Eye

The human eye is a complex part of the body that is used for seeing. Eyes enable people to perform daily tasks and to learn about the world that surrounds them. Sight, or vision, is a rapidly occurring process that involves continuous interaction between the eye, the nervous system, and the brain. When someone looks at an object, what he really sees is the light reflected from the object. This reflected light passes through the lens and falls on the retina of the eye. Here the light induces nerve impulses that travel through the optic nerve to the brain and then over other nerves to muscles and glands.

The eye is similar to a television camera. Both the eye and the television camera convert light energy to electrical energy. The eye converts light to nerve impulses that are interpreted by the brain as the sense perception called sight. A television camera converts light to electronic signals that are broadcast and transformed into light images in a television receiver.

The eye is well protected. It lies within a bony socket of the skull. The eyelids guard it in front. They blink an average of once every six seconds. This washes the eye with the salty secretion from the tear, or lachrymal, glands. Each tear gland is about the size and shape of an almond. These glands are situated behind the upper eyelid at the outer corner of the eye. After passing over the eye, the liquid from the gland is drained into the nose through the tear duct at the inner corner of the eye.

Hearty laughter or weeping causes muscles in the upper eyelid to squeeze the lachrymal gland. This produces tears that flow too fast to be drained away. The eyelashes catch many flying particles that otherwise would enter the eye. As a further protection, the eyelids automatically close when any object suddenly moves close to the eye.

Structure

The eye is shaped like a ball, with a slight bulge at the front. It...
is this bulge that a person sees when looking at the eyes of someone else. When the eyelids are closed, the bulge is covered. The rest of the eye is protected by the bones of the skull. Each part of the human eye has a special function. (For descriptions of some animals' eyes see Birds; Fish; Insect; Invertebrates.)

**Cornea and sclera.** The eye is made of three coats, or tunics. The outermost coat consists of the cornea and the sclera; the middle coat contains the main blood supply to the eye and consists of the choroid, the ciliary body, and the iris. The innermost layer is the retina. The sclera, or the white of the eye, is composed of tough fibrous tissue. On the exposed area of the eye the scleral surface is covered with a mucous membrane called the conjunctiva. This protects the eye from becoming dry. The cornea, a part of the sclera, is the transparent window of the eye through which light passes. The focusing of light begins in the cornea.

Behind the cornea is a watery fluid called the aqueous humor. This fluid fills a curved, crescent-shaped space, thick in the center and thinner toward the edges. The cornea and the aqueous humor together make an outer lens that refracts, or bends, light and directs it toward the center of the eye.

**Iris.** Behind the aqueous humor is a colored ring called the iris. The color of the iris is inherited and does not affect vision. The iris is like a muscular curtain that opens and closes. It controls the amount of light entering the eye through the pupil, an opening in the iris. The pupil looks like a black spot. Light from everything a person sees must go through the pupil. When more or less light is needed to see better, the pupil becomes larger or smaller through the movement of the muscle in the iris. The aqueous humor flows through the pupil into a small space between the iris and the lens.

A simple way to see how the pupils respond to light is to stand in front of a mirror with the eyes closed, covered by the hands for about ten seconds. When the hands are removed and the eyes opened, the pupils begin to get smaller, or contract, in response to the light. When light is reduced, pupils expand; when it is increased, they contract.

The choroid is a layer of blood vessels and connective tissue squeezed between the sclera and the retina. It supplies nutrients to the eye. The ciliary body is a muscular structure that changes the shape of the lens.

**Lens.** Behind the pupil and iris are the crystalline lens and the ciliary muscle. The muscle holds the lens in place and changes its shape. The lens is a colorless, nearly transparent double convex
structure, similar to an ordinary magnifying glass. Its only function is to focus light rays onto the retina. The lens is made of elongated cells that have no blood supply. These cells obtain nutrients from the surrounding fluids—the aqueous humor in front and the vitreous body, a clear jelly, behind.

The shape of the lens—essentially that of a flattened globe—can be changed by the movement of the ciliary muscles surrounding it. Hence, the eye can focus clearly on objects at widely varying distances. The ability of the lens to adjust from a distant to a near focus is called accommodation. By contracting, the ciliary muscle pushes the lens to make it thicker in the middle. By relaxing, the muscle pulls the lens and flattens it. To see objects clearly when they are close to the eyes the lens is squeezed together and thickened. To see distant objects clearly it is flattened.

For people with normal vision, the relaxed ciliary muscle flattens the lens enough to bring objects into sharp focus if they are 20 feet (6 meters) or more from the eye. To see closer objects clearly, the ciliary muscle must contract in order to thicken the lens. Young children can see objects clearly at distances as close as 2 1/2 inches (6.4 centimeters). After about age 45 most people must have objects farther and farther away in order to see them clearly. The lens becomes less elastic as a person grows older.

**Retina.** The retina is a soft, transparent layer of nervous tissue made up of millions of light receptors. The retina is connected to the brain by the optic nerve. All of the structures needed to focus light onto the retina and to nourish it are housed in the eye, which is primarily a supporting shell for the retina.

When light enters the eye it passes through the lens and focuses an image onto the retina. The retina has several layers, one of which contains special cells named for their shapes—rods and cones. Light-sensitive chemicals in the rods and cones react to specific wavelengths of light and trigger nerve impulses. These impulses are carried through the optic nerve to the visual center in the brain. Here they are interpreted, and sight occurs.

Light must pass through the covering layers of the retina to reach the layer of rods and cones. There are about 75 to 150 million rods and about 7 million cones in the human retina. Rods do not detect lines, points, or color. They perceive only light and dark tones in an image. The sensitive rods can distinguish outlines or silhouettes of objects in almost complete darkness. They make it possible for people to see in darkness or at night. Cones are the keenest of the retina's receptor cells. They detect the fine lines and points of an image. The cones, for example, make it possible to read these words. There are three types of
cones that receive color sensations. One type absorbs light best in wavelengths of blue-violet and another in wavelengths of green; a third is sensitive to wavelengths of yellow and red.

**Visual purple.** Rods detect images in the dark because the cells contain a rose-red pigment called visual purple, or rhodopsin. When exposed to bright light, visual purple undergoes a chemical change in which it loses its color. This causes the rods to lose their sensitivity to light, thus enabling the eye to endure glaring light.

Before the eye can see in the dark, visual purple must be re-formed in the retina. As more visual purple is produced, the eye's sensitivity to light increases. Thus when a person enters a darkened motion-picture theater his eyes do not contain much visual purple. As the visual purple is re-formed, the person can see better. In a short time his eyes' sensitivity to light is multiplied about 2,000 times. Visual purple can be produced only if the body has a sufficient quantity of vitamin A (see Vitamins). Lack of vitamin A in the diet may lead to night blindness, or nyctalopia.

**Vision**

The optic nerve delivers its impulses to a special area of the brain called the visual center (see Brain). This is where people "see" objects in the sense of recognizing and reacting to what their eyes look at. In other words, seeing always involves the brain's visual center. Here sensation turns into perception.

The brain must learn by experience to analyze correctly the impulses it receives from the eyes. For instance, the lens system of the eye, like that of a camera, transmits its light pattern upside down. The brain has to learn that the impulses received from the upper part of the retina represent the lower part of the object sighted and vice versa.

In the brain also are located the centers that control all the eye's muscular movements, such as the opening and closing of the iris, the focusing of the main lens, and the movement of the eyeball. The eyeball's movement is voluntary. Other eye adjustments are reflexes (see Reflexes).

**How two eyes work together.** Most individuals use both eyes to see an object. This type of sensory perception is known as binocular vision. Thus two images of the object are formed—one on the retina of each eye. Impulses from both images are sent to the brain. Through experience these impulses are interpreted as two views of the same object. Because the eyes are about 2 1/2 inches (6.4 centimeters) apart from pupil to pupil...
and therefore are looking at the object from different angles, the two views are not exactly alike. This is known as the stereoscopic effect. If the object is far away, the difference between the images is slight. If it is a few inches away, the difference is very great.

The brain makes good use of this phenomenon. It learns to judge the distance of an object by the degree of difference between the images it receives from the two eyes. In the same way the brain perceives what is called perspective. It estimates differences in distance between two different objects or between two parts of the same object (see Stereoscope).

