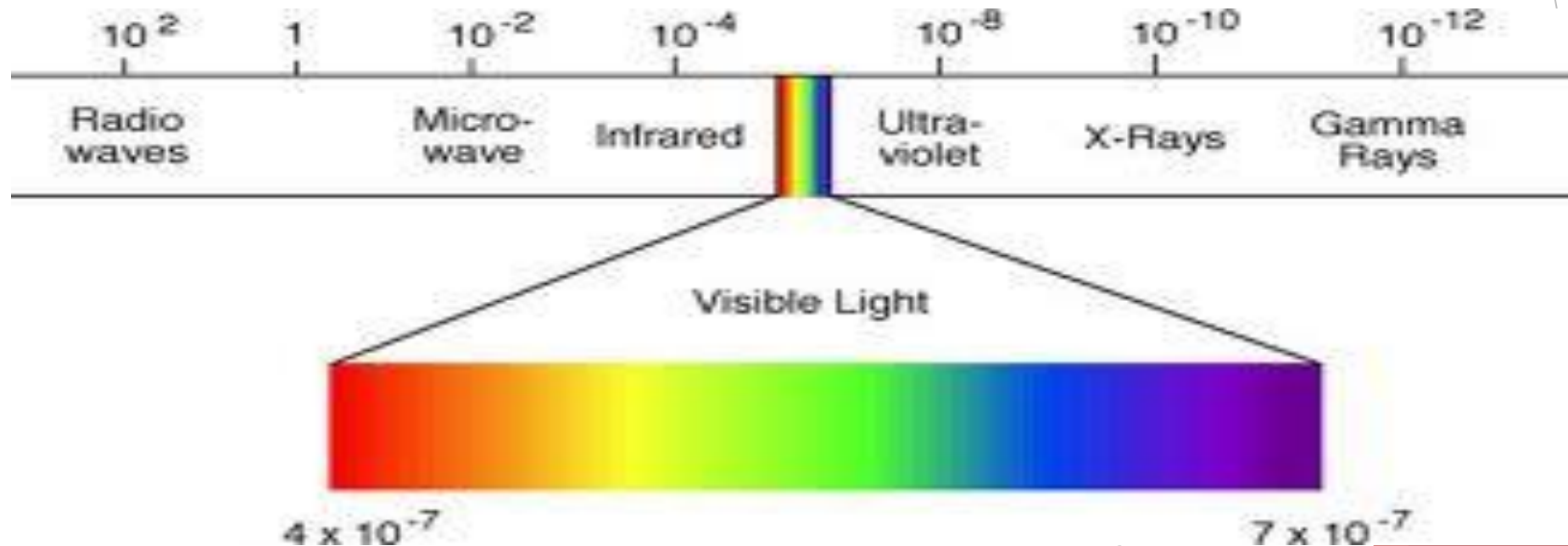


# Optics and Refraction

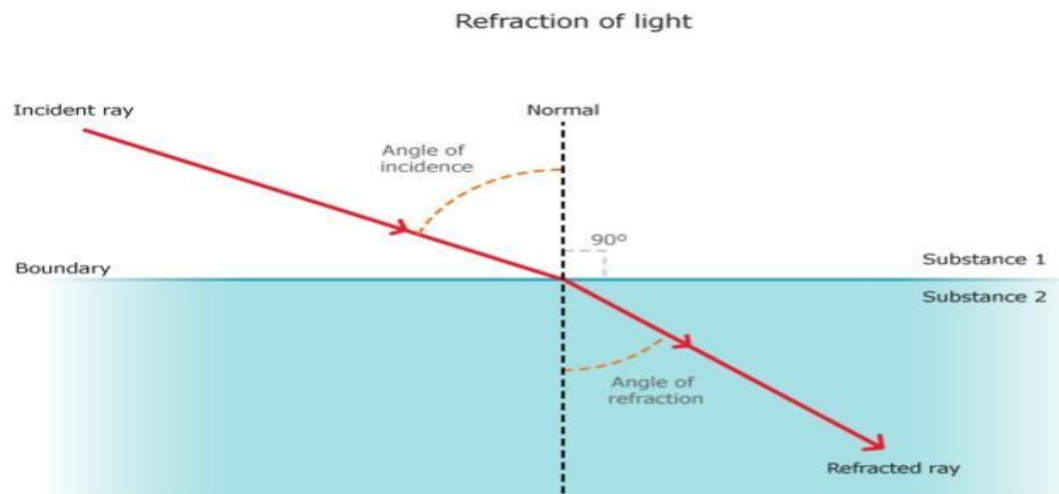
# Physical optics

- The visible part of the EM spectrum, to which the retina is sensitive, lies between the wavelengths 390nm & 760nm.
- Light should be correctly focused on the retina for the eye to generate accurate visual information.



Light travels in a straight line. But when it reaches another medium it will bend. This is called refraction.

This is how lenses work, and also how we see.



The focus must be adjustable to allow clear vision for both near & distant objects (accommodation).

