Medical Physics Module
Semester 1

Session 5
Lecture 10

Physics of eyes and vision

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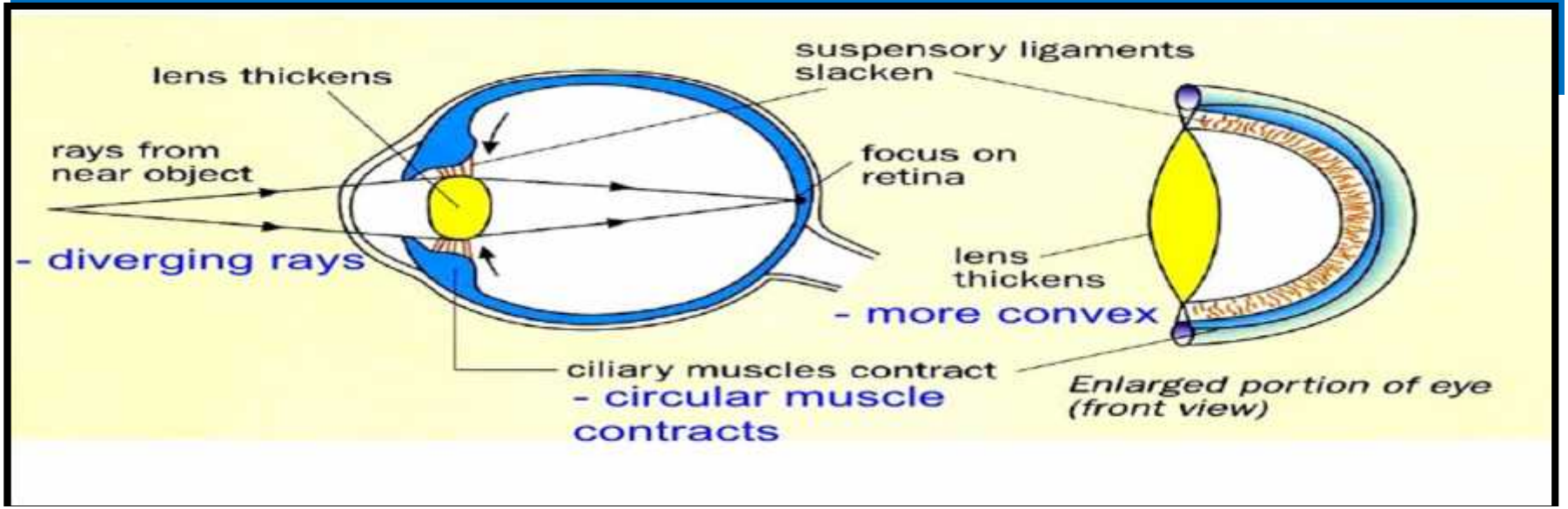
Objectives

- Physical principle of vision.
- The effect of diffraction of light in the process of vision.
- How eyes focus on object ?
- Physics of different focusing diseases & their correction.

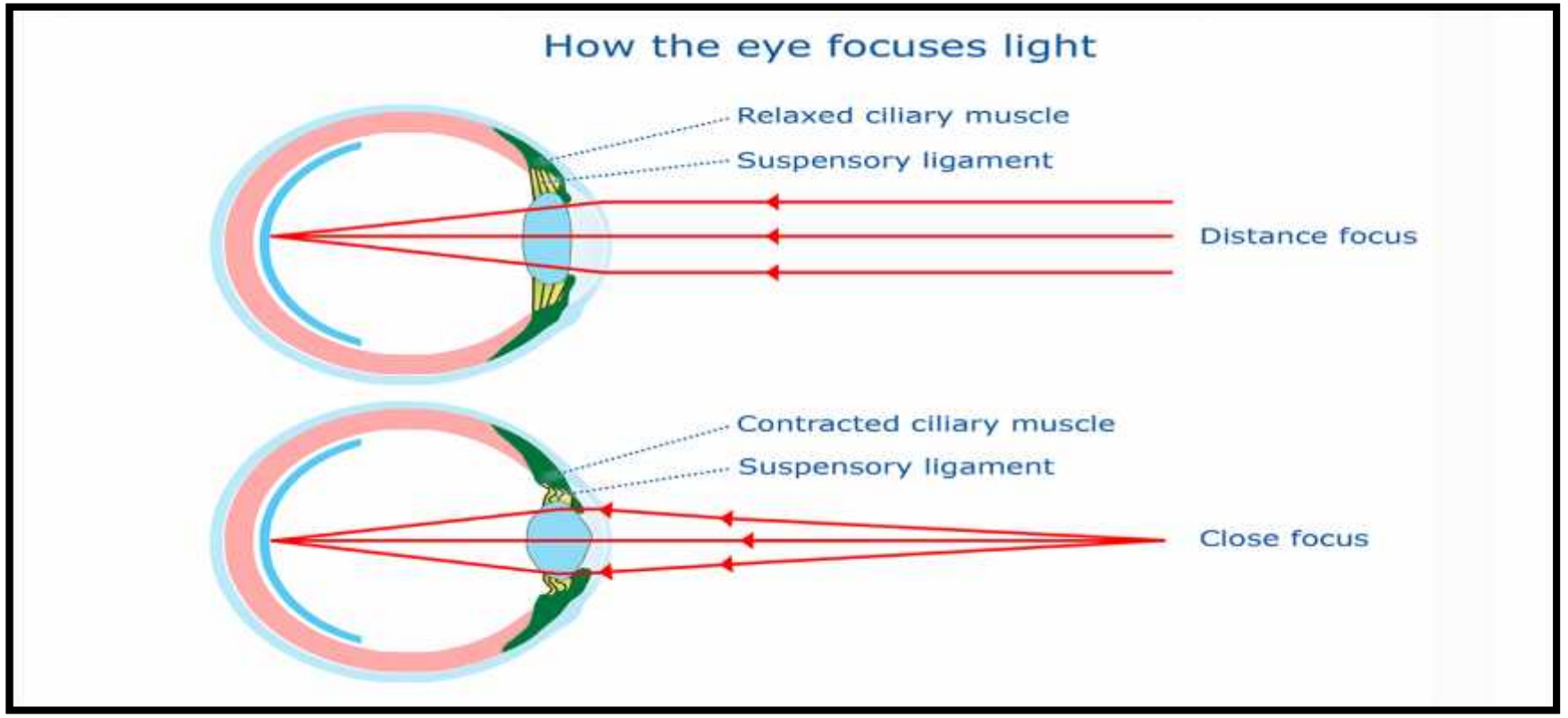
Obj.1 Physical principle of vision.

