Ministry of Higher Education and Scientific Research
Al-Mustaqbal University
College of Medicine

Medical Physics

Physics of the eye and vision

First stage

Lecture 10

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Physics of the eye and vision

Introduction

Vision **depends** on three **important supports** :

1-The eye directs images of visible objects around it to the retina

2-The optic nerve that carries information through millions of nerve fibers to the brain

3-The visual center in the brain that interprets and analyzes this information

The eye has important properties:

1-It has a wide and large viewing **angle**, in addition to being concerned with seeing a specific target that falls directly on it

2-Eyelash process **helps clean the eye through detergents in the eye glands**

3-The eye operates over a wide range of light intensities(**$1:10^{10}$**)

4-The human eye opening works automatically

5-The eye has a system that regulates the pressure inside it and maintains it at ***20 mm Hg***

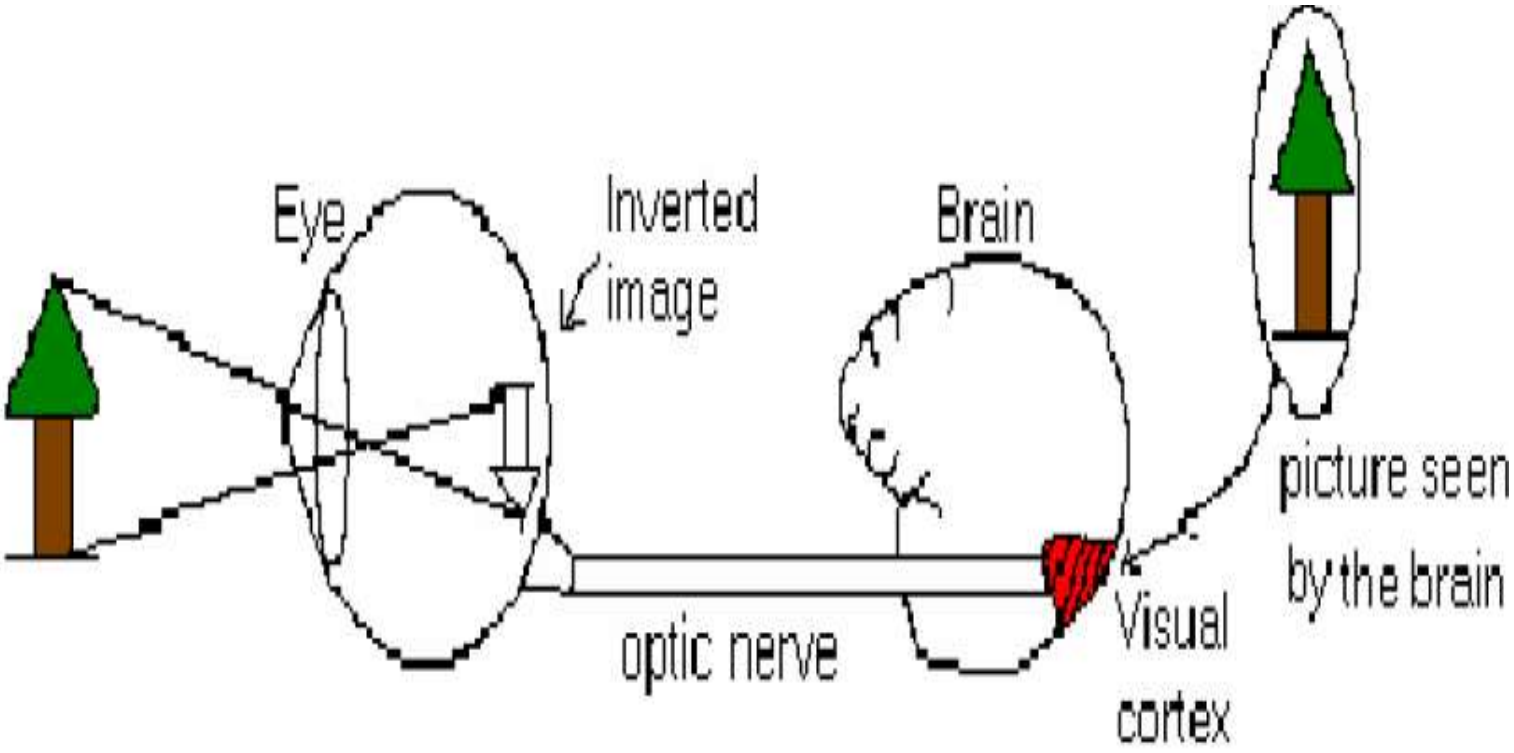
6-The cornea is transparent and blood vessels do not pass through it.

