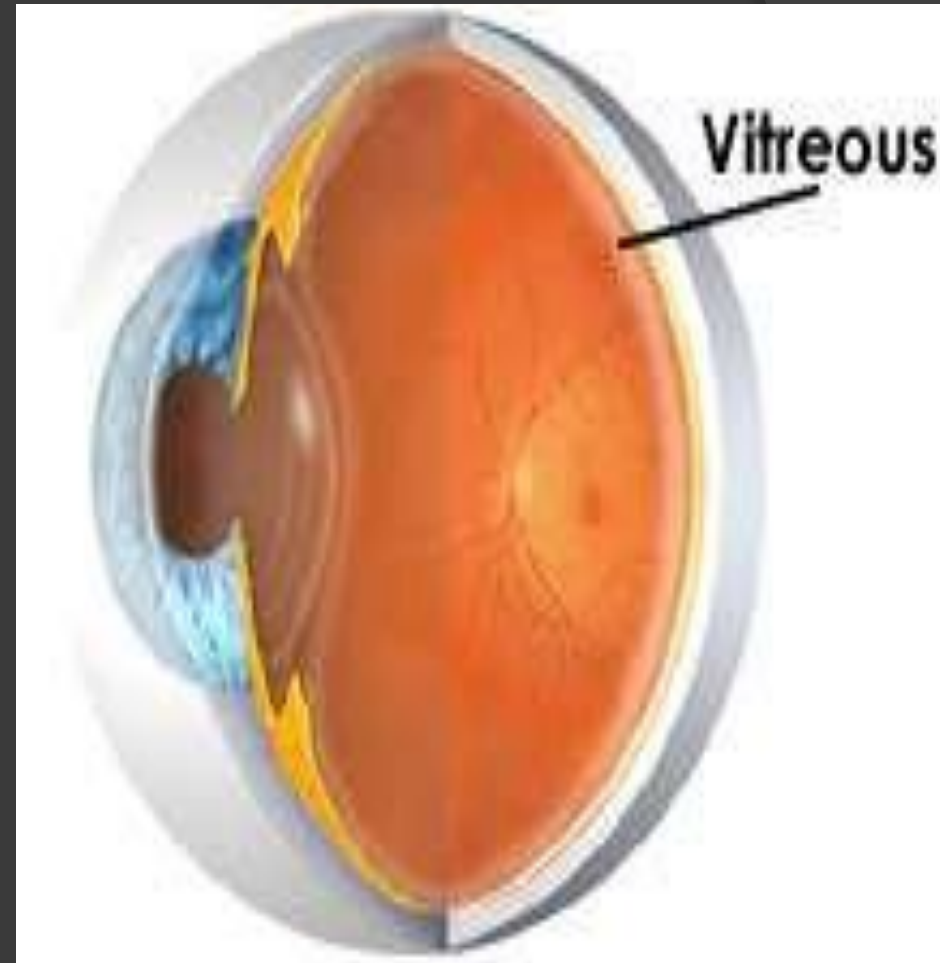
Scotoma- Blind spots in regions other than optic disc



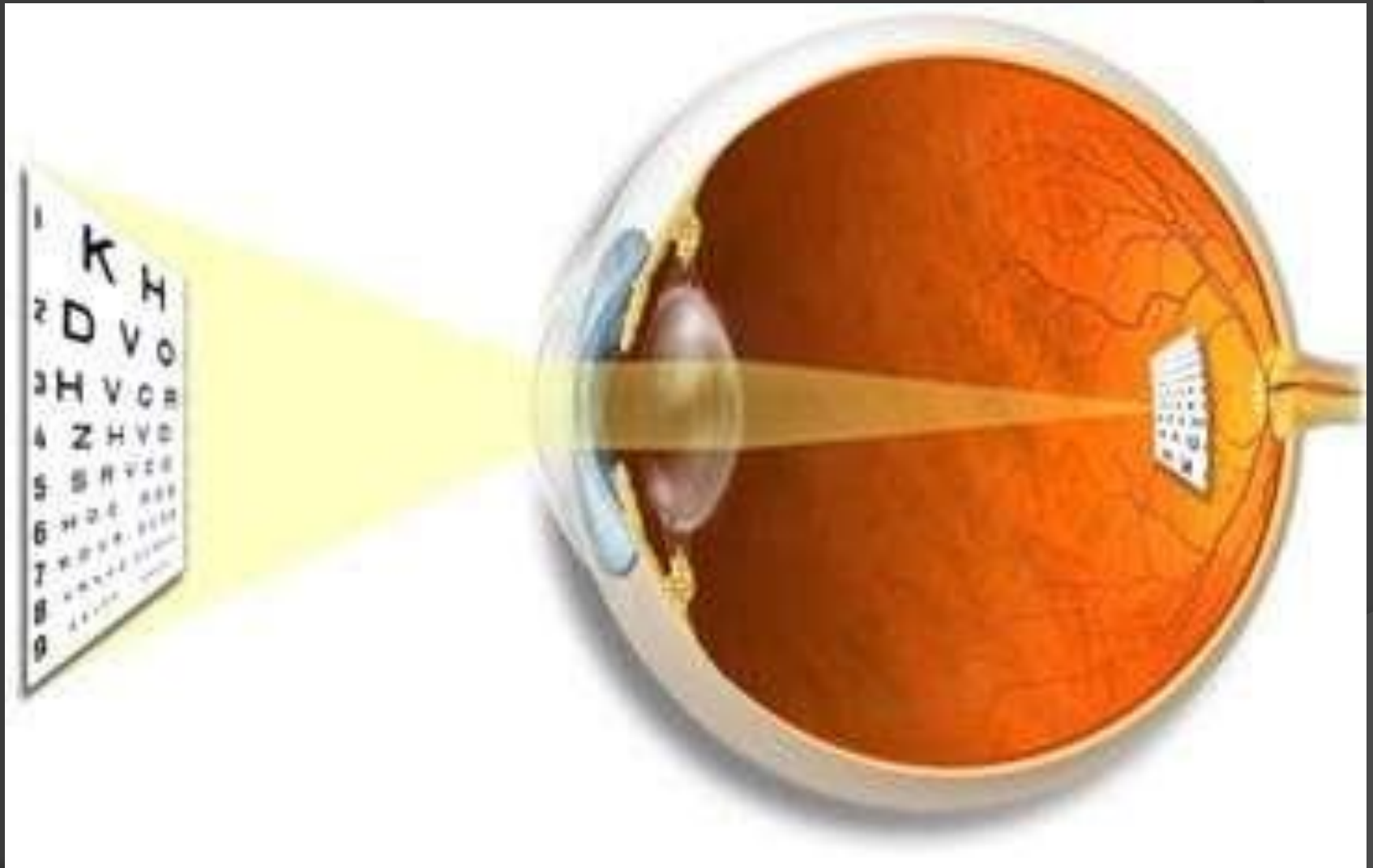
Normal refractive condition

- **(1). Ocular refractive system**

- **The ocular refractive system is composed of the cornea, the aqueous humor, the lens and the vitreous.**

