

Physics of eye and Vision

The sense of vision consists of three major components:

1. The eyes that focus an image from the outside world on the light-sensitive retina Fig 15.1 .
2. The system of millions of nerves that carries
3. The visual cortex-that part of the brain.

Blindness results if any on of the part does not function.

The eye has same striking similarities to camera (TV system) .

1. The lens of TV camera is analogous to the lens of the eye.
2. The signal cable is the optic nerve.
3. Viewing monitor the visual cortex.

Figure 15.2 . The sense of light is in many ways similar to a closed circuit TV system

- a. Formation of the image on retina its correction by brain
- b. Formation of the image on camera and its correction by viewing monitor.

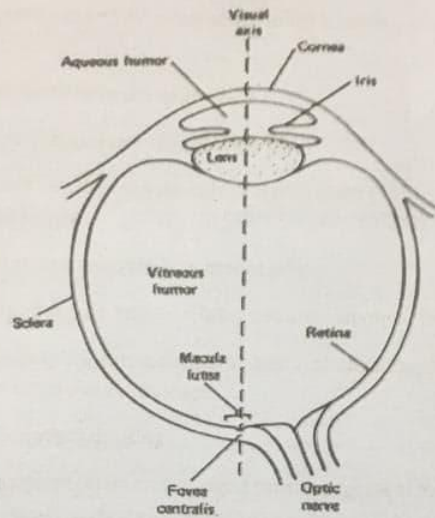


Figure 15.1. Cross-section of the left eye as seen from above.

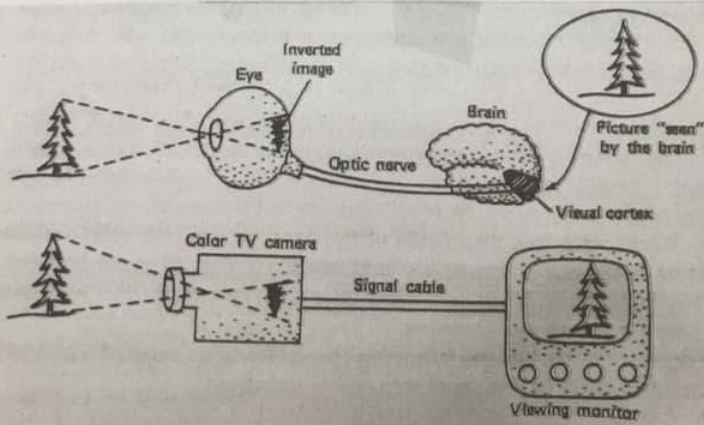


Figure 15.2. The sense of sight is in many ways similar to a closed circuit color TV system. It is superior in all respects except ease of replacement.

Specifications of the Optical System

1. Observation of events over $\sim 180^\circ$ angle when looking intently at an object directly ahead of it.

1. Blinking to clean and lubricate the lens.

3. Clear distance viewing between. $\sim 25\text{cm}$ to infinity.

4. Operating effectively between the daylight and dark night ($\sim 10^{10}$: 1 intensity). Brilliant day light to a very dark night. *10 billion to one*

5. The eye has an automatic aperture adjustment (Iris).

6. Cornea (has no blood supply) made of living cell and can repair the local damage.

7. The eye has a self-regulating pressure system that maintains the internal pressure of $\sim 20\text{mm Hg}$ and thus keeps the eye in shape.

8. Mounted in a well-protected casing.

9. The image appears upside down on the light sensitive retina at the back of the eyeball, but the brain automatically corrects for this.

10. The brain blends the image from both eyes giving as good depth perception and the 3D viewing. *Three-dimensional*

11. The muscles of the eye (six muscles, the muscles work in pair) permit flexible movement up, down, side-ways and diagonally. All six muscles are attached to the skull.

One pair control up and down movement.

= = = left and right movement.

= = = rotation.

After a little practice, the eye can even be made to go in circle.

Vision Elements of the Eye

1. The cornea: does about two-third of focusing of light Fig 15.1.

*by refracting the light rays
i.e. $n = \frac{c}{v}$*

Part of the eye	Index of Refraction
Cornea	1.32
Aqueous humor	1.33
Lens cover	1.35
Lens center	1.41
Vitreous humor	1.35

Table 15.1 The indexes of refraction of the cornea and other optical parts of the eye

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

It is helieved that iris aids the eye by increasing or decreasing incident light on the retina, the retina to adapted the new lighting condition.

In addition , under bright light conditions it plays an important role reducing lens defects

3. 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 absarbed inside 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.

4. **The lens:** It is variable in shape and has the ability to focus objects at various distances at both its front and back surfaces. It is more curved in the back than in the front

The focusing power of lens is smaller than that of the cornea (1/3), because it is surrounded by substance that have indexes of refraction close to its own.

The lens is made up of layers somewhat like onion and all layers do not have the same n .

5. **The aqueous humor:** it fills the space between the lens and the cornea. This fluid is mostly water, $n \approx 1.33$.

