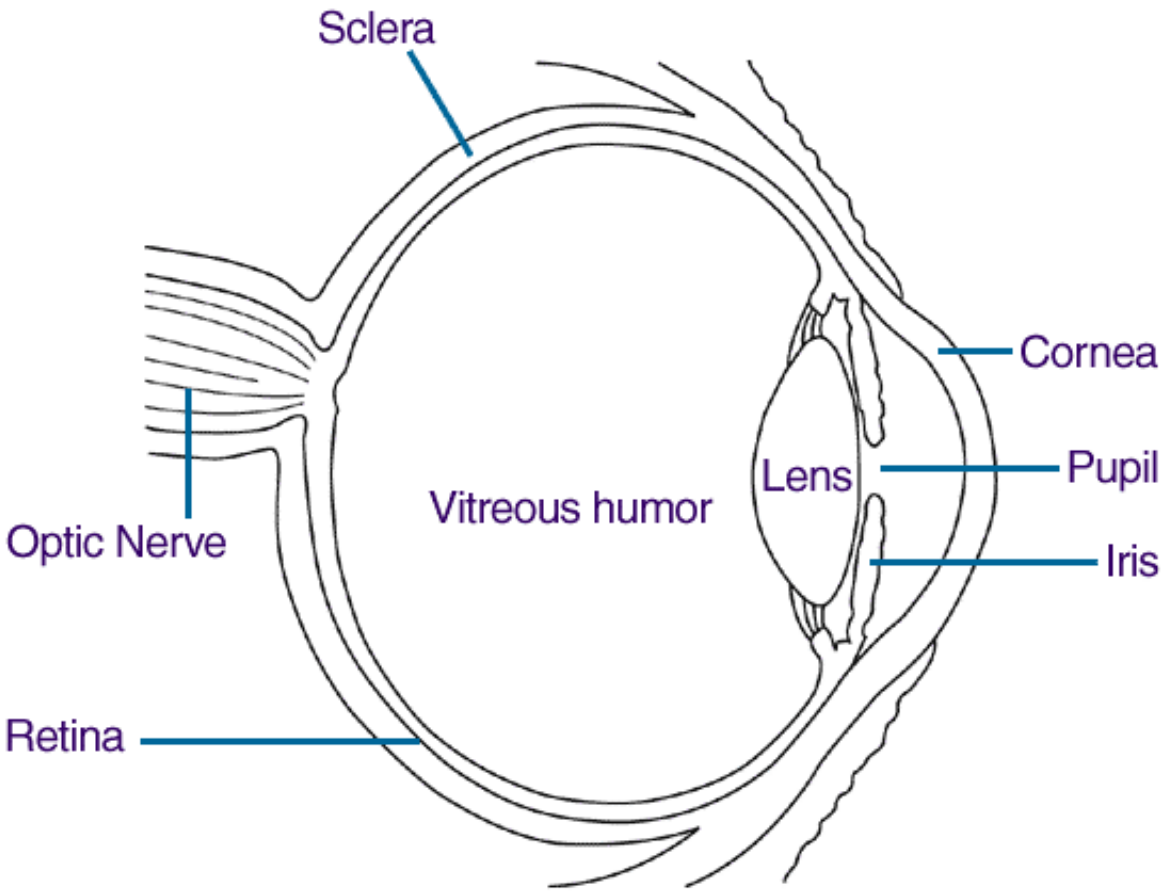
The Eye and Vision

By Linda S. Shore, Ed.D.
Director, Exploratorium Teacher Institute, San Francisco, California, United States
lindas@exploratorium.edu



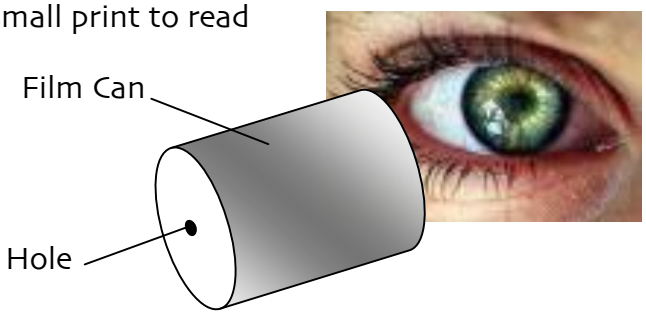
Activities:

Film Can Eyeglasses – a pinhole can help you see better
Vessels – using a flashlight, you can see the blood supply for your retina
Blind Spot – find the diameter of your optic nerve

Film Can Eyeglasses

Materials Needed

- 1 black film can without a lid
- 1 push pin
- printed paper with small print to read



What To Do

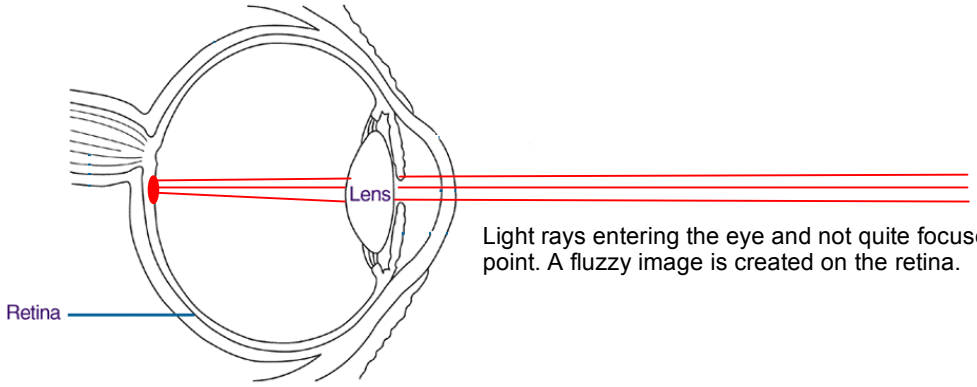
1. Using the pin, make a single small hole in the center of the bottom of the film can.
2. If you wear eye glasses or contact lenses, you can remove them for this activity,
3. Keeping the open end of the film can up to right eye, look at the tiny hole you have made with the push pin. *Keep your other left eye closed*.
4. Looking through the pinhole with your right eye, look at objects around the room. Do they appear clear or out of focus. How well can your unaided right eye see when you remove the film can? *Remember to keep the left eye closed*.
5. Looking through the pinhole with your right eye, get as close as you can to very small print. How close can you get to the page and still be able to clearly see the print. When you are as close as you can get, remove the film can and see how well your unaided eye does. *Remember to keep your left eye closed*.
6. You can try to repeat steps 3 through 5 holding the film can up to your left eye and closing your right eye. You can also try some other experiments. Try making more than one hole or making a larger hole. How large can the hole be before images are no longer any sharper than they are with the unaided eye?

What's Going On?

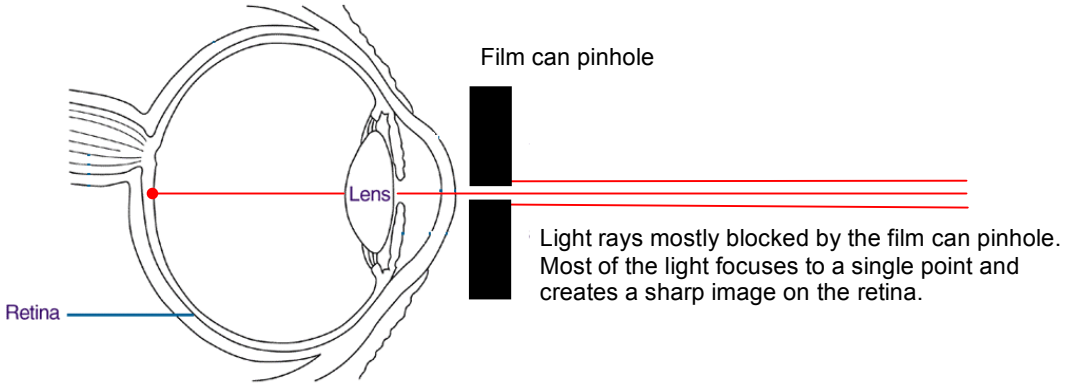
Your pupil regulates the amount of light that enters your eye. When a lot of light is available and enters the eye, the pupil constricts so that less light strikes the retina. When there is less light available, the pupil dilates which allows as much light as possible to enter the eye. You might believe that the pupil does this to protect the eye from too much light. But actually, the primary function of light control is to keep images formed on the retina as sharp as possible without sacrificing brightness at the same time. How does this work? The lens inside your eye is responsible for fine-tuning the sharpness of the image, but like all lenses, it is not perfect. Images formed by the lens of the eye do not all arrive at a single point of focus. Some light rays always miss – especially light rays that don't pass through the center of a curved lens. The larger your pupil, the more light rays enter your eye, and the more light rays miss the focus and the blurring the image becomes. By using a pinhole to filter out most of the incoming light rays, you create an image that is both very dim (because the number of light rays is substantially reduced) and also very sharp. Notice just how small your film can pinhole is compared to the diameter of your pupil in bright light. It isn't possible for your pupil to get this small (see Figure 1).