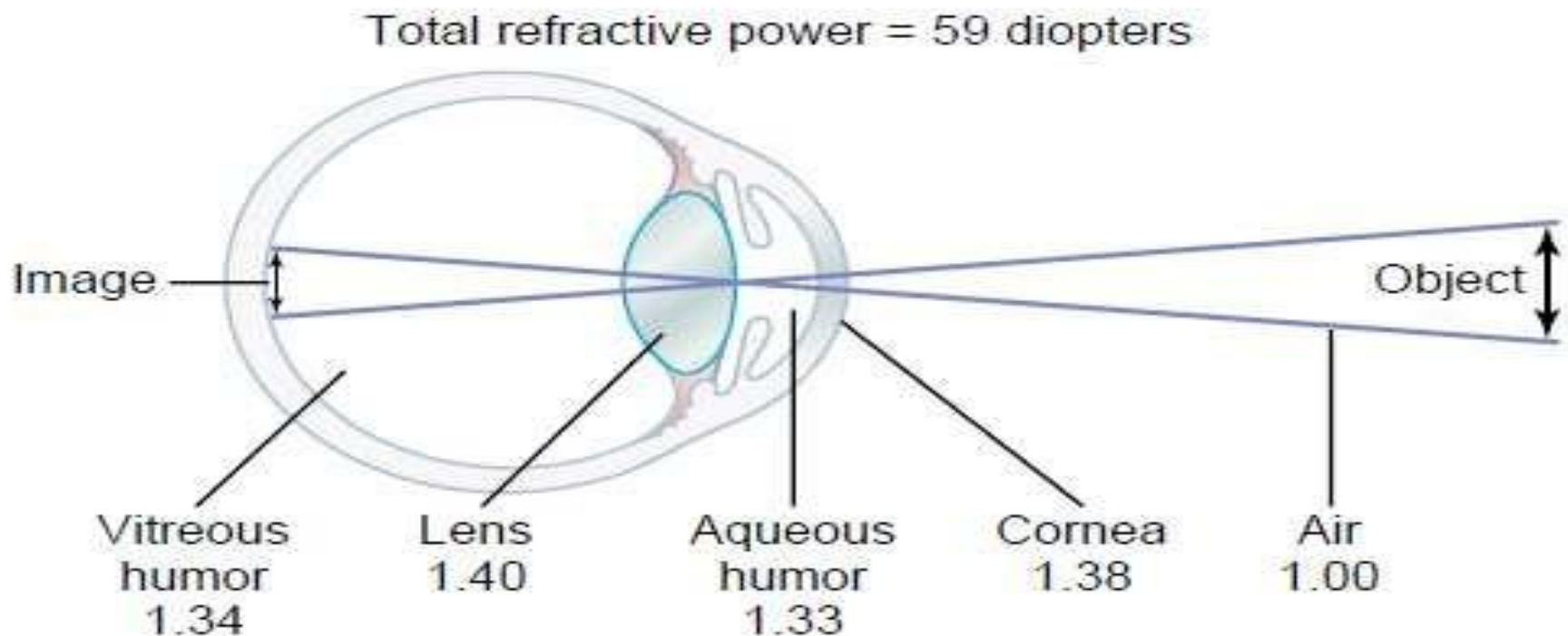


People can see object clearly ,for the light rays sent out by object pass through eye refractive system, form images on retinal macula.



Reduced eye or schematic eye

- All the refractive surfaces of eye are algebraically added & considered as a single lens
- It has a central point 17mm in front of retina
- Refractive power of +59D- 2/3rds provided by cornea & 1/3rd by lens



Refractive power

- Refractive power is diopter (D), if the focal length of a spherical lens is 1m, its refractive power is one diopter (D).

$$D = 1 / f$$

- Corneal refractive system : 43.05D
- Lens refractive system : 19.11D
- Total refractive power of globe : 58.64D

Emmetropia

Emmetropia:

The condition is the absence of refractive error. Or nonaccommodated parallel rays refracted by ocular refractive system accurately focus on the retina which is called emmetropia.

2) Ametropia (nonemmetropia)

- ☐ **Ametropia:**
- ☐ **The refractive power and the length of the globe are not correlated so that parallel light rays refracted by ocular refractive system do not come to focus on the retina (fovea centralis). Including hypermetropia, myopia and astigmatism. Or is the presence of refractive error.**

Errors of refraction

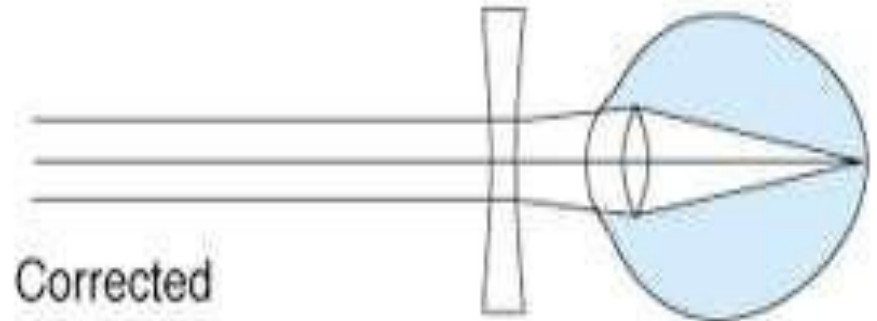
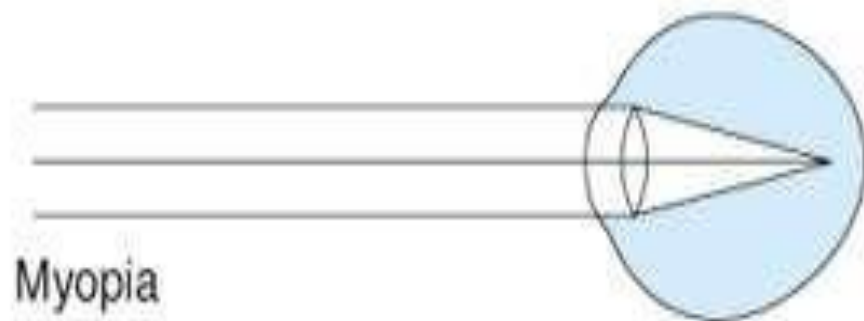
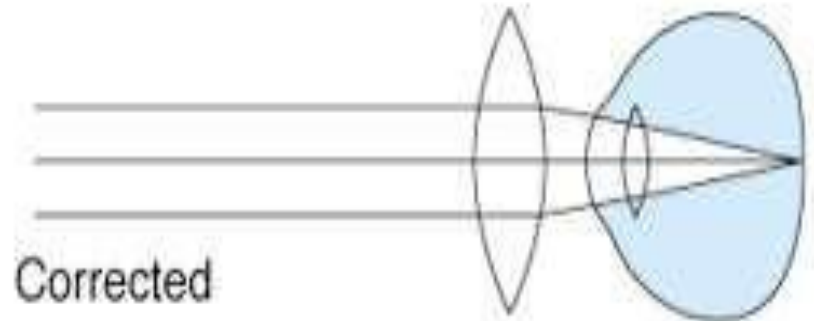
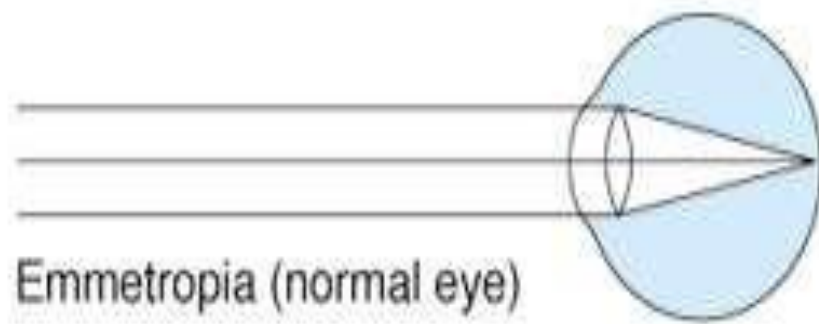
1. Myopia: near sightedness

Correction- concave lens

2. Hypermetropia: far sightedness
uses accommodation

Correction- convex lens

3. Emmetropia: sharp normal vision



(1) Myopia(nearsighted)

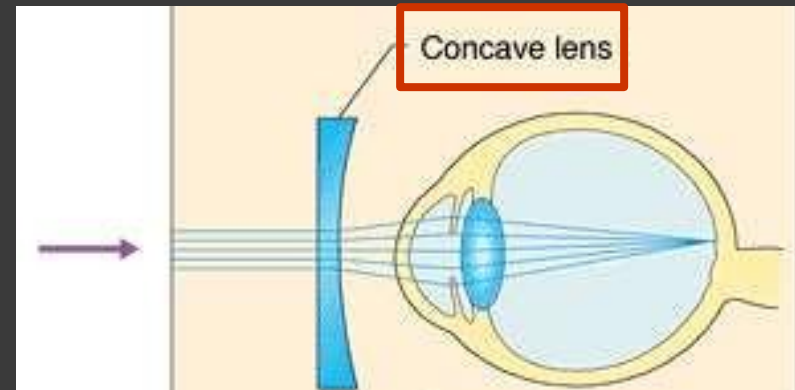
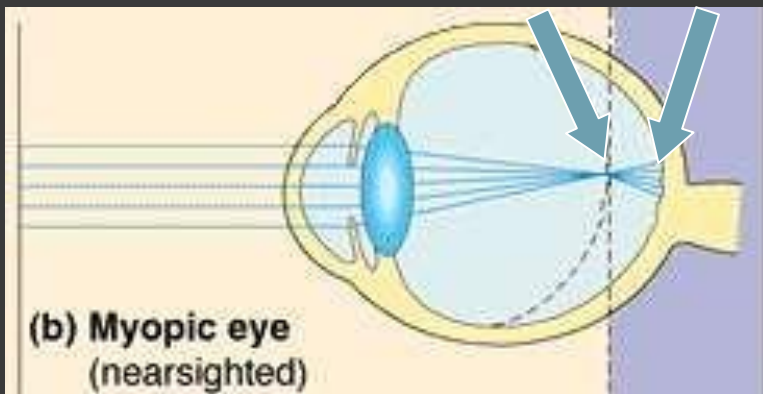
Under nonaccommodated condition, parallel light rays refracted by ocular refractive system come to focus in front of the retina

Classification:

- ★ Mild : below -3D**
- ★ Moderate : from -3D to -6D**
- ★ High myopia : more than -6D**

Myopia (Nearsighted)

- Eyeball too long
- Distant objects focused in front of retina
- Image striking retina is blurred

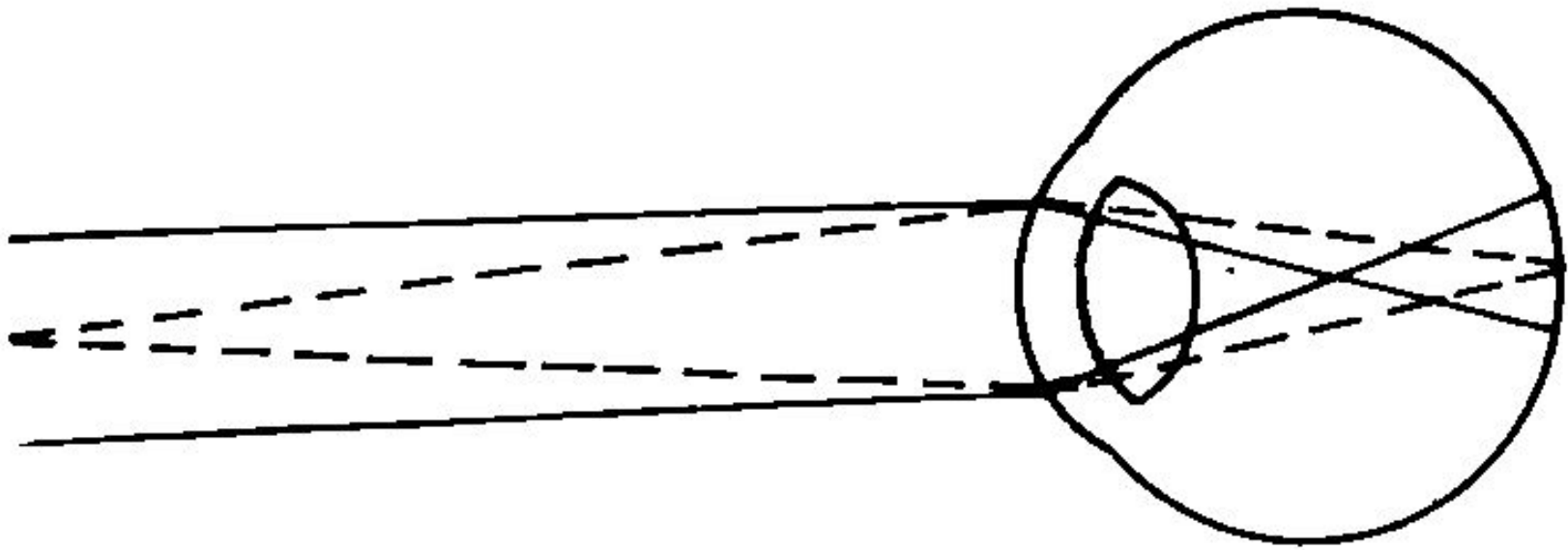


Correction:

- Concave lens or
- laser surgery to slightly flatten the cornea

(1)

Myopia(nearsightedness)



(1 Myopia (nearsighted))

□ Nearsightedness or myopia, occurs when light entering the eye focuses in front of the retina instead of directly on it. This is caused by a cornea that is steeper, or an eye that is longer, than a normal eye.

Nearsighted people typically see well up close, but have difficulty seeing far away.

(1 Myopia(nearsightedness))

- **This problem is often discovered in school-age children who report having trouble seeing the chalkboard.**

1 Myopia (nearsighted)

□ Detection

Nearsightedness is detected with a vision test and refraction.