Refractive components of the eye or the focusing power is :

- \*\* 2/3 (cornea and “air/tear” interface), fixed power
- \*\* 1/3 lens, power increases with accommodation

These two elements converge parallel rays because :-

- 1) Cornea has higher refractive index than air.
- 2) lens has higher refractive index than aqueous and vitreous humours.
- 3) Cornea & lens are spherically convex in shape



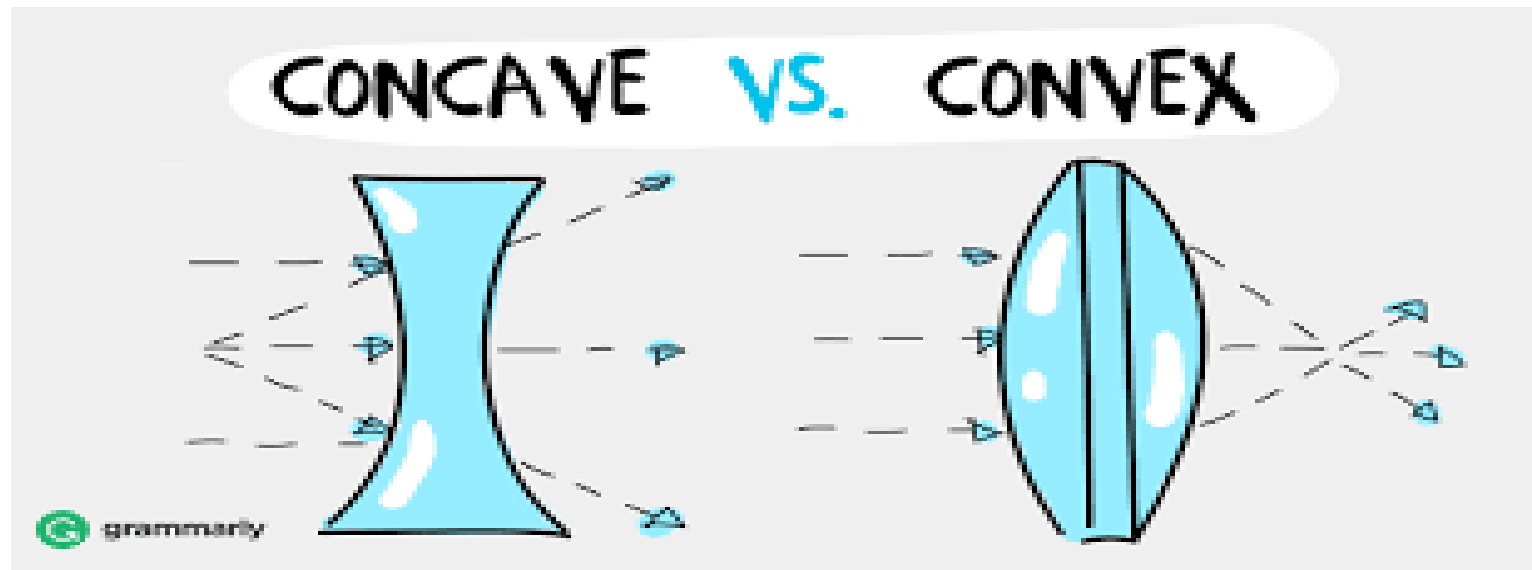
Rendia

**Diopter (D)** : measurement of the refractive power of a lens, equal to the reciprocal of the focal length in meters “ 1/meters” . Simply describes the power of the lens.



