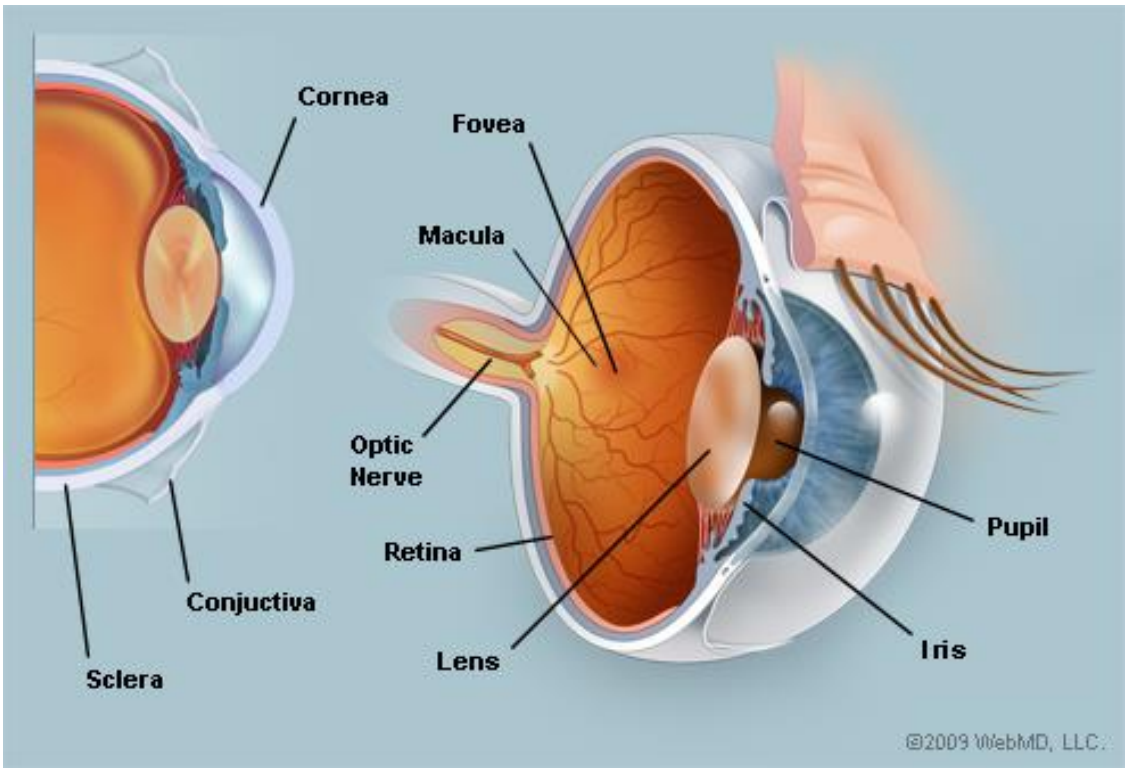
Investigation

3.12B: The Eye

In the preceding case study marker of the problem of greatest concern to you lay in finding the pupils fixed in a dilated position. But what is the “pupil” and what makes it normally dilate and constrict depending on the amount of light?

In the following diagram the parts of the eye are visualized and labeled for you.



Suppose you are a beam of light reflecting from a beautiful piece of art to be visualized in Alice’s occipital lobe. How does that light beam travel from the art to become an image perceived in Alice’s occipital lobe? In order for Alice to enjoy the art the light beam must travel into one or both of Alice’s eyes. Let’s follow that light beam on that journey. We’ll identify each point on our journey as we travel.

Cornea

Light reflected from the piece of art travels all about the room, but the light Alice sees first contacts Alice at her **cornea**. The cornea is a **transparent** layer of tissue that

covers the front of the eye. It protects the iris and lens from the outside world, keeping out dust and microbes in the air while also keeping the fluids in the eye from leaking out. The cornea plays a role in gathering or turning light in toward the lensof the eye directly under the cornea. The cornea has a fixed geometry, while the lens can change its shape to bring images to a sharp focus inside the eye.