7-The eye is supported by fatty bases that protect it from shocks and absorb them. It is also surrounded by an orbit as a protective shield.

8-Images appear upside down on the retina, but the brain corrects them.

9-The brain controls the images and gives the signal and feeling of seeing.

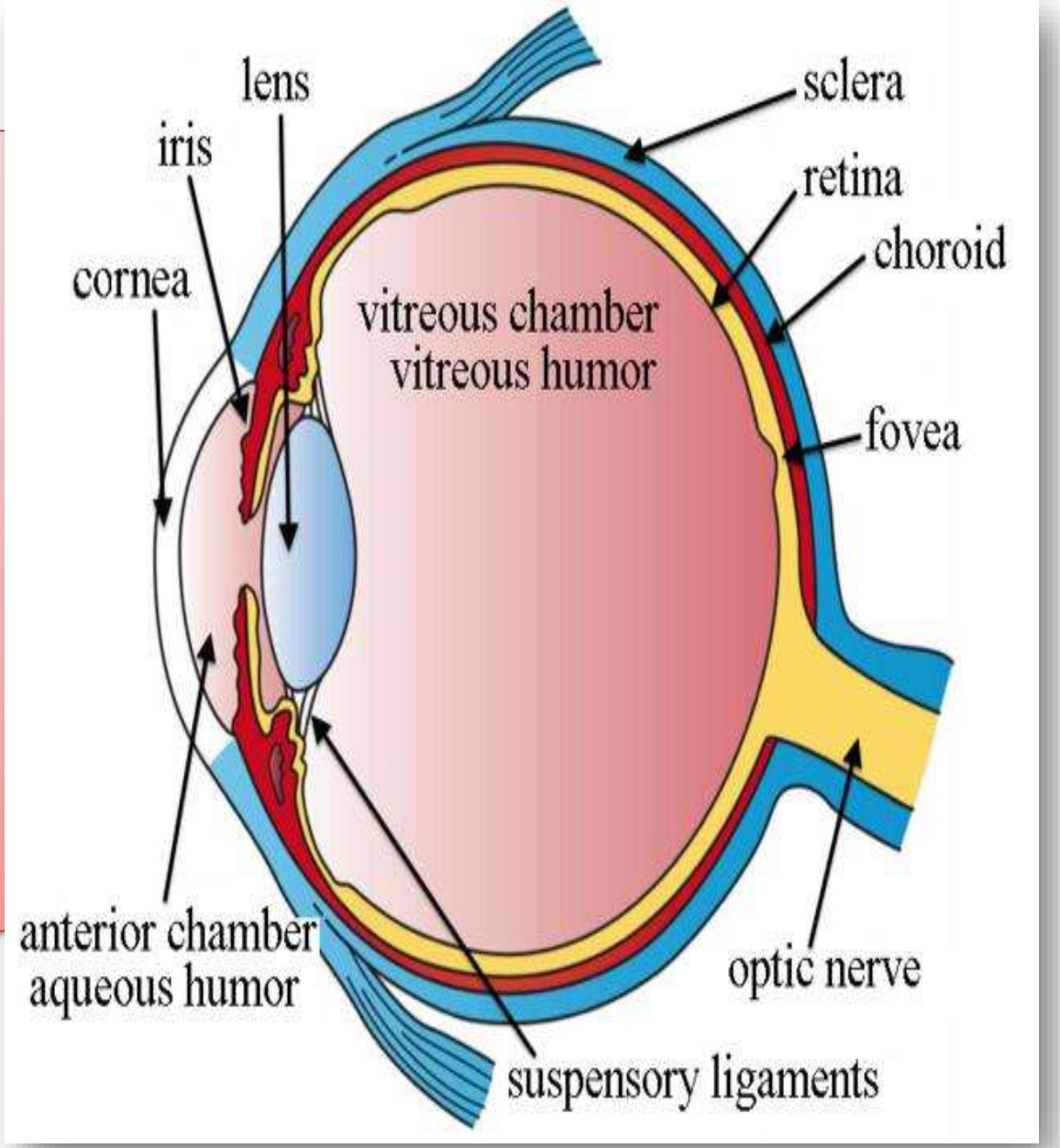
10-The flexible muscles of the eye enable it to move in every direction.