The eye is an optical instrument that can focus automatically on objects over a wide range of distances.

- **To view a near object, the eye muscles must become tight so that the muscle fibers shorten and make the eye lens thicker and more powerful.**

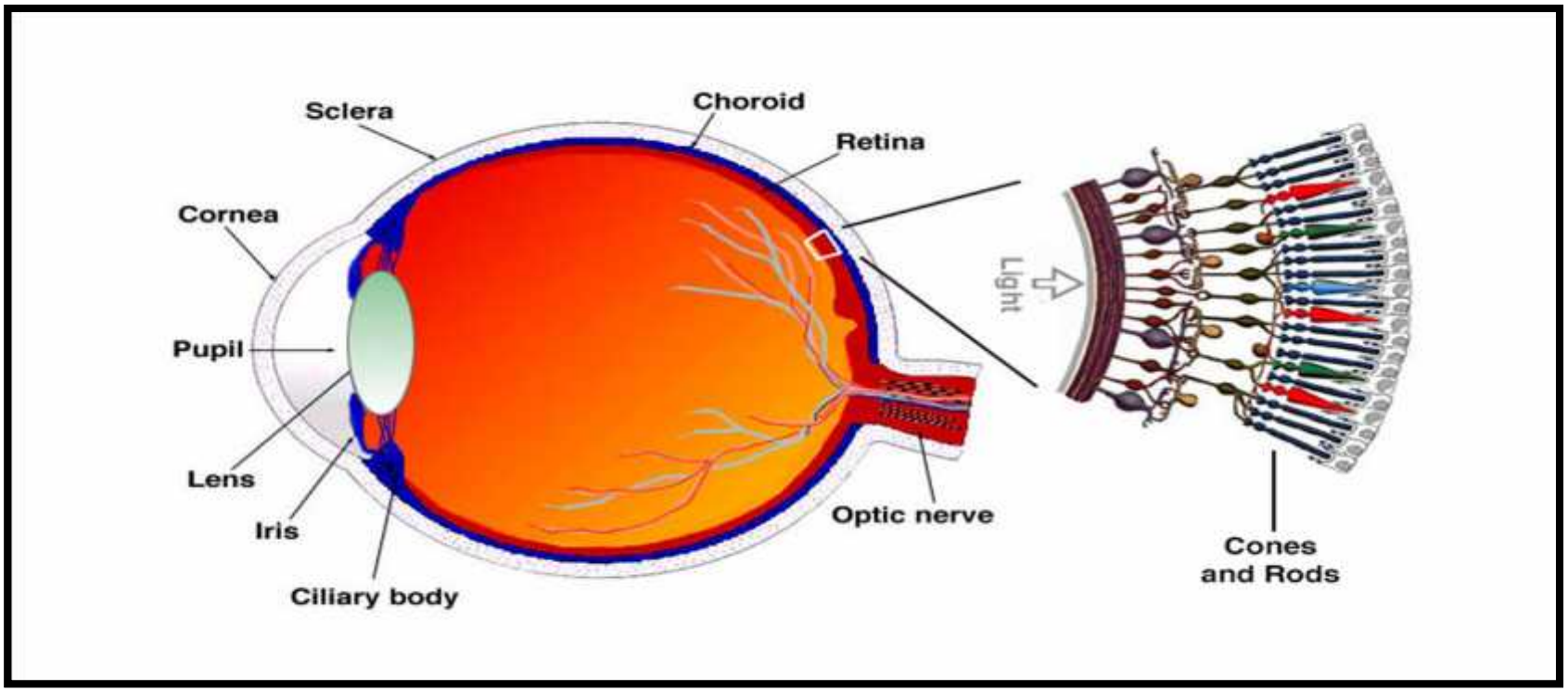


➢To view a distant object, the eye muscles must relax so that the muscle fibers lengthen, allowing the eye lend to become thin and less powerful.



