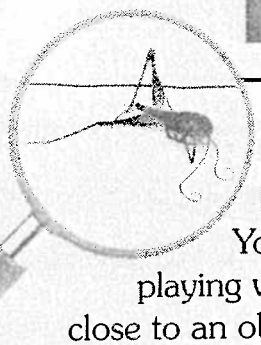
RESOURCE

Light and Lenses



How Lenses Bend Light

You've probably had fun playing with a hand lens. Held close to an object, a hand lens lets you see details you didn't know were there. Held at arm's length, it shows a world turned upside down! What "magic" is at work here?

Actually, you already know something about this "magic." When light passes from one transparent material into another, the light bends, or changes direction. A **lens** is a transparent object with at least one curved surface. Lenses come in a variety of shapes, but all types refract light that passes through them.

Lens Shape

A lens that is thicker in the center than it is at the edges is called a **convex lens**. Such a lens brings parallel light rays together at a point known as the **focal point**. The thicker the lens, the more it bends light. So the thicker the lens, the closer the focal point is to the lens.

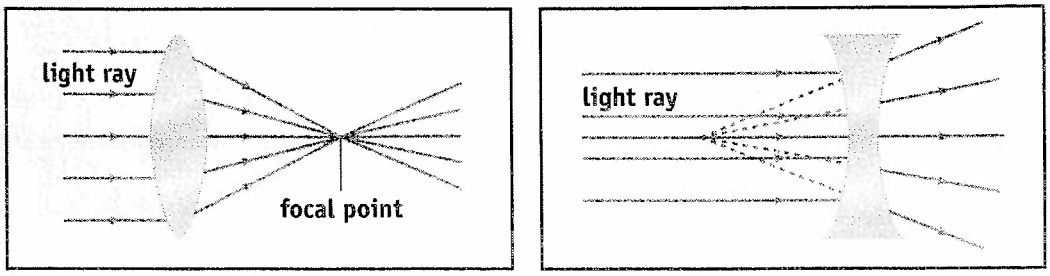
As you saw in the activity on lenses on pages F30 and F31, when you hold an object near a convex lens and look through the lens, you'll see a right-side-up image that is larger than the object. This is how hand lenses work. It's refraction, not magic, that produces a larger image. If a convex lens isn't very close to an object, the image that forms is small; it's also upside down!

A lens that is thicker at the edges than at its middle is called a **concave lens**. A concave lens causes parallel light rays to spread apart. The image of an object viewed through a concave lens is smaller than the object but the image formed is always right side up.

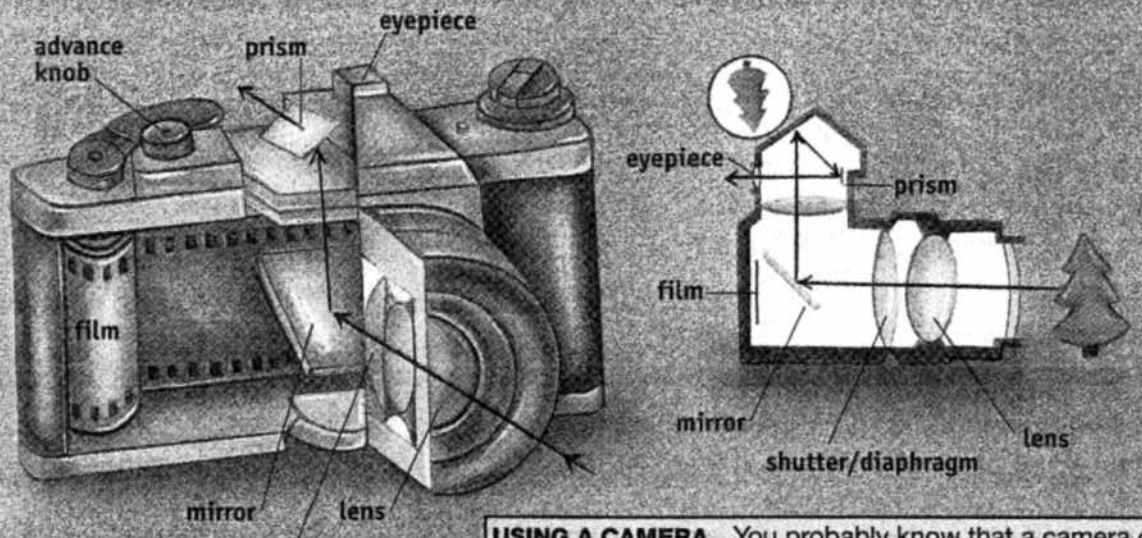
The Eye and a Camera

Both the human eye and a camera contain convex lenses. An important difference between your eyes and a camera is that a camera takes only one picture at a time. But your eyes are constantly "taking pictures." The lens of your eye focuses an image on the **retina** (ret'n ə). The retina is the light-sensitive layer at the back of the eye.

A convex lens brings light rays together at a focal point (*left*); a concave lens causes light rays to spread apart (*right*).

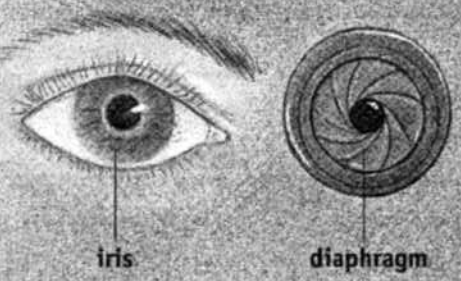


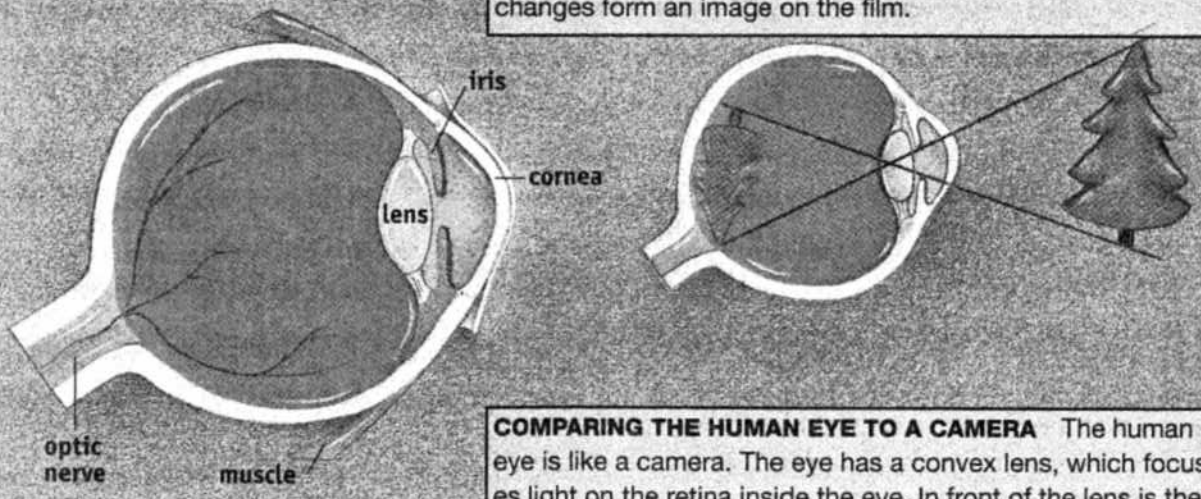
Comparing the Human Eye to a Camera



USING A CAMERA You probably know that a camera contains lenses. A very simple camera has one convex lens. Here's what happens when you take a picture.

1. You point the lens toward an object.
2. Then you press a button on the camera, and the shutter behind the lens opens.
3. Light reflecting from the object passes through the lens.
4. The lens bends the light so that it comes together, or focuses, on the film.
5. The light causes chemical changes in the film. These changes form an image on the film.





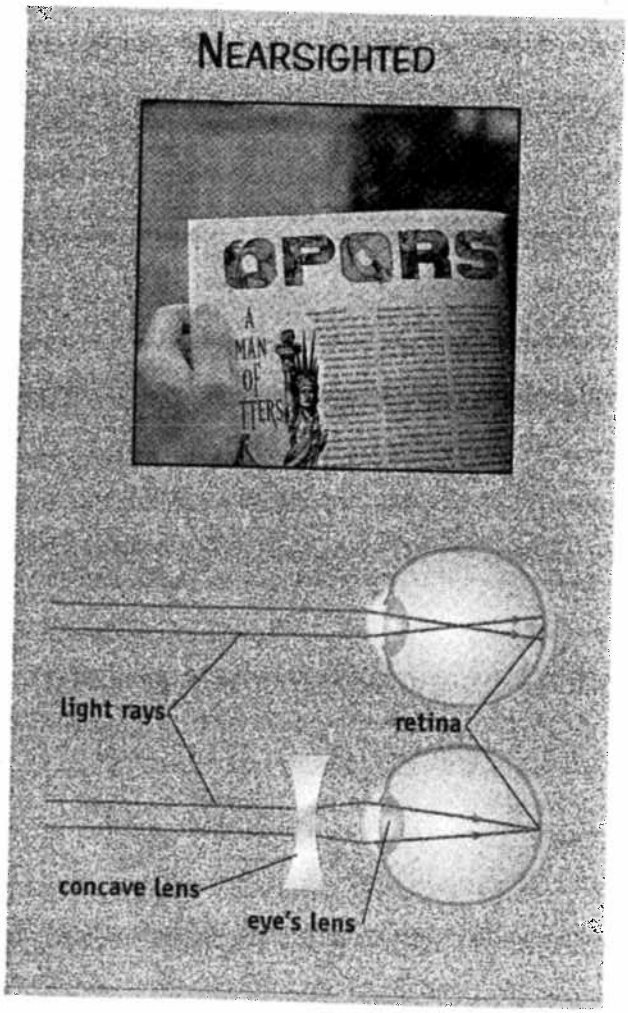
COMPARING THE HUMAN EYE TO A CAMERA The human eye is like a camera. The eye has a convex lens, which focuses light on the retina inside the eye. In front of the lens is the iris, the colored ring around the pupil. The pupil is actually a hole through which light can enter the eye. The iris acts like a camera's diaphragm. Tiny muscles in the iris make the pupil smaller in bright light. The muscles enlarge the pupil when the eye is in dim light.

It sends nerve impulses to the brain along the optic nerve. The brain then interprets the pictures and figures out what you're seeing.

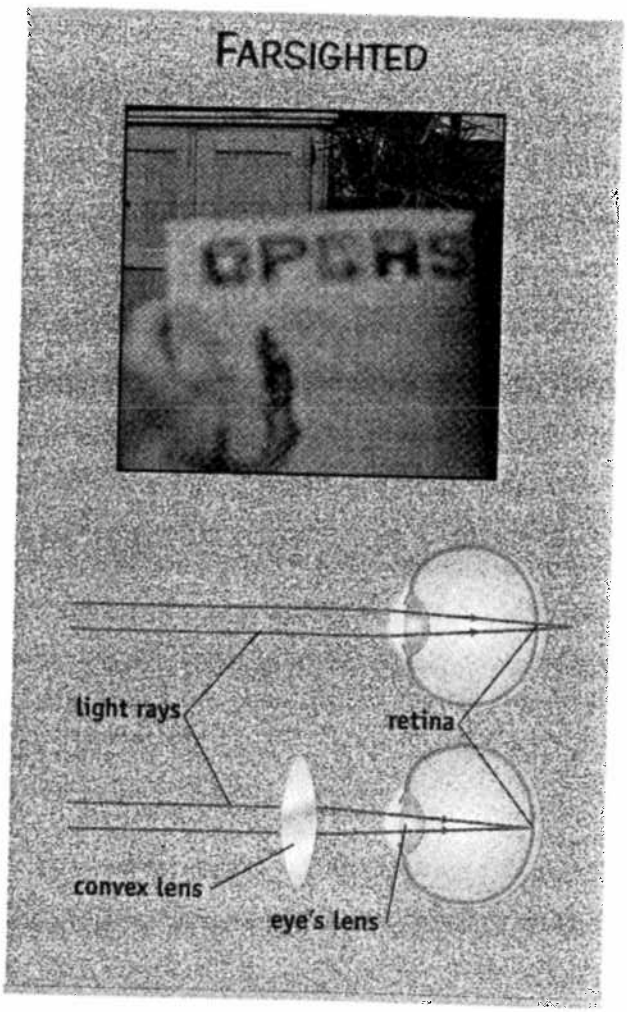
Another difference between your eyes and a camera is in how the eyes focus. You can focus on objects that are close to you and on objects that are far away, but the eye's lens can't move in and out the way a camera lens does. Instead, the lens of the eye changes shape. When you look at something nearby, muscles in the eye pull on the edges of the lens and make it thinner. When you look at something far away, the muscles relax, and the lens gets thicker again.

