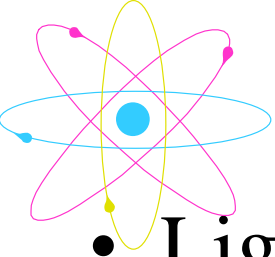


Light



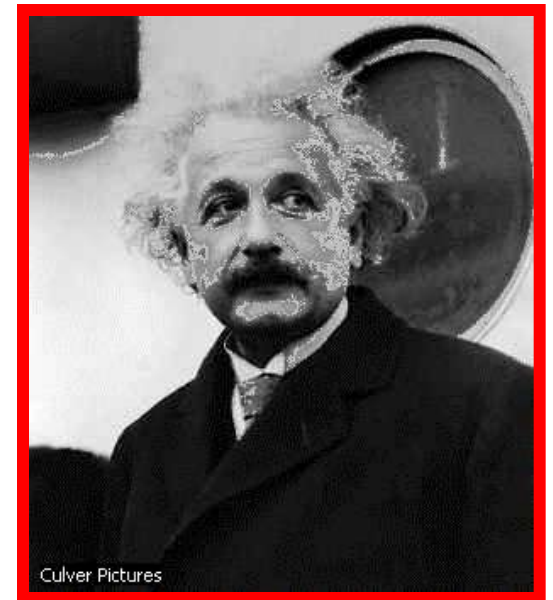
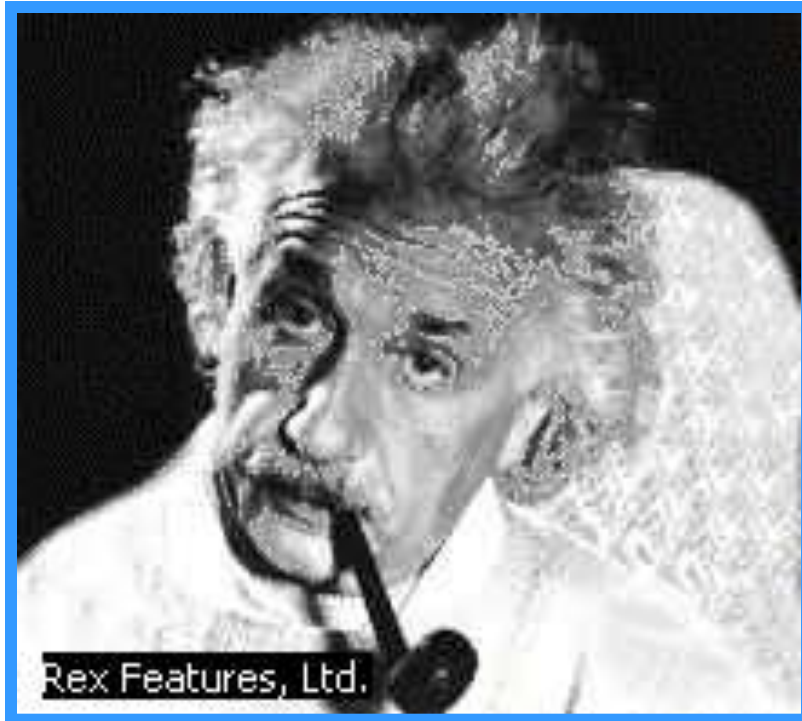
LIGHT: What Is It?

- Light Energy

- Photons - are bundles/packets of energy released when the electrons fall
 - Streams of Photons
 - How light energy is released
 - Atoms
 - » As atoms absorb energy, electrons jump out to a higher energy level.
 - » Electrons release light when falling down to the lower energy level.
- Electromagnetic wave because it can be created with electricity and magnetism.

