The human ability to see is the result of an intricate interconnection of muscles, receptors and neurons. Muscles in the eye allow light to be focused, the receptors transfer the light into electrical impulses and the electrical impulses travel along neurons to the brain where the light is recognized. In this module, participants will see an anatomic model of the eye and a functional model of the eye.

Keywords: eyes, vision, optics, refraction, focus
Content Standards

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History & Process Standards

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“To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different
distances, for admitting different amounts of light, and for the correction of spherical and
chromatic aberration, could have been formed by natural selection, seems, I freely confess,
absurd in the highest possible degree.”

Charles Darwin in On the Origin of Species
I. OBJECTIVES
Students will:
- learn how the eye focuses by observing a functional model.
- see anatomical cross sections of the human eye.

II. SAFETY
Caution should be used with the gooseneck lamp as it gets hot to the touch and is very bright. Everyone should avoid looking directly into the lamp.

III. LEVEL, TIME REQUIRED AND NUMBER OF PARTICIPANTS

LEVEL
This module is appropriate for 3rd graders and up. For older students, more time can be spent on the optics of lenses.

TIME REQUIRED
10-15 minutes

NUMBER OF PARTICIPANTS
Smaller groups (less than 10) are better for this module because many of the activities require the observation of the functional model of the eye. Only a handful of participants can view the model at any one time.

IV. LIST OF MATERIALS
Anatomy of Eye (poster)
Anatomy of Eye Model
Functional Model of Eye
Gooseneck lamp

V. INTRODUCTION
Vision is the primary way humans have of getting information from their surroundings. The eyes are an intricate combination of fine muscles, receptors, and neurons that collect, analyze and transfer information to the brain, where images are recognized. Although the function is complicated, the overall design of the eye is quite simple, some even say beautiful. Even Charles Darwin was so impressed with the design and function of the eye that he had trouble when he tried to explain the eye’s evolutionary development via natural selection.
The Eye’s Function

The eyeball is a small, enclosed volume whose overall function is to refract light to form sharp images on the back wall of the eyeball, and then send the information in the form of electrical impulses to the brain. The inside surface of the eyeball is the retina and it contains all the photoreceptors that are responsible for transforming the light into electrical impulses. In order for us to “see” an object, light from the object must hit the retina. Light passes through many transparent parts of the eye (the cornea, the pupil, the lens and the aqueous and vitreous humor) before finally getting to the retina. Each of these transparent parts helps to refract (bend) and converge the light so that the image appears in focus on a particular part of the retina, called the fovea. Muscles control the opening of the iris, which controls the amount of the light that reaches the retina. Muscles also control the shape of the lens, which allows us to change focus on objects as they come closer or move farther away. The photoreceptors in the retina are called rods and cones. When light falls on rods and cones, they send an electrical impulse along the nerves to the brain. Rods get their name because they look like long rods. They respond mainly to black and white and motion (and are therefore very useful night vision). Cones are cone-shaped and are responsible for our sharp and color vision (and are most useful during the day or in lighted environments). Most of the retina is covered with many rods and a few cones and this makes up our peripheral vision. The fovea contains a dense concentration of cones with very few rods, and this is where we get the sharpest and most colorful image and is usually the center of our vision. The fovea is so central to our visual acuity that all the work of focusing and refracting light is done so that we may get the clearest image on the fovea. There is also a place on the retina where all the nerves go out of the eyeball to convey the information from the receptors to the brain and no rods or cones are in place. This place is called the blind spot. Although we are not usually aware of the blind spot, all human beings have it. Most of the time we are not aware of the blind spot because our brains fill in any small gaps in our vision. So we can only tell we have a blind spot if we are specifically looking for something in the blind spot. The blind spot is located in the peripheral vision and so does not often pose a problem for people. Figure 1 shows a cross-section of the inside of the eye, and figure 2 shows a 3-D drawing of the inside of the eye.
In many ways, a camera is a good man-made imitation of the human eye. Light passes through the iris, which can be adjusted to control the amount of light entering the eye, like the iris diaphragm of a camera. Light eventually reaches the receptors on the retina which send the information to the brain where it can be processed and understood, much like film captures a scene on light sensitive paper. The lens can also be adjusted to focus on objects near or far, much like the lens of a camera.

