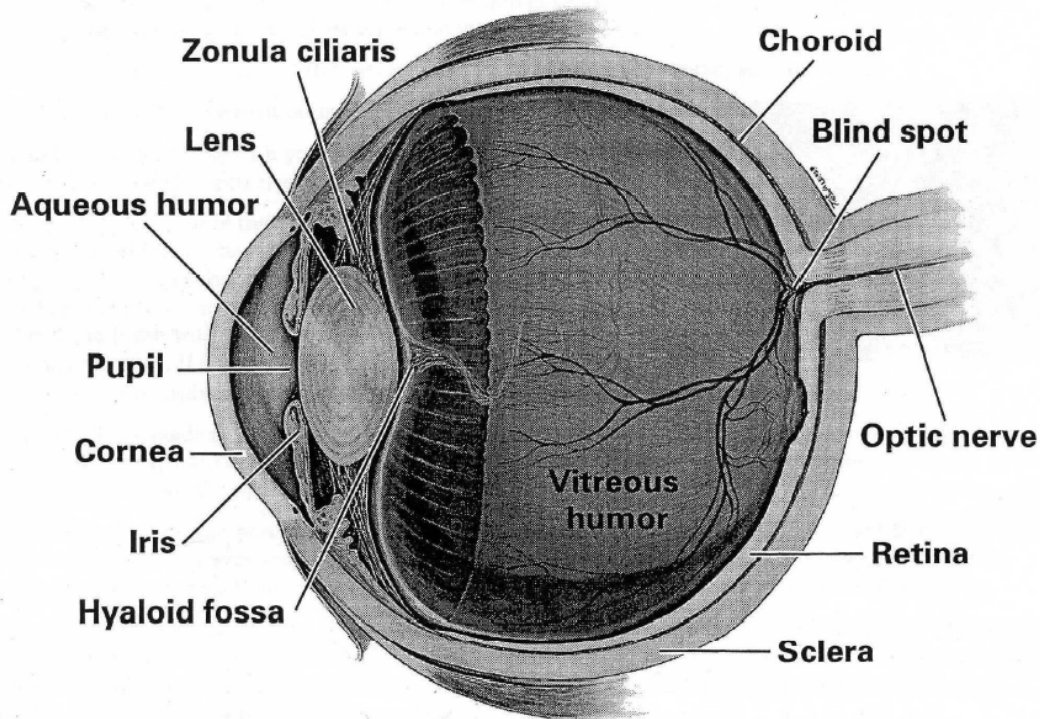


**Cow-Eye Lab**

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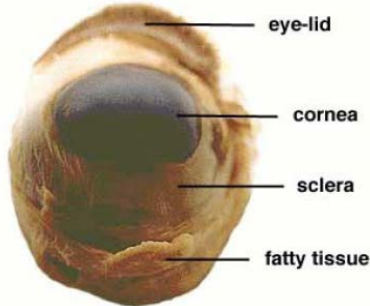
**I. Introduction**

The first step in any type of sensory processing is the transmission of information from the outside world to the nervous system. In the visual system, the eye is the organ responsible for this task. When reflected light enters the eye, it is focused on to the thin layer of light-sensitive cells lining the back of the eyeball, called the retina. These cells translate this reflected radiation into electrical impulses that are then transmitted into the brain to perform the daunting task of decoding this complex image into useable, specific information about color, luminance, depth, movement and shape. In this lab you will explore the eye and its functions. You will learn the anatomy of the eye and how the specific pieces work together to produce a functional image on the retina.



## II. The Biology of the Eye - Dissection of a Cow Eye

1. Obtain a dissecting tray, scalpel, dissecting scissors, and one fresh cow eye from the supply. Gloves are optional here because the eye is fresh and has not been treated with any fixatives.