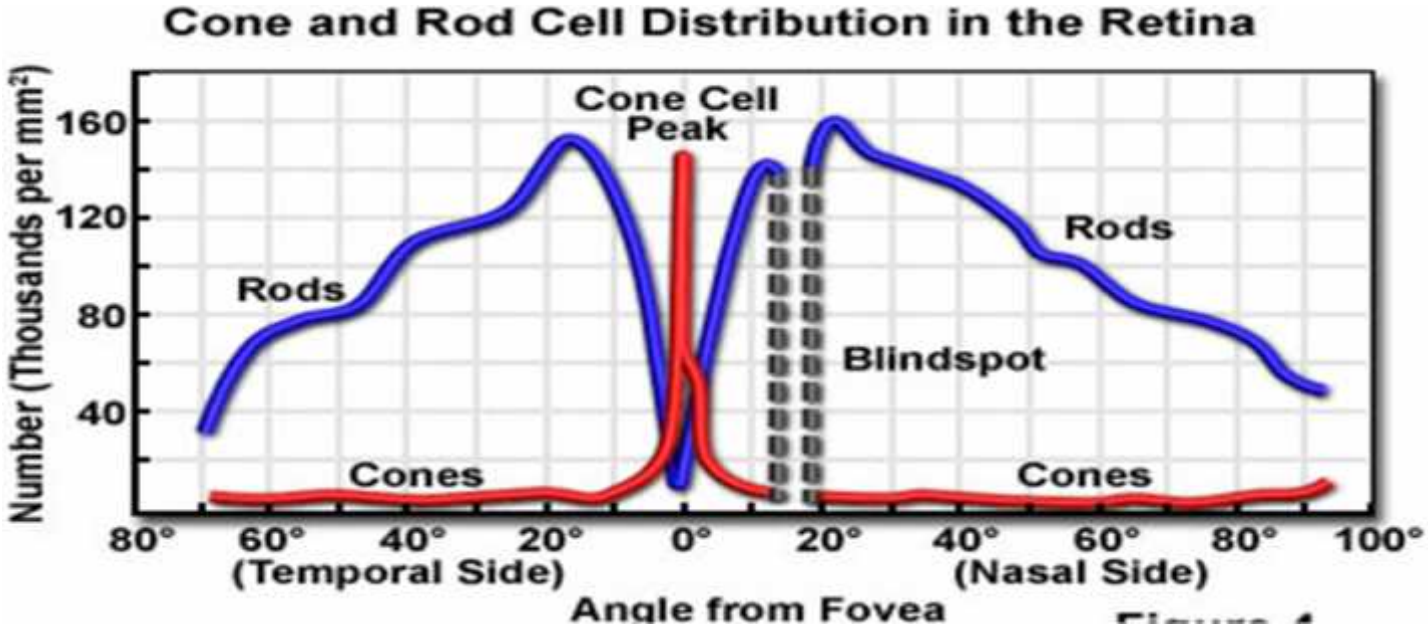
Sensitivity of the eye consists of three major components:

1. Rods are sensitive to low levels of light intensity but cannot distinguish between colors.

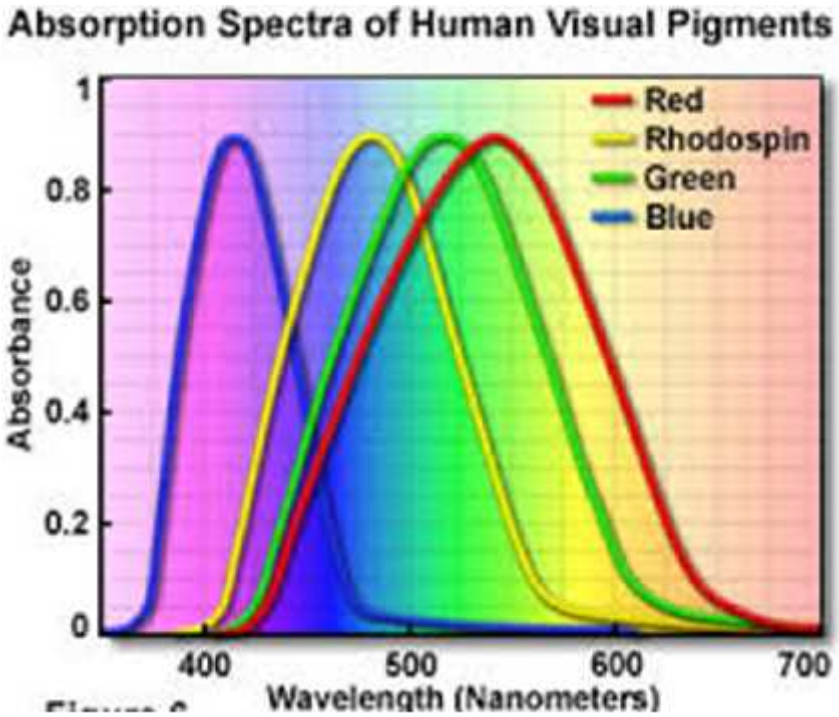


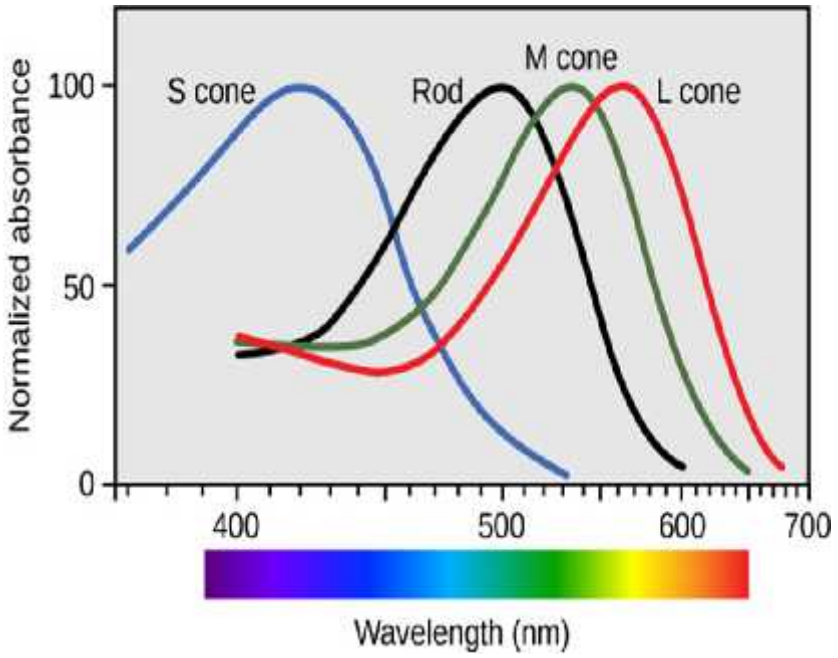
2. Cons are of three types, each sensitive to a different range of wavelengths.

These ranges correspond broadly to red, green or blue light.The system of millions of nerves that carries information deep into the brain.