Linda Shore, Ed.D.
Exploratorium Teacher Institute

Figure 1: The Effect of a pinhole on image formation of the eye.



Light rays entering the eye and not quite focused to a point. A fluzzy image is created on the retina.



Light rays mostly blocked by the film can pinhole. Most of the light focuses to a single point and creates a sharp image on the retina.

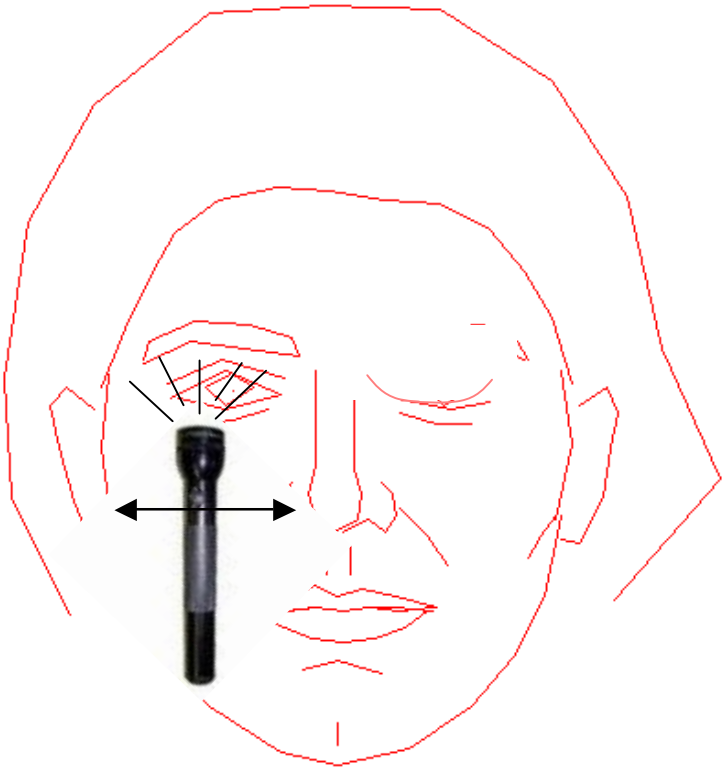
Linda Shore, Ed.D.
Exploratorium Teacher Institute

Vessels

You can use a flash light to cast a shadow of the blood supply of your retina onto the retina itself. This will allow you to see these blood vessels, and even your blind spot.

Materials Needed

- A Mini MagLite
- A room which you can darken
- A sheet of black construction paper



What To Do

1. Turn on the MagLight. Darken the room- turn off the lights and close the shades.

2. Hold the Mini MagLite about 1 cm in front of, and slightly below the center of, the pupil of one of your eyes. Look at the sheet of black construction paper. The black paper should fill your field of view.

3. Move the light slowly from side to side a short distance (0.5 cm). Do not follow the motion of the light with your eye. Keep doing this for 20 seconds. Notice the network that appears. It will look like the branches of a tree or the branching of a river viewed from high above.

What's Going On?

The network is the pattern of arteries and veins that supplies blood to your retina. It spreads out from the dark blob of your blind spot. In human eyes, the blood supply of the retina is in front of the retina. That is, light passes through the blood supply on its way to the retinal detectors. You do not see the retinal blood supply because it never changes, and your eye ignores unchanging images. The point source of light casts a shadow of the retinal blood supply on your retina. When you move the point of light from side to side, the shadow moves. You can then see the changing shadow.

What Else?

Glaucoma is a disease of the eye in which pressure builds up inside the eyeball. The pressure squeezes on the retinal blood supply network, reducing blood flow to the periphery of the eye and resulting in the death of the retina, starting at the periphery and working in toward the center. One of the symptoms of glaucoma is tunnel vision.