Correcting Vision

Many people wear glasses. Nearsighted people see nearby things clearly, but cannot see distant objects clearly. As the drawings below show, the eyes of a nearsighted person focus images in front of the retina. Glasses with concave lenses correct such a condition by spreading out the light rays before they enter the eye. The eye's lens then focuses the light rays on the retina.

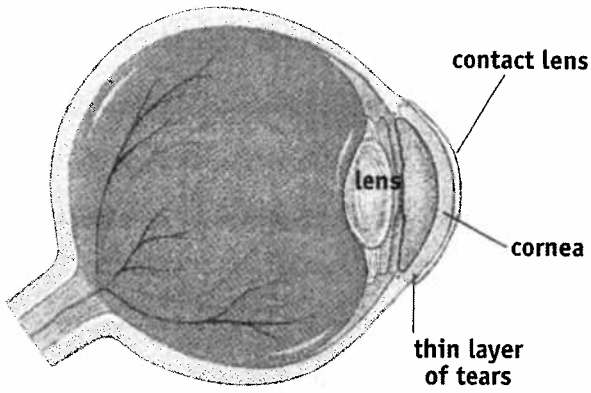


▲ Correcting nearsightedness



▲ Correcting farsightedness

People who are farsighted see faraway objects clearly, but they have trouble seeing nearby things. This condition is corrected with convex lenses, which bring the light rays closer together before they enter the eye. The lens of the eye then properly focuses the light rays on the retina.



▲ **A contact lens floating on a layer of tears**

Contact Lenses

Many people wear contact lenses instead of eyeglasses. **Contact lenses** are clear, thin lenses that are placed on the eye in front of the cornea. Contact lenses don't contact, or touch, the eye. They stick to a thin layer of tears that covers the cornea.

Like eyeglasses, contact lenses change the path of light. But with contact lenses, concave lenses are used for both nearsighted and farsighted people. Because contact lenses are so close to the eye, they don't need to be thick to bend the light enough to correct a person's vision.

The earliest contact lenses were made of rigid plastic and were often uncomfortable. In 1965, soft contact lenses were invented. These lenses are flexible and more comfortable than the older lenses. Most soft contact lenses must be removed and cleaned each day. The removal also allows oxygen to reach the living tissue of the cornea. Some soft contact lenses let oxygen pass through, so they can be worn for many days at a time. When they are taken out, they also must be carefully cleaned. ■

INVESTIGATE FURTHER!

EXPERIMENT

To see how the iris responds to the brightness of light, work with a partner. Take turns observing each other's eyes in dim light. Then turn on bright lights or move toward a sunny window. Observe the pupils of your partner's eyes. How did the pupils look in dim light? How did they change in bright light?

INVESTIGATION 1

1. A convex lens projects an image that is upside down. If the image on your retina is upside down, why doesn't the world look upside down to you?

2. Compare and contrast the way light is changed as it moves through convex and concave lenses.