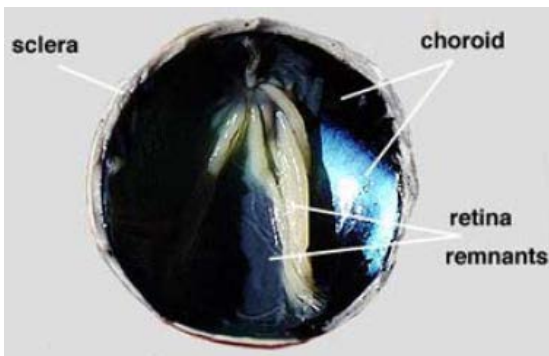


2. Examine the exterior of the eye. There may be quite a bit of muscle and tissue attached to the eye. **What purpose do these muscles serve?** Note that humans have six exterior muscles to move the eye around; cows have four. **Compare the external anatomy of the cow eye with the human eye. Name the six external human eye muscles. What cranial nerve instructs these muscles? What direction do each of the eye muscles move the human (and cow) eye?** Note that the eye also has a considerable amount of fatty tissue surrounding it. **What purpose does this fat serve?**

Cut away the external eye muscles using your dissecting scissors. The best way to do this is to cut small holes in the tissue, separating it from the sclera, and then pull it back forcefully. Don't worry about being too rough. The sclera is extremely tough and the muscles are well attached.

3. Identify the **sclera**, **cornea** and **optic nerve**. The sclera is the tough, white outer covering which helps to maintain the shape of the eye. The cornea is the clear, hard protective layer covering the iris. Along with the lens, the cornea bends light as it enters the eye to bring the light into focus. **What is the relative refractive power of the cornea versus the lens?** The optic nerve extends outward from the back of the eye. This structure is made up of nerve fibers that travel from the retinal cells to the brain.

4. Carefully hold the eye and make an incision with the scalpel halfway between the cornea and the optic nerve. The sclera is tough, so be careful apply enough pressure to make an incision without damaging the rest of the eye. Once you have made an incision, use your dissecting scissors to cut the rest of the way around the eye, separating it into two halves.



5. The center of the eye contains the **vitreous humor**. Separate this from the two halves of the eyeball. If it is attached, pull gently but firmly, being careful not to damage other structures. **What is its purpose of the vitreous humor? Why is it transparent?** Interestingly, John Dalton believed his colorblindness was caused by a tinted vitreous humor (For more on this see: D. Hunt *Science* (1995) 267: 984-988). It was not, of course, **but what affect do you think a tinted vitreous humor would have on color vision?**

6. Float the back half of the eye in a dish of water, letting the **retina** separate from the rest of the eye. Look closely at this structure and see if you can identify the **fovea** and **optic disk**, the place where the retina becomes the optic nerve. **What do you know about the cellular composition of the retina at these points? How does this affect your vision? Can you find your own blind spot? What two kinds of photoreceptors are their in the eye, and what distinguishes them? The**

photoreceptors undergo “adaptation” in response to changes in light. Describe one psychophysical observation that reflects the process of adaptation. What is the Weber function? How does it relate to the input-output function of the photoreceptors converting light-to-electrical impulses?

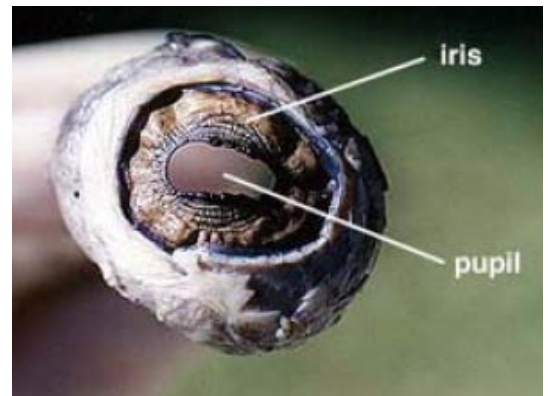
7. Pull the retina back to see the **choroid**. This layer of tissue is part of the vasculature that provides the retina with oxygen. In humans, the choroid is dark due to melanin. **Why is it important that this layer is dark and not reflective?** In the cow eye you will see that part of the choroid is an iridescent blue green that causes incident light to reflect back through the retinal cells. This is called the **tapetum** and is found in cats and many nocturnal animals. **What purpose does this serve?** The choroid is responsible for the glow that you see in the eyes of a deer in the headlights and why sometimes a camera flash will cause an image of “red eye.” Explain why.