Linda Shore, Ed.D.
Exploratorium Teacher Institute

Blind Spot

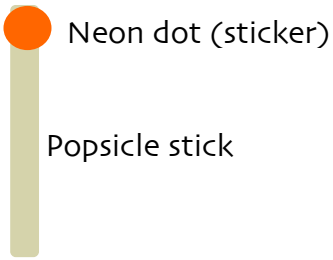
Using math and a popsicle stick, you can measure the diameter of your optic nerve

Materials: (per pair students)
- A popsicle stick
- A small, neon-colored, round sticker
- A meter stick
- A ruler
- A friend to help you measure
- Calculator (optional)

What To Do:

(1) Put a neon dot at the end of your popsicle stick (or pencil). You are now ready to measure the size of your right eye's blind spot. (see **Figure 1**)

Figure 1

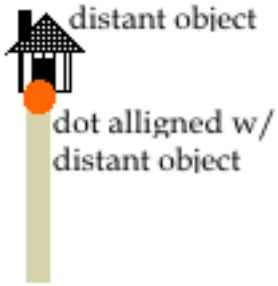


Your blind spot is a hole in your retina where the optic nerve enters the back of your eyeball. Because it a hole, this part of the retina has no rods or cones. So images that form on this part of the retina are not received by the brain—so, you have a blind spot.

(2) Close your left eye and keep it closed. With your right eye open, look at some object in the distance (something more than ten feet away). *It is very important that you keep your left eye closed and your right eye fixed on this object while you examine your blind spot.*

(3) With your arm extended straight out in front of you (elbows straight), hold your neon dot so that the red dot appears to cover the distant object you are looking at with your right eye. (see **Figure 2**)

Figure 2



(4) *Keeping your right eye 's gaze fixed on the distant object*, slowly move the neon dot to the right. Eventually, the bright red dot should disappear in your peripheral vision. If you have moved the red dot more than about 20° from its position straight out in front of you, you have gone too far.

Linda Shore, Ed.D.
Exploratorium Teacher Institute

exploratorium

(5) When you find the location of the spot where the red dot disappears, move the dot up and down. *Remember to keep your right eye focused on the distant object straight in front of you and keep your arm straight with your elbows locked!* How high is your blind spot when the dot is held out at arm's length? Using a ruler, have a friend help you measure the height (H) of your blind spot. (see **Figure 4**)

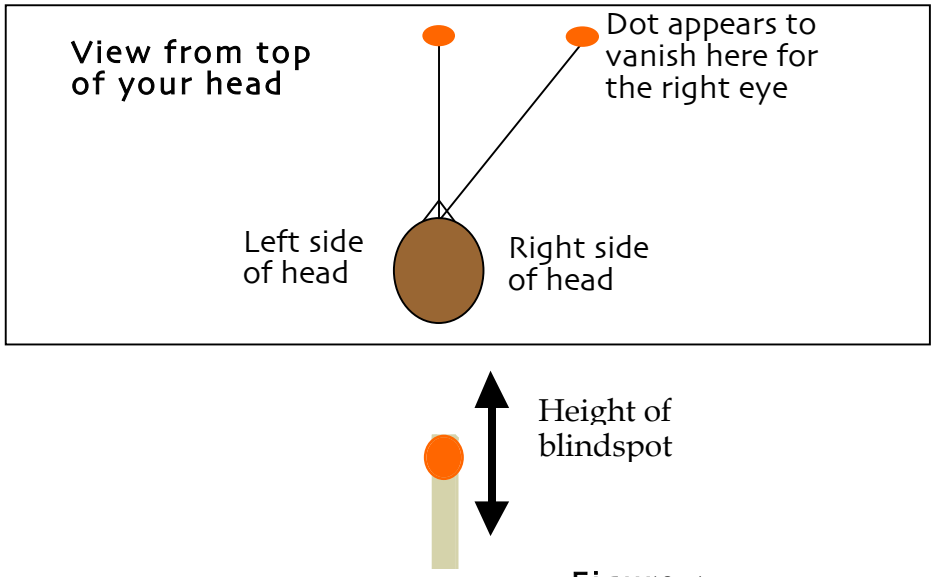


Figure 4

(6) Collect the following measurements:

H = The height of your blind spot (in cm)
D = The distance from your eye to the stick (in cm)

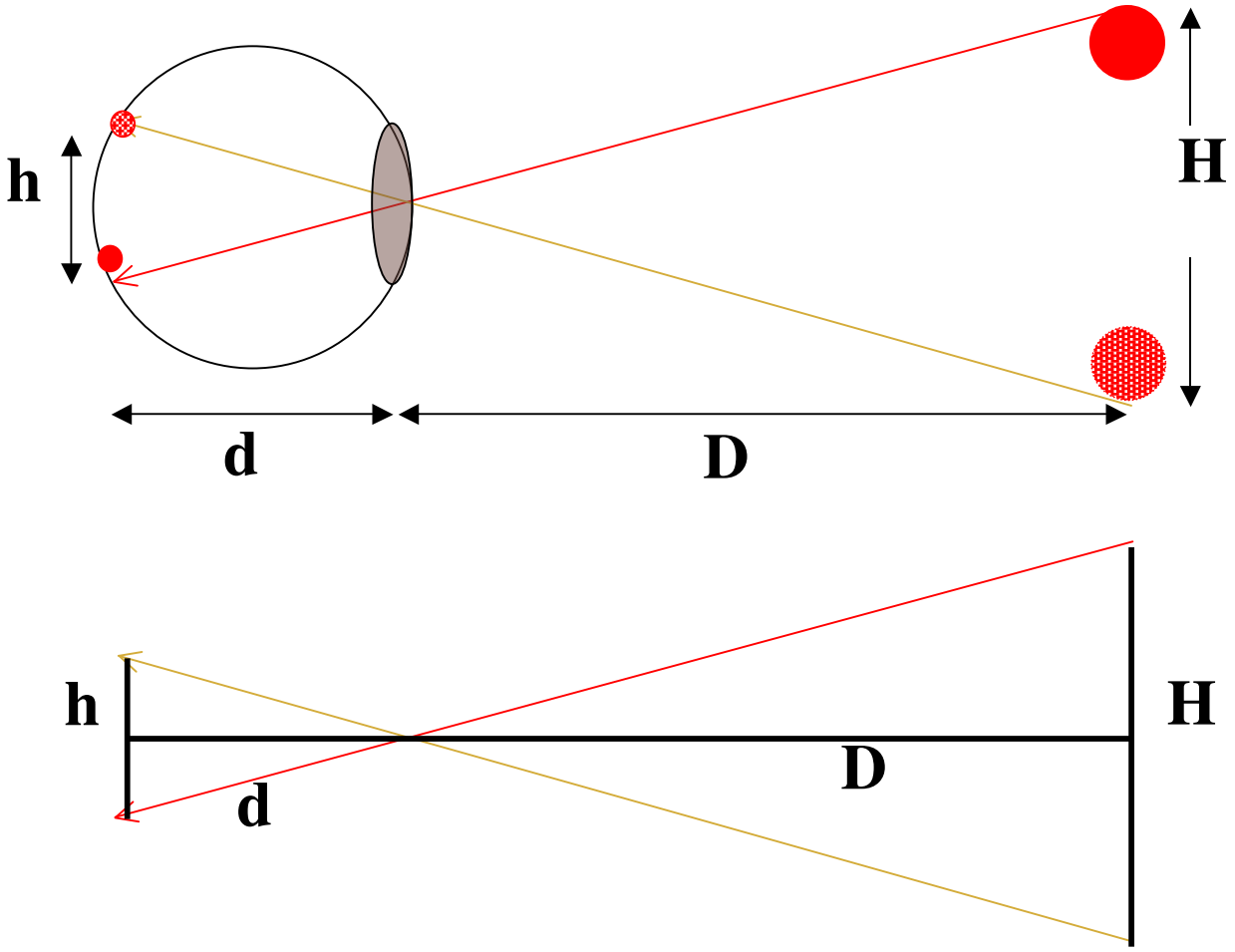
Here is a measurement you'll need:

d = The diameter of your eyeball = 2 cm

(7) With this data you are ready to estimate the size of your optic nerve. You'll use the geometry and mathematics of similar triangles to make this estimate. **Figure 5** below shows the relationship between the sides for triangles that are similar. Because light travels in a straight line from objects to your retina, we can make use of these same relationships to find the size of any image on the back of your eye (the retina). **Figure 5** also shows a ray diagram that demonstrates how the size of any object and the size of its image can be found by applying the knowledge that the ratio of the length and height of similar triangles are equal.