\*\*\*\* A negative lens is a diverging lens ,concave ,corrects for myopia

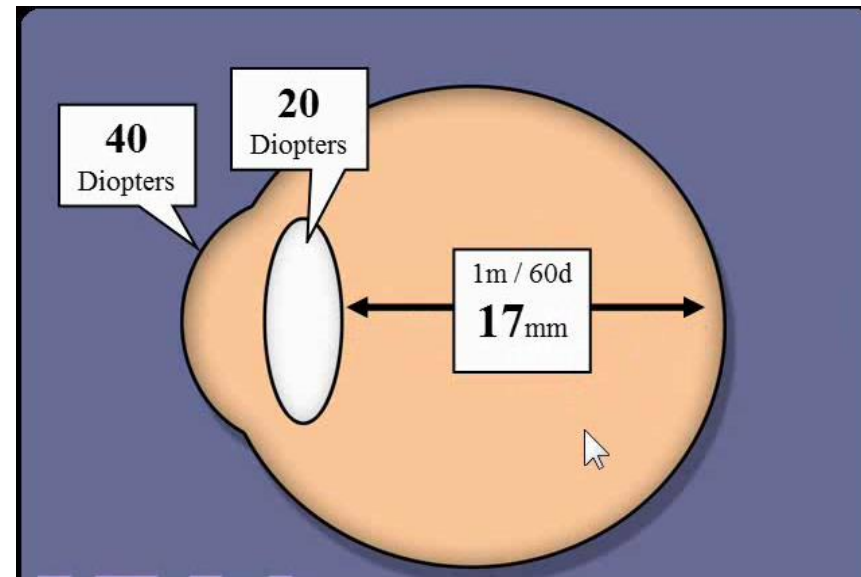
\*\*\*\* A positive lens is a converging lens ,convex ,corrects for hypermetropia.



# Definition

- ▶ Refraction is the bending of light rays as they pass through one object to another
- ▶ The cornea and lens bend (refract) light rays to focus them on the retina
- ▶ When the shape of the eye changes, it also changes the way the light rays bend and focus – and that can cause blurry vision

Eye is a bunch of lenses.





# causes

Refractive errors can be caused by:

- Eyeball length (when the eyeball grows too long or too short)
- Problems with the shape of the cornea (the clear outer layer of the eye)
- Aging of the lens (an inner part of the eye that is normally clear and helps the eye focus)

# symptoms

The most common symptom is blurry vision. Other symptoms include:

- Double vision
- Hazy vision
- Seeing a glare or halo around bright lights
- Squinting
- Headaches
- Eye strain (when your eyes feel tired or sore)
- Trouble focusing when reading or looking at a computer