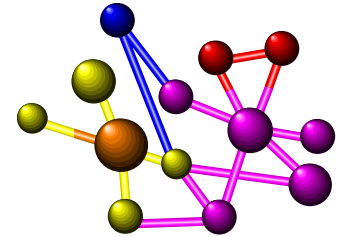
Albert Einstein

- Helped define and describe light



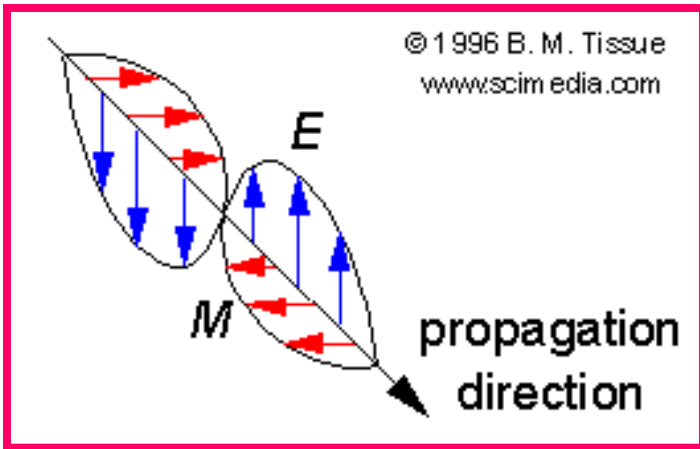
Speed of Electromagnetic Waves

- Speed in Vacuum
 - Measured by Danish astronomer Olaus Roimer .
 - 300,000 km/sec
 - 186,000 mi/sec
- Speed in Other Materials
 - Slower in Air, Water, Glass



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Electromagnetic waves are Transverse Waves

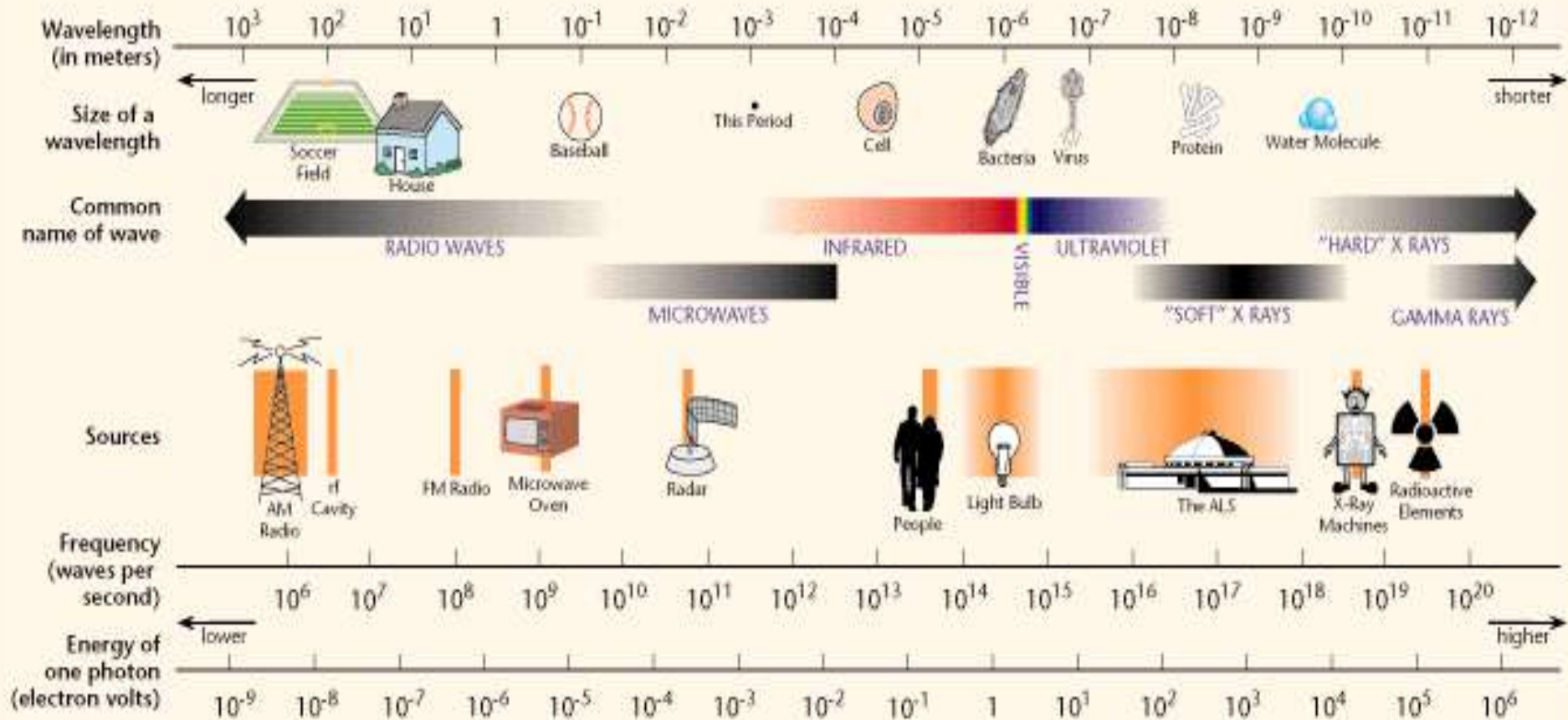


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- Energy is perpendicular to direction of motion
- Moving photon creates electric & magnetic field
 - Light has BOTH Electric & Magnetic fields at right angles!

