**23B-3 Objectives**

- Identify the anatomical structures of the eye
- Discuss how sound waves are transformed into nerve impulses
- Summarize the functions of the structures involved in vision
- Explain the difference between rods and cones

## 23B-3 The Eye and Sight

The eyes are a set of spheres a bit smaller than table tennis balls. They supply a continuous series of nerve impulses for about sixteen hours per day and then operate repair and maintenance systems while the body is sleeping. Normal eyes can focus on a hair as near as a few inches and on large objects as distant as several miles.

The brain controls muscles that move and focus the eyes so that they work harmoniously to provide a stereoscopic image that permits depth perception. While only silhouettes can be seen in near darkness, one can distinguish minute variations in color in bright light. Scientists have not been able to explain completely how the eyes operate. The beauty and wonder of the eye is that it is perfectly designed to permit sight.

### The Eye

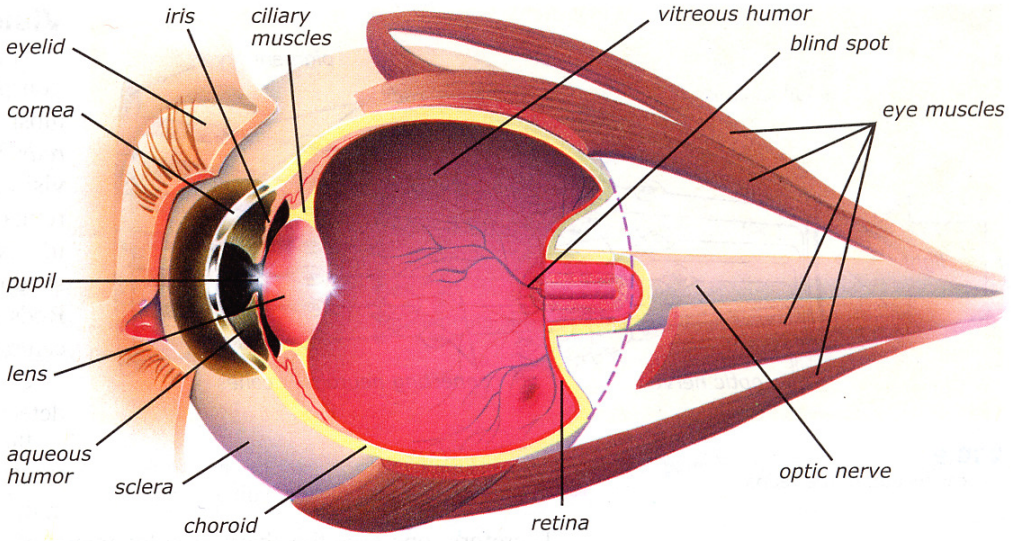
The eyeball has three tissue layers. The outer layer, known as the **sclera**,* is "the white of the eye." This white fibrous tissue maintains the shape of the eyeball. The transparent, anterior portion of the sclera, the **cornea** (KOHR nee uh), allows light to enter the eyeball. The cornea lacks blood vessels but receives nourishment from the fluid underneath it in the eyeball.

The middle layer, the **choroid** (KOHR OYD), is fragile and thin with many blood vessels for nourishing the retina. The anterior portion of the choroid, the **iris*** (EYE ris), contains muscles and is the colored part of the eye. The circular opening in the iris is the **pupil**, which lets light into the eyeball. Muscles in the iris change the diameter of the pupil, regulating the amount of light entering the eye. In bright light the pupil is almost closed, protecting the retina from too much light. In dim light, however, it dilates (opens), permitting all the available light to enter.

* **sclera:** (hard)
**iris:** (Gk. IRIS, rainbow)

The third and innermost layer of the eyeball is the **retina**, composed of thousands of specialized neurons and their fibers. The neurons of the innermost layer are *photoreceptors** that can be stimulated by light. The impulses from the photoreceptors are transmitted to the occipital lobe of the brain by way of the *optic nerve*.

There are no photoreceptors where the optic nerve fibers leave the eye to form the optic nerve. This area is the *blind spot*, or *optic disc*. In people with normal eyes, the blind spot of each eye affects a different area of vision; therefore, the total field of vision is unbroken.




**23B.7**
Human eye anatomy

The **lens** of the eye is a biconvex, semisolid substance supported by the **ciliary*** (SIL ee UHR ee) **muscles** and **suspensory ligaments**. The ciliary muscles and suspensory ligaments can change the shape of the lens. When looking at a close object, the muscles contract, making the lens thicker (more convex) and focusing the image on the retina. When looking at a distant object, the muscles relax and the lens flattens to focus the image.

The ability to focus on objects at different distances from the eye is *visual accommodation*. The lens is elastic in children but becomes more rigid with age. Therefore, at about age forty some people begin having difficulty focusing on things closer to them; they hold reading material farther from their eyes. Lenses in glasses can compensate for the hardened natural lenses.

There are two cavities in the eyeball: one in front of the lens and one behind. The anterior cavity is filled with the **aqueous** (AY kwee us) **humor**,* a transparent, watery fluid that diffuses from blood vessels located near the ciliary muscles. This fluid nourishes the cornea and diffuses into the blood by way of canals on the edge of the cornea. The posterior chamber of the eyeball contains a clear, permanent, jellylike substance called the **vitreous*** (VIT ree us) **humor**.

In the upper lateral region of each eyelid is the *lacrimal** (LAK ruh mul) gland (tear gland). It secretes about 1 mL of fluid each day, which is spread evenly over the surface of the eyeball with each blink. The fluid moistens and cleanses the cornea and lubricates the eyelid. It also contains *lysozyme*, an enzyme that kills bacteria. If the eyeball is irritated or if the person is under emotional stress, the lacrimal gland secretes more fluid, often resulting in tears.

Several sets of muscles control the movement of the eyeballs so that both eyeballs are directed toward the same object. In some individuals, muscles that are not equal in length or strength, or are paralyzed, cause the eyes to cross.

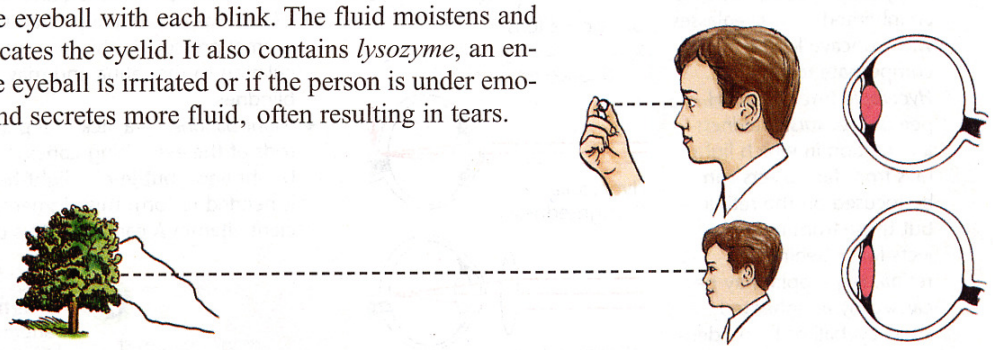
* **photoreceptor:** photo- (light) + -receptor (L. RECEPTARE, to receive)

**ciliary:** cili- (eyelid) + -ary (related to)

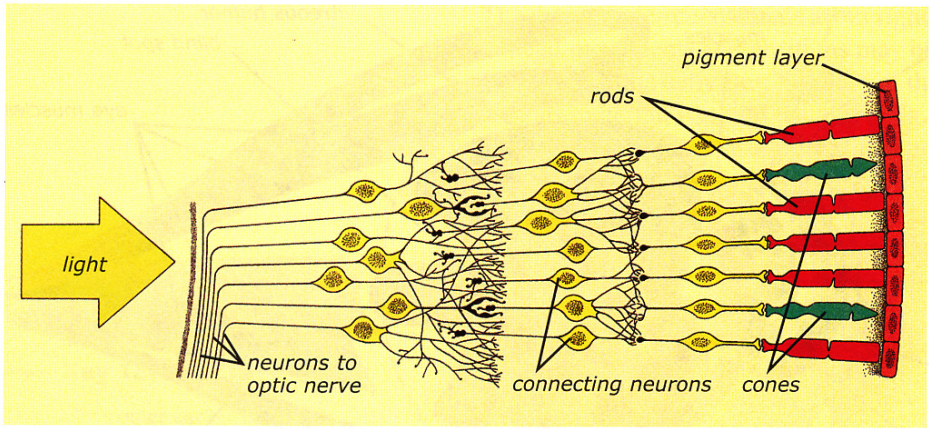
**aqueous humor:** aqueous (L. AQUA, water) + humor (fluid)

**vitreous:** (glass)

**lacrimal:** (L. LACRIMA, tear)



**23B.8**
The thickness of the lens changes, permitting the eye to focus on objects at different distances.




**23B.9**
Cross section of the retina

## Vision

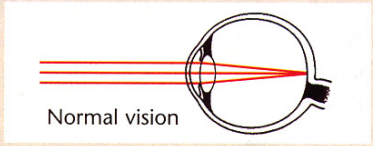
There are more than 100 million photoreceptors in each eye, most of which are shaped like *rods*. Rods—responsible for night vision—are scattered over the retina. They are sensitive to low intensity light and produce a shadowed or silhouette image. Rods cannot determine color but can rapidly discern movements.

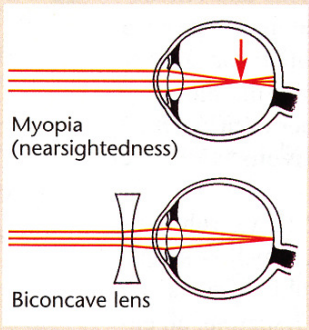
Cone-shaped photoreceptors detect colors. The *cones* are especially concentrated at the *fovea** (FOH vee uh), a small depression in the central region of the retina. Therefore, one sees the sharpest color image of an object when looking directly at it in a well-lit environment; in dim light the image would not be clear because there are no rods at the fovea.

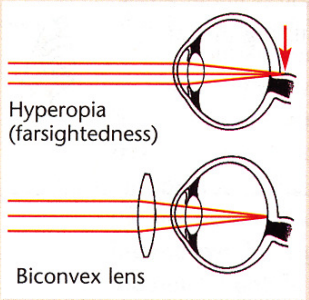
Both rods and cones contain light-sensitive pigments, and when the rods and cones are stimulated by light, the pigments decompose. These substances initiate a complex biochemical pathway that changes light energy into an action potential that is carried to the brain by the optic nerve. The brain then interprets the sensory input as images and colors.

**fovea:** (L. FOVEA, pit)

### Eye Disorders




- *Myopia* (mye OH pee uh), or *nearsightedness*—a condition in which light rays from close objects can be focused on the retina, but those from distant objects are focused in front of the retina and therefore are not seen clearly. The problem is usually caused by an abnormally long eyeball, which is an inherited trait. Eyeglasses with concave lenses may compensate for myopia.
- *Hyperopia* (HYE puh ROH pee uh), or *farsightedness*—a condition in which light rays from far objects can be focused on the retina but those from near objects focus behind the retina. Hyperopia may be caused by an inherited short eyeball or by hardening lenses. Eyeglasses with convex lenses may help a farsighted person to see close objects. Occasionally bifocal glasses, which have lenses for farsightedness in the lower portion and other lenses in the upper portion, are necessary.
- *Astigmatism** (uh STIG muh TIZ uM)—condition in which either the cornea or lens or both are uneven or unequally curved and the light rays from an object are not focused properly on the retina. This results in an area of the person's vision being out of focus. Sometimes the other eye will compensate for mild astigmatisms.
- *Cataracts*—clouded lenses that may be caused by old age, overexposure to bright sunlight, or diseases such as diabetes. Treatment may involve the surgical removal of the lens and the implant of an artificial one. Sometimes special eyeglasses are used to compensate for the loss of the lens. Clouded corneas can be removed and replaced with transplants.
- *Glaucoma*—the buildup of aqueous humor resulting in abnormal pressure within the eye. This causes a decrease of circulation to the retina and may damage the retina and cause blindness.
- *Night blindness*—a lack of a pigment (visual purple) in the rods of the eye. Using cones, the person can see clearly in bright light, but in dim light he cannot see well. Vitamin A is needed to form this pigment; therefore, a diet with insufficient vitamin A can cause this condition.

**astigmatism:** a- (without) + -stigma- (Gk. STIGMA, spot) + -ism (E. -ISM, indicating a condition)