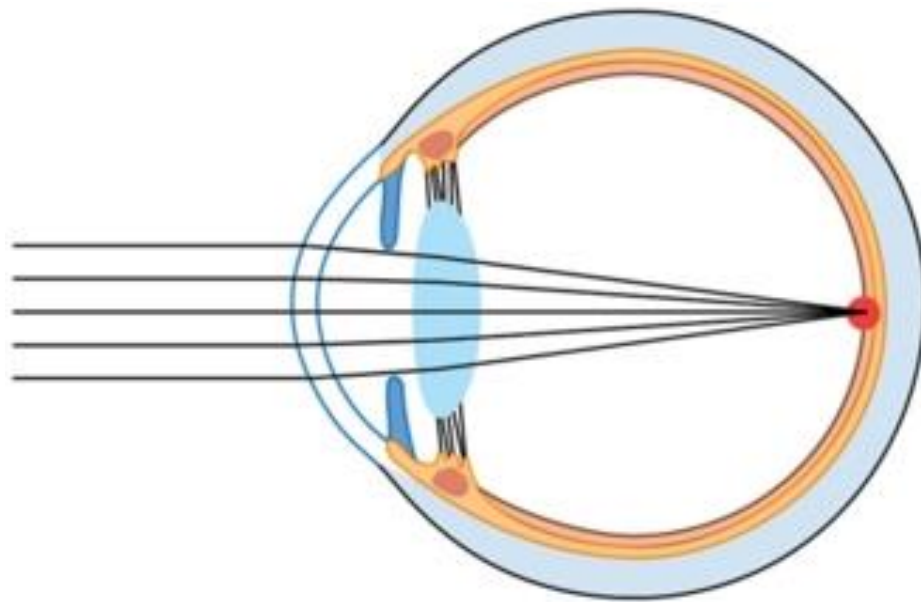
# Definitions

There are 4 common types of refractive errors:

- ▶ **Nearsightedness (myopia)** makes far-away objects look blurry
- ▶ **Farsightedness (hyperopia)** makes nearby objects look blurry
- ▶ **Presbyopia**: Loss of accommodative ability of the lens resulting in difficulties with near tasks. i.e. makes it hard for middle-aged and older adults to see things up close
- ▶ **Astigmatism**: the curvature of the cornea and/or lens is Not spherical and therefore causes image blur on the retina. Optical power on different planes is not equal. i.e. can make far-away and nearby objects look blurry or distorted
- **Aniseikonia**: a difference of image size between the 2 eyes as perceived by the patient.
- **Anisometropia**: a refractive power difference between the 2 eyes (usually > 2D)
- **Aphakia**: ( Phakos=lens), aphakia is no lens.
- **Pseudophakia**: artificial lens in the eye.

# Refractive errors

**Emmetropia** :- when parallel rays of light from a distant object are brought to focus on the retina with the eye at rest “not accommodating”.



**Emmetropia**  
(normal vision)

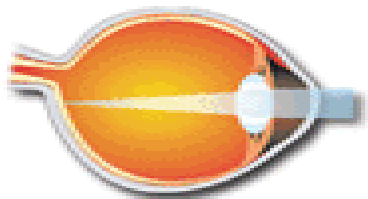
**Ametropia** :- when parallel rays of light are not brought to a focus on the retina in an eye at rest. It's simply "refractive error". A change in refraction is needed to achieve sharp vision.

Ametropia is divided into:

- 1) Myopia: Short sightedness
- 2) Hyperopia (Hypermetropia):  
= Long (far) sightedness.
- 3) Astigmatism :non spherical cornea.

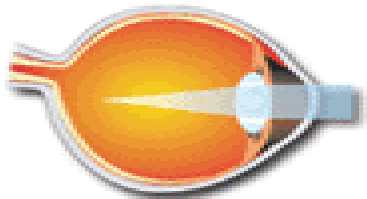
## **REFRACTIVE ERRORS**

**Normal Eye**



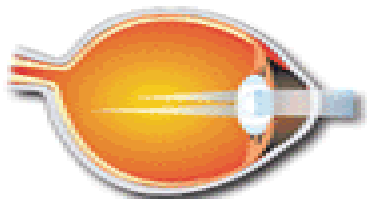
Light rays focus on the retina

**Myopia**



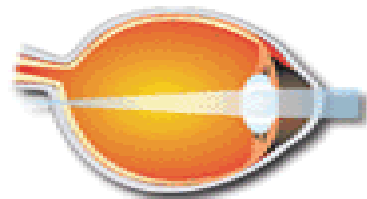
Light rays focus in front of the retina

**Astigmatism**



Light rays focus on more than one point (unequal refraction of light in different meridians)

**Hypermetropia**



Light rays focus behind the retina

# Hypermetropia

## Aka **Farsightedness (Hyperopia)**

a refractive error that makes nearby objects look blurry. It happens when the shape of the eye makes light focus behind the retina (a light sensitive layer of tissue at the back of your eye), instead of on it.