3. Visual acuity, the minimum angular separation of the two equidistance points of light which can just be resolved by the eye.

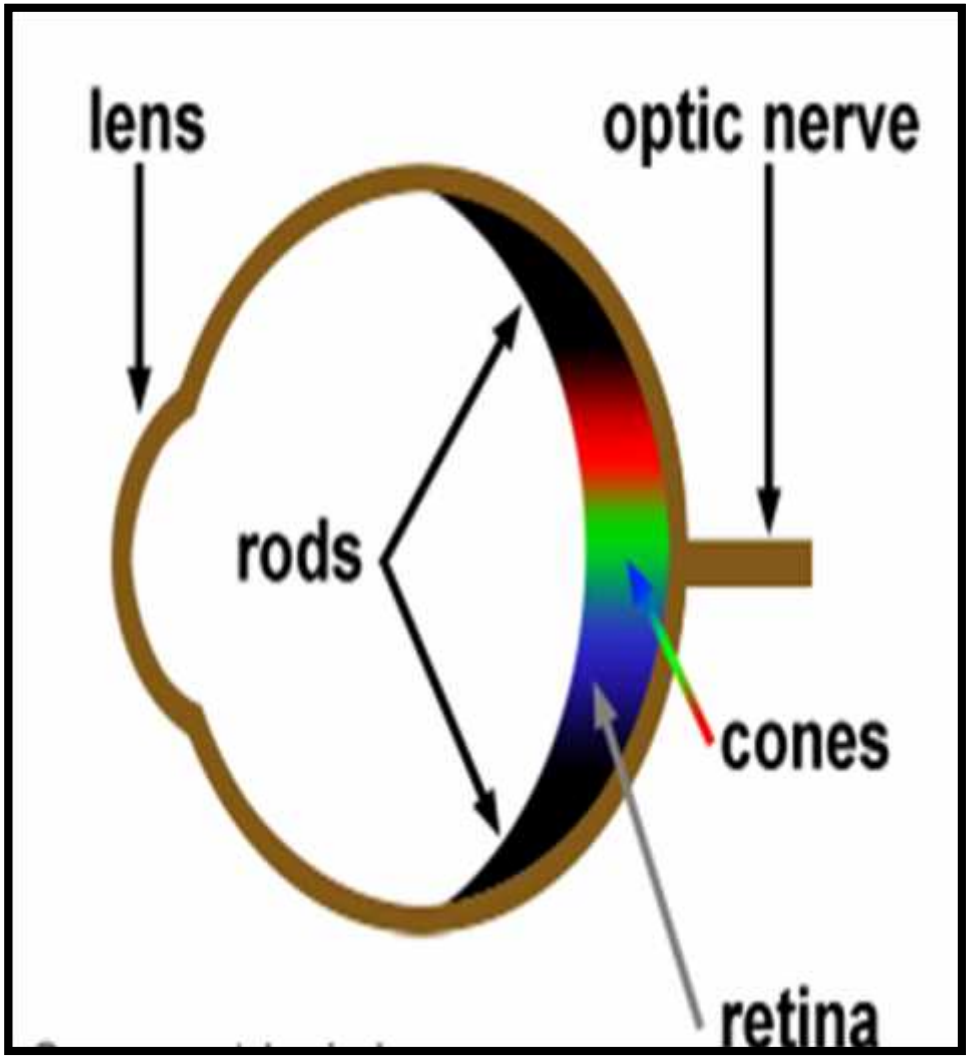


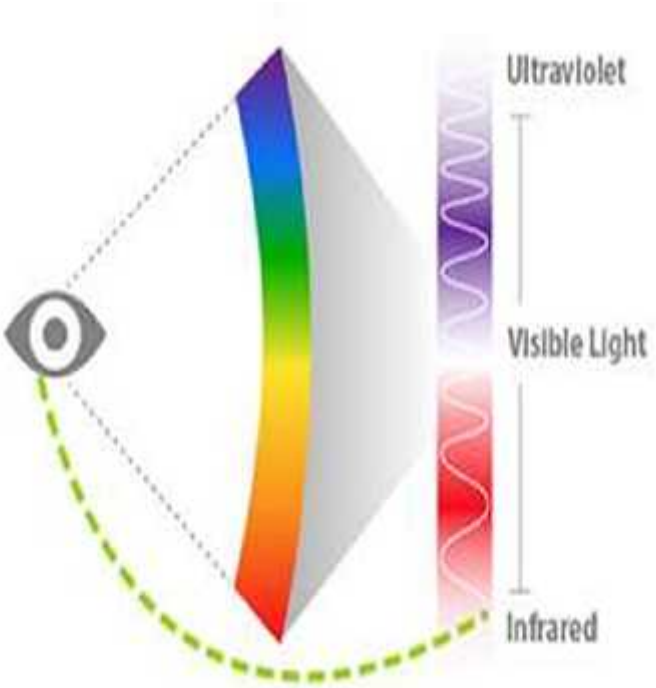


Retina is the light detector of eye

Retina the light sensitive part of eyes, converts the light images into electrical nerve impulses that are sent to the brain. The photon must be above minimum energy to cause the reaction.