A very uniform symmetric shape of the cornea is important to its ability to allow light onto the lens without introducing any distortion. A misshaped cornea provides will prevent the lens from creating a clear image. Modern medicine has devised methods of reshaping the cornea to remove such defects commonly classified as **astigmatism**. Beginning in the 1980's **radial keratotomy** (RK) surgery was introduced to make these corrections. In this procedure a tiny scalpel or knife controlled by a surgeon peering though a binocular microscope makes small cuts into the cornea to correct myopia, or nearsightedness caused by an abnormally shaped cornea. Since 2002 **Lasik** surgery has provided eye surgeons a better tool to improve patients' vision. In Lasik surgery a laser makes the cuts precisely to allow reshaping of the cornea to correct **myopia** (near-sightedness), **hyperopia** (far-sightedness), and **astigmatism**.

Your eye lid slams shut very rapidly to protect the delicate surface of the cornea from impending trauma. If something does strike the cornea damage occurs quite easily; we call that a **corneal abrasion**. Such an abrasion can easily occur should dust, sand, wood or metal get into your eye, and cause small scratches on the surface of the cornea. Superficial scratches usually heal in a day, but deep scratches can scar an potentially permanently affect vision. Persistently painful injuries to an eye deserve a trip to an urgent care facility for evaluation and treatment.

Iris

After passing through the cornea light reaches the layer of the **iris**. As the light reflected from objects around us passes through the cornea some is absorbed by the **iris** and some passes through the hole in the iris we call the **pupil**.

The iris is that pigmented, or colored part of your eye so important in romantic poetry. In some eye the iris appears blue, in others green or brown. Blue is the most common color found in babies, but the least common color for the rest of us because it requires matching of the recessive blue-eye gene, meaning both of your parent must carry that gene. Green and brown eye color we classify as dominant gene traits. On rare occasion you might see someone whose irises look pink or red; they have an absence of iris

pigment. The reddish color comes from the blood flowing in the tissues of the eye. When someone compliments your beautiful brown eyes, they are actually complimenting the color of your iris. When the poet says our eyes constitute windows into our soul, they are not explaining physiology.

Your iris is shaped like a donut, like a glazed donut, not a jelly filled one. The iris opens and closes to control the amount of light passing through. In bright light conditions the iris gets smaller, or contracts, to allow less light into your eye. In dim light conditions the iris opens, or dilates, to allow in more light. Commands to dilate or contract come from the occipital lobe in the brain, where our brain processes the images captured by the eye. Alice's eyes dilated because they were no longer receiving directions from her brain because her brain cells were not functioning normally.

The Pupil

Light from the world about us passes through the cornea, and if too bright gets cut down by the iris allowing the right about to enter through the pupil. What is the pupil? It's simply the open space in the center of the iris through which light passes headed for the retina at the back of the eye. The pupil doesn't dilate or contract, even though people often say "her pupil is contracted or dilated". Instead of saying "the pupil is dilated", to be accurate we should be saying "the iris is dilated". The pupil is just a void or hole in the center of the iris.

Lens

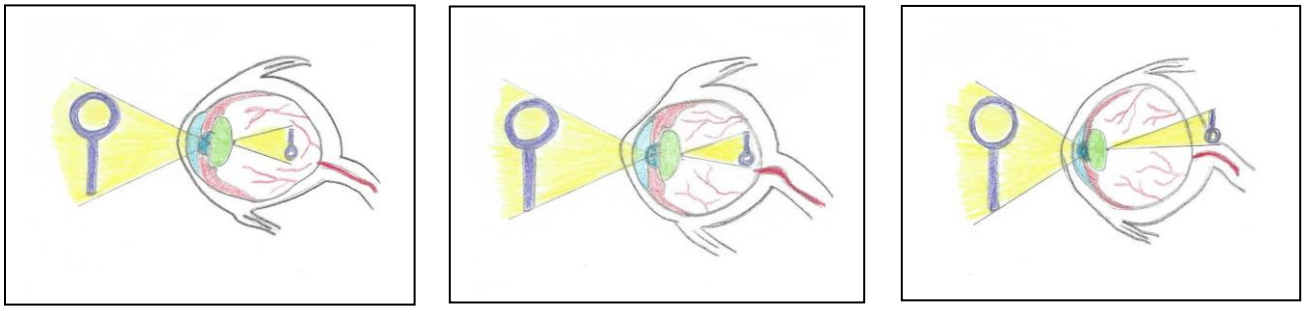
Light passing through the pupil enters the **lens**. If you recall, the cornea bends light toward the lens. The lens further bends the light such that all the light meets at a single pointin focus on the retina. In the study of physics you will learn that the light changes its direction of travel inside the lens because the lens material actually decreases the velocity of the light slightly. Reflected light from objects in front of us is spreading out as it comes to us, but the lens turns that light back together so that the light energy from a single spot out in our field of view comes back together at a single spot on the surface our the retina in our eye. The lens changes its shape to focus the light from a specific distance depending on the object we choose to see most clearly. As we age, beginning for most people around age 40, our lens begins losing its flexibility, and thus its ability to focus equally on nearby and faraway objects. It may become necessary to have reading glasses for near vision or **bifocals**, which have two corrections, one for reading and the other for distance vision. Unfortunately the eyes of a large number of people throughout

