Tishk International University

Faculty of Applied Science

Department of Anesthesia

Light in Medicine
And
Visible light in vision

Fall Semester

Course Name : Biophysics

Stage : First

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Introduction

Light is a form of electromagnetic radiation that can be detected by the human eye. Visible light is only a small part of the electromagnetic spectrum.

Light plays an important role in medicine, biology, and daily life. It is used in:

- Vision
- Medical imaging
- Microscopy
- Laser surgery
- Endoscopy
- Phototherapy
- Ophthalmology

The study of light and its interaction with matter is called optics.

Nature of Light

Light has both wave and particle properties.

Wave Nature of Light

As a wave, light has:

- Wavelength
- Frequency
- Amplitude
- Speed

The wavelength of visible light ranges from about 400 nm to 700 nm.

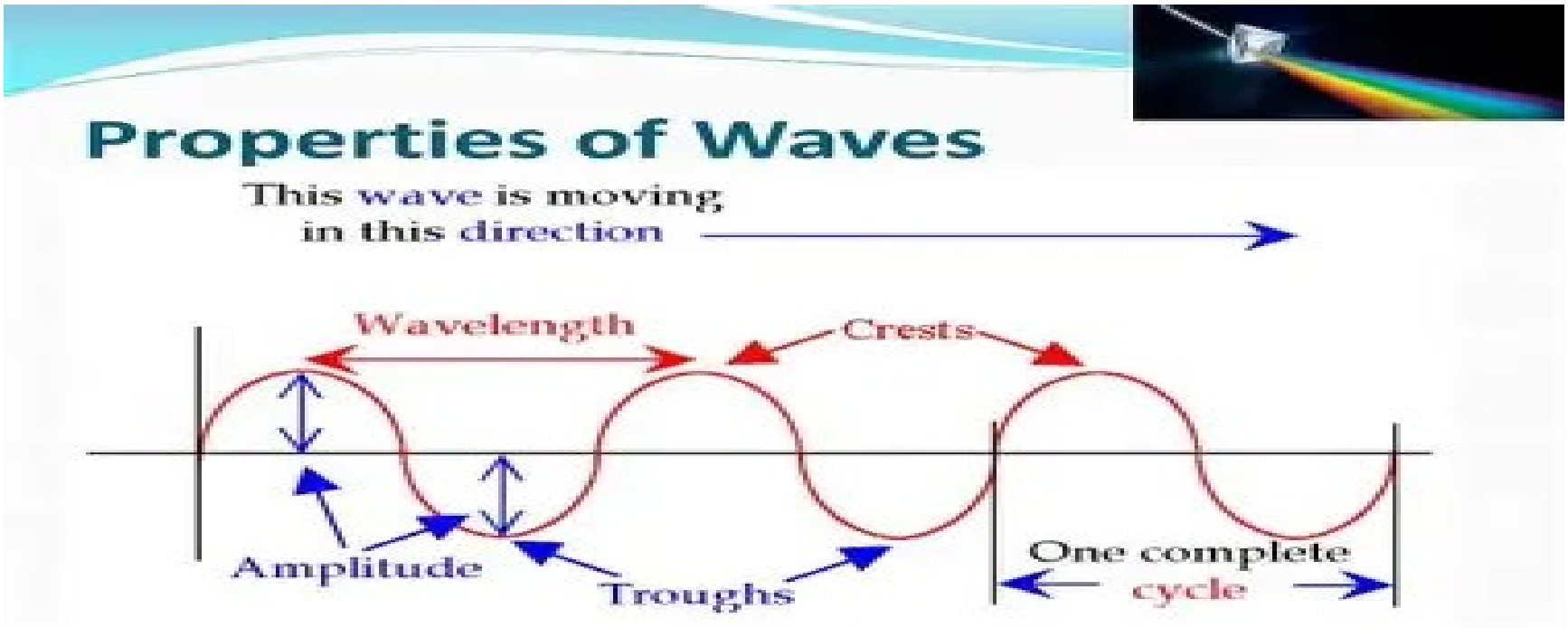


Figure :-Wave Properties of Light

Wavelength = Distance between two crests

Amplitude = Height of the wave

Relationship Between Speed, Frequency, and Wavelength

$C = \lambda f$

Where:

- c = speed of light
- f = frequency
- λ = wavelength

Light travels in vacuum at a speed of about 3×10^8 m/s.

Particle Nature of Light

Light can also behave as particles called photons.

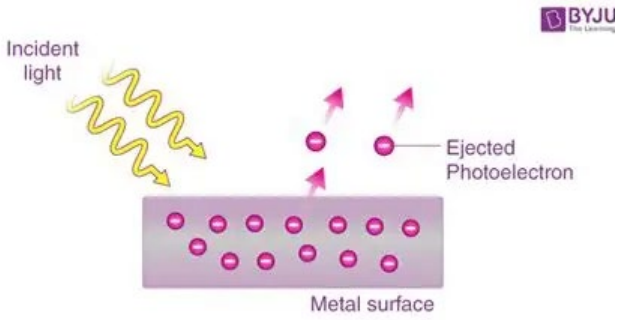
Each photon carries energy.

The energy of a photon depends on its frequency.

$E = hf$

Where:

- E = photon energy
- h = Planck constant
- f = frequency



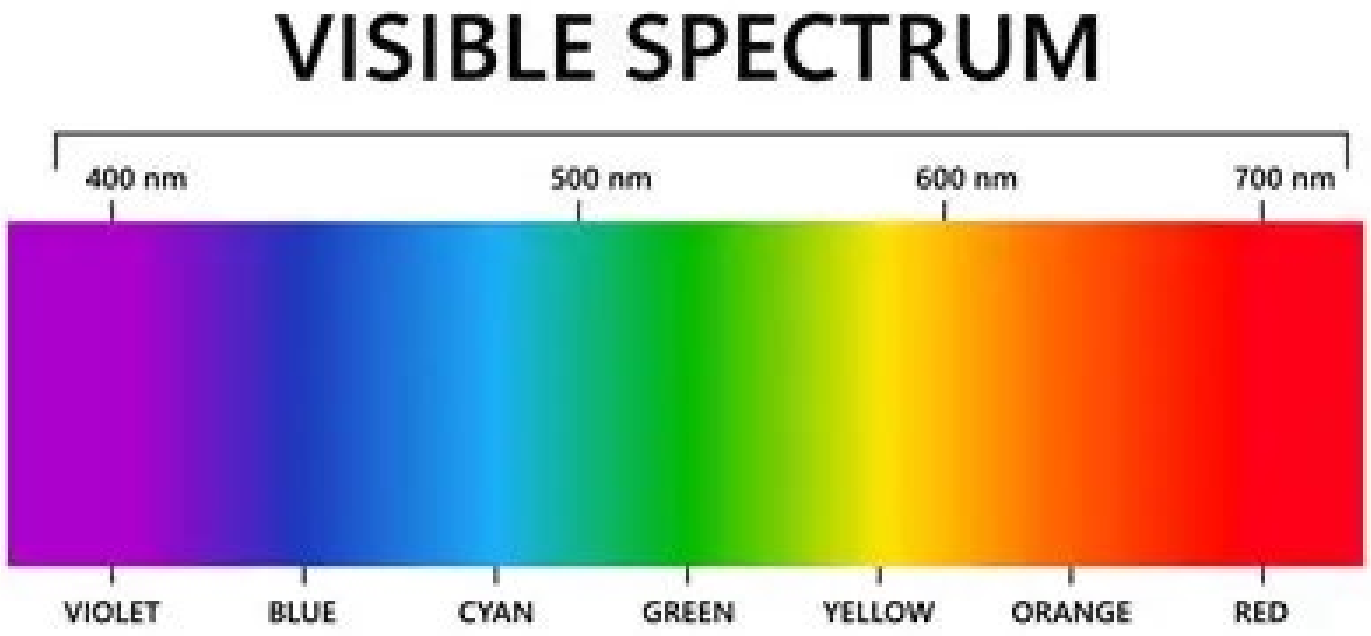
High-frequency light has more energy than low-frequency light.

