Light & Optics

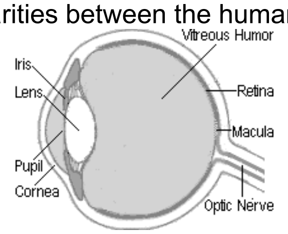
Links: **http://www.hazelwood.k12.mo.us/~grichert/sciweb/optics.htm**
http://dir.yahoo.com/Science/Physics/Light_and_Optics/
http://camillasenior.homestead.com/optics4.html

Unit 3 - Light and Optical Systems

4.0 Eyes and Cameras capture images using the properties of light.

4.1 Image Formation in Eyes and Cameras (pgs. 231-235)

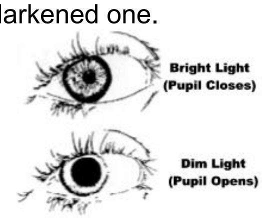
There are many similarities between the human eye and the camera.



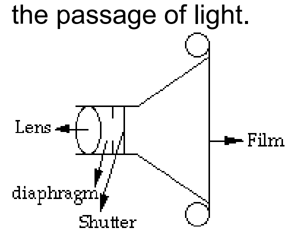
There is also a detailed color image of the eye in Science In Action (Figure 4.1, p. 231)

How Light Gets In
In order to adjust the amount of light that enters the eye and the camera, a special device opens and closes to let just the right amount of light in.

In the eye, the device (or part of the eye) that controls the amount of light entering is called the **iris** (the colored part of the eye), which changes the size of the **pupil** - in much the same way as the **diaphragm** controls the **aperture** (opening) of the camera lens. The natural adjustment in the size of the pupils is called the **iris reflex**, which is extremely rapid. This iris reflex action automatically adjusts the pupil when you go from a darkened area to a well-lit area, or, from a well-lit area to a darkened one.



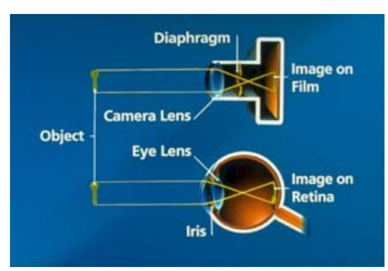
In the camera, the **diaphragm** controls the **aperture** (opening) of the lens and the **shutter** limits the passage of light.



Parts of the Eye - http://www.college-optometrists.org/public/eyeparts.htm

When Light Gets Inside

In the eye, when the **photoreceptor cells** in the retina detect light (**rods** are highly sensitive to light and **cones** detect color), they produce small electrical impulses from the **retina** to the brain, by way of the **optic nerve**.
The film at the back of the camera contains light sensitive chemicals, which change when light hits it. These chemicals form the image on the **film**.



The parts of a camera are housed in a rigid light-proof box, whereas layers of tissue hold the different parts of the eye together. The eyeball contains fluids, called **humours**, which prevent the eyeball from collapsing and refract the light that enters the eye.

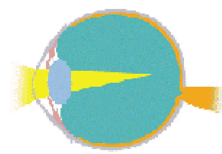
Focusing The Light

In a camera, if an object moves closer to the film, the lens must move away to keep the image in focus. In the human eye, the lens cannot move, so the **ciliary muscles** change the shape of the lens (by making the lens bulge in the middle if the image comes closer to you and stretch if the object is further away). This is done so that the eyeball isn't stretched. The process of changing the shape of the lens is called **accommodation**. As people become older, the lens stiffens and loses its' ability to change shape (doesn't bulge) and many people need to wear (convex lens) reading glasses, so that the images can be focused.

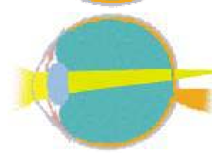
Image Formation

The lens in the human eye is a convex lens, which focuses the light rays entering your eye to a point on your retina (a light sensitive area at the back of the eye). The image you see is formed on the retina. Some people however have eyes that are too long or too short.

If their eye is too long, the image forms in front of the retina - this is a condition called **Myopic**, or **near-sightedness** (they have trouble seeing distant objects).



If their eye is too short, the image forms behind the retina. This condition is called **Hyperopia** or **far-sightedness**. (objects that are close to them are difficult to see)



Correcting Vision Problems With Lenses

Knowledge of how light behaves when it travels through **lenses** helps eye specialists correct vision problems. The shortest distance at which an object is in focus is called the ***near point of the eye***. The longest distance is called the ***far point of the eye***. On average, an adult has a near point of about 25 cm, whereas babies have a near point of only 7 cm. The far point is infinite (because you can see the stars).

Laser Eye Surgery

Instead of wearing glasses many people are now opting to have an eye surgeon use a **laser** to correct a vision problem. The surgeon cuts a thin flap of tissue covering the eye, fold it over, then the cornea is reshaped with a laser. The reshaped cornea acts like a corrective lens, allowing the light to be bent so it will properly focus on the retina.
In 1966, Theodore H. Maiman, a physicist at Hughes Aircraft Company in California became the first person to use a process called ...

light **a**mplification by the **s**timulated **e**mmission of **r**adiation

or **laser** light.