**The Lens**

Figures 1 and 2 show all of the parts of the eye. Each part is essential for the eye to function normally and for the person to be able to “see”. Occasionally, one of the parts will be damaged or cease to function normally. The lens is very flexible (at least in the young) and can be made very flat (to focus on the far-away) or rounded (to focus on the nearby) by the ciliary muscles and ligaments that surround the lens (see figure 3). Without the flexibility of the lens, it would be impossible for human beings to see both near and far. Indeed, as a person ages, he/she loses the ability to focus both near and far, a direct result of hardening of the lens.

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**Figure 1 – Image of the interior of the eye. Copyright 1996 Dorling Kindersley.**

**Figure 3 – Diagrams showing the difference in the lens for distance or near viewing (a and b are cross-sectional views, c and d are side-on views of the lens). In distant viewing (a and c), the lens is flat. In near viewing (b and d), the lens is more spherical.**
VI. PROCEDURE

Accommodation

1. Setup: The Functional Model of the Eye requires some setup. First remove the front casing (cornea), the lens and the syringes from the frame of the model. You will need to fill the syringes with the distilled water and then remove as much air as possible from the syringes and the tubing by pushing the syringe plungers inward (just make sure to leave 50 ml of water in each syringe). Before connecting the tubing of the syringe to the lens, evacuate as much air as possible from the lens by using your mouth to withdraw the air and pinch the tubing at the end of the lens closed. Connect the tubing to the lens, then put the lens in place and make sure it rests flush against the iris. Make sure the cornea is also in place before proceeding.

Here are the removed lens and syringe plungers:

![Removed Lens and Syringe Plungers](image)

Here is the entire functional eye model put together:
Execution: Place the gooseneck lamp about 1 meter away from the eye model, projecting the light towards the model. Put the Plexiglas sheet with the “Y” on it directly in front of the lamp. Adjust the amount of water in the lens by using the syringes until a sharp image of the Y (it will be upside down and although you can’t tell with a ‘Y’, backwards) appears on the paper behind the lens (the retina). Now alternate removing and adding water to the lens with the syringes while watching the lens. Ask the students to describe what they see. They should see the lens alternate between being flat (when water is removed) and being fatter (when water is added). Refocus the image of the Y by adjusting the amount of water in the lens. Now ask the students to watch the image of the Y when you bring the eye model closer so the distance is about 50 cm to the lamp (it will get out of focus). Ask the students if you should make the lens fatter or flatter to refocus the image (fatter will refocus a closer image). Show the students that making the lens fatter will bring the image of the Y into focus. Emphasize that the lenses in our eyes behave the same way, except that the fatter or flatter response is made possible by the muscles in our eyes, not water from syringes. Ask the students to focus on something across the room, then focus on their hand in front of their face. While they were doing this, their lenses went from flatter to fatter. Point out the lens and muscles surrounding the lens on the anatomic eye model and the anatomy of the eye poster.

Explanation: The relaxed state of the eye is good for seeing things that are far away. Light rays from the object enter, pass through the lens and are focused on the retina at the back of the eye. If you want to see something closer, the lens changes shape, which is called accommodation. The ciliary muscle controls the lens and causes it to become rounder when you’re focusing on something close. The rounder lens can then focus the object so that the image still hits the retina.

Cleanup: Remove all the water from the lens by using the syringes. When all but a drop or two is left in the lens, disconnect the syringes and dump all the water down a sink. Do not use solvents on the lens or wipe it – it is a soft polymer that is easily scratched.
VII. FREQUENTLY ASKED QUESTIONS

VIII. TROUBLE SHOOTING

IX. HANDOUT MASTERS

X. REFERENCES: