HOW THE EYE WORKS

Consider the simple things your eyesight makes possible. You can drive home from work, open your freezer, and choose the meatball lasagna instead of the lemon-pepper fish. You can read the directions on the package and press the right buttons on the microwave. You can decide whether the lettuce is too brown to use in a salad. And as the kids play out back, you can keep an eye on them through the kitchen window.

Like our cars, computers, and cell phones, we rely on our eyesight to accomplish everyday tasks, but have only a vague idea of how it works. Vision is a complex sense—a process, really—that requires precise choreography between the brain and the structures of the eye as you interact with the people and objects around you. Let's take a look behind the scenes.

ANATOMY OF THE EYE: A BACKSTAGE TOUR

To understand vision, first we need to know a thing or two about the anatomy of the eye. Think of the human eye, with its elegant design and remarkable anatomical details, as a miniature theater in which the process of vision takes place.

The Eyeball

The eyeball, or globe, is spherical (round), measures about 1 inch (2.5 cm) across, and houses many of the structures needed for sight. It sits in a cone-shaped pocket within the skull called the orbital cavity, or "eye socket." This bony orbit is cushioned by fatty tissue to protect the eyeball from trauma (injury). The eyelids, eyelashes, and eyebrows also shield the eye by filtering out or blocking dirt and dust particles.

Layers of the Eye

The human eye has three primary layers: the sclera, the choroid, and the retina. Like the actors and stagehands on a set, each layer and internal structure of the eye performs a distinct function. Let's take them one by one.

Outer layer: The sclera

The outer layer of the eye is made up largely of a tough tissue called the sclera, often called "the white of the eye." The sclera helps protect the eyeball and maintain its shape.

At the front of the eye is an equally durable but transparent structure called the cornea, which covers the iris (the colored part of the eye) and pupil, the dark opening at the center of the eye. Although the cornea may seem no more substantial than a sheet of plastic wrap, it's actually a highly specialized, finely constructed network of cells and proteins. The cornea and sclera together act as a barrier against harmful microbes (germs), dirt, and dust. But the cornea has a second function: It refracts (bends) light waves to project them onto the lens of the eye, as we'll explain in a moment. Because the cornea must remain absolutely transparent to refract light properly, it's the only tissue in the body that contains no blood vessels.

Middle layer: The choroid

Below the sclera lies the choroid, called the vascular layer of the eye because it contains blood vessels that nourish and supply oxygen to the eye's internal structures. The choroid layer measures about 0.5 mm, a little less than half the thickness of a U.S. dime.

Inner layer: The retina

The retina lies below the choroid and comprises the innermost layer, or lining, of the eye. It contains the light-sensitive rod cells and cone cells, which are called photoreceptors because they capture and transmit images along the optic nerve to the brain.

VISUAL PERCEPTION

To illustrate the process of vision, let's follow an image as it travels through the structures of the eye and brain.

As you look at an image—the screen of your iPhone, your chipped fingernail polish, whatever—the light rays travel through the eye to the retina. Several structures help to refract the light so that it focuses properly. Light first passes through the clear cornea at the front of the eye, and then through a watery substance called the aqueous humor which fills the small chambers located behind the cornea. As light continues on its pathway it passes through the pupil, a round opening in the center of the iris. The iris is the part of the eye that gives the eye its color. Its specialized muscles control the size of the pupil to regulate light.

This light passes through the lens, a clear, layered structure shaped like a large lentil (about 10 mm in diameter). It's attached to muscles that contract or relax to change its shape. The changing lens shape helps focus light in response to the need for clarity. (The loss of this focusing ability as humans age is the reason that many adults over age 40 need reading glasses.)

Light then passes through the posterior (back) portion of the eye. This chamber is filled with a clear, jelly-like substance called the vitreous humor. Finally, the light reaches the retina, where rod and cone cells initiate a series of split-second chemical reactions that convert the light into electrical impulses. The cone cells—about 7 million of them—are concentrated in a tiny spot at the center of the retina. This area, called the macula, is responsible for producing sharp details and color. Rod cells are more plentiful, numbering about 100 million. They're found in the peripheral retina, away from the macula. These cells help us see in dim light.

Even if all of the structures of the eye work perfectly, what we know as vision cannot happen without the brain's interpretation of the electrical impulses sent by the retina. The optic nerve is a bundle of retinal fibers that exits the back of the eye and transports these impulses to the brain, where they are interpreted in the primary visual cortex.

When all parts of the visual system are working, the eyes move together, adapt to light and dark, perceive color, and determine an object's location in space. They're sensitive to differences in contrast, providing detail vision, or visual acuity. Good visual acuity is reported as 20/20. A higher bottom number indicates less visual acuity. For example, the start of the range known as "legal blindness" is represented by the visual acuity finding of 20/200. In other words, the eye being tested sees at 20 feet what a "normal" eye would see at 200 feet.

VISION CORRECTION

Vision problems caused by disease or injury sometimes can't be corrected by conventional means. But poor vision related to the shape of the eye can often be addressed with standard eyeglasses, contact lenses, or refractive surgery. Eyeballs, like people, come in many shapes and sizes. Some eyeballs are too long and have too much focusing power, causing the person to be myopic (nearsighted). Others are too short and have too little focusing power, resulting in hyperopia (farsightedness). And some eyeballs have an uneven curvature, called astigmatism. There's really no such thing as a perfect world, a perfect democracy, or a perfect golf swing. Likewise, there are no perfect eyeballs.