A lot of children are farsighted, this makes sense as they have small weak eyes. So it's a stage in normal development of the eye (physiologic), or due to any cause that shortens the globe (pathological Hyperopia).

Special forms: Ectopia lentis (displacement of lens from its normal position).  
Post operative aphakia.

Rays of light converge behind the retina, which causes blurring of vision for near objects  $\pm$  distant objects.

Hypermetropes must accommodate with distant gaze to bring image into retina.

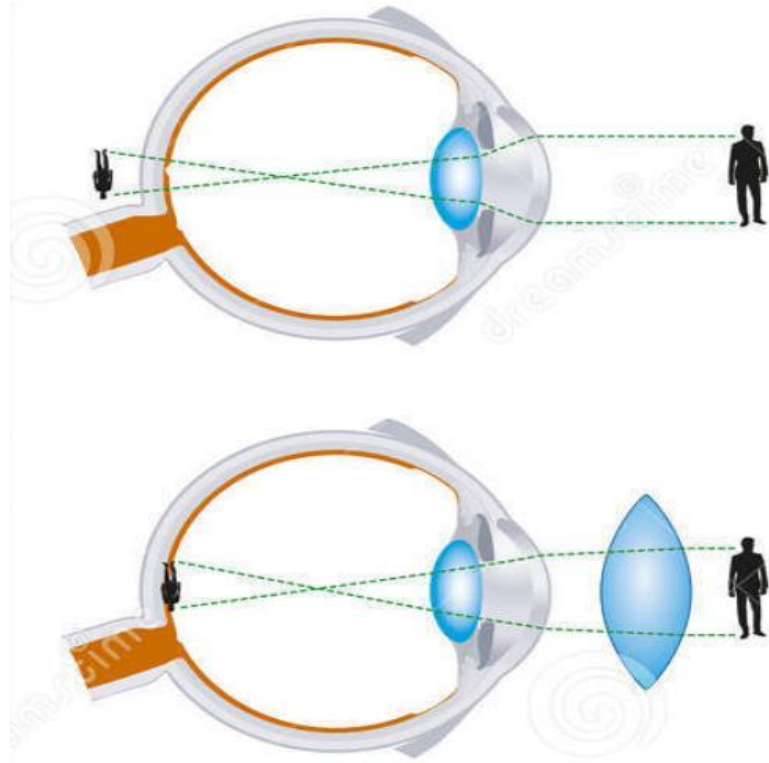
# Hypermetropia- why?

- ▶ Farsightedness happens when your eyeball grows too short from front to back, or when there are problems with the shape of your cornea (clear front layer of the eye) or lens (an inner part of the eye that helps the eye focus).
- ▶ These problems make light focus behind the retina, instead of on it – and that makes nearby objects look blurry.
- ▶ Most people who are farsighted are born with it, but it may not cause vision problems until you get older. You're more likely to be farsighted if other members of your family are farsighted too.
- The length of the eyeball is shorter than it should be.
- stage in normal development of the eyes—at birth eyes are hypermetropic
- When persists in adulthood it represents an imperfectly developed eye.

# Hypermetropia -symptoms

- ▶ The most common symptoms of farsightedness are:
  - Trouble seeing things up close
  - Eye strain ; ciliary muscle is straining to maintain accommodation (when your eyes feel tired or sore)
  - Headaches – especially when reading
- ▶ If you have mild farsightedness, you may not notice any symptoms. That's why it's important to get regular eye exams
- ▶ Children with severe farsightedness may also be at higher risk for other eye problems, like [strabismus \(crossed eyes\)](#) or [amblyopia \(lazy eye\)](#).
- In a child with an equal degree of long sight in both eyes, a convergent squint may develop because of increased accommodative effort to focus distant, and particularly nearby objects.