Eye
Inverted image
Brain
picture seen by the brain
optic nerve
Visual cortex

Focus elements in the eye

1-cornea

is a transparent part in the front of the eye that performs the task of focusing by refracting the light passing through it.



2-The lens of the eye

performs the process of precise focusing because it is flexible and fixed by flexible muscles that enable it to change its strength and focal length

It should be noted that the **refraction of light through the cornea** depends on:

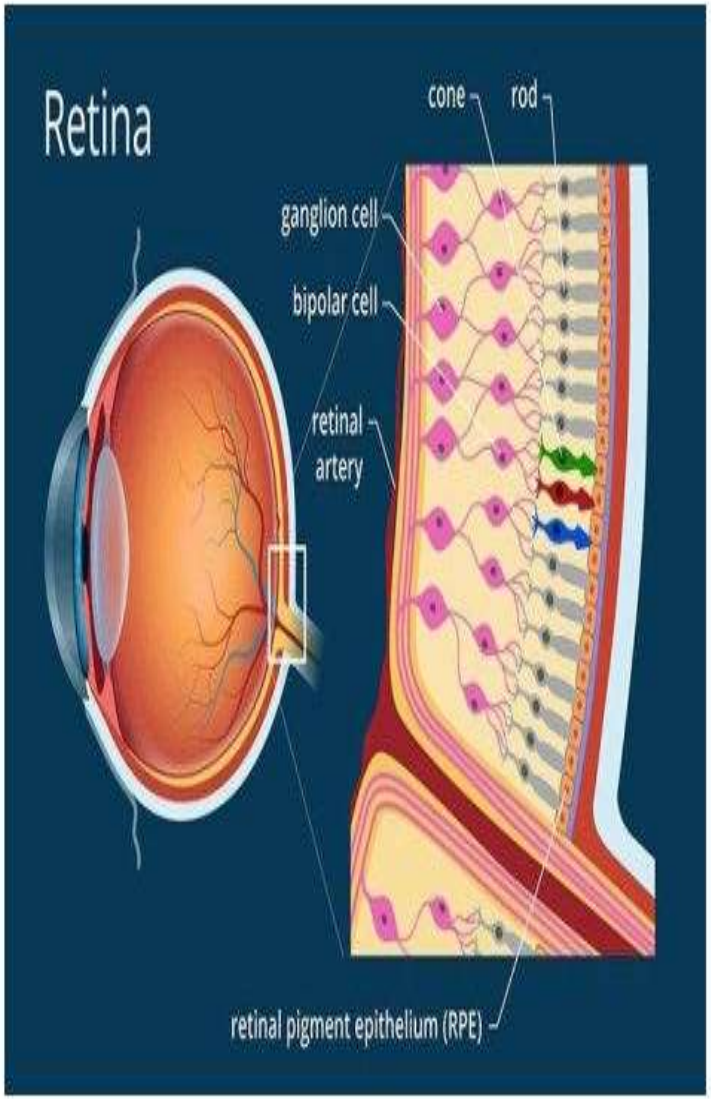
1-The radius of curvature of the surface

2-The velocity of light in the eye lens.