It is continuously being produced and the surplus escapes through drain tube.

"Canal of Schlemm. Blockage of the drain tubes results in increased pressure in the eye. "Glaucoma".

It maintains the internal pressure of the eye at about 20 mm Hg.

It contains many of the components of blood and provides nutrients to the non-vascularized cornea and lens.

6. **The Vitreous humor :** is a clear jelly-like substance that fills the large space between the lens and the retina. It helps to keep the shape of the eye fixed and is essentially permanent.

7. **The sclera:** is the tough, white, light-colored covering over all of the eye except the cornea. The sclera is protected by a transparent coating called the conjunctiva.

8. **The Retina :** the light-sensitive part of the eye, it converts the light image into electrical nerve impulses that are sent to the brain. "Its lining is the most of sclera"

Rods and cones

The Rods and Cons are distributed symmetrically in all directions from the visual axis.

Except in one region blind spot.

A. cones: The cones (6.5 million in each eye)

1. Are primarily used for daylight or photopic vision. With the cones, we can see fine details and recognize different colors.
2. The cones are primarily found in the fovea centralize although some are scattered throughout the retina.
3. Each of the cones in the fovea has its own telephone lines to the brain, in the rest of the Retina several cones share on nerve fiber.
4. The cones are not uniformly sensitive to all color but have a maximum sensitivity at about 550nm in the yellow-green region.
5. The cones adapted most rapidly (dark adapt) at the ~ 5 min in the fovea centralize has reached its best sensitivity.

B. Rods: the rods (~120 million in each eye and covered most of the retina).

- 1- Are used for night or scotopic vision and for peripheral vision.
- 2- They are not uniformly distributed over the ^{retina} retina, but have a maximum density at an angle of about 20°.
- 3- Hundreds of rods send their information to same nerve fiber.
- 4- the rods are most sensitive to the blue-green light (~510nm) which has a wavelength shorter than the optimum for the cones (~550nm).
5. The rods continue to dark adapted for 30-60 min although their adaptation occurs in the first 15 min. Fig. 15.9

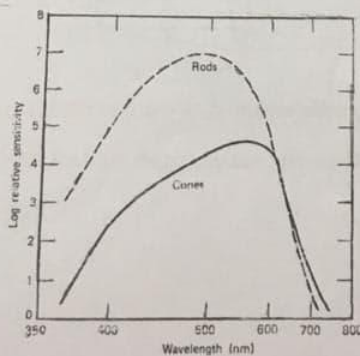


Figure 15.9. The rods are much more sensitive than the cones. The vertical axis is a log scale; each division represents a factor of 10 in sensitivity. The best sensitivity of cones is at about 550 nm, while the best sensitivity of rods is at about 510 nm.

Optical Defect of the Eyes

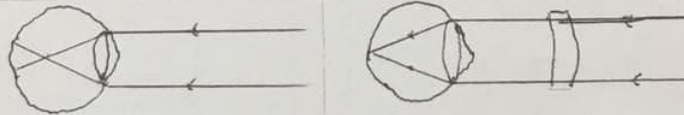
1. **Myopia (Short sight)**: The eyeball is too long and parallel rays are focused in front of the retina. Therefore only near objects can be seen clearly. Near point $< 25\text{cm}$, far point $\leq \infty$.

The defect can be corrected by use of spectacles, which diverging spectacle lenses (**negative lens**).

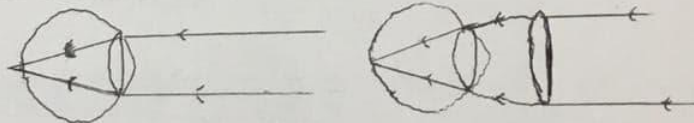
2. **Hypermetropia (Long sight)**: The eyeball is too short, and parallel rays are focused to a point behind the retina. Therefore the near point is much further from the eye than normal. Near point $> 25\text{cm}$, far point $= \infty$. The defect can be corrected by using converging spectacle lenses (positive lens).

3. **Astigmatism**: when an astigmatism is present, point objects do not form clear point images see lines going in different directions. (25 \rightarrow ∞). The defect is corrected by the use of cylindrical spectacle lenses (**-ve or +ve**) with axes about $\theta \rightarrow 180$.

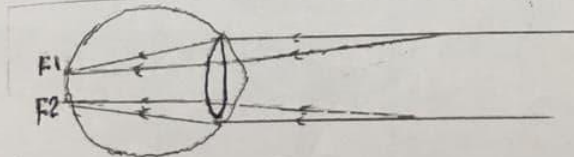
Myopia (short sight)



Hypermetropia (long sight)



Astigmatism



Snellen chart,

A. Normal eyes test 20/20ft or 6/6m, that means good vision can read detail from 20ft or 6m

b. If eye test 20/40ft, 6/12m, that means, you can just read from 20ft, the line appears with good vision from 40 ft.