Hyperopia

# Myopia

## Nearsightedness

- ❑ a refractive error that makes far-away objects look blurry. It happens when the shape of the eye makes light focus in front of the retina (a light sensitive layer of tissue in the back of your eye), instead of on it.
- ❑ usually starts between ages 6 and 14 and gets worse until your early twenties
- ❑ Usually presents in 1<sup>st</sup> or 2<sup>nd</sup> decades ,rarely begins after the age of 25,except in pts with D.M or cataract.
- ❑ Keratoconus(conical cornea) is a pathological cause of myopia, (comes also with irregular stigmatism).
- ❑ Blurring of distance vision, the near isn't affected .
- ❑ Complications ( though rare) : retinal tear or detachment, macular hole, and open angle glaucoma.
- ❑ Not prevented with refractive correction.
- ❑ Management: corrected by a diverging lens “concave”, or refractive eye surgery.

People who have severe nearsightedness (also called high myopia) may also be at higher risk for other eye conditions, like [retinal detachment](#) (when the retina is pulled away from its normal position).

# causes

- ▶ Nearsightedness happens when your eyeball grows too long from front to back, or when there are problems with the shape of your cornea (clear front layer of the eye) or lens (an inner part of the eye that helps the eye focus).
- ▶ These problems make light focus in front of the retina instead of on it – and that makes far-away objects look blurry.

# DEGREES OF MYOPIA

Low myopia:  
usually describes  
myopia of  $-3.00$   
diopters or more



Medium myopia usually  
describes myopia  
between  $-3.00$  and  
 $-6.00$

diopeters Those with  
moderate amounts of  
myopia are more likely to  
have

Pigmented dispersion  
syndrome or pigmented  
glaucoma



High myopia usually  
describes myopia of  
 $-6.00$  or less  
(toward  $-10.00$ ). People  
with high myopia are  
more likely to have  
retinal detachment and  
primary open angle  
glaucoma,  
also more likely  
to experience floaters,  
shadow-like shapes which  
appear singly or  
in clusters in the field of  
vision.