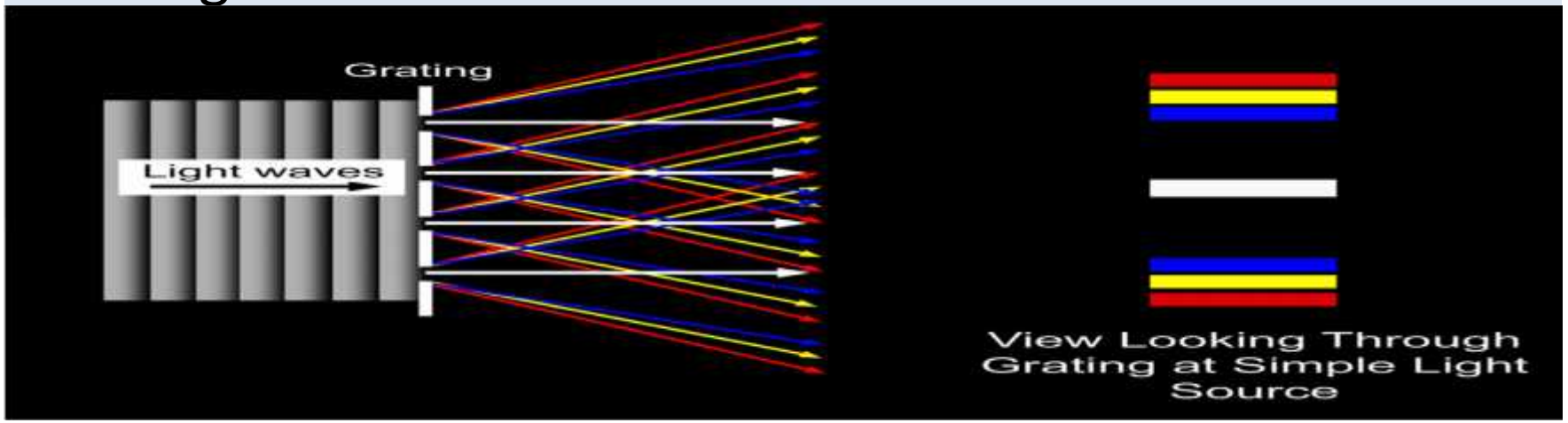
- Infrared photons have insufficient energy and are not seen.
- Ultraviolet photons have sufficient energy but they are absorbed before they reach the retina and also are not seen.


lens
optic nerve
rods
cones
retina


Ultraviolet
Visible Light
Infrared

Obj.2 Diffraction effects on the eye

All light waves undergo diffraction when it passes through small openings thus the iris produces diffraction pattern on the retina. All lenses have defects aberration. The effect of such aberration is reduced if the lenses opening are made smaller. A point source of light will not be focused on single cone because of diffraction effects.



The angular spread (2ɵ) of the central bright spot at retina for (λ = 555 m)and pupil (3 mm) diameter (a) is given by:

$$2\theta = 2(1.22)\,\lambda / a$$

$2(1.22)\,(555 \times 10^{-9} / 3 \times 10^{-3}) = 4.5 \times 10^{-4}$ radians

Obj.3
Focusing elements of the eye

The eye has two major focusing components:

1. The cornea which is clear transparent bump on the front of the eye. the cornea is fixed focus element.
2. The lens is variable in shape and has ability to focus at various distances.

- The cornea focus by bending (refraction) the light rays, the amount of bending depends on the curvature and speed of the light in lens.
- When cornea under ware it losses most of its focusing power because the index of refraction of water (1.33) close to that of cornea (1.37).

Structure of the Human Eye

Cornea
- protects eye
- refracts light

Iris
- colored muscle
- regulates pupil size

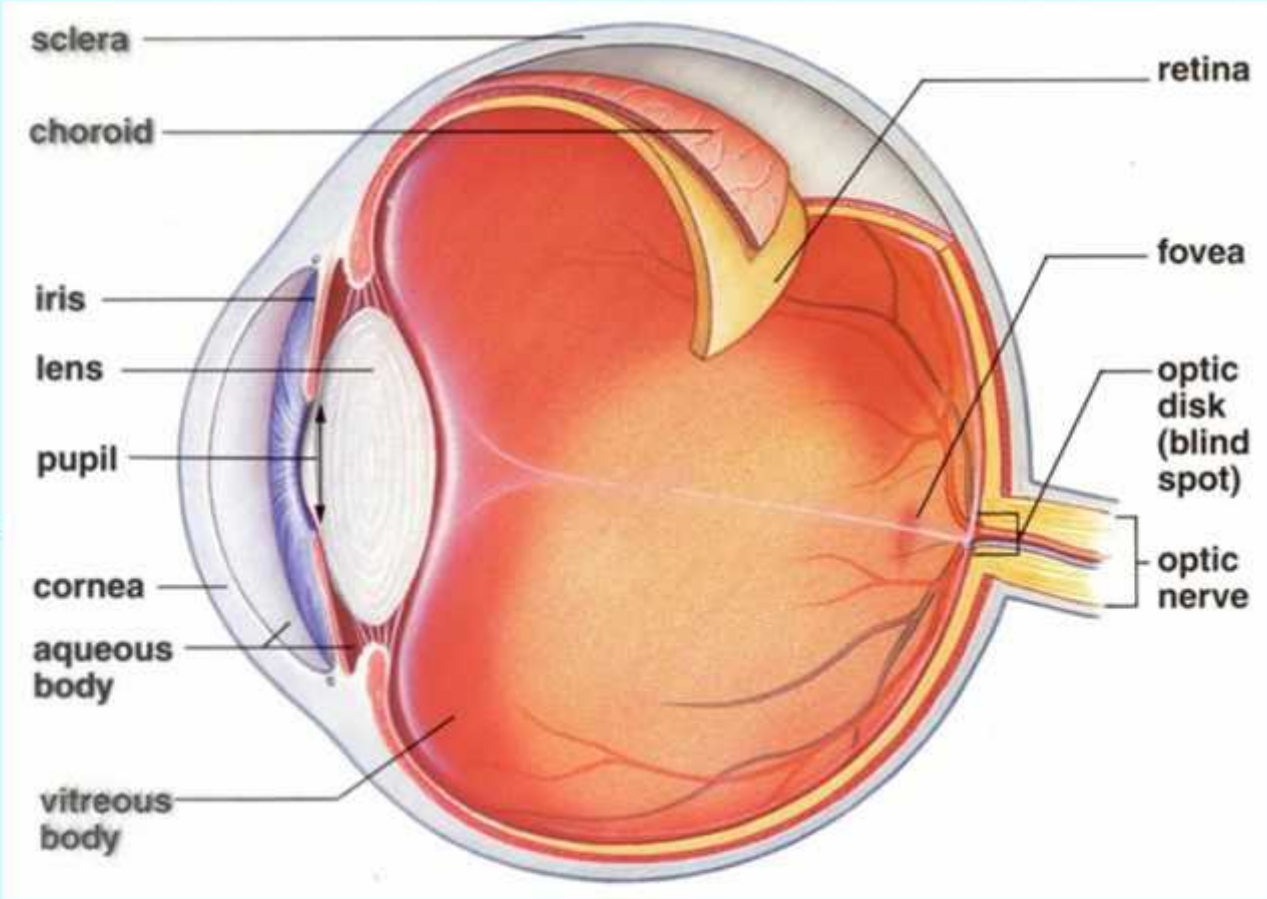
Pupil
- regulates light input

Lens
- focuses images on retina

Ciliary Muscles
- controls shape of lens
- accomodation

Fovea
- point of central focus
- contains most cones
- birds of prey/rodent variation

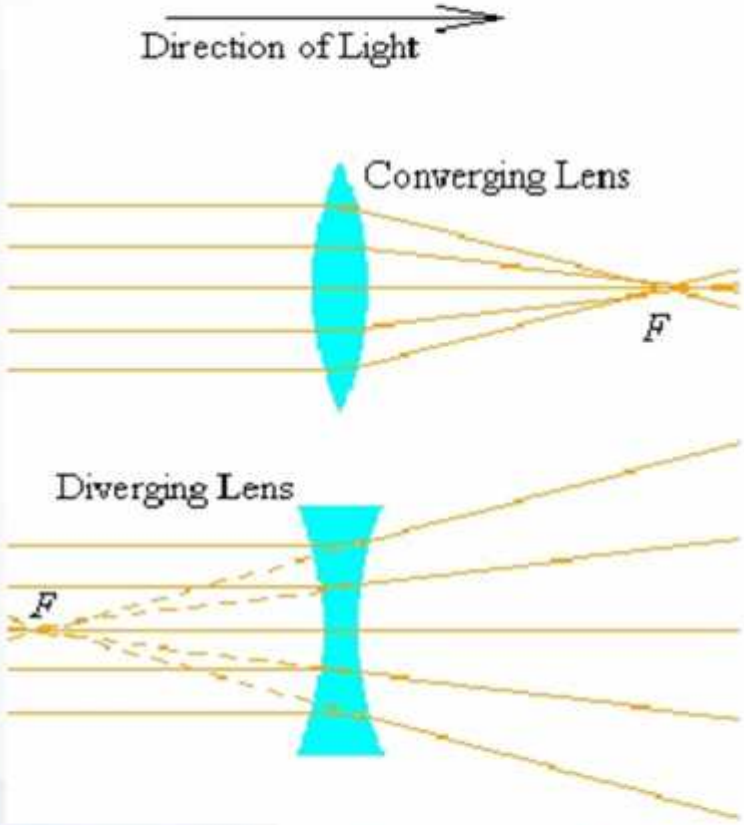
Retina
- contains photoreceptors



Convergent & Divergent Lenses

- Convex lenses refract light in a towards each other: **convergent**

- Concave lenses refract parallel light rays away from each other: **divergent**



Light that travels through the center of either lens continues straight through and is NOT refracted.

Defective vision & its correction

Converging and diverging lenses:

- A converging lens makes parallel rays converge to a focus.

-A diverging lens makes parallel rays diverge (spread out).

$$1/F = 1/U + 1/V$$

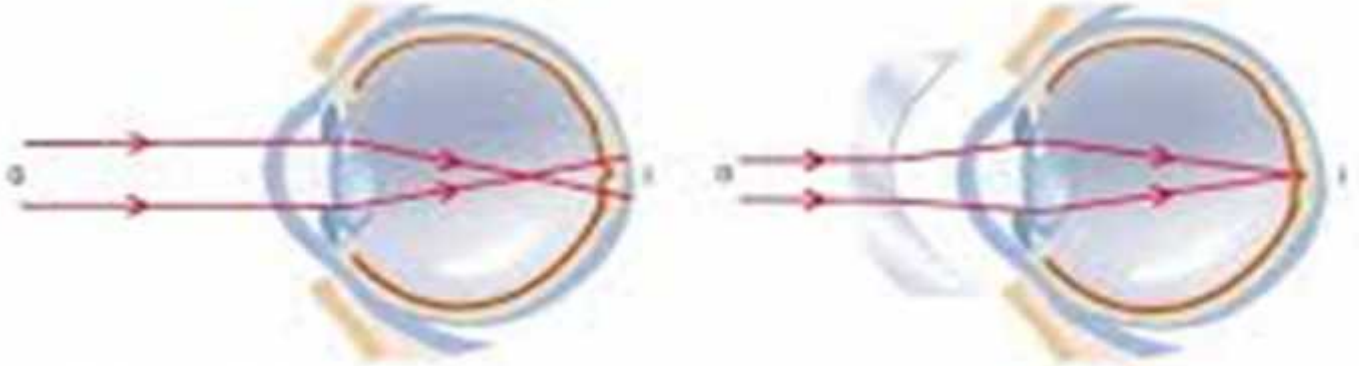
F = focal length **U = object distance**

V= image distance (F)