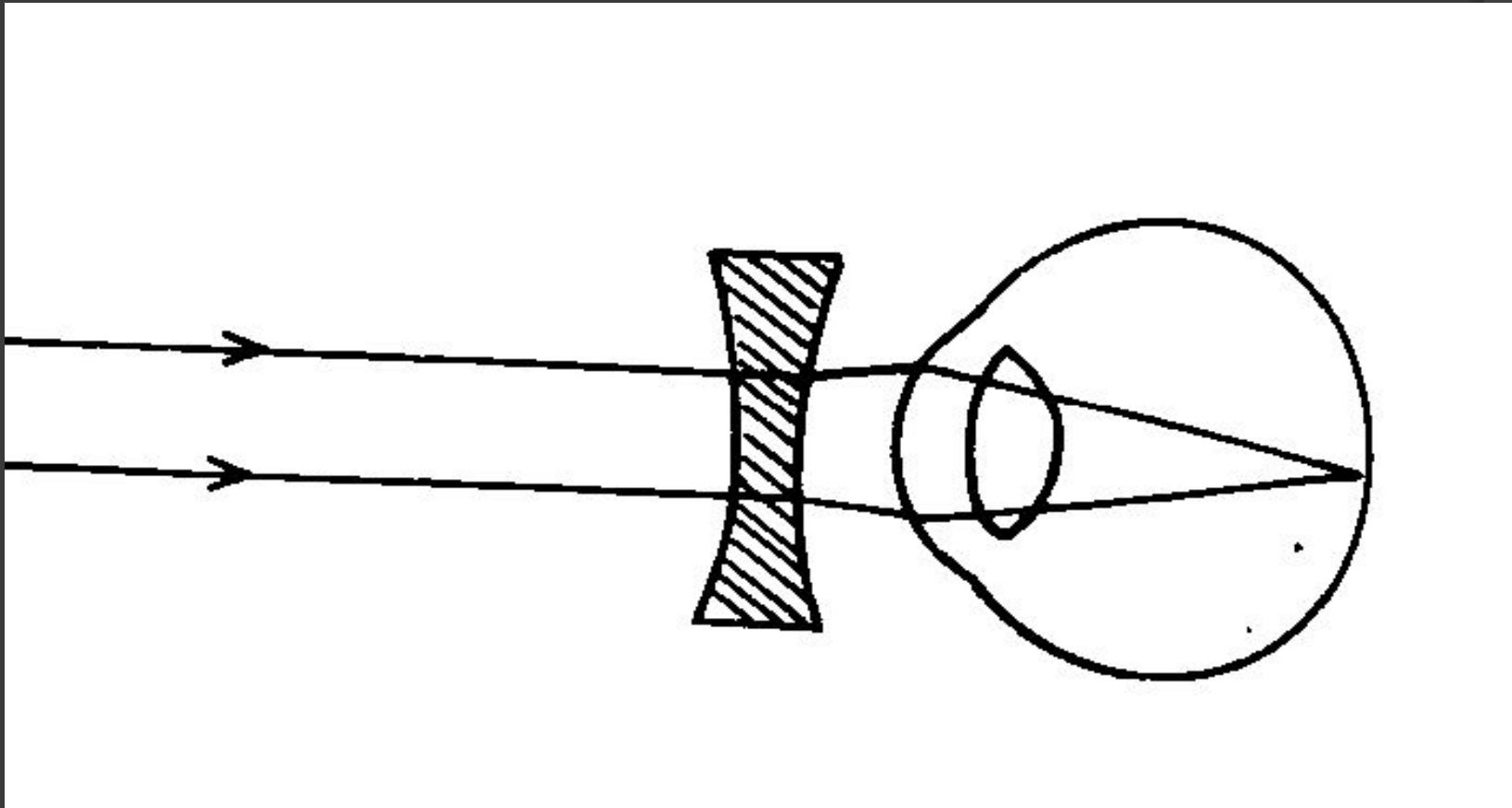
《Etiology》

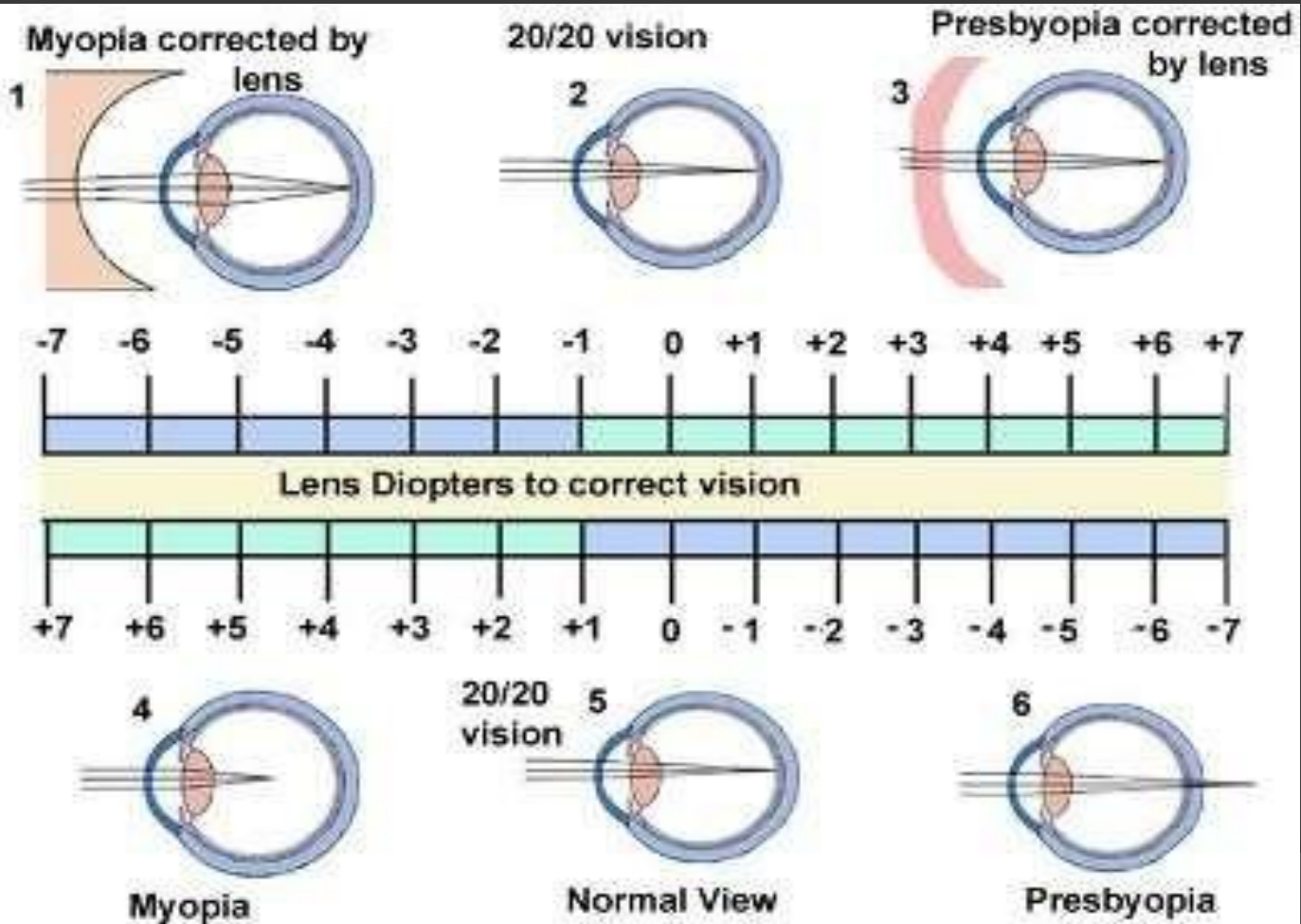
- **<1>.Axial myopia: Axial of the eye is quite long,but the power is normal. refractive**
 - *The eye longer than average**
 - *Most high myopia are axial**

《Etiology》

- 〈2〉. **Refractive myopia**: The axis is normal but the refractive power increases.

《Correction of myopia》



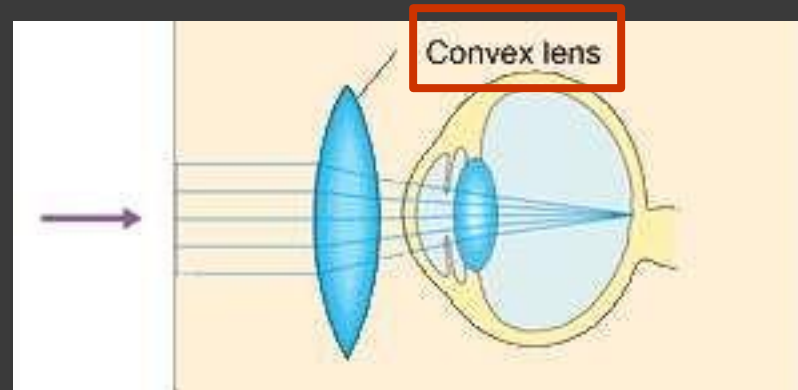
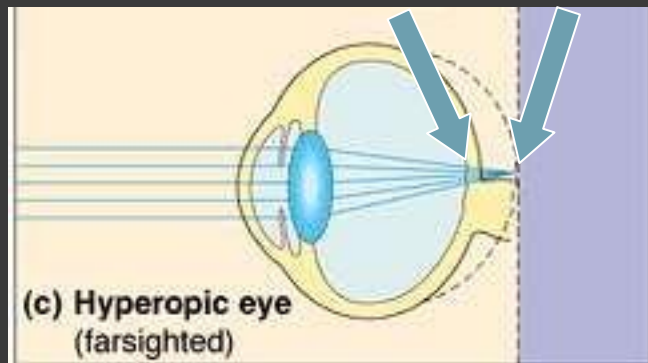


.Hypermetropia

- **Hypermetropia is the state in which the unaccommodated eye would focus the image behind the retina.**
- **Parallel light rays refracted by ocular refractive system focus behind the retina, not form clear image.**

Hypermetropia (Farsightedness)

