HISTORICAL PERSPECTIVE

Ancient Times	Chinese	used mirrors
	Archimedes	used mirrors in war
	Pythagoras	thought light was beams of light coming from our eyes
	Euclid	light is reflected travels in straight lines
1st Century	*Ptolemy*	light bends when it travels from air to glass
1000 AD	*Al-Haythem*	first to accurately describe how vision worked
1670	*Isaac Newton*	light is a mixture of different colors of light
1676	*Ole Romer*	determined the speed of light

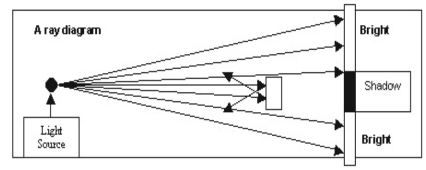
OPTICAL DEVICES

1300 AD	Alessandra della Spina	wore the 1st pair of eyeglasses
1595	Zacharias Jansen	built the 1st microscope
1600's	Antonie van Leeuenhoek	discovery of cells using a very simple microscope
	Galileo Galilei	invented the **refracting** telescope
	Isaac Newton	invented the **reflecting** telescope
1854	Ignatio Porro	prism erecting system (simple binoculars)
1900	1st Endoscope *Hubble Space Telescope*	

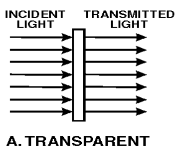
PROPERTIES OF LIGHT

- Light travels in straight lines
- Light can be reflected
- Light can be bent
- Light is a form of Energy

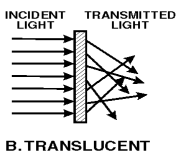
A ray is a straight line that represents the path of a beam of light. Ray diagrams help to demonstrate brightness or intensity of light through changes in distance. The ray model helps to explain how shadows can be formed when an object blocks the ray of light.



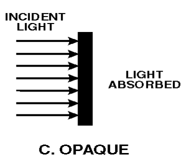
LIGHT INTERACTIONS



Transparent - light passes through it undiffused, you can see clearly the details of whatever is on the other side (a glass window is *transparent*).

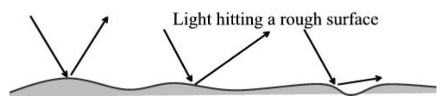


Translucent - light passes through but is diffused, you cannot see clearly details on the other side (a frosted glass window is *translucent*).

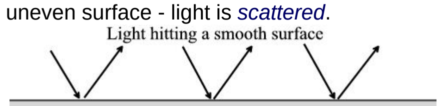


Opaque - no light passes through, you can see nothing through it at all (a door is *opaque*).

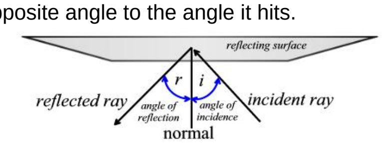
LAW OF REFLECTION



Diffuse reflection occurs as light hits an uneven surface - light is *scattered*.

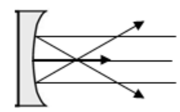


Regular reflection occurs as light hits a smooth surface, the light reflects at an opposite angle to the angle it hits.

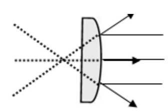


The <u>Law of Reflection</u> states that *the angle of incidence equals the angle of reflection* *when light reflects off a smooth surface*

MIRRORS



Concave mirrors form an image that appears to be closer than it actually is and can be useful because it can also reflect light from a large area
rear-view mirrors and side mirrors on automobiles



Convex mirrors form images that appear much smaller and farther away than the object - but they can reflect light from a large area
security devices, flashlights, telescopes, cosmetic mirrors and car headlights

LAW OF REFRACTION

Refraction is the process in which light is bent, when it travels from one medium to another. Light bends because it changes speed when it moves through materials that have different densities. The bending of light makes the object's image appear to be in a different position than it really is.

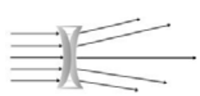
The ***Law of Refraction*** states that when light travels from one medium, to a more dense medium, the light will be bent ***toward*** the normal, and when it exits the denser medium into a less dense medium it will bend ***away*** from the normal. The new direction of light is called the ***angle of refraction***.