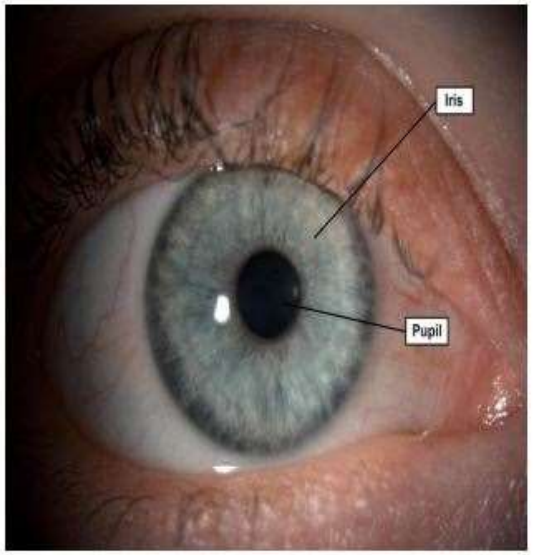
It **takes** into **account** the **refractive index and** the **refractive index of the cornea**

The **aqueous fluid** adjacent to its **inner surface** provides it with the nutrients it needs **because it contains all the components of blood except for red blood cells.** It **obtains oxygen** from the **air** and the cornea heals itself like other living cells if it is scratched. However, if it is **exposed** to some **radiation such as ultraviolet rays or X-rays** and others, the opacity will increase and its **transparency** will decrease. It can be **replaced** and **accepted** by the **body because the rate of construction in it is slow**

The Retina: The light sensitive part of the eye. It converts the light image into electrical nerve impulses that one sent to the brain.



The Iris: It is the colored part of the front eye. The function of iris is adaptation of vision from light to dark and vice versa.

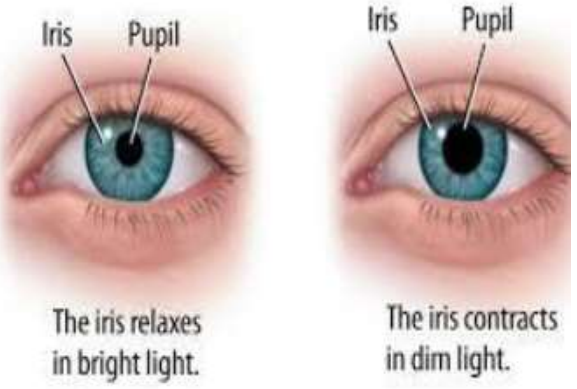


- It is believed that the iris aids the eye by increasing or decreasing incident light on the retina until the retina to adapted the new lighting condition.
- In addition, under bright light conditions it plays an important role reducing lens defects.

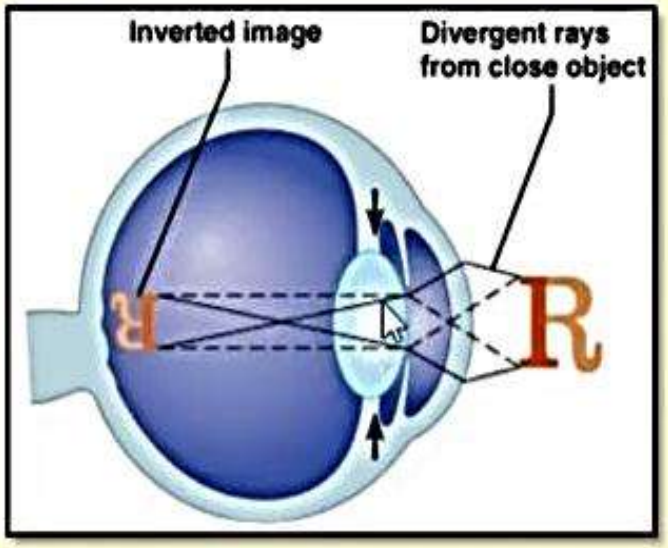
The Pupil: It is the small opening in the center of iris where light enters the lens.