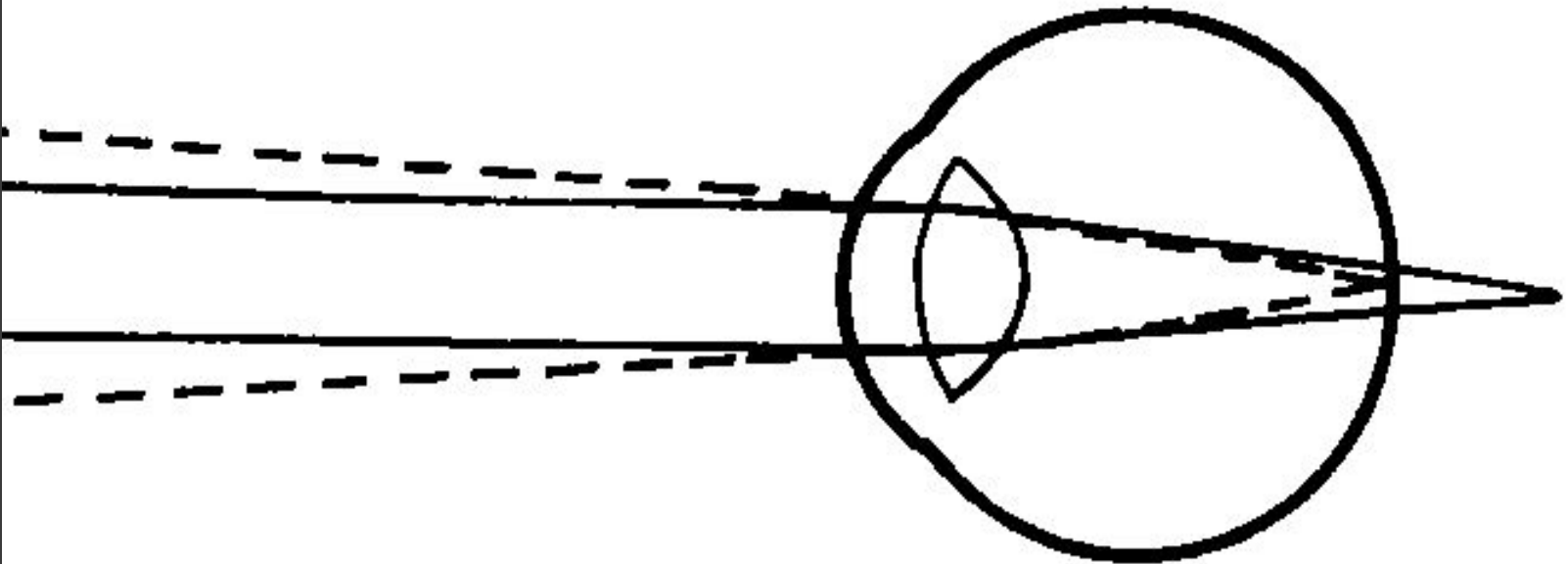
- Eyeball too short, lens too thin or too stiff.
- Nearby objects are focused behind retina.
- Image striking the fovea is blurred.



Correction:

- Convex lens

Hypermetropia



Hypermetropia

- Farsightedness or hyperopia, occurs when light entering the eye **focuses behind** the retina, instead of directly on it.
- This is caused by a cornea that is **flatter**, or **an eye that is shorter**, than a normal eye. Farsighted people usually have trouble seeing up close, but may also have difficulty seeing far away as well.

Hypermetropia

- Young people with mild to moderate hyperopia are often able to see clearly because their natural lens can adjust, or accommodate to increase the eye's focusing ability.
- However, as the eye gradually **loses the ability to accommodate** (beginning at about 40 years of age), **blurred vision** from hyperopia often becomes more apparent.

Hypermetropia

- **Signs and Symptoms**
- Difficulty seeing up close
- Blurred distance vision (occurs with higher amounts of hyperopia)
- Eye fatigue when reading
-
- Eye strain (headaches, pulling sensation, burning)

Hypermetropia

□ Classification

- ① **Mild: less than +3D,**
- ② **moderate: +3D or less than +5D**
- ③ **High: more than +5D**

《Etiology》

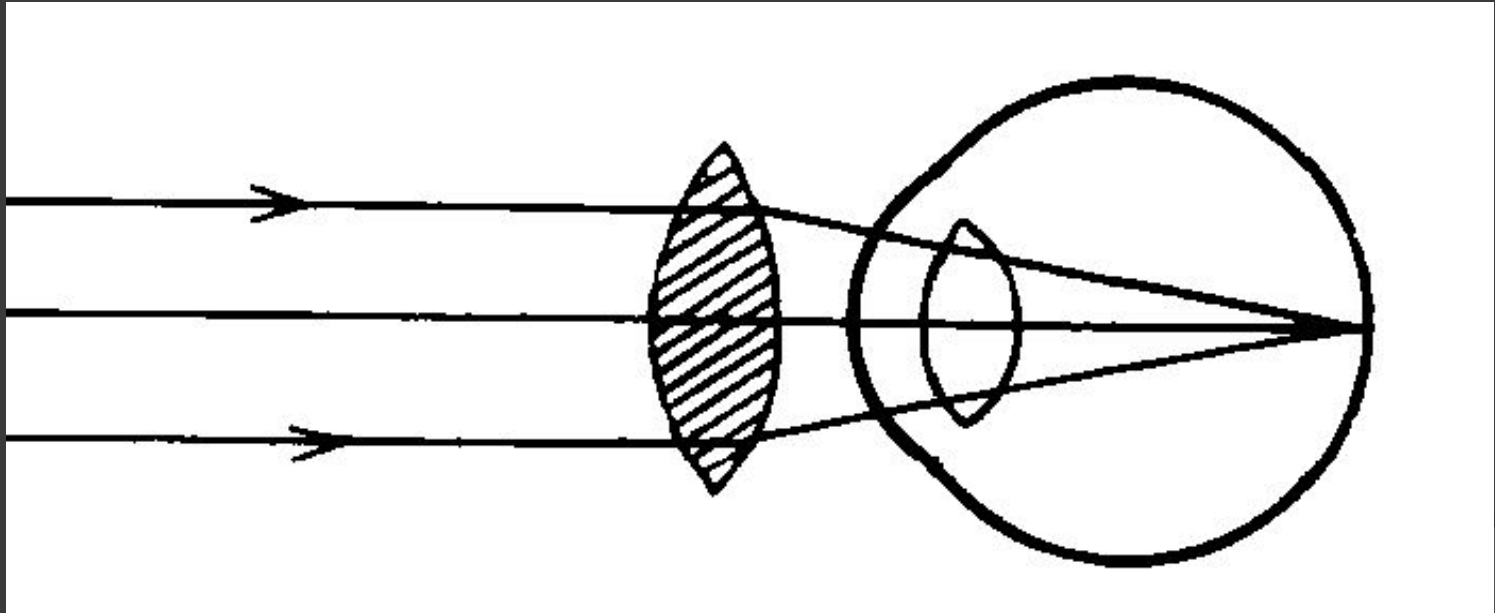
- <1>. **Axial hyperopia** is indicated that ocular axis is short but refractive power is normal.
- <2>. **Refractive hyperopia** is indicated that ocular axis is normal, but refractive power is weak.

《Clinical findings》

□ <1>.Visual acuity Mild hyperopia may be compensated by accommodation, so far or near vision may be normal in mild hyperopia of juvenile,

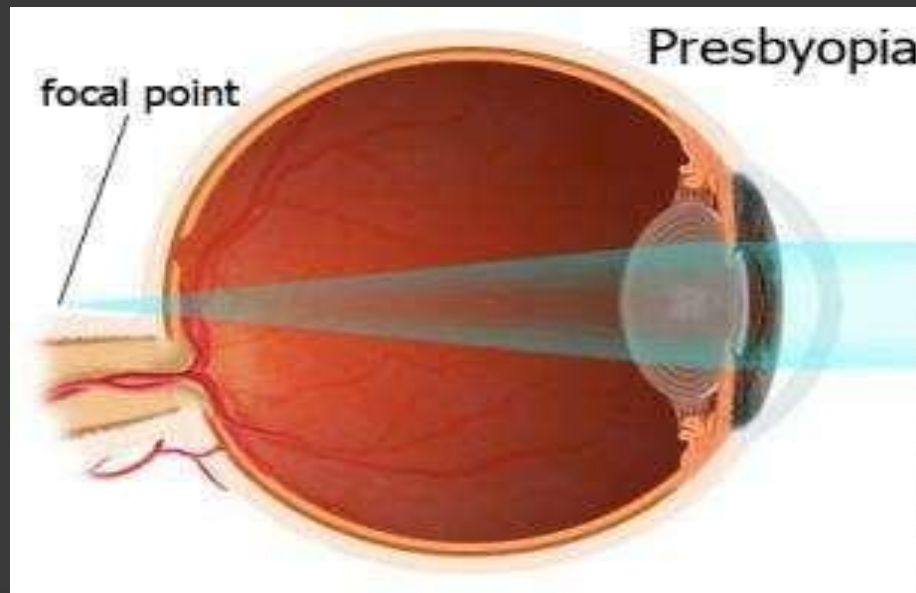
□ if the degree of hyperopia is large or accommodative power decreases with aging, both far and near vision decrease in different degrees, and near vision is much worse than far one.

