Lecture (8)

Medical Physics

Fourth Stage

Department of Physics

College of Science

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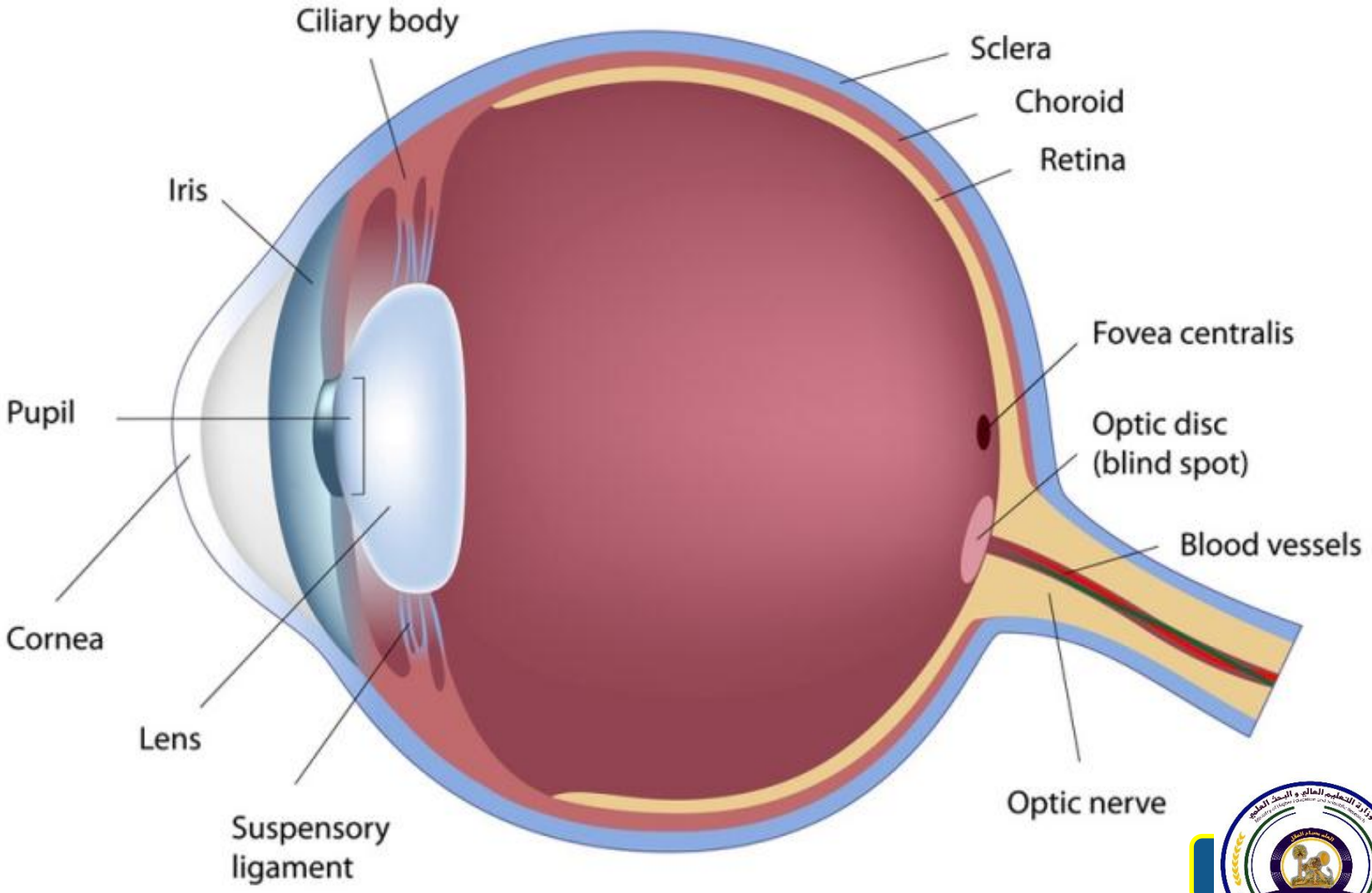
Medical Physics