It appears black because essential all of the light that enters is absorbed inside the eye.

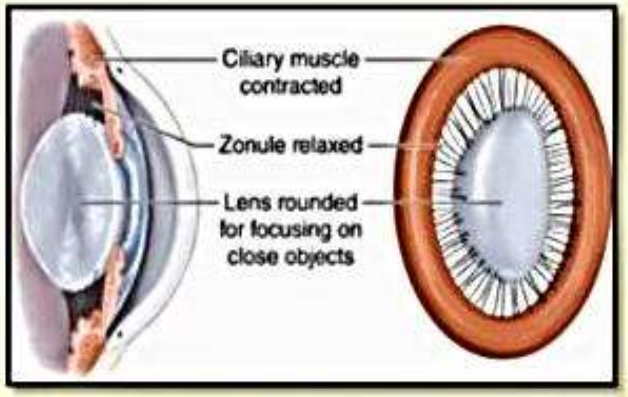
- (Under average light conditions, the opening is about ≈ 4mm). It can change from ≈ 3mm in diameter in bright light to 8mm in diameter in dim light. The physiologic reason form this change in size is not clear.



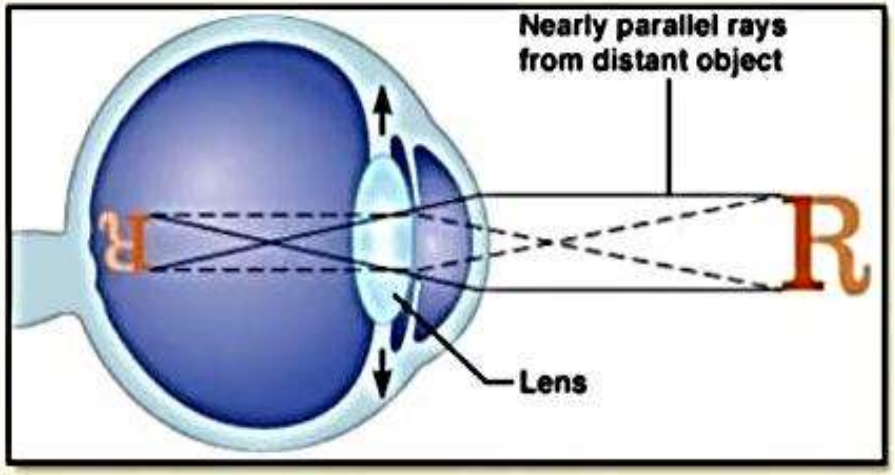
Near objects



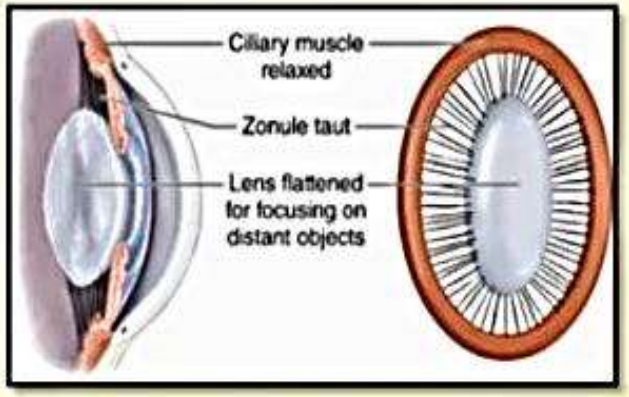
The eye muscles taut → the muscle fibers shorten → eye lens thicker and more powerful.



Far objects

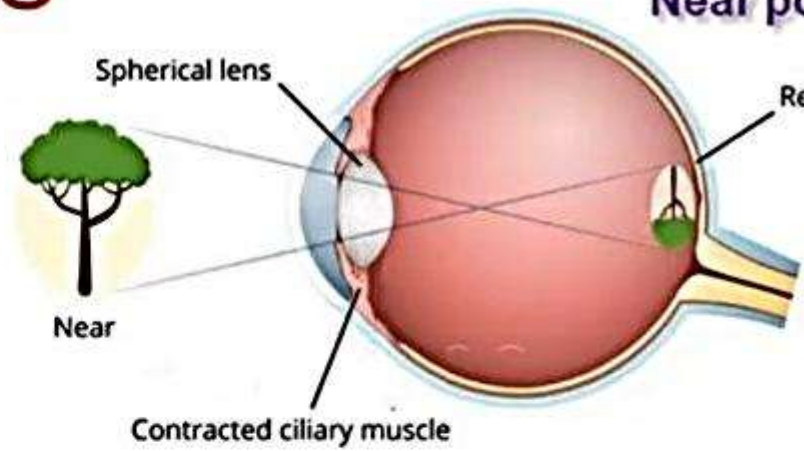


The eye muscles relax → the muscle fibers lengthen → eye lens to become thin and less powerful.



Near and Far Points

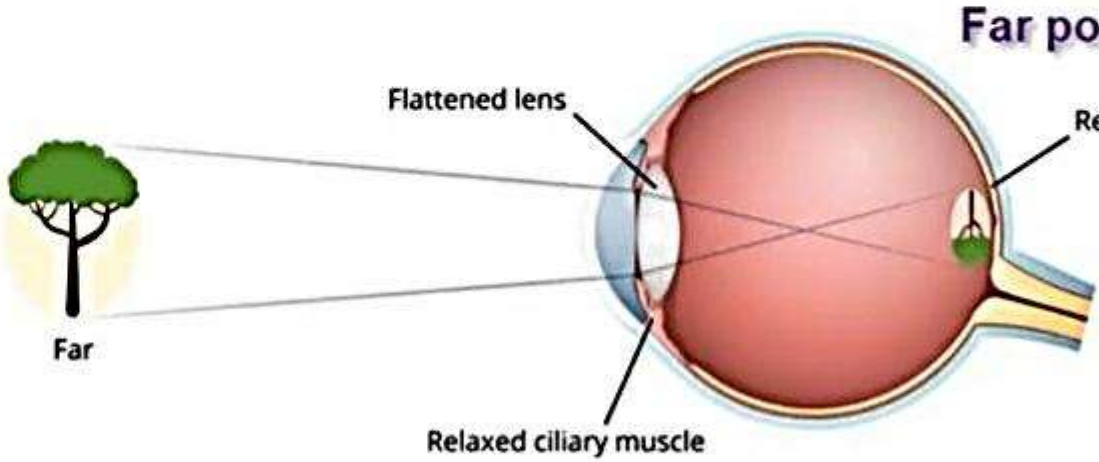
- A person with normal vision:
  Typical near point (d_o) = 25cm
  Typical far point (d_o) = ∞



- The focal length of the eye lens:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

Where, d_i = 2 cm = 0.02 m



- So;

At near point is given by: $\left(\frac{1}{f}\right)_{near} = \frac{1}{0.25} + \frac{1}{0.02} = 4 + 50 = 54\ m^{-1}$

At far point is given by: $\left(\frac{1}{f}\right)_{far} = \frac{1}{\infty} + \frac{1}{0.02} = 0 + 50 = 50\ m^{-1}$

Accommodation

The strength of the eye lens can be expressed in term of the optical power (P), where

$$P\ (diopter) = \frac{1}{f(m)}$$

- Power of the convex (convergence) lens is positive.
- Power of the concave (divergence) lens is negative.