Incandescent lights give off many different colors and therefore have many different frequencies and wavelengths. The waves are jumbled and crests from one wavelength might overlap the trough of another, making the waves work against each other. This type of light is **incoherent**. Laser light is quite different. It gives off a single wavelength (frequency) of **coherent** light. Lasers have many useful ***applications***:

- Scanners (bar codes in retail shops are scanned to give the price)
- Digitized data are read by a laser on a compact disk (CD)
- Lasers are use by law enforcement officers to detect the speed of vehicles.
- Laser light can be released in pulses or in a continuous beam. In either form, it is so powerful, that it can make precise cuts through metal and can also be used in surgery, as a scalpel - or, to instantly seal broken blood vessels, because it produces such intense heat.

Night Vision Goggles

In night vision goggles, light is focused onto an image intensifier. Inside the intensifier, the light energy releases a stream of particles, which hit a phosphor-coated screen. These glow green and the person looking in the goggles can view a green image.

Can you find your blind spot?

The point where the retina is attached to the optic nerve does not have any light sensitive cells. This point is known as the **blind spot**.

View this image at arm's length. Cover your right eye with your hand. Stare at **x**, slowly leaning closer to the image, until the dot disappears (when you reach your blind spot) and then reappears when you have passed your blind spot.

4.2 Other Eyes in the Animal Kingdom (pgs. 236-238)

http://www.astc.org/exhibitions/eyes/introeyes.htm

Camera Eyes

Eyes that have a cornea, a lens and a retina are called **camera eyes**. **Vertebrates** (animals with backbones) for the most part have camera eyes.

http://www.ski.org/CWTyler_lab/Eyepage/index.html

Fish have camera eyes with a perfectly round lens, which bulges out from the pupil, allowing it to see in practically every direction.
Birds have sharper vision than humans because they have five types of cones (humans have only 3), each sensitive to different wavelengths of light.
Nocturnal animals have eyes that collect as much light as possible because of their very large pupils. They also have a layer, called *tapetum lucidum*, inside their eye, which acts as a mirror. They also have many more rods than cones in their retina making their eyes more sensitive to low levels of light.

Compound Eyes

Insects and crustaceans have compound eyes. Each eye is made up of many smaller units called **ommatidium**. An ommatidium looks like a long tube with a lens on the outer surface, a focusing cone below it, and then a light sensitive cell below that.
The compound eye is great for spotting movement, but with so many lenses it is difficult to form a single **coherent** image. Instead it forms a **mosaic image** (much like a tv screen).

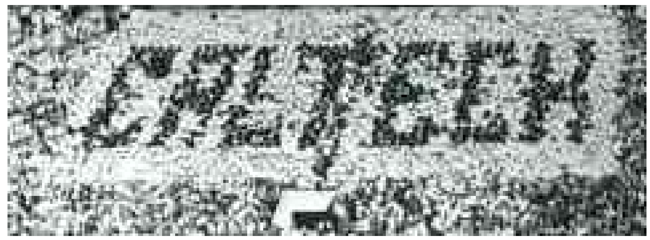
4.3 Image Storage and Transmission (pgs. 239-244)

Most information today is stored **digitally** (converted into numbers).

Stadium Images

The stadium image is made up of people holding different colored cards. Each card is assigned a seat based on the graphic representation of where the colors need to be to produce the correct effect.

This stadium image was one of many designed by college students from Caltech – even though their team was not in the **1961 Rose Bowl** – Read the story of how it stunned the world by clicking on the image



http://www.museumofhoaxes.com/pranks/rosebowl.html

Digital Images

Just as in the stadium image, a big picture made out of small colored squares, a digital image is a picture made up of smaller colored pieces called **pixels** (**pic**ture **el**ements). Each small pixel is assigned a place and is represented by a number. This long series of numbers can then be stored in the memory of a computer to be accessed at a later time.

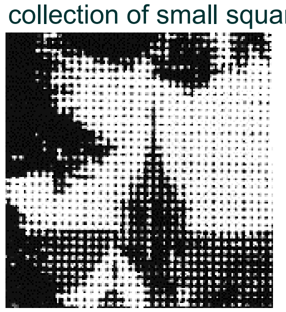
Coloring A Digital image

Once the individual pixels are in the correct order, each pixel is assigned a value, which corresponds to a specific color. When the picture gets reassembled, the computer reads the value of each pixel and makes that pixel the correct color.

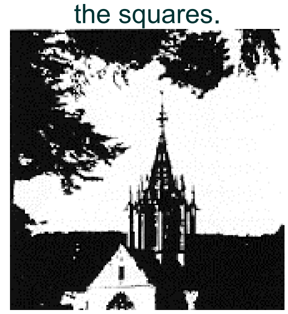
Digital Image Quality

The quality of the digital image depends on the size of the pixels.

If the pixel is large you will see the image as a collection of small squares.



If the pixel is small you will not notice the squares.



The quality of the image is represented by its **resolution**. The more pixels there are in the image, the higher the resolution.

Capturing Digital Images

Scanners, digital video recorders, and digital cameras use a **charge-coupled device** (CCD) to capture the light. The CCD is a grid similar to graph paper. As the light enters each grid square it creates a small electrical charge, which is then converted into digital information and stored on a hard drive, compact disk or digital tape.

Transmitting Digital Images

Digital images can be sent over vast distances, without having to be processed. A powerful computer can convert the digital information very quickly. Digital imaging can also collect different parts of the electromagnetic spectrum, allowing infrared as well as visible images to be captured.