Physics of eye and vision

Optics of eye:



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Optical system of eye have special features:

1. Eye can observe an event over a very large angle.
2. Blinking is possible in eyes.
3. Eye can operate effectively over a wide range of intensity 10^{10}: 1.
4. It has automatic aperture adjustment.
5. The cornea has no blood supply it is made up of living cells and can repair local damages.
6. Eye has self regulating pressure system (pressure of eye ≈ 20 mm of Hg).
7. The eye are mounted in a well protected casing surrounded by bone.
8. Image appear upside down on the retina at the back of the eye ball but brain automatically correct it.
9. The muscle movement of eye permit flexible movement (up, down, sideways and diagonally).

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Focusing Elements : Eyes consist of two focusing elements:

a) Cornea

1. Cornea: it is a fixed focusing element.
2. Cornea made up of living cells and no blood supply is there.
3. They must get their oxygen from air.
4. The nutrient for the cells in the cornea are supplied by the aqueous humor.
5. Aqueous humor contains all blood component except blood cell.
6. If cornea is scratched, it will repair itself but in some cases the damages may permanent.

b) Lens

1. Lens can focus from front and back surface.
2. Lens is more curved in the back than front.
3. Focusing power of lens is less than cornea.
4. The lens is made of layers and all layers do not have same refraction index.

There are some other focusing elements:

c) Pupil

1. It is in the center of iris.
2. It absorbs all light that enters in eye, so it is black.

d) Aqueous Humor

1. It fills the space between lens and cornea.
2. The fluid is like water.

e) Vitreous Humor

1. Its fills the space between lens and retina.
2. It is a clear jelly like substance.
3. It help the shape of eye fixed.

f) Sclera: it is a white cover on eye except cornea.

Diffraction effect on eye (Defect in eye)

1. In diffraction, a monochromatic light focus on fovea centralis.
2. The diffraction pattern on retina is produced by pupil.
3. The diffraction pattern consist of a central bright spot of 8 μm in diameter.
4. This is surrounded by ring of light.
5. If the pupil is made 1mm diameter the diffraction produces a effect on visual acuity.
6. Lenses have some defects which called aberration.
7. The aberration can be reduced if lens opening is smaller.
8. If pupil is made very small, the acuity becomes worst due to diffraction.
9. Best acuity is obtained when size of pupil is 3 to 4 mm. this is normal size for a good image.
10. The point source will not be focus on single cone due to diffraction defect, so angular speed is 2θ of central bright spot.

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$$2\theta = 2 \times 1.22 \frac{\lambda}{a}$$

Where,

$$\lambda = 555\, nm = 555 \times 10^{-9}\, m$$

$$a = 3\, mm = 3 \times 10^{-3}\, m$$

$$2\theta = \frac{2 \times 1.22 \times 555 \times 10^{-9}}{3 \times 10^{-3}}$$

$$2\theta = 4.5 \times 10^{-4}\, Radian$$

The diameter of central bright spot on retina.

$$d = 17 \times 2\theta$$

$$d = 17 \times 4.5 \times 10^{-4}$$

$$d = 8 \times 10^{-3}\, mm$$

$$d = 8\, \mu m$$

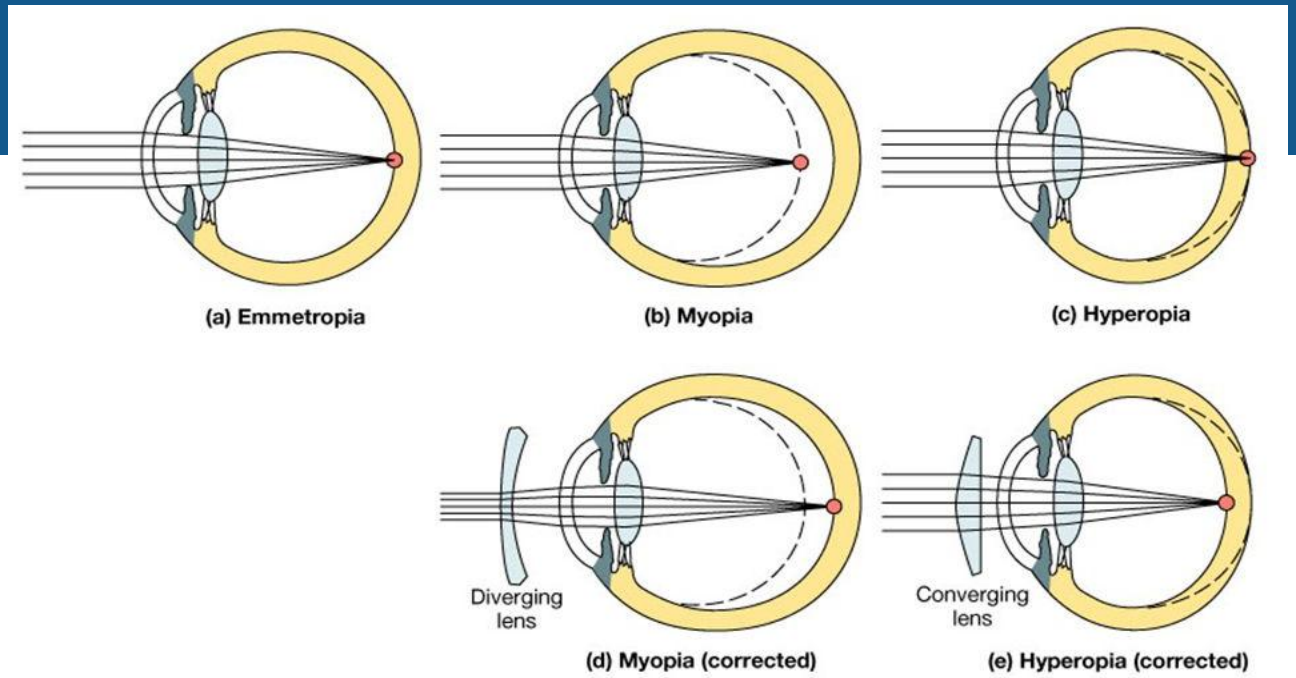
Visual Acuity

Visual acuity is a sharpness of vision. The normal acuity is 20/20. This means that you can read details from 20 feet. Under normal condition, eye can resolve 15 Lp/mm. the resolution is often given in terms of angle. (1 Foot = 0.3048 m)

Visual Abnormalities

(a)

1. Myopia: (Near sighted vision) eye cannot see distance object clearly, this is because the image is focused in front of retina. This is happen when eye ball get elongated.
2. Hyperopia: (Far sighted vision) eye cannot see close object clearly, this is because the image id focused behind the retina. This is happen when the eye ball become short in length.
3. Astigmatism: the shape of the cornea changes to a sphere instead of normal shape, hence light rays focuses on two points in front of eye rather than single point.
4. Presbyopia: this is error cause due to age.



(b) Glaucoma: when pressure with in the eye is raised above normal (20 mm of Hg).

(c) Trachoma: Trachoma is a contagious bacterial infection which affects the conjunctival covering of the eye, the cornea, and the eyelids. It is often associated with poverty and lack of proper hygiene.

(d) Iritis: inflation of iris by spread of inflammation from surrounding or by injury (physical harm).

Correct Vision

The following table shows how abnormalities of eye are corrected:

Focusing Problem	Common Name	Usual Name	Corrected with
Myopia	Near Sighted Vision	Long eyeball or cornea too curved	Negative lens (concave)
Hyperopia	Far Sighted Vision	Short eyeball or cornea not curved enough	Positive lens (convex)
Astigmatism	-	Irregular cornea	Cylindrical lens
Presbyopia	Old Age Vision	Lack of accommodation	Bifocal lens

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