- So; for normal vision:

At near point : $$P_{near} = \left(\frac{1}{f}\right)_{near} = \frac{1}{0.25} + \frac{1}{0.02} = 54m^{-1} = 54D$$

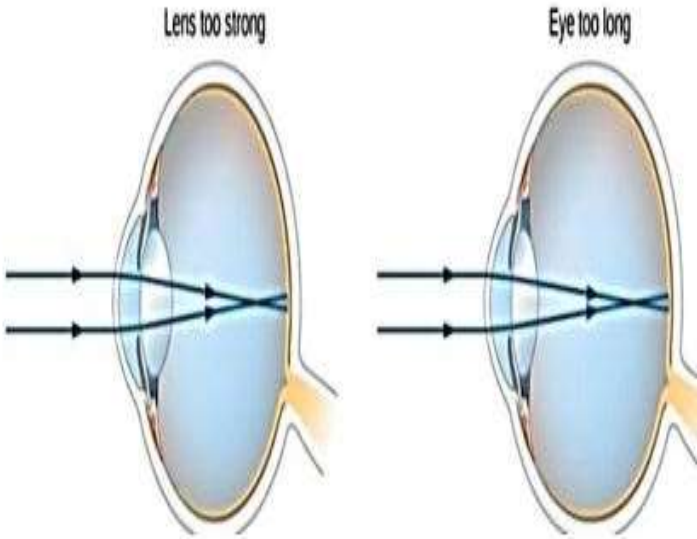
At far point : $$P_{far} = \left(\frac{1}{f}\right)_{far} = \frac{1}{\infty} + \frac{1}{0.02} = 50m^{-1} = 50D$$

$$P_{accomm.} = [P]_{near} - [P]_{far} = \left[\frac{1}{d_o} + \frac{1}{d_i}\right]_{near} - \left[\frac{1}{d_o} + \frac{1}{d_i}\right]_{far}$$

Vision Defects

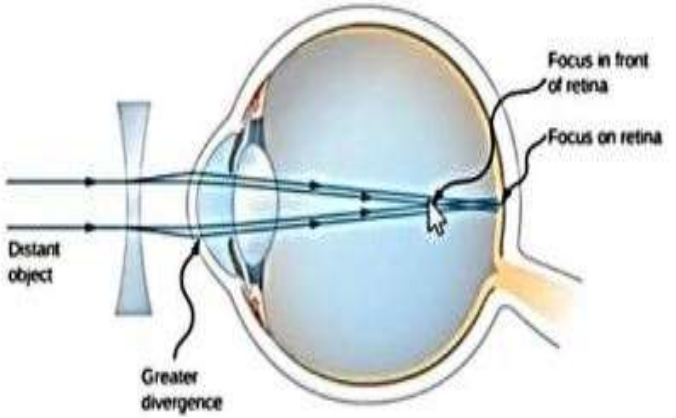
Nearsightedness (Myopia)

- It is the ability to see **near** objects clearly, whereas distant objects are blurry.
- Due to the **too strong eye lens or too long eye ball.**
- • The eye over converges the nearly parallel rays from a distant object, and the rays cross in front of the retina.



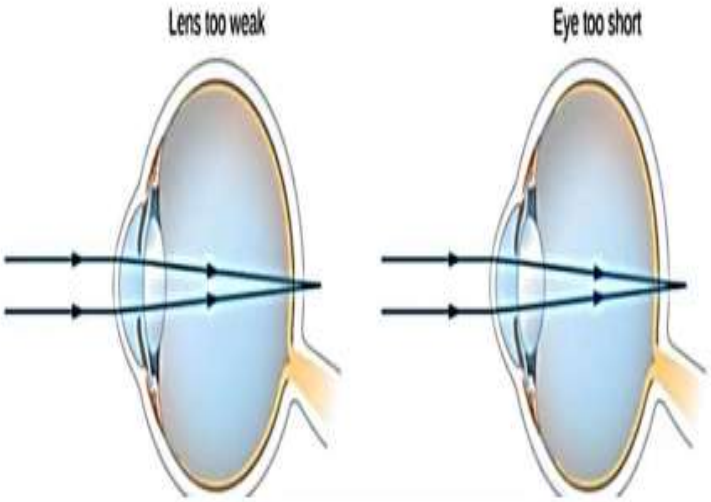
Vision Correction Myopia

The correction for nearsightedness consists of placing a diverging eyeglass (concave) lens in front of the eye.