Obj.4 Some diseases of refractive errors of vision

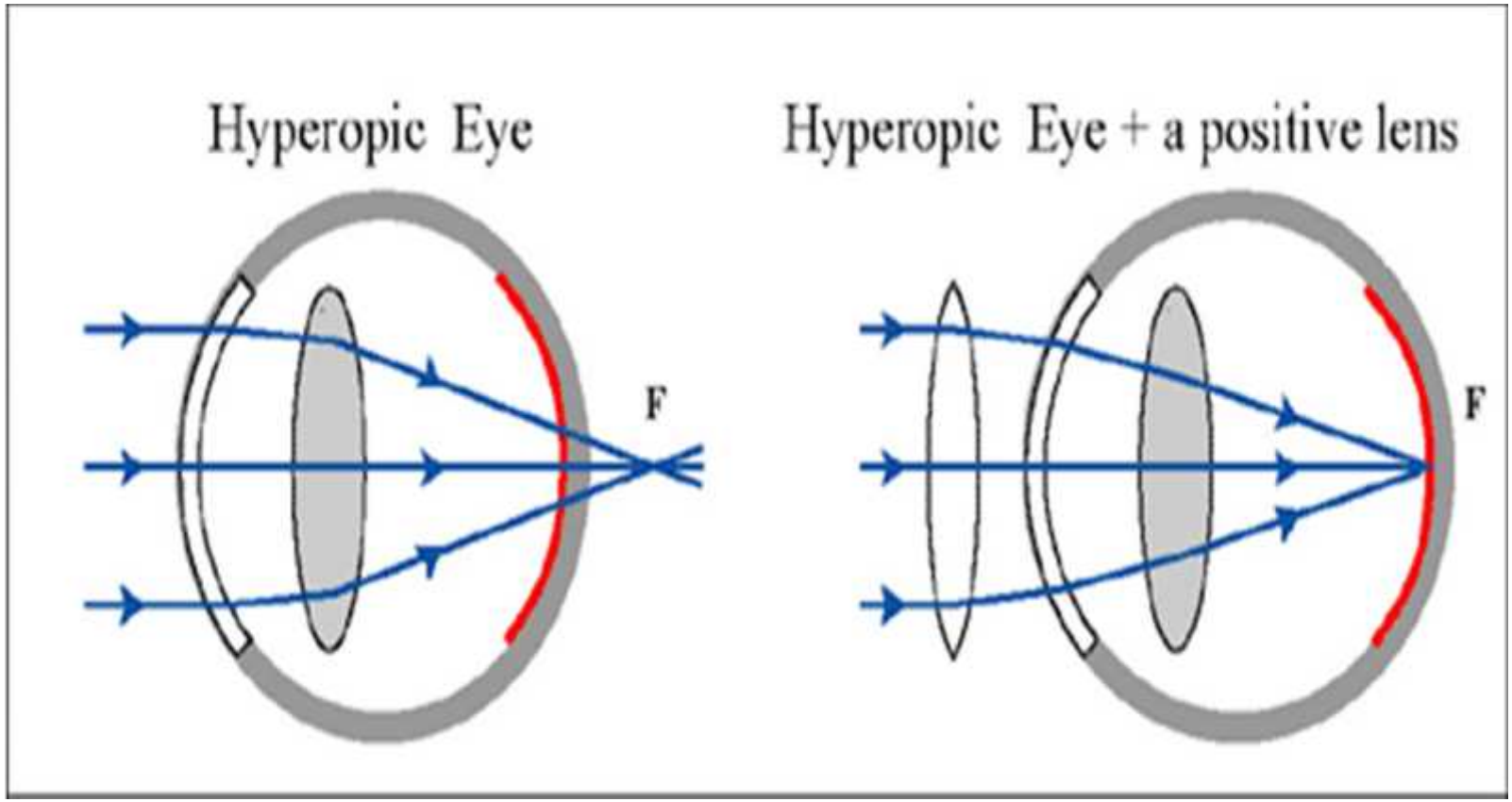
Focusing problem	Common name	Usual cause	Correction
Myopia	Near sighted vision	Long eye ball or cornea too curved	Negative lens or cornea too curved
Hyperopic	Far sighted vision	Short eye ball or cornea not curved Enough	Positive lens
Astigmatism		Unequal curvature of cornea	Cylindrical lens
Presbyopia	Old age vision	Lack of accommodation	Bifocals

Vision Problem: Myopia

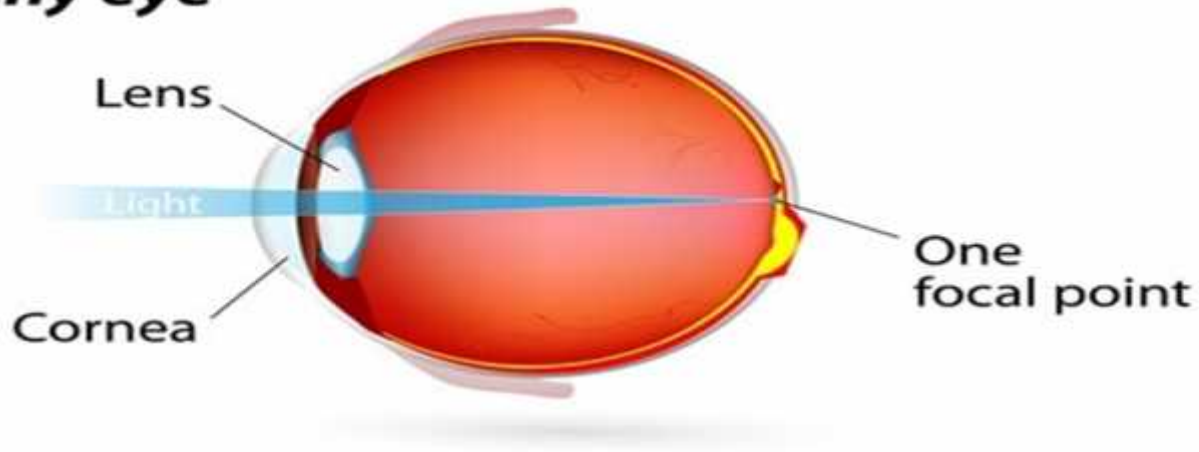


A nearsighted (myopic) eye focuses the light rays to a point **in front** of the retina

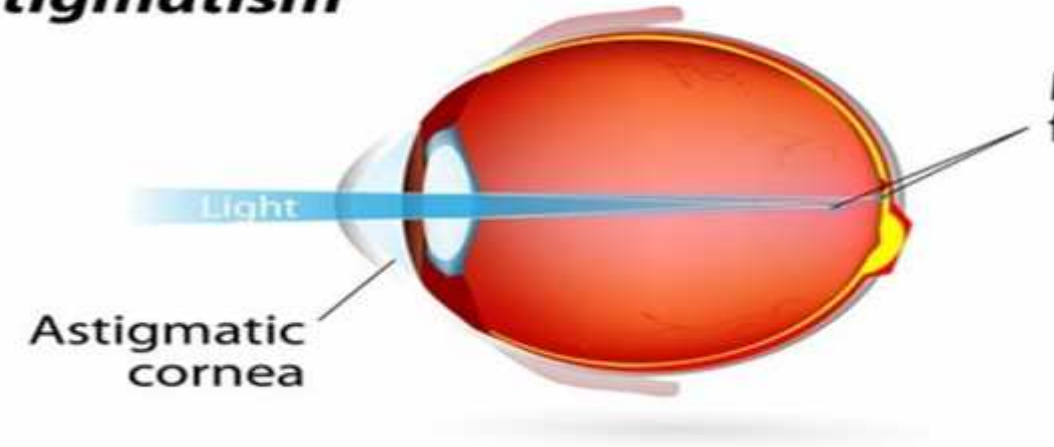
Myopia can be corrected with **diverging** lenses

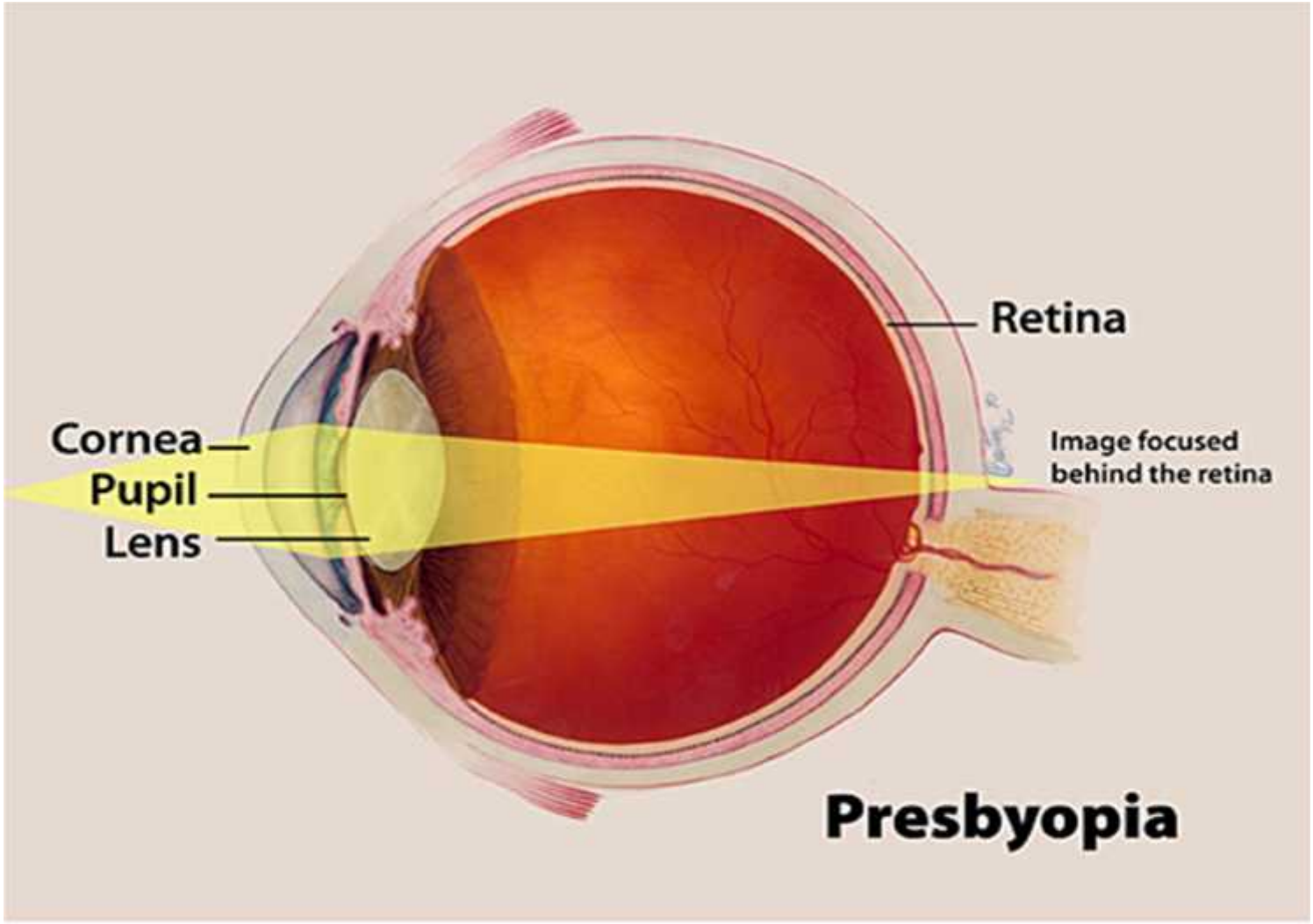

Hyperopic Eye
F
Hyperopic Eye + a positive lens
F

Healthy eye



Astigmatism




Retina
Cornea
Pupil
Lens
Image focused
behind the retina
Presbyopia

Thank
you