8. Remove the **lens** from the eye carefully. If it is still partially attached to the iris or vitreous humor, make small incisions along its edge, being careful not to damage it. Muscles called **ciliary muscles** are connected to that stretch when necessary. **What two muscles are used to regulate the shape of the lens? How does contraction of each set affect lens shape and the focal length of the eye? Why are these muscles important for vision?** Note the appearance and rigidity of the lens and put it aside to be used in the second part of the lab. **Does the lens change as the individual ages? If so, how?**

9. Pull the **iris** out of the eye. Note that the iris is round in humans and oval in cows. The clear liquid between the cornea and the iris is called the **aqueous humor**. It maintains the shape of the cornea. The hole in the iris is called the **pupil**. The iris can contract or relax, making the pupil larger or smaller. **Why is this important?** This will be explored further in part IV of the lab.

10. Cut the **cornea** away from the remaining sclera using your dissecting scissors. Place it on your tray and cut through it with your scalpel. Observe its appearance, texture and rigidity. **What purpose does it serve and how do your observations correlate with that purpose?**



11. Once you have finished the dissection and explored the anatomy of the eye as much as possible, dispose of the tissues in the labeled trash bag. Please wash the tray and all the dissecting instruments and place them on the drying rack. Wash your hands thoroughly to remove any blood. Make sure to save the lens for the second part of the lab.

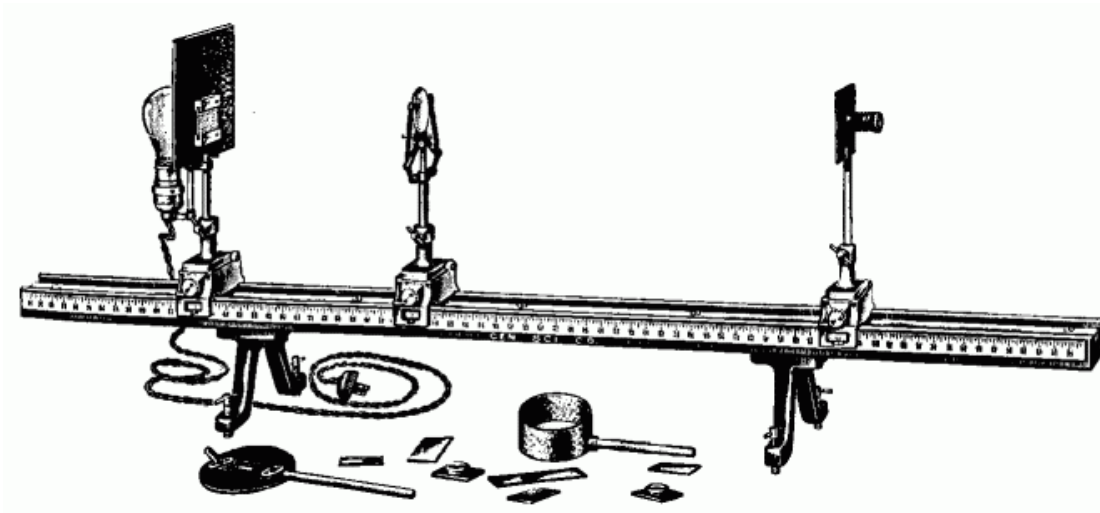
\*Dissection section (including pictures) adapted from:

Carolina™ *Mammal Eye Dissection Guide*

Exploratorium *Cow Eye Dissection* [www.exploratorium.edu/learning\\_studio/coweye](http://www.exploratorium.edu/learning_studio/coweye)

## Part II: The Physics of the Eye using an Optical Bench and Focal Length

The purpose of this section of the lab is to use the lens dissected from the fresh cow eye to investigate the physics of the lens, specifically the relationship between image and object distance as they relate to focal length for different lenses. This portion of the lab is based on one used in the Introductory Physics course. The entire lab manual for that course (which contains lots of useful information!) is located on the course conference.