Visible Light Spectrum

Visible light is the portion of the electromagnetic spectrum seen by the human eye.

Colors of Visible Light

Color	Approximate Wavelength
Violet	400–450 nm
Blue	450–495 nm
Green	495–570 nm
Yellow	570–590 nm
Orange	590–620 nm
Red	620–700 nm



Short wavelengths correspond to violet light, while long wavelengths correspond to red light.

Reflection, Refraction, and Absorption

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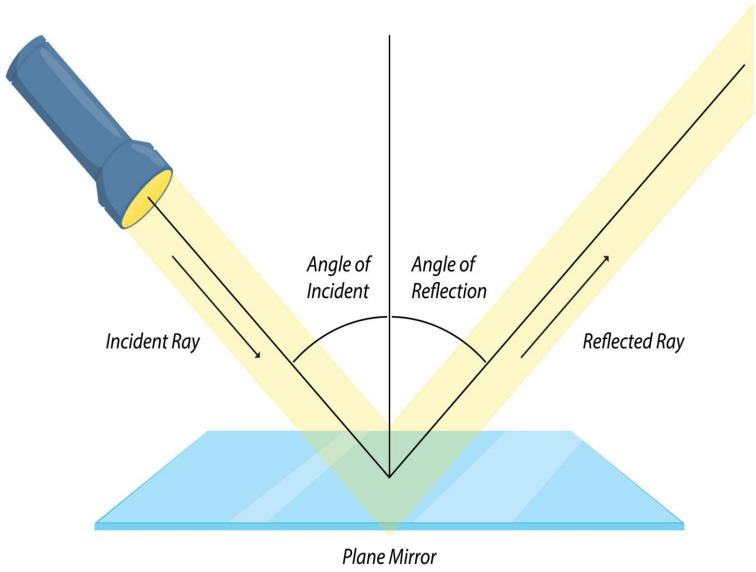
When light reaches a surface, several things may happen.

Reflection

Reflection occurs when light bounces off a surface.

The angle of incidence equals the angle of reflection



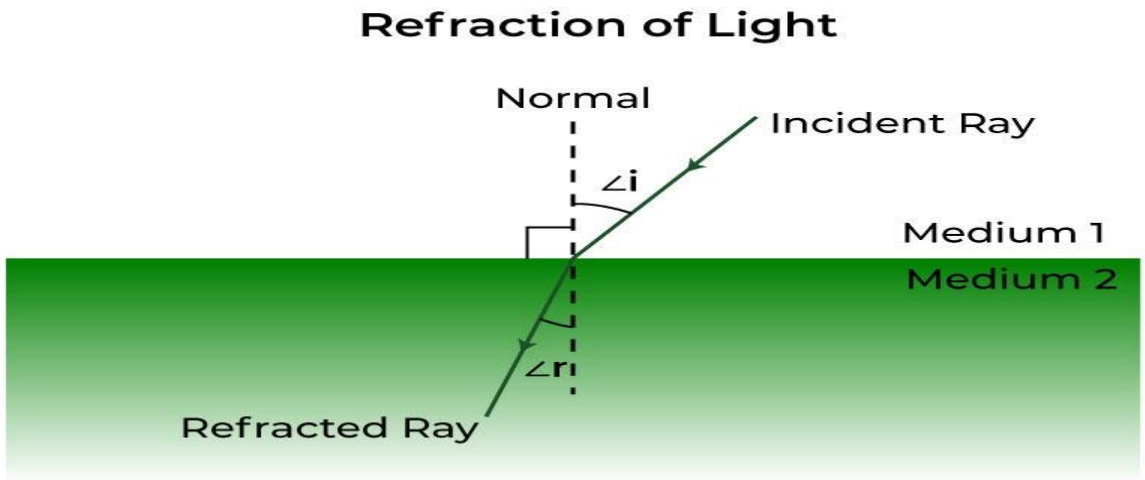
Refraction

Refraction is the bending of light when it passes from one medium to another.

For example, light bends when passing from air into glass or water.

The amount of bending depends on the refractive index.

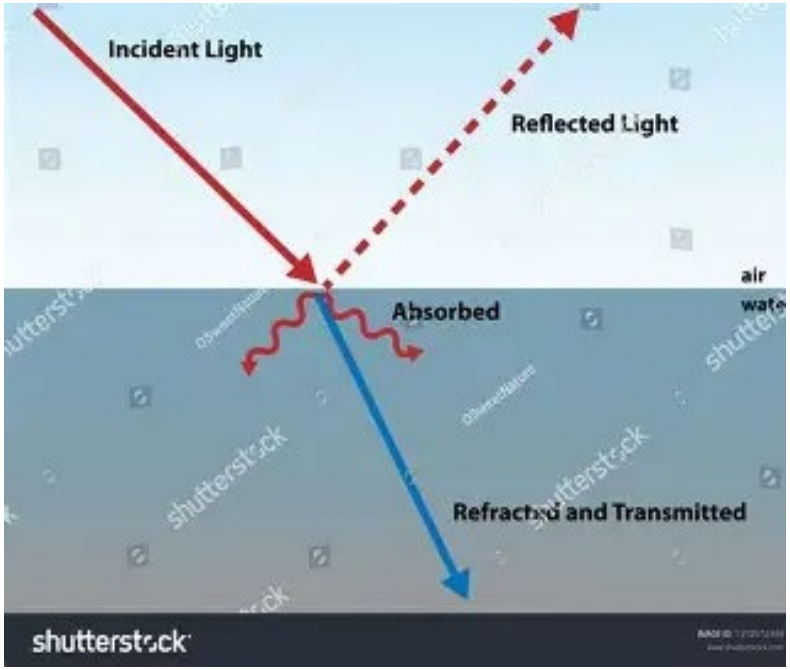
Snell's law describes refraction.



Absorption

Absorption occurs when light energy is absorbed by a material.

Dark materials absorb more light, while light-colored materials reflect more light.



Medical uses of visible light

1-Pediatricians use a shine light into the bodies of infants and observe the amount of scattered light produced in order to detect water –head or collapsed lung.

2-Pediatricians use visible light for treating jaundice in premature infants.

3-Light source in endoscope uses to see inside the body.

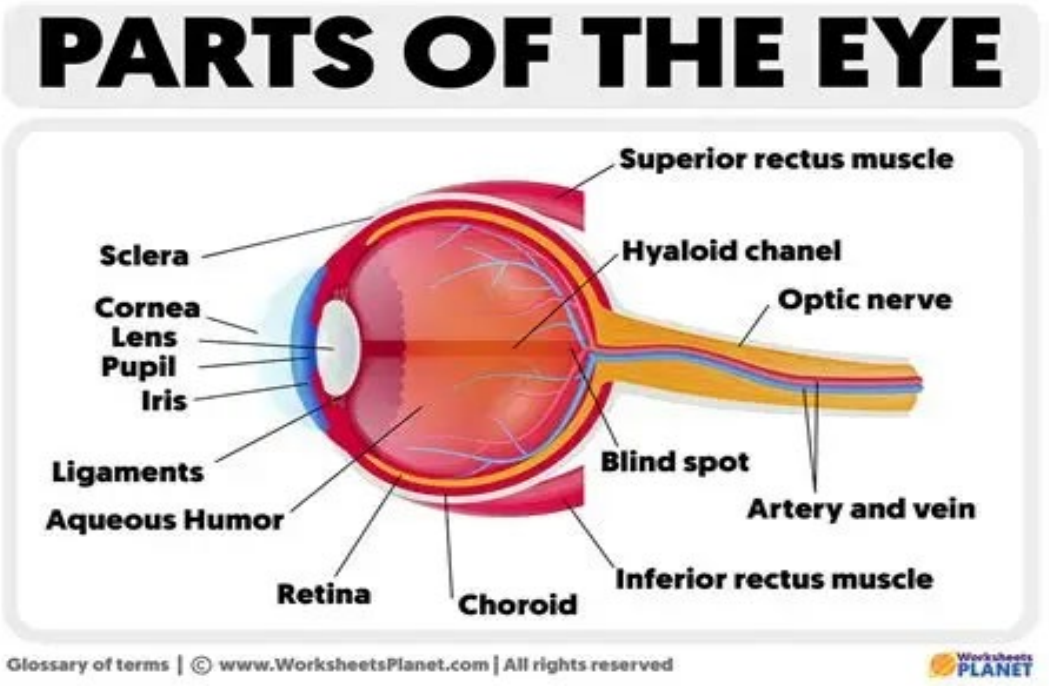
4-Physician use normal light to examine the skin.

5.The visible light used in the ophthalmoscope for looking into eyes ,and in the otoscope for looking into ears by using a concave mirror to direct light in the body and a hole in the middle of it for the physician to look through.

Physics of Vision

Vision occurs when light enters the eye and is converted into nerve signals.

The eye works like a camer



Main Parts of the Eye

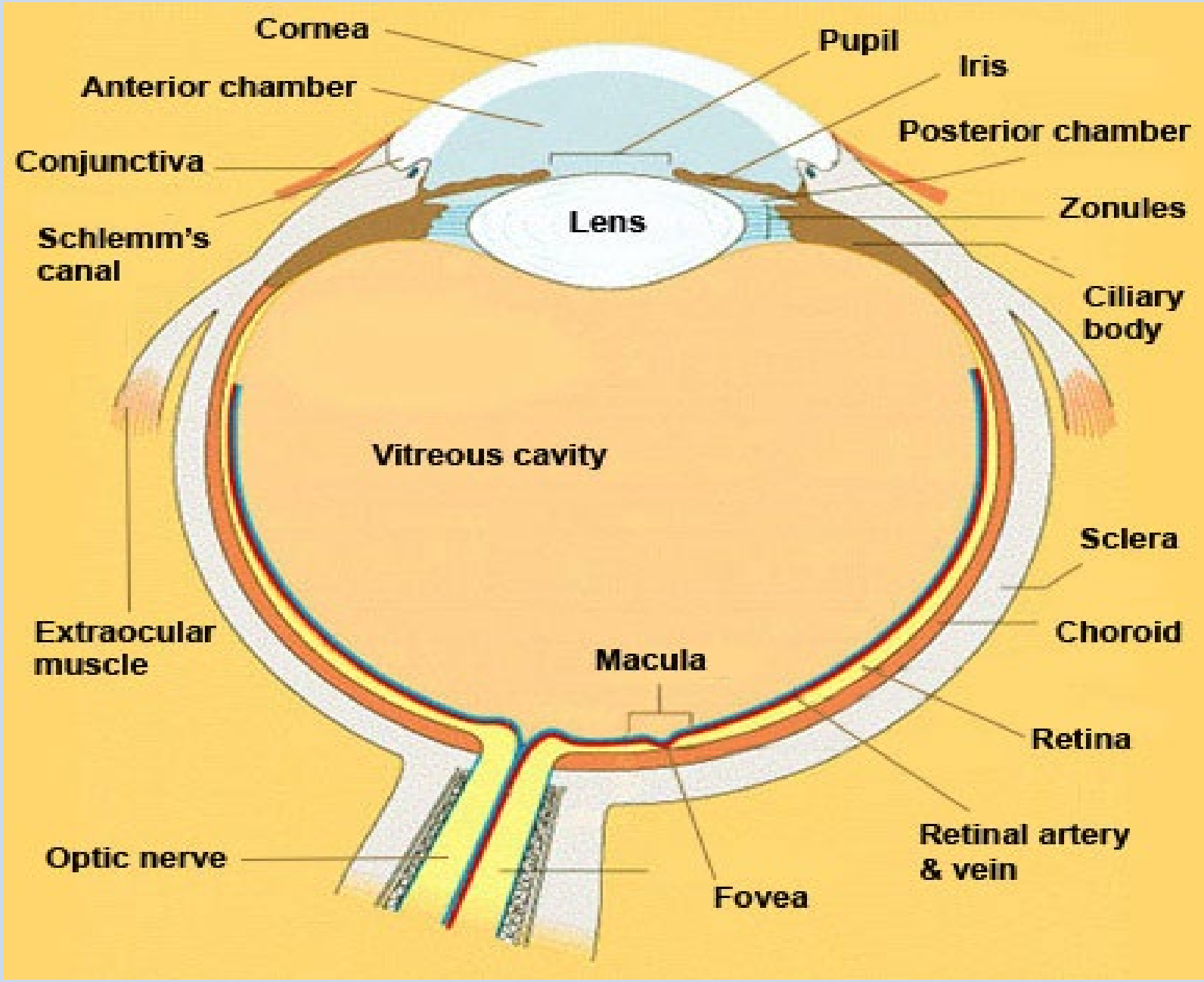
- Cornea
- Iris
- Pupil
- Lens
- Retina
- Optic nerve

The sense of vision: -

A- The Eyes.

B- Optical Nerves.

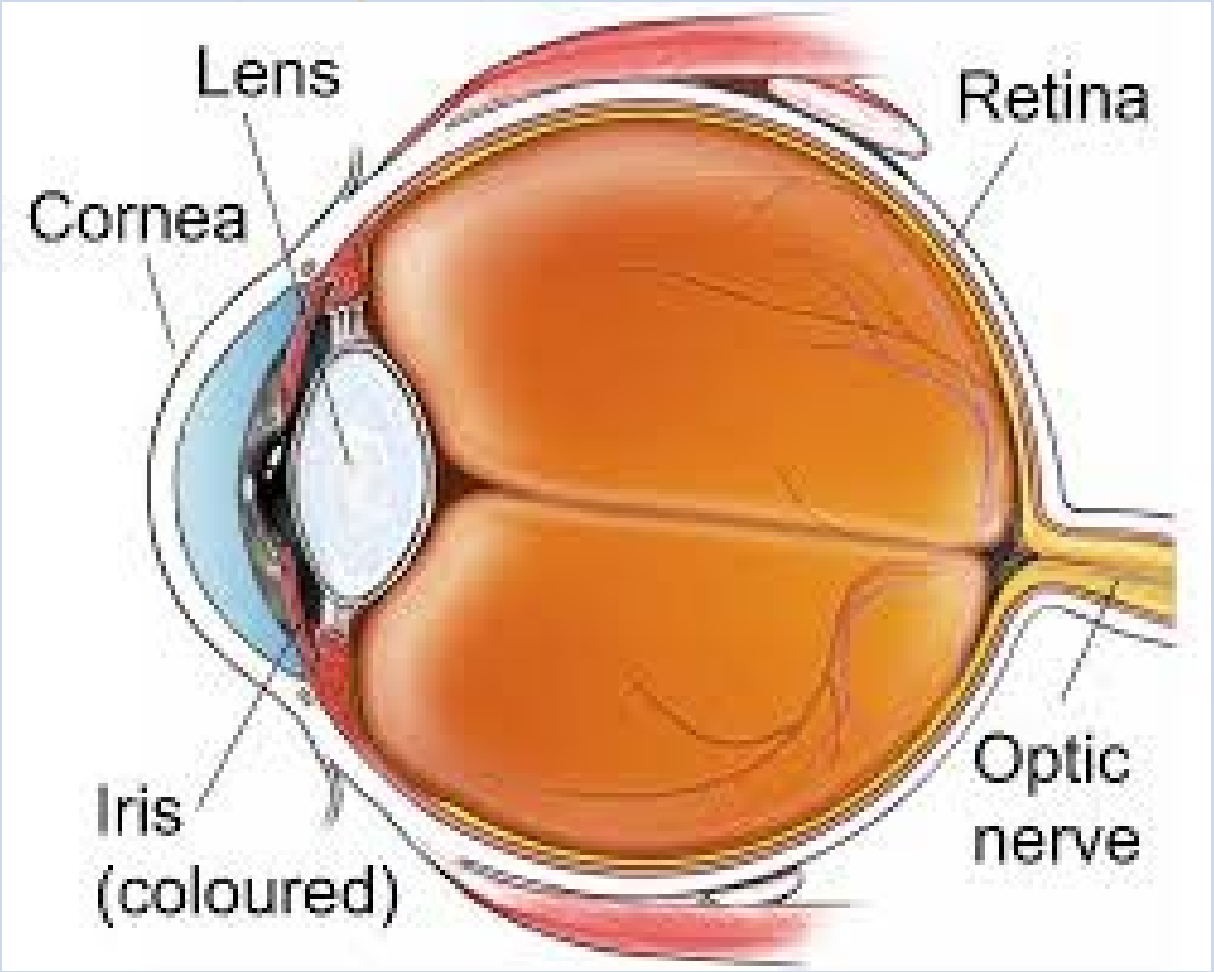
C-Visual Corte (Brain).


Cornea
Pupil
Iris
Anterior chamber
Posterior chamber
Conjunctiva
Zonules
Lens
Schlemm's canal
Ciliary body
Vitreous cavity
Sclera
Extraocular muscle
Choroid
Macula
Retina
Retinal artery & vein
Optic nerve
Fovea

Focusing Elements of the Eye

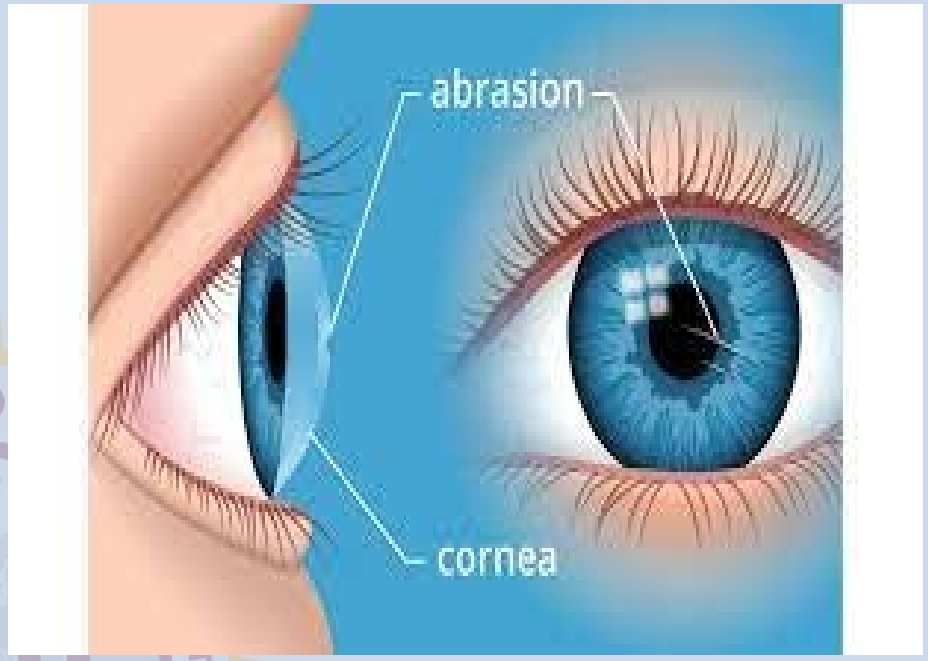
1- The Cornea.

2- The Lens.

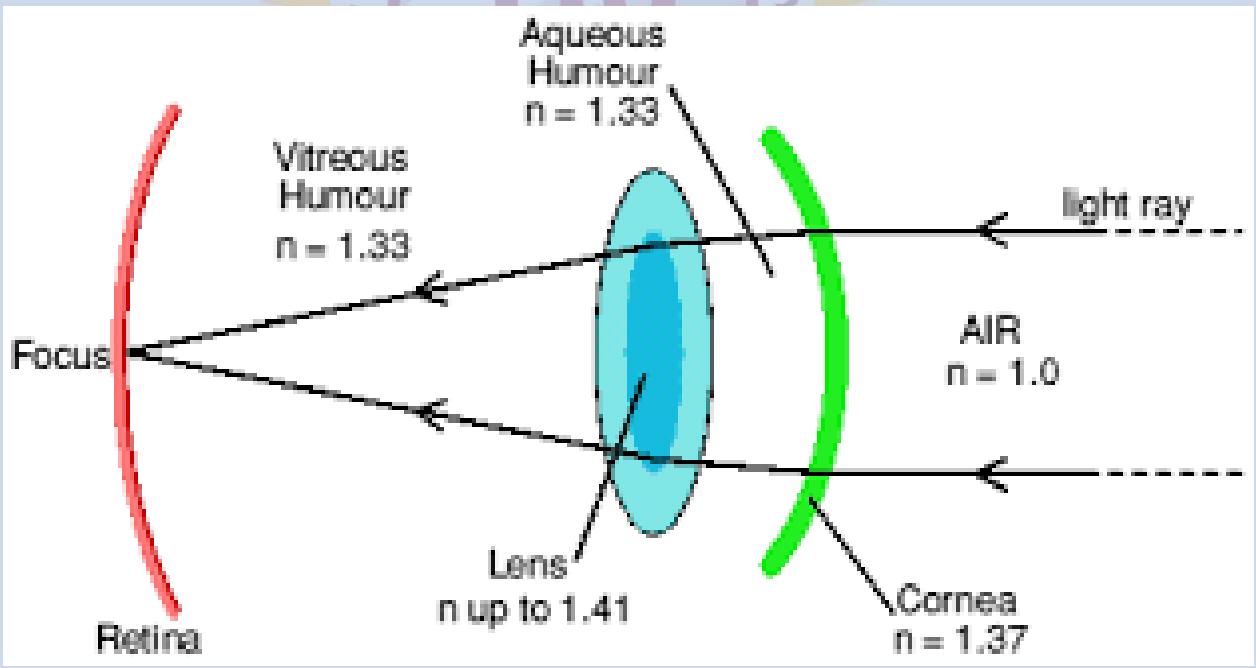


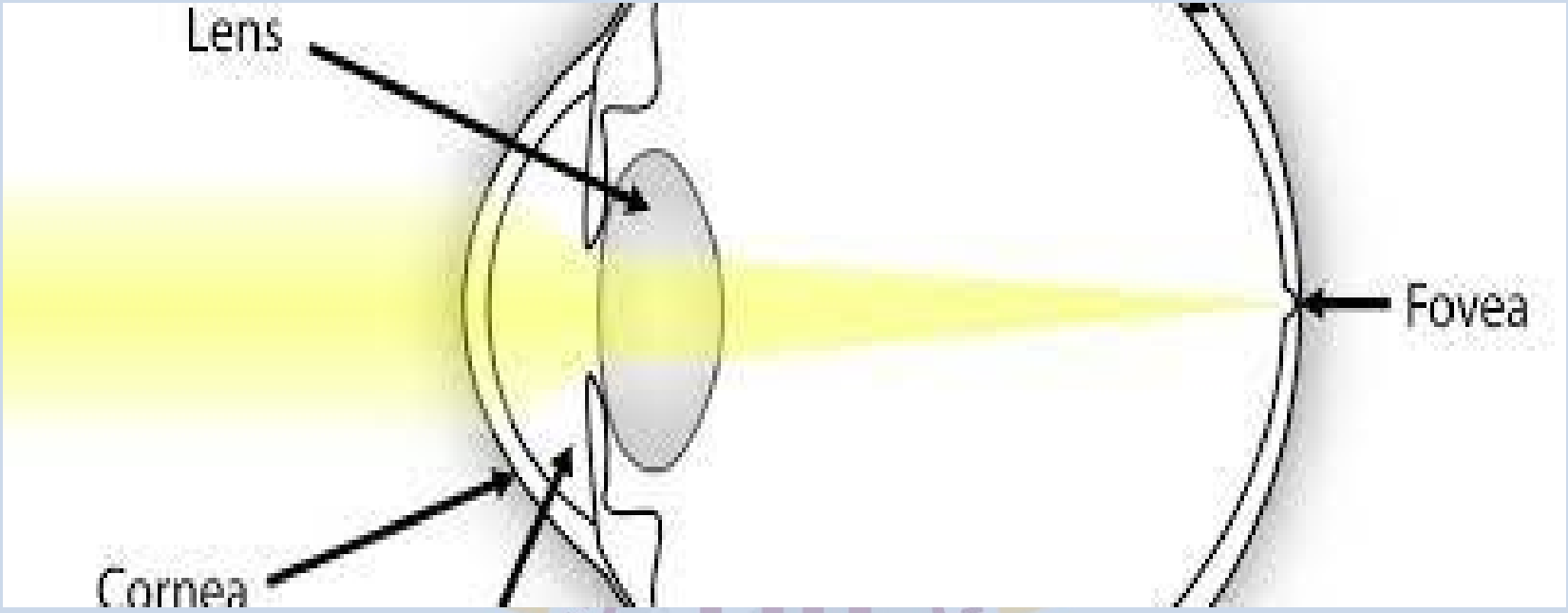
1- The Cornea

A- It is clear transparent on the front of the eye that does about 2/3 of the focusing.



B- It is a fixed focus element.





C- The amount of refracting depend on: -

- The curvature of its surfaces
- The refractive index (n).

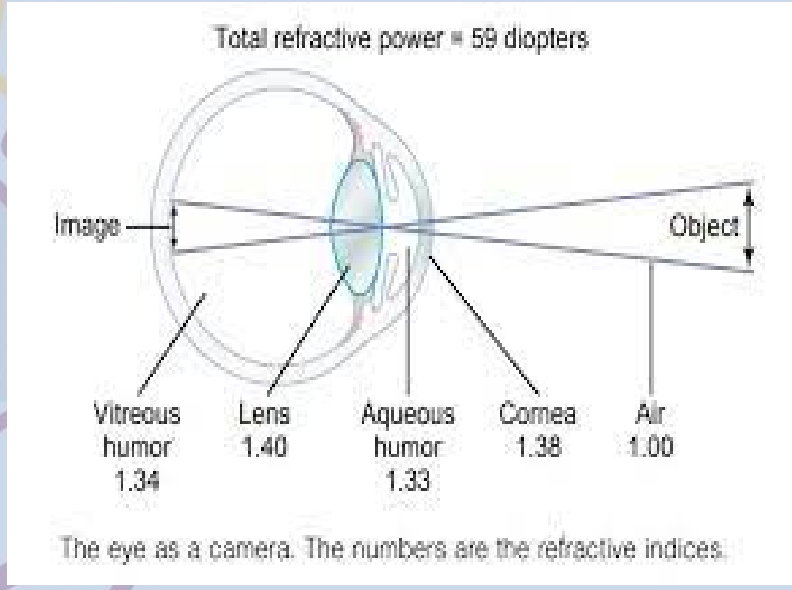
D- When the cornea is under water it lost most of its focusing power, because $n_w = 1.33$ is close to $n_{cornea} = 1.37$.

2- The Lens

A- It is a fine focus element.

B- Its changes its focal length by changing its curvature.

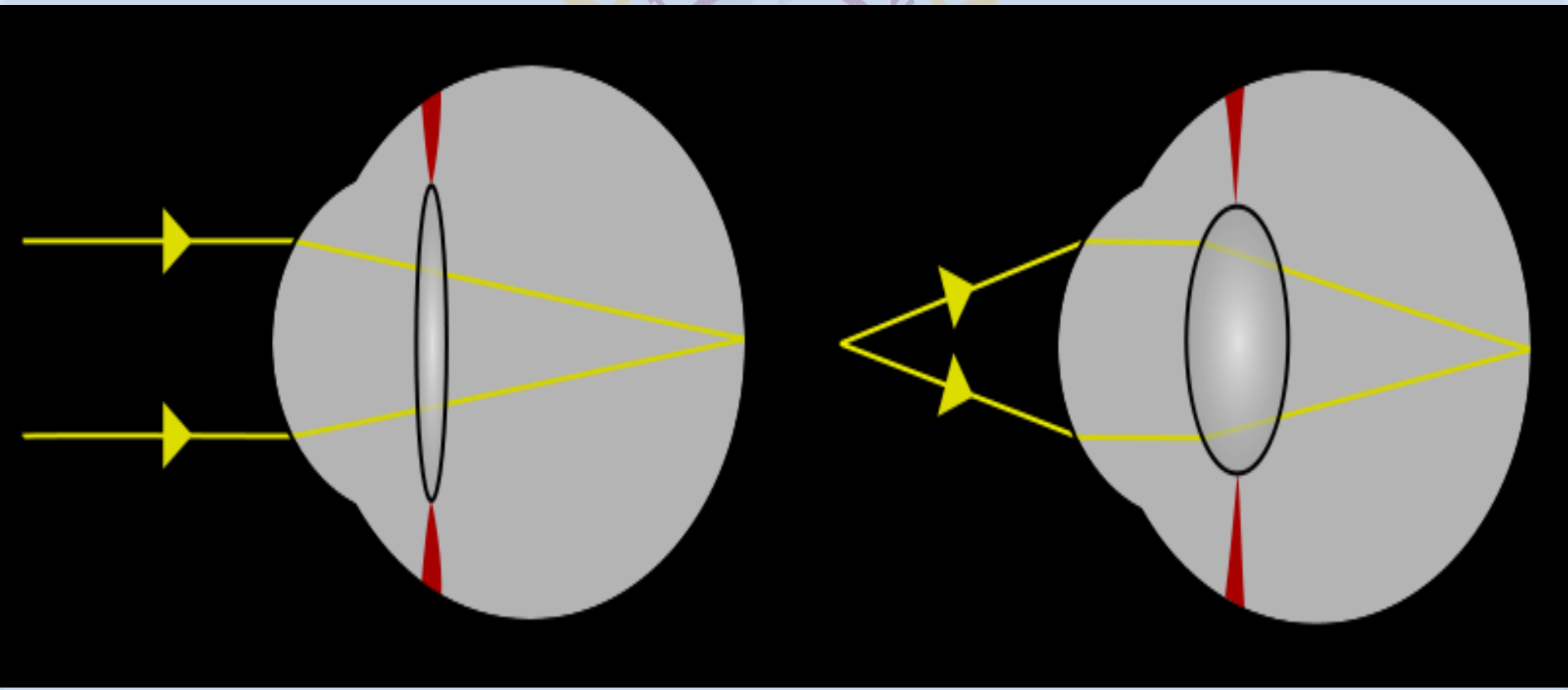
C- Focusing power of the lens < Focusing power of the cornea, because it is surrounded by substances that have indexes of refraction close to its own.



The eye as a camera. The numbers are the refractive indices.

D- Accommodation

The ability of the eye to focus an objects over a wide range is called "**Accommodation**", it is the ability to change focal power of the eye.



Focal power = 1/Focal Length = Diopter.

Range of Accommodation

The power of the normal eye: -

i) When it is relaxed, u = ∞ = Far point.

$$P_{\infty} = \frac{1}{F} = \frac{1}{u} + \frac{1}{v}$$

$$P_{\infty} = -\frac{1}{\infty} + \frac{1}{v} \ldots\ldots\ldots\ldots 1$$

ii) When focused on the near point.

U = 25 cm = 25cm/100.

$$P_n = \frac{1}{F} = \frac{1}{u} + \frac{1}{v}$$

$$P_n = \frac{1}{\frac{25}{100}} + \frac{1}{v} \ldots\ldots\ldots 2$$

* Range of accommodation = Pn - P∞.

$$= \frac{1}{v} + \frac{1}{\frac{25}{100}} - \frac{1}{\infty} - \frac{1}{v}$$

*Range of accommodation (P_n - P_∞) = 4 Diopters.

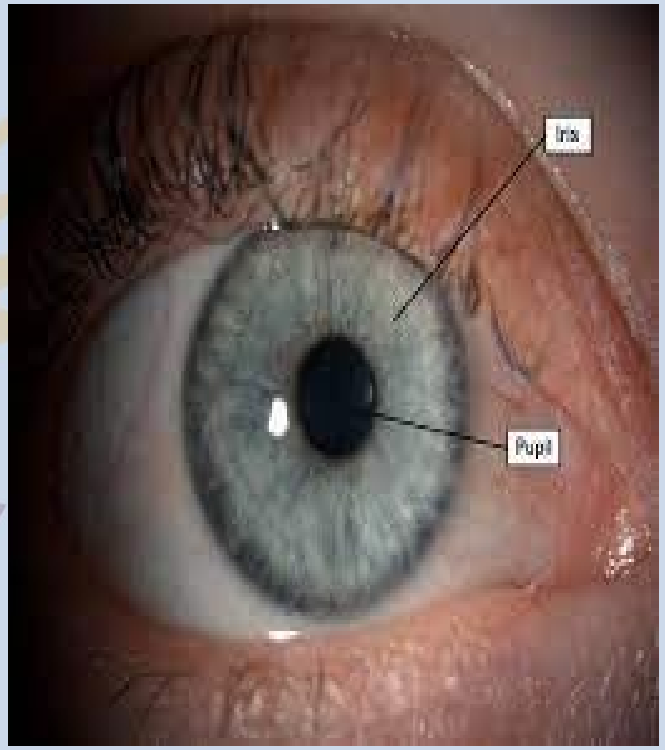
*The range of accommodation of the eye decreases with age as a result of loss in elasticity of the lens.

Pupil

1- It is the opening in the center of the iris.

2- Its function is to regulate the quantity of light entering the eye, this is called "**Adaptation**".

- Its diameter change from 3mm (bright condition) to 8mm (dark light).



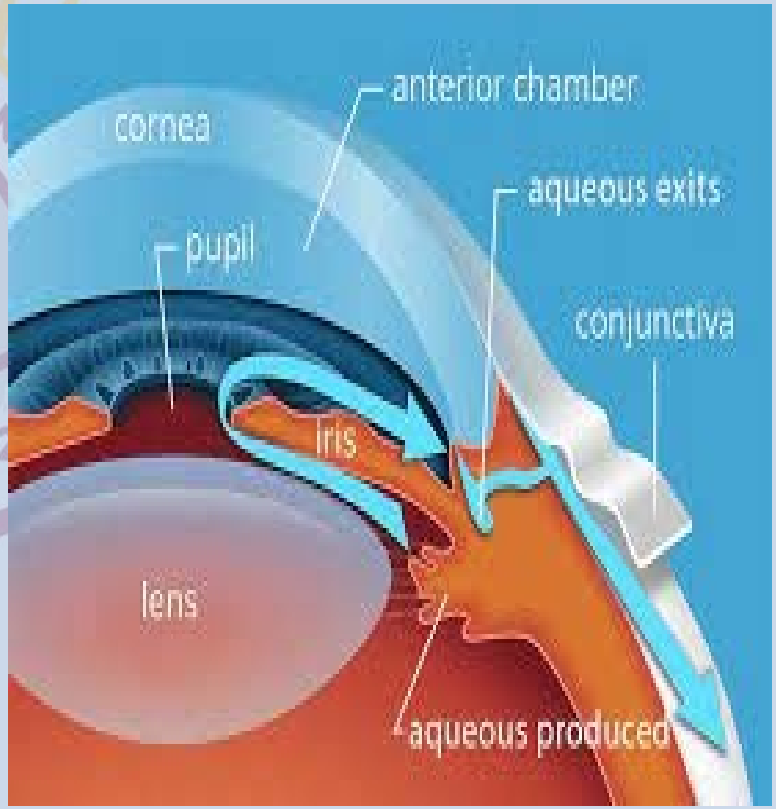
Average diameter under normal condition = 4mm.= opening of pupil.

Aqueous Humor

1- Fill the space between the lens and cornea.

2- Mostly water, n = 1.33.

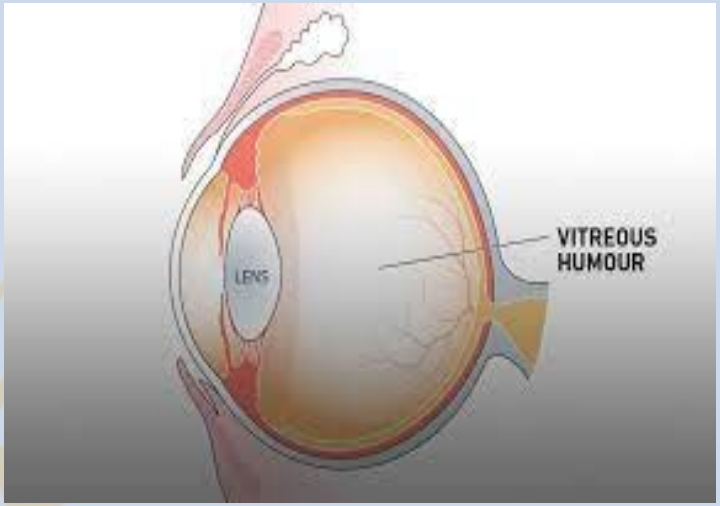
3- It is continuously produced, and the surplus escapes through a drain tube. Blockage the drain tube results in increases pressure in the eye, condition is called "**Glaucoma**".



4- It maintains the internal pressure of the eye at ≈ 20mmHg.

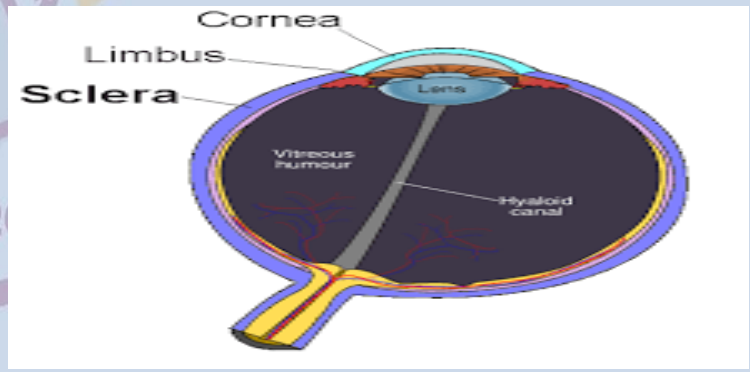
Vitreous Humor

1. Fills the large space between the lens and the retina.
2. Keep the shape of the eye fixed.



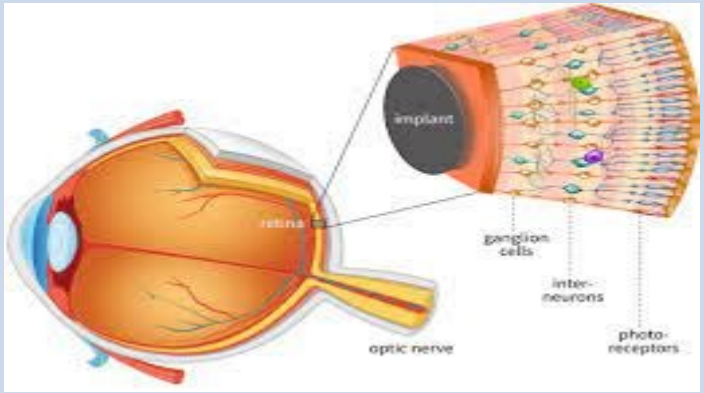
Sclera

It is the tough, white, light-covering over all of the eye except the cornea.



Retina

It is light sensitive part of the eye convert the light images into electrical nerve impulses that sent to the brain.