the world have less than perfect vision; in fact, it is estimated that nearly 40% of the world population is myopic (near-sighted). Professional baseball players must have exceptional vision in order to hit a 95 mile-per-hour cut fast-ball. For those of us in the more normal category of vision we may have to pin our hopes on different careers.

A **cataract** is a **progressive** condition in which the eye lens gets cloudyespecially in its center. Sun glasses that reduce ultraviolet rays may slow this progression, but it appears that cataracts eventually develop. Cataracts consistute the most common cause of loss of vision around the world in those over the age of 40? By age 80 half of all Americans have cataracts or they have had a very sophisticated, quick surgical procedure to remove the cataract and replace it with an artificial lens.

Retina

The **retina** is the movie screen of the eye. It is the area at the back of the eye upon which the lens focuses the light images that give us vision. **Myopia** is a condition where the lens focuses the light beam in front of the retina. **Hyperopia** is the opposite condition, where the beam is not yet focused when the light hits the retina, and would need to have more distance to come into focus. The images below demonstrate the difference in focal concentration between myopia (left), normal vision (center) and hyperopia (far-sightedness,right).



There are three important things to notice in the diagram:

1. The tip of the smaller cone represents the point of focus in each condition.
2. Eye shape differs slightly in each condition, altering the relationship between lens and retina
3. Images are displayed on the retina inverted from their actual orientation in life. Our brain turns the image upright without our awareness.

The retina is a complex and fragile structure of ten layers having light sensitive cells including rods and cones. **Rods** are photoreceptor cells concentrated at the **peripheral** edges of the retina and used for peripheral vision in less intense light. **Cones** are responsible for our color vision and work best in relatively bright light conditions. It is estimated that each eye has about 7 million cone receptors in three colors: around 64% are red receptors, 32% green receptors, and about 2% are blue receptors. These three receptor types work together so you can see all of the blended variations of our kaleidoscopic world of color.

In order to percieve a nice, clear picture your lens must focus the image onto a smooth layer of receptors. Things can go wrong within the retina. The retina can detach from the posterior surface of the eye; a **detached retina** is an urgent medical condition that must be treated within a couple of days or permanent loss of vision can result in that eye.

The retina is well supplied with small blood vessels. The condition of those vessels can be an indicator of your overall vascular health and because the retina is transparent physicians can inspect these vessel more easily then others in the body using a small instrument called an ophthalmoscope. Diabetes causes changes in the blood vessels that can be seen readily during an eye examination with that device. Small vessel disease of the retina from diabetes creates a common complication of diabetes disrupting vision.

When we look directly at a specific object, for example a word we are reading, our eyes place the image of that word in a place in the retina packed with cones making our vision there most acute. That region we call the macula. Older individuals can suffer progressive failure of the macula called **macular degeneration.** We have no cure for macular degeneration but ophthalmologists can now provide treatment that slows the progression of this condition.