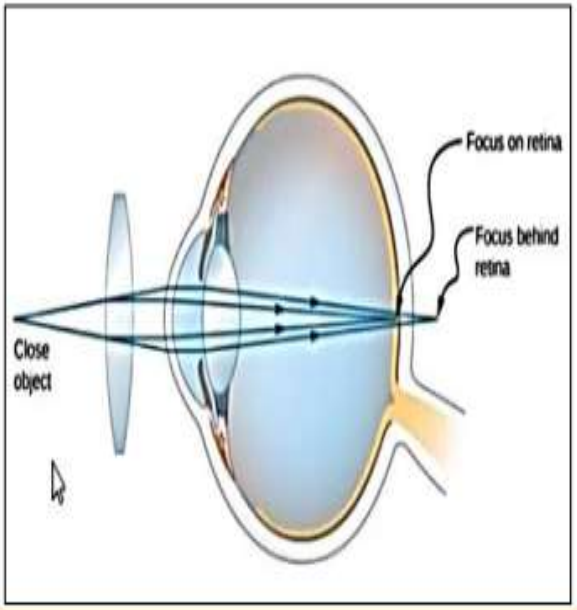


Vision Defects

Farsightedness (Hyperopia)



- It is the ability to see far objects clearly, whereas distant objects are blurry.
- Due to the too weak eye lens or too short eye ball.
- A farsighted eye does not sufficiently converge the rays from a near object to make the rays meet on the retina.

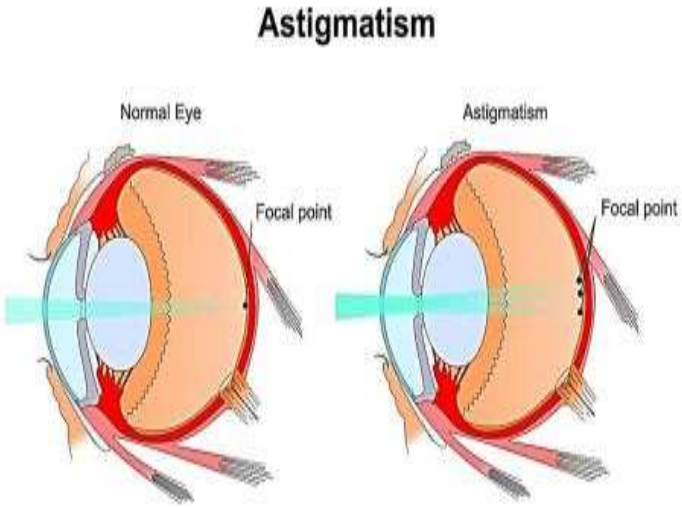


Vision Correction Hyperopia

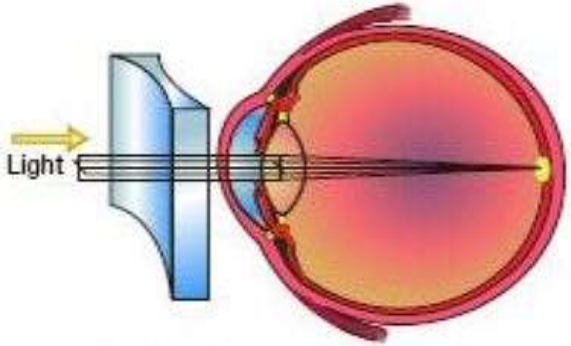
The correction for of far sightedness consists placing a converging eyeglass(convex) lens in front of the eye.

Astigmatism

when astigmatism is present, point objects do not from clear point images on the retina this normally due to the corneas heaving unequal curvature in different directions



Astigmatism is **corrected** with asymmetric lens



Astigmatism corrected by lens