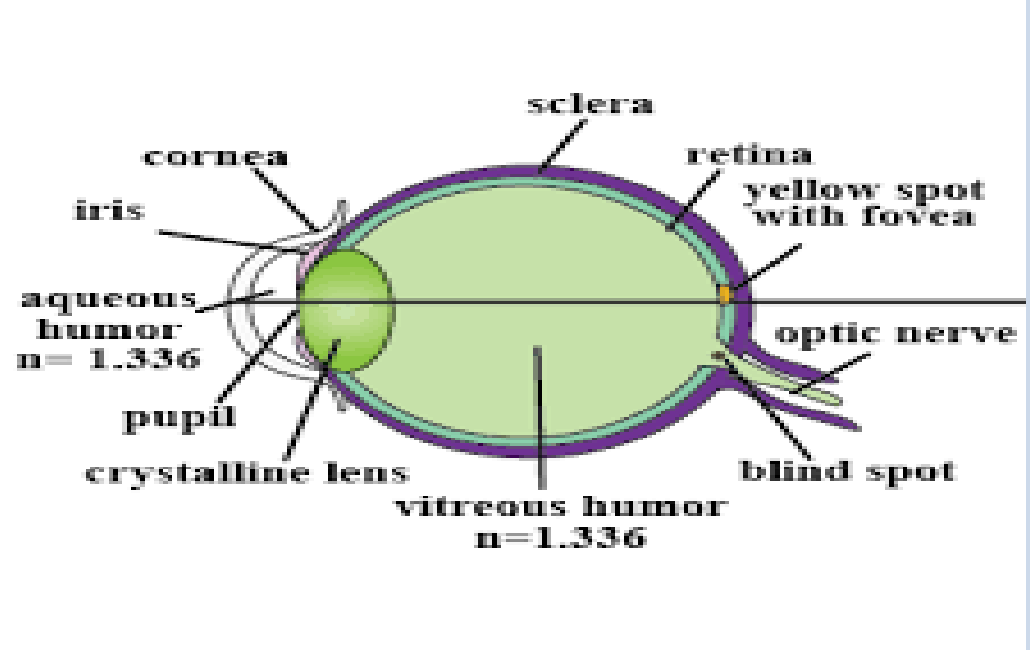


- Energy of photon ==> Retina ==> photochemical reaction in the photoreceptors ==> initiates the action potential.

$$\text{Energy of photon} = \lambda f \approx 3\text{eV}.$$

* The energy of photon must be > 3eV to cause photochemical reaction, and must reach to the photoreceptor.

• Most vision is restricted to small area called "**Yellow Spot**".

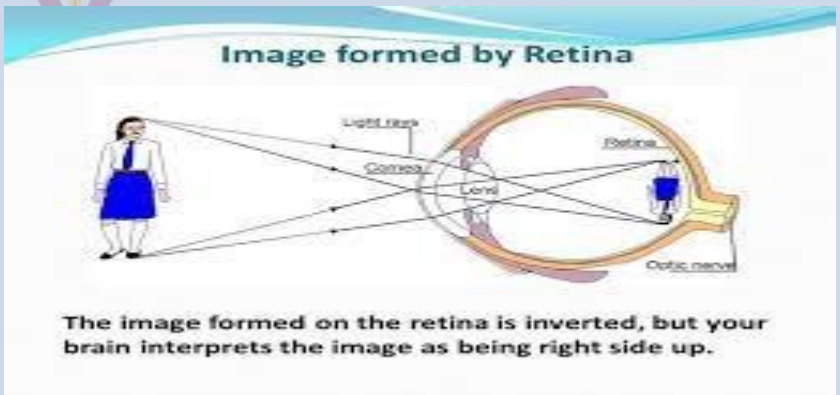


• The characteristics of image on retina are: -

1- Real.

2- Inverted.

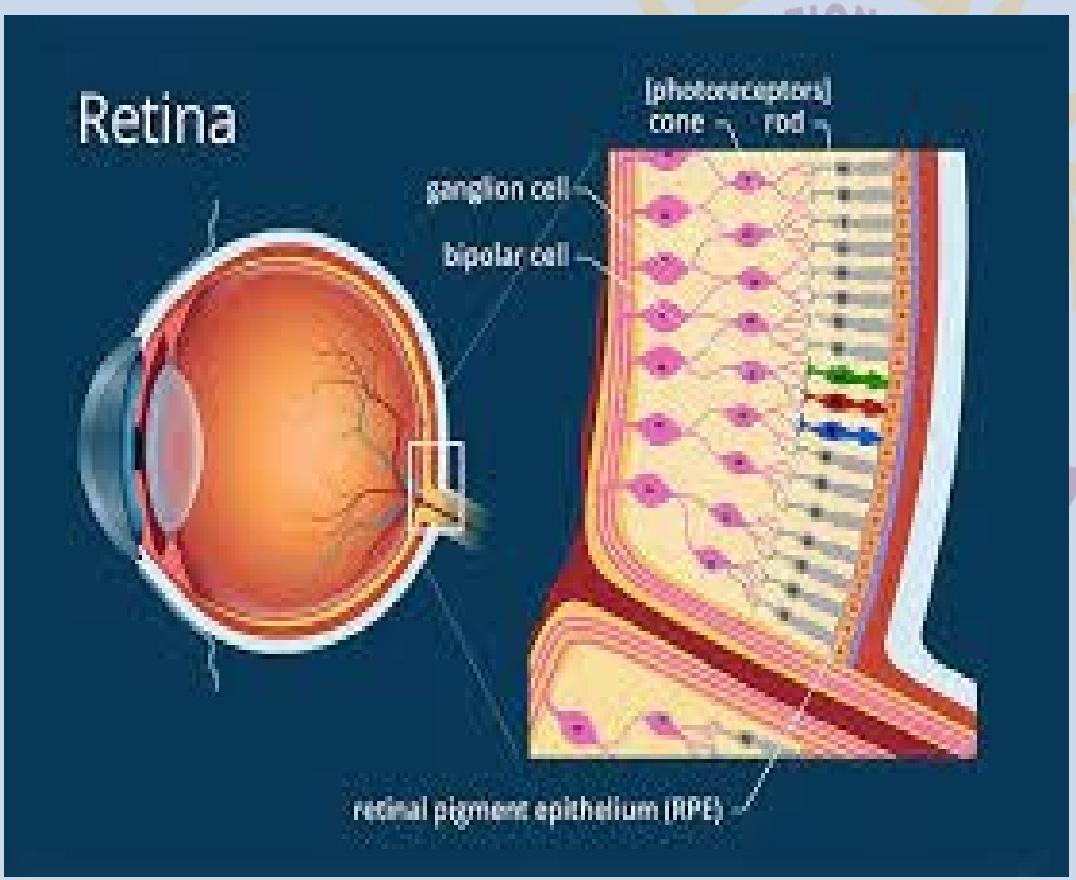
3- Small Size.

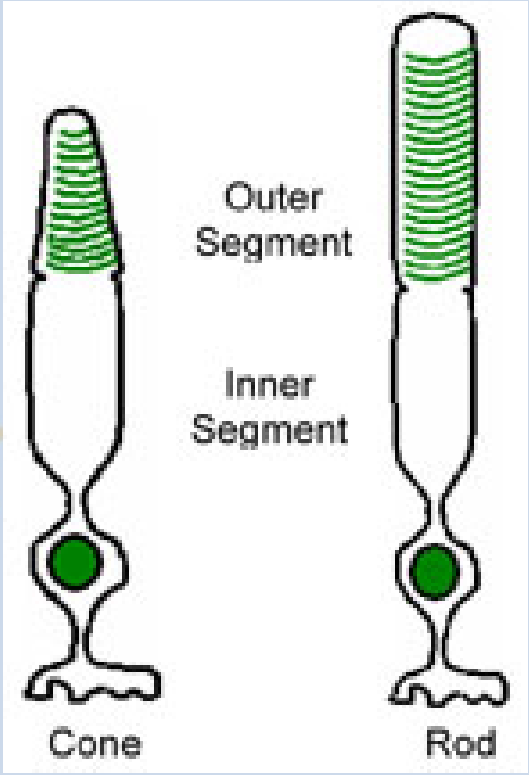


The types of photoreceptors in the retina: -

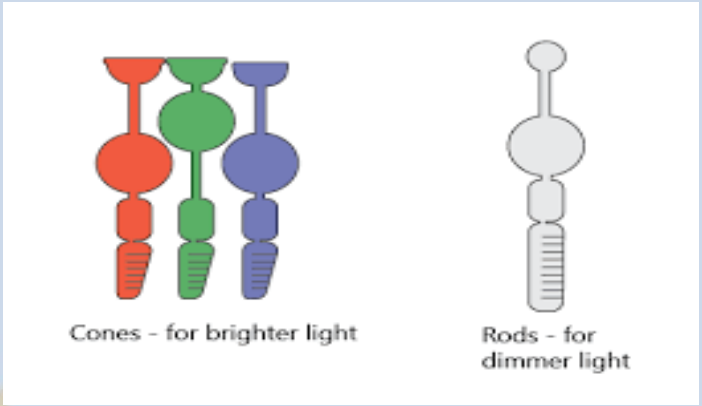
1- Cones.