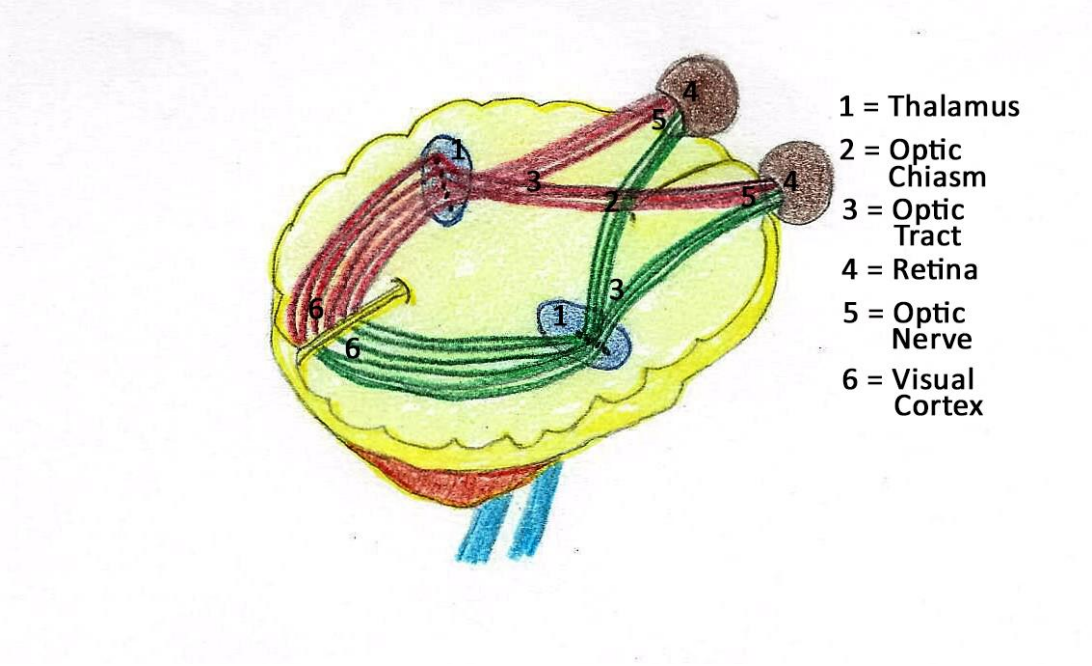
Optic Nerve (and Where it Goes)

Traditionally health care providers have called the connection of the retina to the brain Cranial Nerve II. Today we know that Cranial Nerve II or the Optic Nerve is not a nerve at all like the other nerves in our body. We should think of the “nerve” as being a part of our brain reaching into the back of each eye. Brain neurons in this structure come together inside the skull in a “node” called the Optic Chiasma and then divide again to form two channels or tracks going back to the region of our brain at the back of our

head. The majority of brain cells in the cortex of our brain participate in vision. Understanding what we are seeing probably represents the most amazing task our brain can perform. Some would even say all of our creativity is visual. Even composers say that they see the music they create. Our dreams and imagination appear to have vision as their basis.

Glaucoma

The eyeball or globe is filled with a clear watery fluid called **aqueous humor.** Cells in one part of the eye constantly make this fluid and it is absorbed back into the blood stream in an area close to the edge of the iris. If something disrupts this process the pressure inside the eye can become elevated and cause damage to the neurons in the retina that carry our visual information into our brain. Eye doctors can measure this pressure and have several methods to treat this condition we call **glaucoma.**



Occipital Lobe

After a quick stop at the **thalamus**, our visual signals journey into the **occipital lobes**. You now understand that we do not really see with our eyes. Our eyes collect information about the light reflected from objects around us and that information we ship to the occipital lobes. Neural networks in the occipital lobes allow us to understand and recognize what we see. Your occipital lobes work in conjunction with your temporal lobes to store images and thus create your visual memories. Without a temporal lobe, everyday would be a new day at school or anywhere else you go. Every TV show, every

video game would be full of new images because you wouldn't remember having ever seen them before. You would walk right by your best friends because you wouldn't remember what they look like.

The loss of vision, blindness, represents a huge disability we have difficulty understanding if our eyes work normally. Individuals who must deal with blindness often prove truly amazing in what their minds can accomplish. We do not fully understand how our brains go about repurposing themselves, but it would appear that in many cases the occipital lobe takes on different roles in the minds of individuals who cannot see. Even the blind have been heard to say, "Yes, I see."