Correction of hyperopia



Presbyopia

- With age, lens becomes less elastic
- Accommodation power becomes +2D at 50 yrs and 0D at 70yrs of age
- Person needs bifocal lens



■ Presbyopia

Presbyopia, also known as the “**short arm syndrome**,” is a term used to describe an eye in which the natural lens can no longer accommodate. With aging, accommodative function decreases gradually, at about **40-45** years of age, difficulty takes place in near work or reading, this decrease of physiologic accommodation caused by aging is known as **presbyopia**.

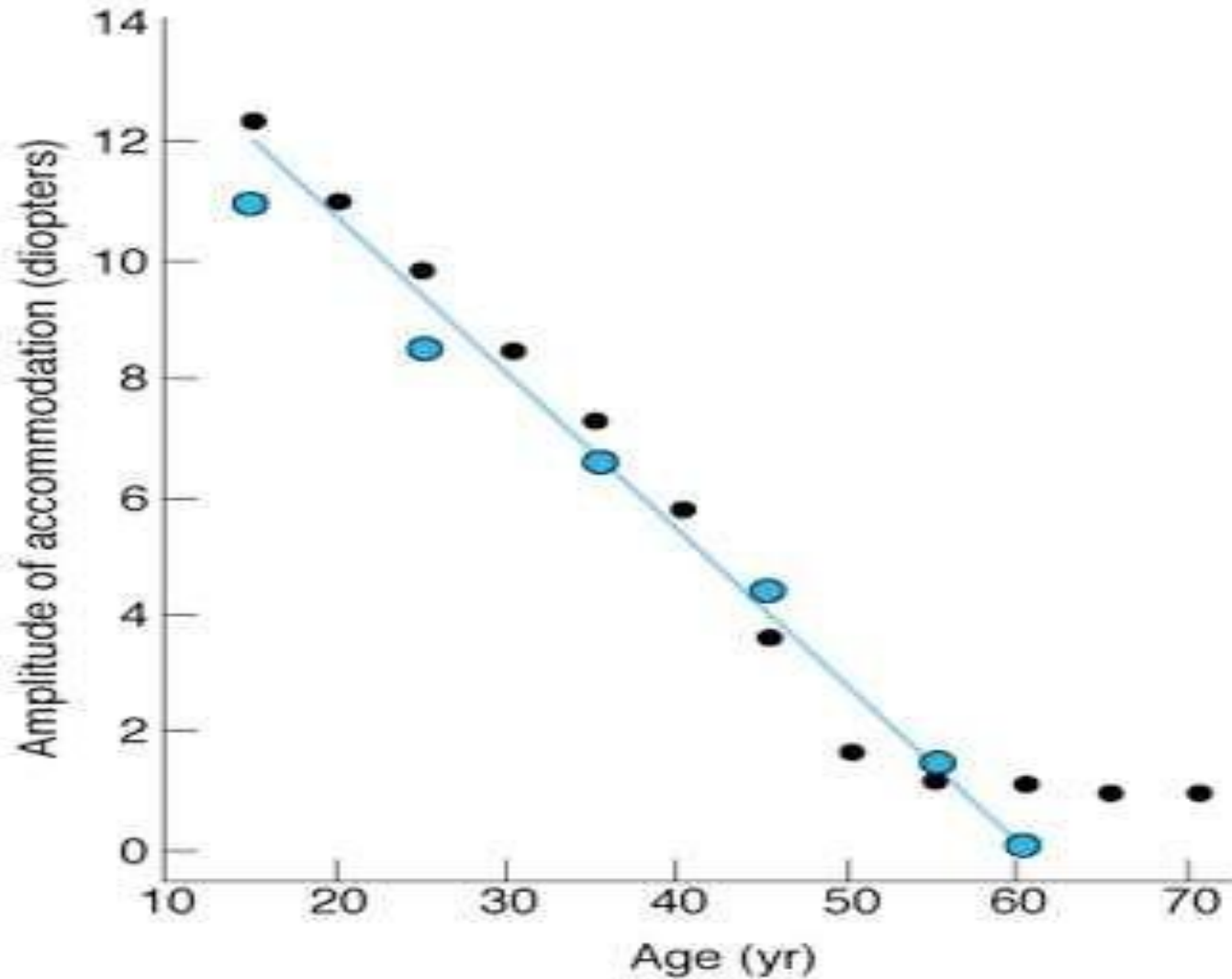
《Clinical finding》

- **Most people first notice difficulty reading very fine print such as the phone book, a medicine bottle, or the stock market page. Print seems to have less contrast and the eyes become easily fatigued when reading a book or computer screen. The symptom of presbyopia is difficult to see near thing.**

Signs and Symptoms

- Difficulty seeing clearly for close work
- Print seems to have less contrast
- Brighter, more direct light required for reading
- Reading material must be held further away to see (for some)
- Fatigue and eyestrain when reading
-

Amplitude of accommodation Vs age



(3). Astigmatism

- **Due to the difference of refractive power in every meridian of eye, so outsidelight rays can'tfocus on the retina to form clear image.**

(3). Astigmatism

- Astigmatism means that the cornea is oval instead of spherical like a basketball. Most astigmatic corneas have two curves – a steeper curve and a flatter curve. This causes light to focus on more than one point in the eye, resulting in blurred vision at distance or near. Astigmatism often occurs along with nearsightedness or farsightedness.

《Etiology》

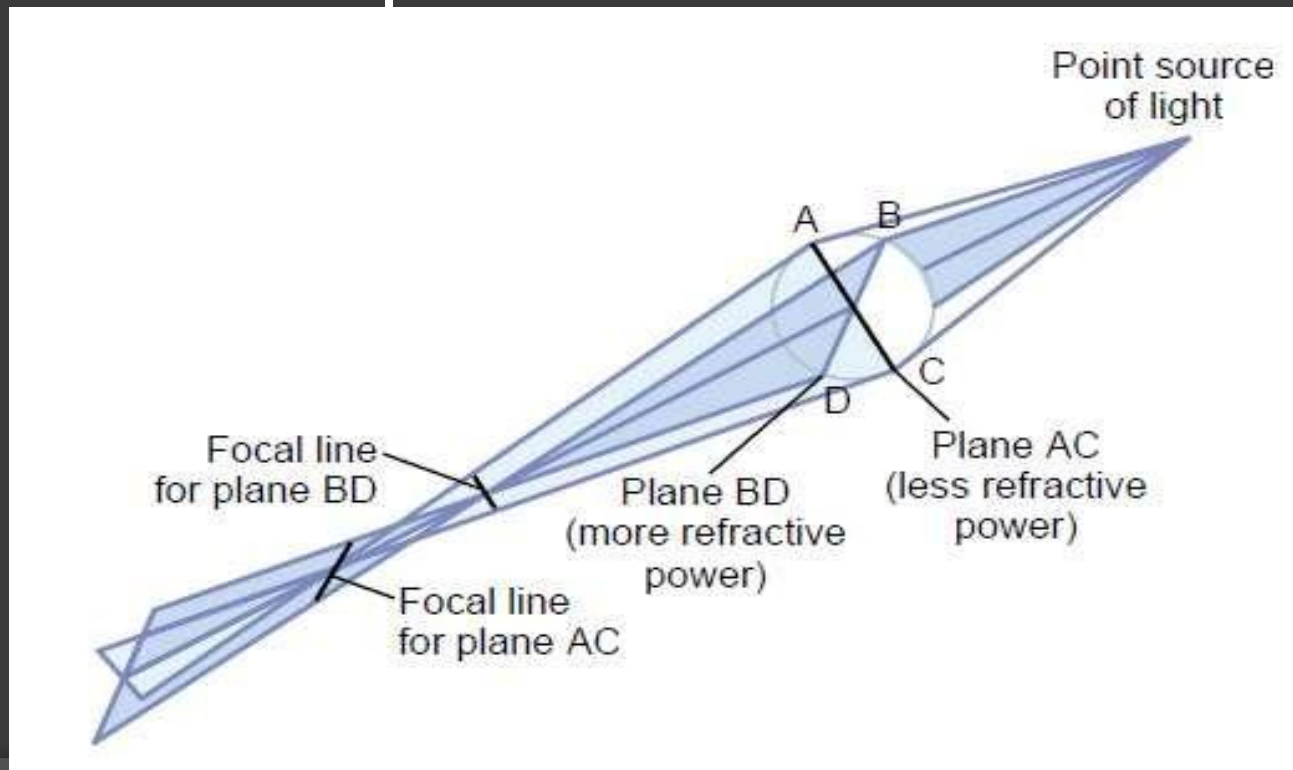
- **Most common cause is that the radii of curvature of cornea and lens are different in each meridian, generally, their difference between two main meridians is biggest.**

4.

Astigmatism:

Stigma=point

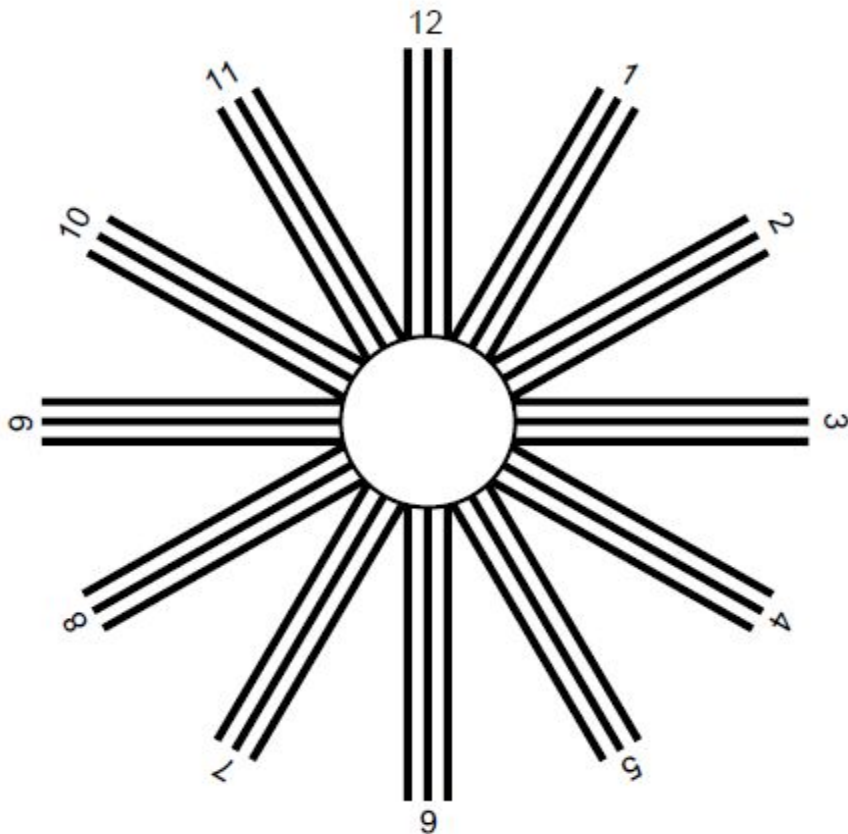
Different curvatures in different planes of



Physiological astigmatism or vertical astigmatism

Types of astigmatism-

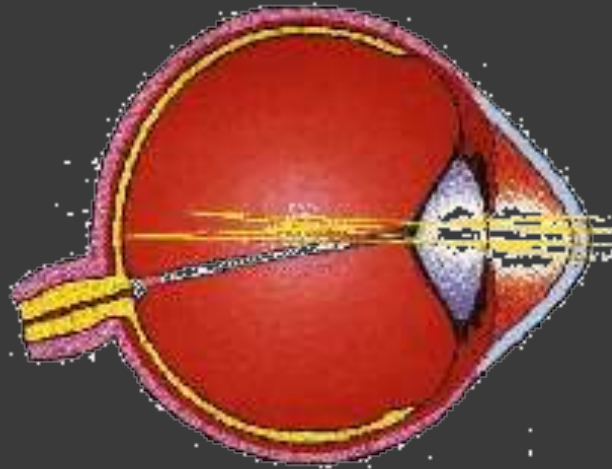
- (a) Curvature astigmatism (cornea)
- (b) Index astigmatism (lens malposition)



Parallel bars to
determine the axis of
cylindrical
abnormalities

Astigmatism

- Irregular Curvature in parts of the cornea or lens
- Causes blurry image



- This may be corrected by specially ground lenses which compensate for the irregularity or laser surgery.

Treatment of astigmatism:

Spherical correction is done first for one of the two planes of astigmatism □

Additional cylindrical correction is done in the perpendicular plane

《Treatment》

- Astigmatism can be corrected with glasses (**cylindrical lens**), contacts, or surgically. The most common surgeries used to correct astigmatism are astigmatic keratotomy (procedures that involve placing a microscopic incision on the eye) and LASIK. The objective of these procedures is to reshape the cornea so it becomes more spherical or uniformly curved.

Optical aberration

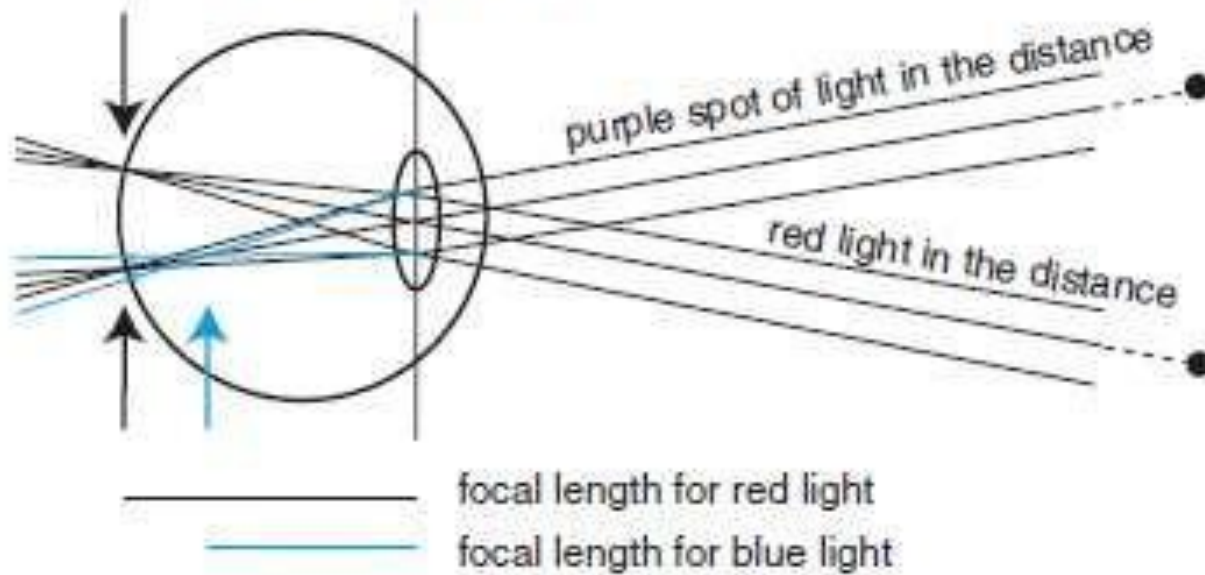
- **Spherical aberration:**

Iris functions to reduce this by covering periphery of the lens

- **Chromatic aberration:**

Red color is refracted least & violet is refracted most

C. Focusing of light in a simplified eye



D. objects viewed

appearance
if objects are red

appearance
if objects are purple



Contact lens

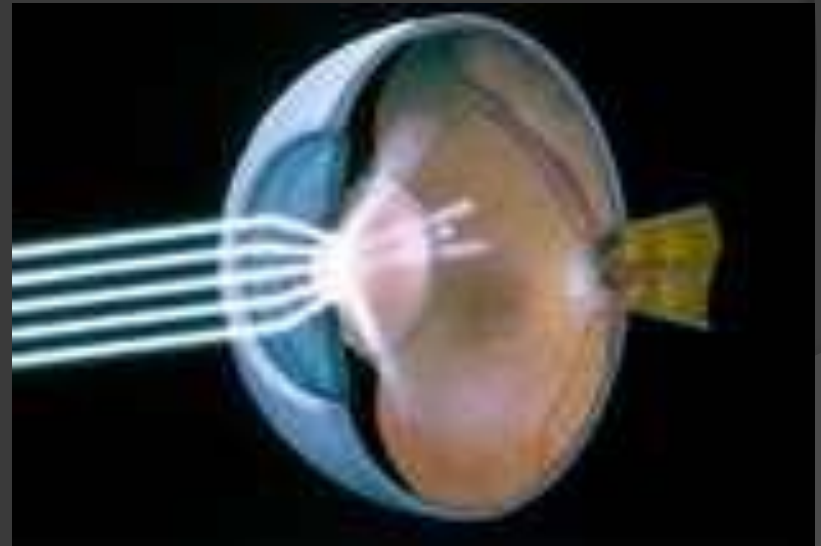
- Broader field of clear vision
- No considerable reduction in object size
- No jack-in-box phenomenon

Cataract

- Cloudiness of lens
- Denaturation and coagulation of lens proteins
- Commonest cause of reversible blindness
- Treatment- extraction and replacement with artificial intra-ocular lens

Cararact

- Clouding of lens due to aging, diabetes mellitus, heavy smoking, frequent exposure to intense sunlight or congenital factors



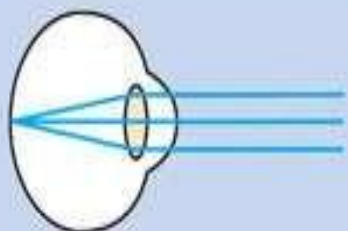
Treatment: Lens
Implant

Visual Acuity

Sharpness of vision

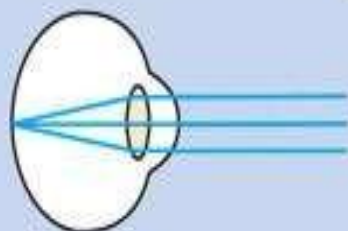
With myopia (nearsightedness) image is focused in front of retina because eyeball is too long

With hyperopia (farsightedness) image is focused behind retina because eyeball too short

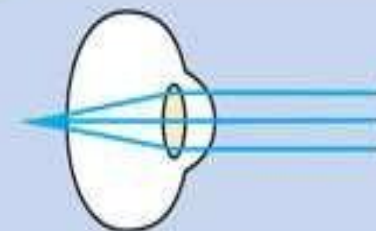


Emmetropia (normal vision)
Rays focus on retina

(a)

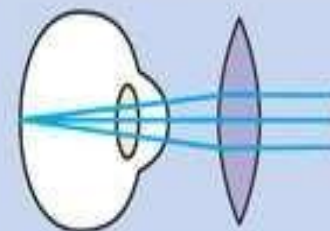


No correction necessary

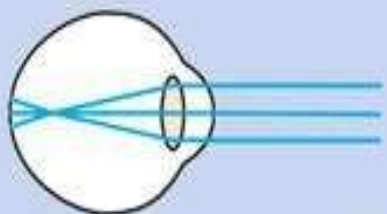


Hyperopia (farsightedness)
Rays focus behind retina

(c)

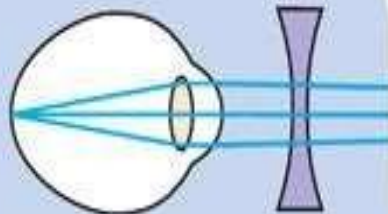


Convex lens corrects farsightedness

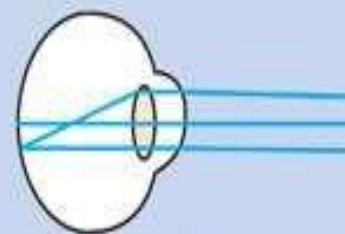


Myopia (nearsightedness)
Rays focus in front of retina

(b)

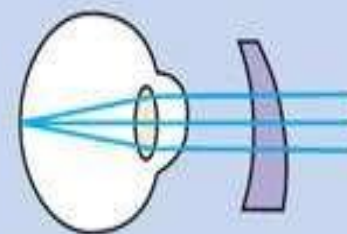


Concave lens corrects nearsightedness



Astigmatism
Rays do not focus

(d)

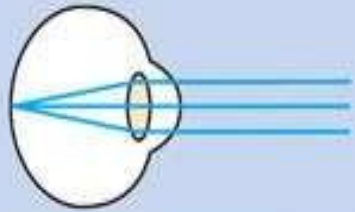


Uneven lens corrects astigmatism

Visual Acuity continued

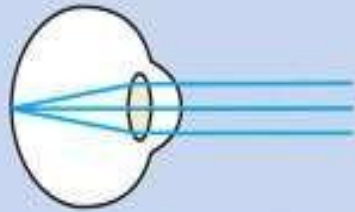
- With astigmatism cornea or lens is not symmetrical

- Light is bent unevenly

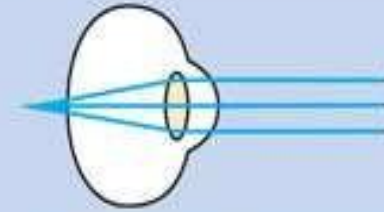


Emmetropia (normal vision)
Rays focus on retina

(a)

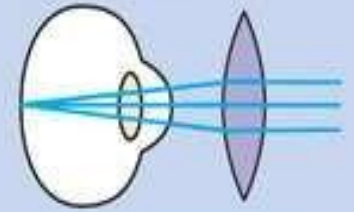


No correction necessary

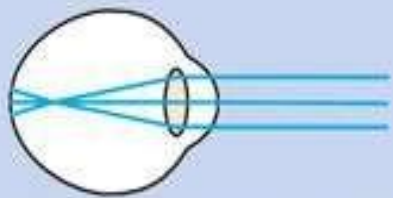


Hyperopia (farsightedness)
Rays focus behind retina

(c)

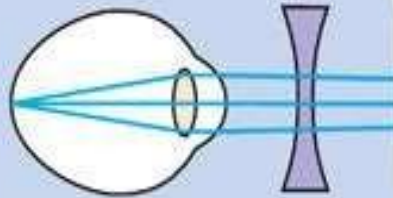


Convex lens corrects farsightedness

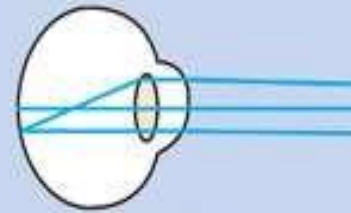


Myopia (nearsightedness)
Rays focus in front of retina

(b)

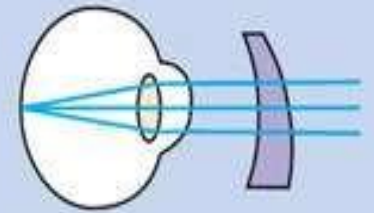


Concave lens corrects nearsightedness



Astigmatism
Rays do not focus

(d)



Uneven lens corrects astigmatism