2- Rods.





Cones



1- Its number ≈ 7.0 million.

2. Are used for day light (photopic vision).

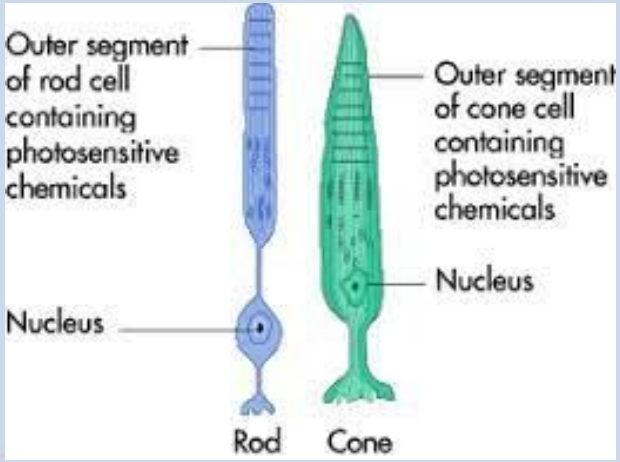
3. Are primary found in the fovea centrails.

4. Its function, to see fine details and recognize different colors.

5. In the rest ≈ (10 cones) share one nerve fiber.

6. Have a maximum sensitivity to a color yellow-green ($\lambda \approx$ 550nm).

Rods



1. Its number ≈ 120 million.

2. Are used for night (Scotopic Vision).

3. Have a maximum density at an angle of ≈ 20°.

4. About (≈ 300 rods) send their information to the same nerve fiber.

5. Are most sensitive to blue-green light ($\lambda \approx 510nm$).

6. Rods are more sensitive to the light than Cones.

Dark Adaptation

1. If the light level suddenly decreases by a factor of 1000, we are momentarily "**in dark**", but after a few minutes we are able to see details that were not visible when the first become dark.

2. This dark adaptation is apparently the time needed for the body to increase the supply of photosensitive chemicals to rods and cones.

3. The first rise of sensitivity is due to cones.

*** It is completed within ≈ 4-5 minutes.**

* The second rise of sensitivity is due to the rods and occupies ≈ 45 minutes.

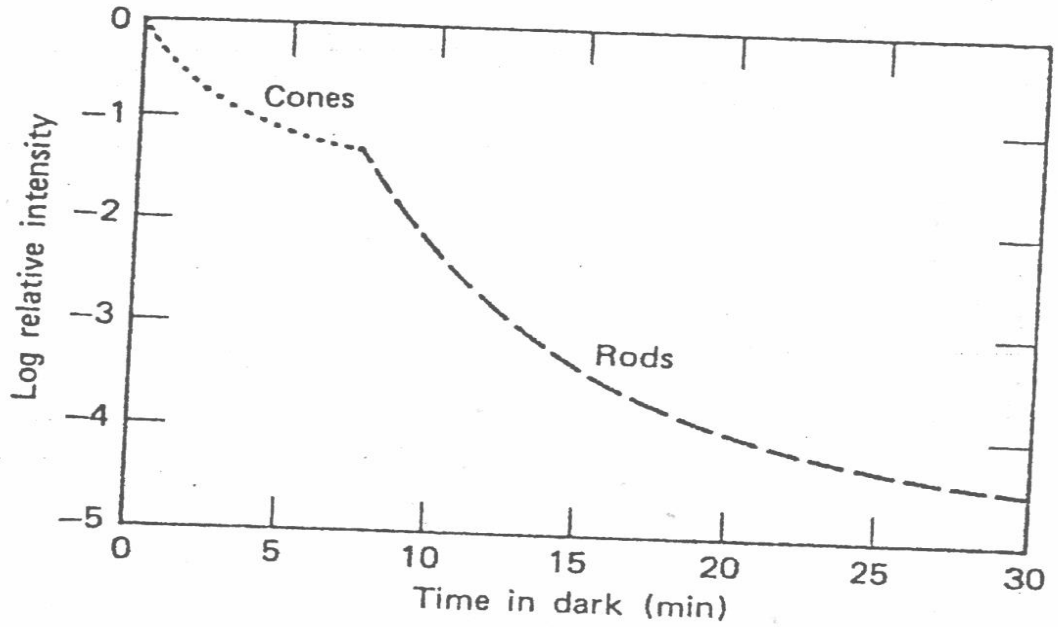
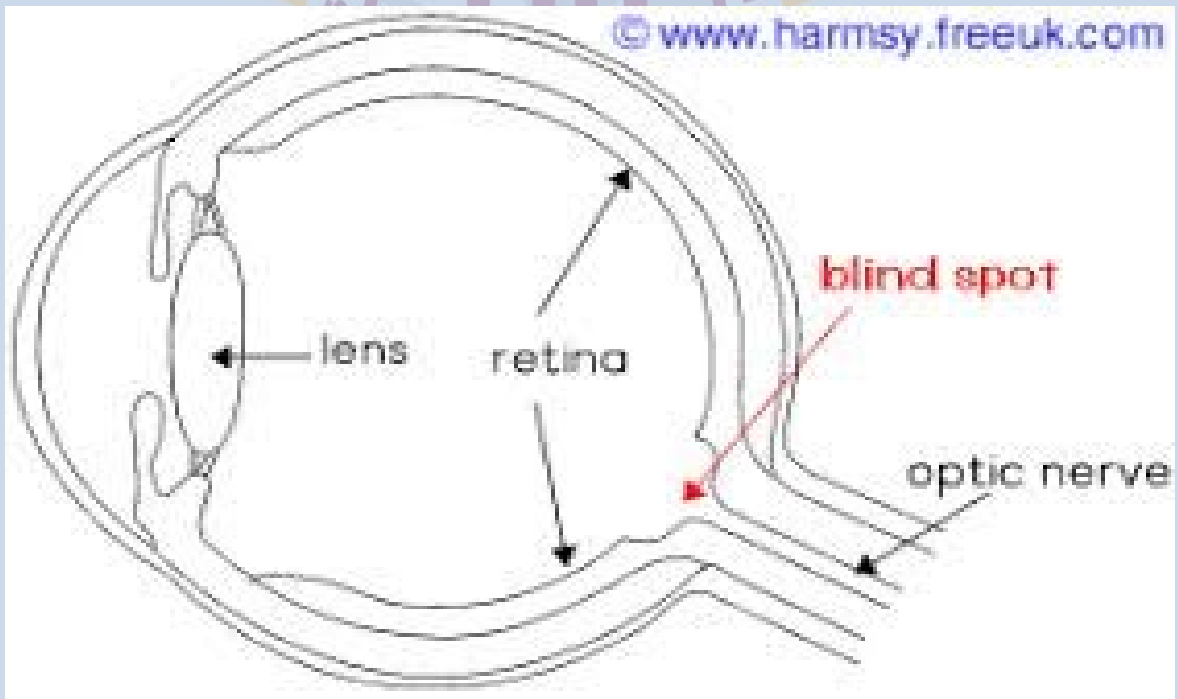


Figure 15.10. The eye dark adapts in two phases. The phase for the cones is completed in 5 to 10 min; the phase for the rods lasts for over 30 min. The increase in sensitivity is a factor of over 10,000.

demonstrate. A simple

Blind Spot

It is a region ≈ 13°-18° that has neither rods nor cones at this point the optic nerve enters the eye.



Thank you