Light travels slower in materials that are denser, because there are more particles.

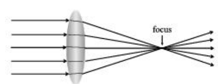
The refraction of light through air is called a *mirage*.

LENSES

A **lens** is a curved piece of transparent material (glass/plastic). When light rays pass through it, the light is refracted, causing the rays to bend.



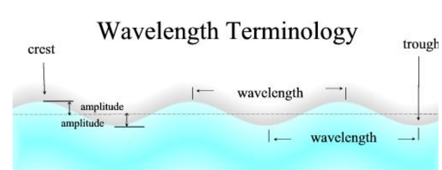
A **double concave lens** is thinner and flatter in the middle than the edges. Light passing through the thicker more curved areas of the lens will bend more than light passing through the thinner areas, causing the light to spread out or **diverge**.



A double convex lens is thicker in the middle than around the edges causing the light to come together at a focal point, or converge.

WAVE MODEL OF LIGHT

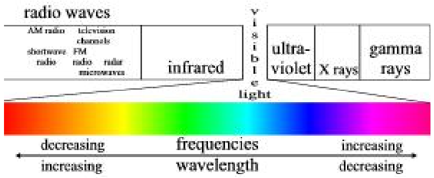
The **wave model of light** describes light traveling as a **wave**. It doesn't explain everything about how light behaves but it helps us visualize it.



The high parts of the wave are called **crests**. The low parts of the wave are called **troughs**. The distance from crest to crest is called **wavelength**. The height of the crest or the depth of the trough from rest position is called the **amplitude**. **Frequency** is the rate at which the crests and the troughs move up and down.

ELECTROMAGNETIC SPECTRUM

The sun is the most abundant source of electromagnetic energy. Each part of the electromagnetic spectrum has different wavelengths and frequencies.



The higher the frequency the more damaging the electromagnetic rays are. **Gamma** rays are the most dangerous, and **Radio** waves are the least dangerous.

Many practical applications utilize different types of electromagnetic energy on a daily basis. Each form of energy is unique because of its distinct properties and wavelength.

NATURAL LIGHT

Light is often called **radiant energy**. Light from the sun is formed by nuclear fusion.

NATURAL Light Sources

Sun

Candles

Oil Lamps

Wood (fire)

Bioluminescence (light produced by living organisms)

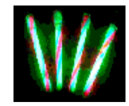
ARTIFICIAL LIGHT

Incandescent (heat causing a filament of metal to glow - visible light)

Florescent (ultraviolet light is absorbed by fabric particles, which in turn emit some of the energy as light - glowing)

Phosphorescent (light energy is stored and released later as visible light) **paint**

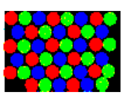
Chemiluminescent (light energy released by chemical reactions) **glow sticks**



COLOR OF LIGHT

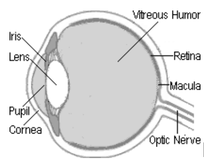
The primary colors of the visible light spectrum are red green and blue.

By mixing the correct intensities of the primary colors, you will observe white light. Secondary colors are cyan, magenta and **yellow**. The mixing of three colors of light to produce many different colors of light is called the **theory of color addition**.

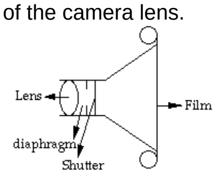


Television puts this theory of color addition into practice. By changing the brightness of the dots that make up the screen many different colors can be produced.

EYES AND CAMERAS



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.

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.

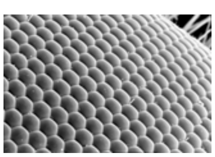
Fish have camera eyes with a perfectly round lens, which bulges out from the pupil, allowing it to see in practically every direction.

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 television screen).

DIGITAL IMAGES

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.

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. A series of numbers represents a color. These series of numbers can then be stored in the memory of a computer to be accessed at a later time. The quality of the image is represented by its **resolution**. The more pixels there are in the image, the higher the resolution.

DIGITAL TECHNOLOGIES

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.