Linda Shore, Ed.D.
Exploratorium Teacher Institute

Figure 5



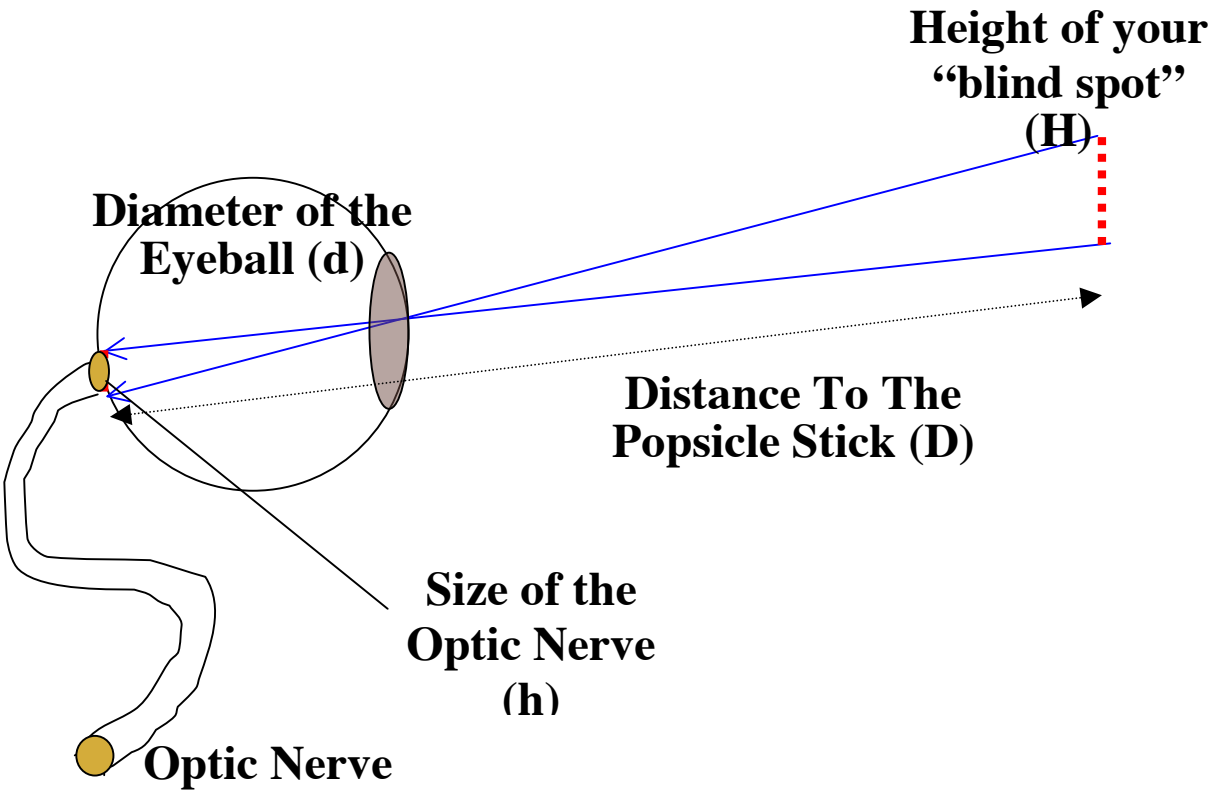
$$D/H = d/h$$

Linda Shore, Ed.D.
Exploratorium Teacher Institute

Figure 6 shows the relationship between the height where the dot appears to vanish (H), the distance between the eye and the stick (D), the diameter of the eyeball (d), and the unknown that you need to solve (the size of the optic nerve or hole in your retina, or h). This calculation will give you the diameter of your optic nerve – the size of the hole in the back of your eye. The formula you will use is:

$$h = d\,(H/D)$$

Figure 6



How Did You Do?

The diameter of your optic nerve is about 2-3 mm. How did your estimate compare?

Linda Shore, Ed.D.
Exploratorium Teacher Institute