**Optical Bench set-up and accessories**

1. Obtain an optical bench, two lens holders of different sizes, one image screen, one object projector light source, one cow eye lens, and one lens. Set up the device in a manner similar to the image shown above.
2. Take the lens from the dissected eye and place it in a 50% 0.9% saline solution for 5 minutes.
3. Place the lens in the lens holder on the optical bench. BE GENTLE!! The lens is fragile and if handled improperly will wither.
4. Turn on the light on the optical bench. Make sure it is placed at the 0 position, this will make measurements easier. Move the lens holder and/or screen until the image from the light is projected onto the screen.
5. Measure the distance from the light to the lens holder, and the distance from the lens holder to the screen. These are your object and image distances. \*\*\*Note: If the lens of the cow eye is not clear, try a different cow eye lens if it is possible to dissect another. If not simply use one of the lenses provided and specify which you chose.
6. Using the *Thin Lens Equation*, calculate the focal length of this lens:

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

where  $f$  is the focal length of the lens,  $s$  is the object distance and  $s'$  is the image distance. How many diopters is the lens? (show your work).

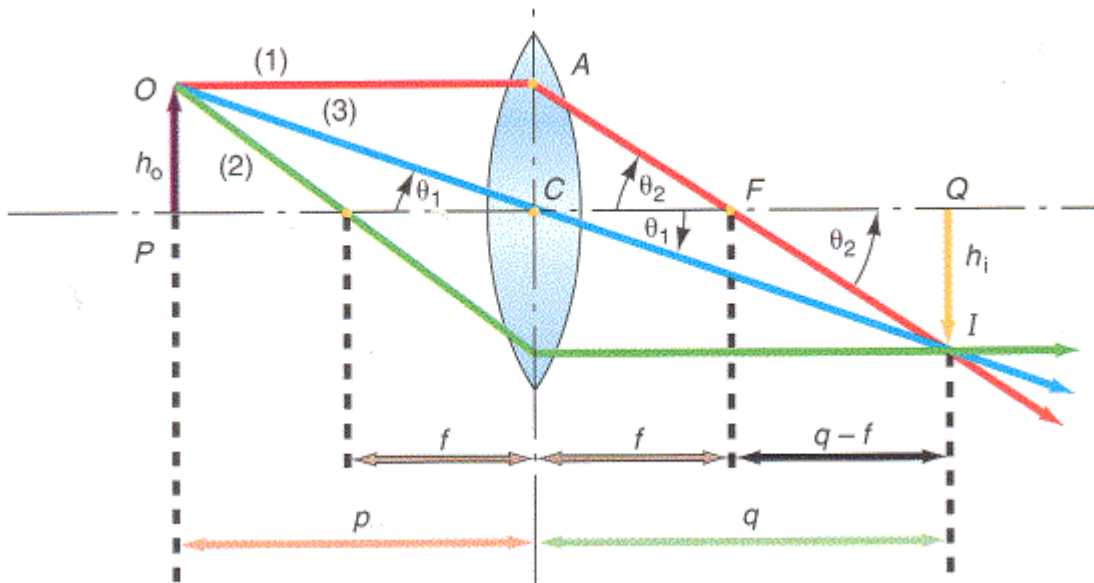
7. Repeat this procedure using one of the lenses provided. Specify which type, concave or convex, lens you chose. If your cow eye lens did not work for the experiment, please be sure that you chose a *different* lens than the one chosen for the first part of this section.

**How do the lenses differ?**

**What do you think some causes for this difference could be?**

**Determine whether each lens is converging or diverging and explain your answer.**

**Using the figure below, how would you determine/derive the Thin Lens Equation?**



**Determining the Lens Equation using a Convex Lens.**

### III. Assignment and Clean Up

1. Write a Lab Report to describe and discuss your observations.

*Abstract, Introduction, Methods, Results, Discussion*

In the course of your report, be sure to address all the questions raised in the lab. During the lab session, we will discuss the format of lab reports (versus assignments). Note that use of the appropriate format along with clarity of writing count as much as content in all written work for this course. In the course of your discussion, be sure to describe the projected image. **What is the total power of the lens and cornea? Do you think the lens has the same refractive power in situ as the measurement you made with the lens free from the rest of the eye apparatus? Explain. What is different between the projected image and the way the object is perceived? How can you account for these differences if we can safely assume that our eye works in a way that is very similar to the way in which the cow eye works?**

**2. Clean Up!**

**\*\*\*PLEASE BE SURE TO CLEAN UP ALL ITEMS  
AND DISCARD WASTE APPROPRIATELY.  
RETURN ITEMS TO WHERE THEY  
WERE AT THE BEGINNING OF THE LAB\*\*\***