The eyes are turned up, down, and sideways by long muscles. At one end these muscles are attached to the top, bottom, and sides of the eyeball. At the other end, these muscles are attached to the bony walls of the eye socket. They are regulated with the most delicate precision so that normally they turn both eyes toward the same object at exactly the same time.

Persistence of vision. While the eyes are in motion they cannot see an object clearly. The image on the retina must come to rest, if only for a fraction of a second. That is why, when the eyes scan a line of type, they move across it in a series of quick jerks.

On the other hand, when the image has registered on the retinas, the vision of it persists from 1/50 to 1/25 of a second. That is how the eyes receive the impression of motion pictures. A movie consists of a rapid series of still pictures that are flashed on a screen, with about 1/60 of a second of complete darkness after each image. But persistence of vision fills in the dark moment. It blends each picture perfectly with the one that went before to create the same impression that true motion produces.

Organic Disorders

The conjunctiva, the membrane lining the inner surface of the eyelids and the exposed surface of the sclera, can become irritated and inflamed. This is called conjunctivitis, and is caused by viral infections or by exposure to smoke, dust, or similar irritants.

A common disorder of the eyelid, particularly in children, is a sty—an infection in the small glands of the eyelash. It is caused by the growth of bacteria and results in reddening and swelling of the entire eyelid.

A cataract is a cloudy or opaque discoloration in the lens of the eye. It can develop until the entire lens is covered with a thin, milky film. Treatment for cataract usually involves surgery, after
which the patient is fitted with special glasses. Glaucoma is a fairly common disorder caused by an increase in pressure within the eyeball. It can result from heredity, tumors, and other causes. Headache, blurred vision, and eye pain are symptoms of glaucoma. Many treatments are used, and it is sometimes necessary to perform surgery to relieve the pressure.

Retinitis pigmentosa is an inherited eye disease in which the retinal pigments degenerate. In the course of the disease the rods are destroyed early, causing night blindness in youth. Deterioration of the retina is progressive. Eventually the affected person sees objects as if looking through a narrow pipe. This stage is followed by complete blindness.

Diabetes, treated or untreated, may cause serious eye complications. The most common condition occurs in people who have had the disease for a long time. The blood vessels of the retina expand and hemorrhage, or bleed, into the retina. In later stages the hemorrhages become more extensive and eventually the retina becomes detached. These changes invariably lead to blindness. The actual cause of the changes in the vessels of the retina is still unknown.

Both benign and malignant eye tumors are usually extremely serious. They not only damage the eye but may also invade the brain.

There is a wide variation in the causes of blindness through the world. Geographic location and climate are contributing factors. Standards of hygiene, however, and the availability of medical care seem to account for the variations in percentages of blindness worldwide. Blindness in many countries, for example, is caused by cataract. This is tragic because the condition is easily cured by surgery (see Blindness).

**Optical Defects**

Some eyes are abnormally long from front to back. The lens, even when stretched to the utmost, cannot bring distant objects to a focus on the retina. Nearsightedness, or myopia, is the result. This defect is corrected by wearing a concave, or negative, spectacle lens. This lens, together with the convex lens of the eye, makes an optical system of longer focus.

When the distance between the front and the back of the eye is too short, the lens cannot bring near objects to a focus. This is a form of farsightedness called hypermetropia. The condition is corrected by shortening the focus with a convex, or positive, lens.
In many eyes the cornea is deformed so that its surface is oval instead of spherical. Light rays are distorted at the entrance of the eye. This produces a blurred image and is known as astigmatism. To correct it, glasses are given a nonspherical or cylindrical curvature. Cross-eyes and walleyes are produced when both eyes do not work together because of weakness of the eye muscles. The images formed on the two retinas are so unlike that they cannot be blended in the brain. Thus a double image is perceived. The condition is known as diplopia, or double vision. Prismatic lenses are prescribed to correct this defect.

Imperfections in the cones of the retina, resulting from heredity or disease, cause defective color vision. This is known as color blindness, or Daltonism. In total color blindness, everything appears in shades of gray. In its more common form, color blindness is the inability to distinguish between reds and greens.

Persistent headaches, blurred vision, and painful inflammation of the eyelids are symptoms that may indicate serious eye disorders. Particles lodged in the eye should be removed without delay. Glasses are prescribed to strengthen vision and to reduce strain and fatigue. (See also Eyeglasses.)

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