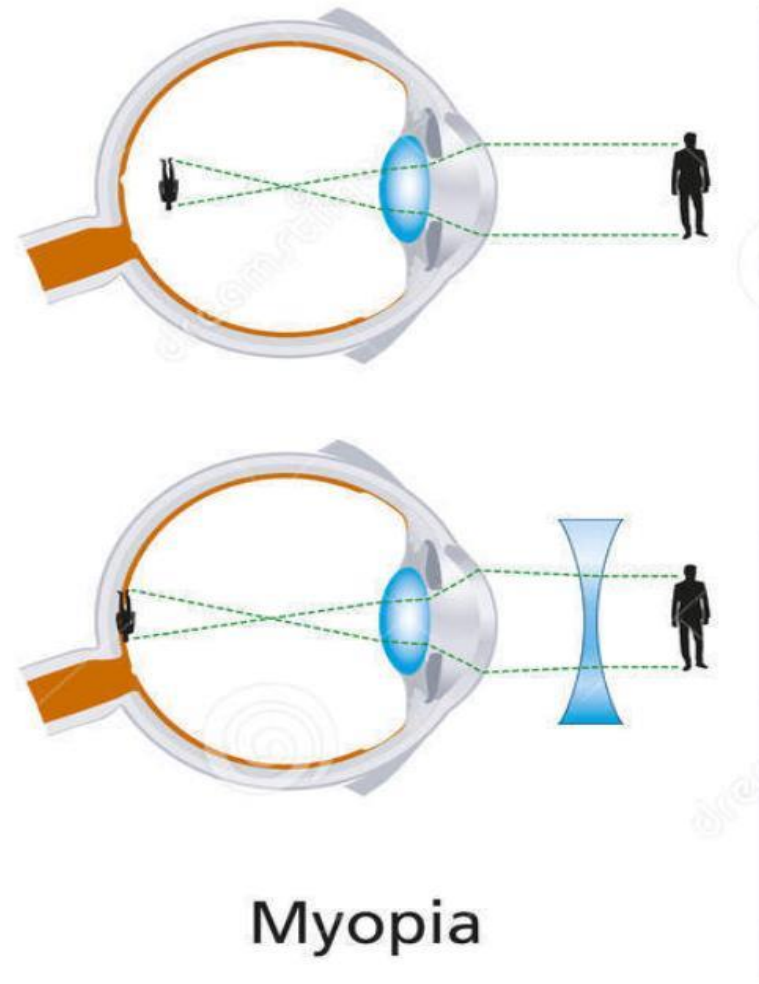
**MILD**  
 $> -2.25$  TO  $-3$



**MODERATE**  
 $> -3$  TO  $-6$



**HIGH**  
 $> -6$



Myopia

# Astigmatism

Light rays aren't refracted uniformly in all meridians due to non spherical shape of cornea or lens, parallel rays passing through these different planes are brought to different points of focus.

The cause of astigmatism is unknown. It is usually present from birth, and often occurs together with nearsightedness or farsightedness.

Astigmatism makes it difficult to see fine details, either close up or from a distance.

Corrected with a cylindrical lens(planoconvex or planoconcave) or refractive eye surgery.

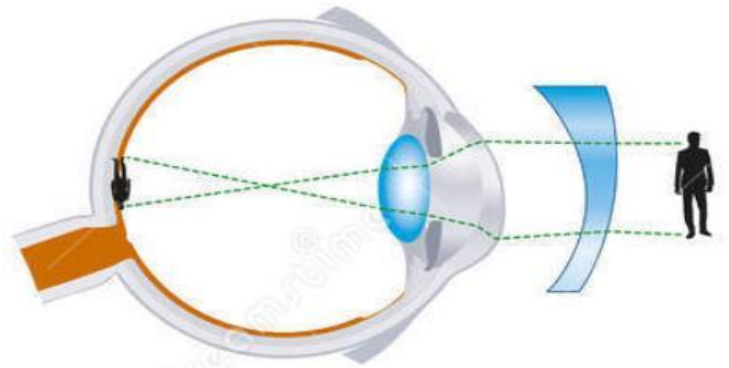
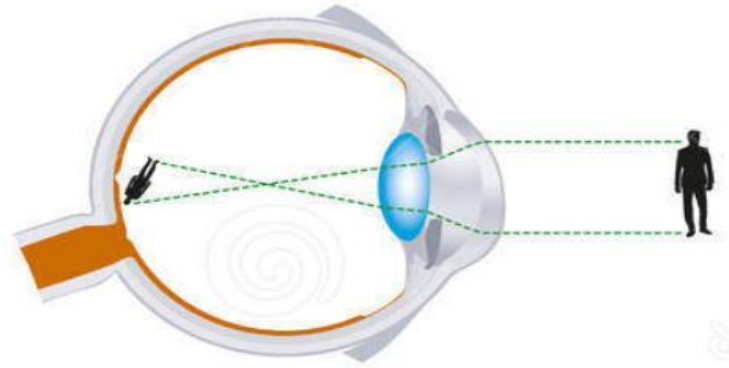
Astigmatism is a common eye problem that can make your vision blurry or distorted. It happens when your cornea (the clear front layer of your eye) or lens (an inner part of your eye that helps the eye focus) has a different shape than normal.



# symptoms

The most common symptoms of astigmatism are:

- Blurry vision
- Needing to squint to see clearly
- Headaches
- Eye strain
- Trouble seeing at night



Astigmatism



# Presbyopia

- A normal aging process, when near images can't be focused on the retina due to reduced accommodative ability.
- The focus is behind the retina as in hyperopia.
- Makes it hard for middle-aged and older adults to see things up close. It happens because the lens (an inner part of the eye that helps the eye focus) stops focusing light correctly on the retina (a light-sensitive layer of tissue at the back of the eye).
- Presbyopia is a normal part of aging. Everyone gets presbyopia as they get older — usually after age 45. Many people have another refractive error in addition to presbyopia.



# symptoms

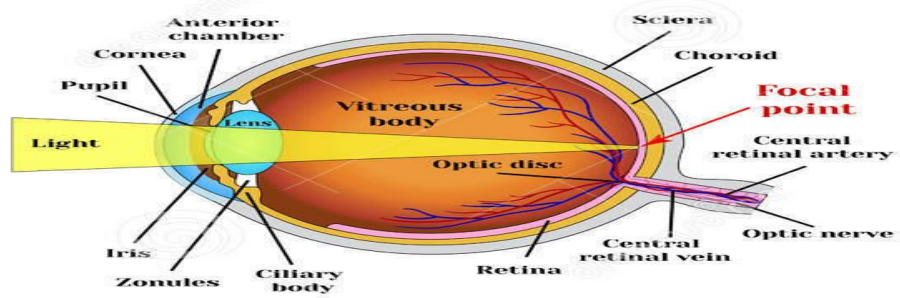
symptoms of presbyopia include:

- Trouble seeing things up close
- Needing to hold reading materials farther away to focus on them
- Eye strain (when your eyes feel tired or sore)
- Headache
- ▶ Presbyopia gets worse over time, but it usually stops getting worse after age 65.

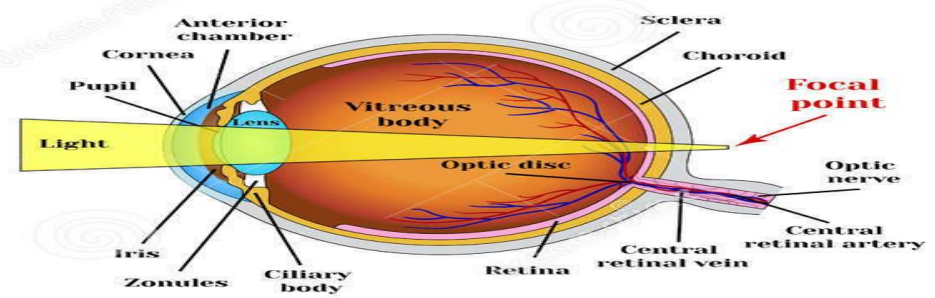
# causes

- ▶ As you age, the lens in your eye gets harder and less flexible, and it stops focusing light correctly on the retina. This makes nearby objects look blurry

## Normal vision

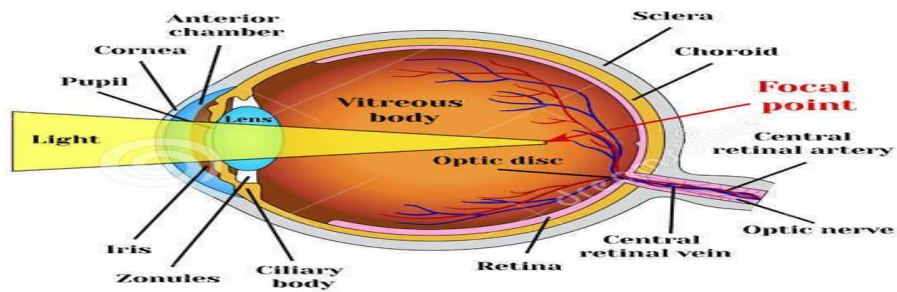


## Hyperopia

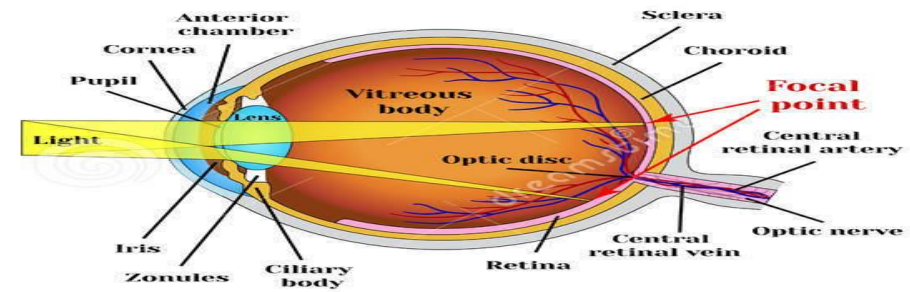


## Refractive errors

### Myopia



### Astigmatism



NORMAL VISION

MYOPIC VISION

HYPEROPIC VISION