Electromagnetic Spectrum

THE ELECTROMAGNETIC SPECTRUM



Describing the Electromagnetic Spectrum

- They all travel the same speed
- Have different wave lengths and frequencies

Electromagnetic Spectrum

- Invisible Spectrum
 - Radio Waves
 - Def. – Longest wavelength & lowest frequency.
 - Uses – Radio & T.V. broadcasting.



Radio waves

- Radio waves
 - Low energy and low frequency waves
 - AM are the longest and lowest frequency waves
 - 1) Amplitude modulation
 - 2) 535 kHz to 1605 kHz
 - FM
 - 1) Frequency Modulation
 - 2) 88 MHz to 107.9 MHz

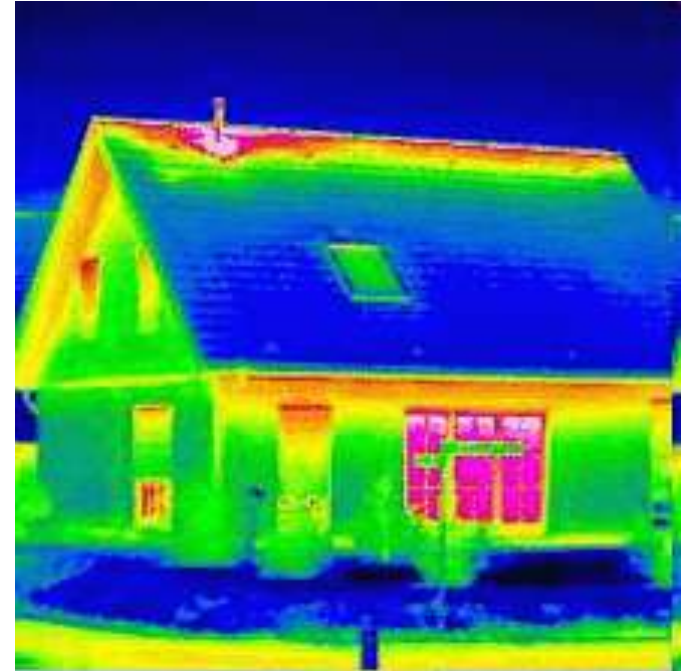
Modulating Radio Waves

- Modulation - variation of amplitude or frequency when waves are broadcast
 - AM – amplitude modulation
 - Carries audio for T.V. Broadcasts
 - Longer wavelength so can bend around hills
 - FM – frequency modulation
 - Carries video for T.V. Broadcasts



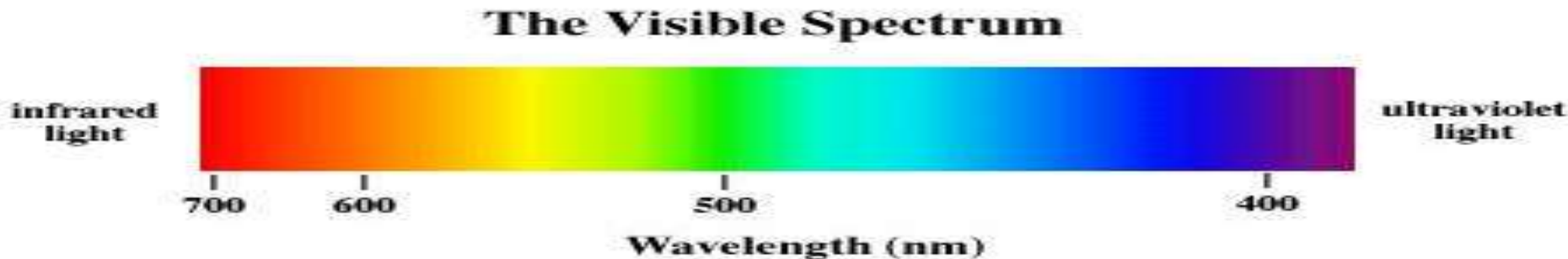
Short Wavelength Radio & Infrared

- Microwave
 - Used for transmitting telephone Messages
 - Cooking food.
- Infrared Rays
 - Def – Light rays with longer wavelength than red light.
 - Uses: Cooking, Medicine, T.V. remote controls
 - All objects give off some infrared radiation
 - Used to warm food
 - Used in thermograms
 - Used to track things in fog in darkness



Visible Spectrum

- Visible Spectrum – Light we can see
 - ROY G. BIV – Acronym for **Red**, **Orange**, **Yellow**, **Green**, **Blue**, **Indigo**, & **Violet**.
 - **Longest to Shortest Visible wavelength.**



Ultraviolet

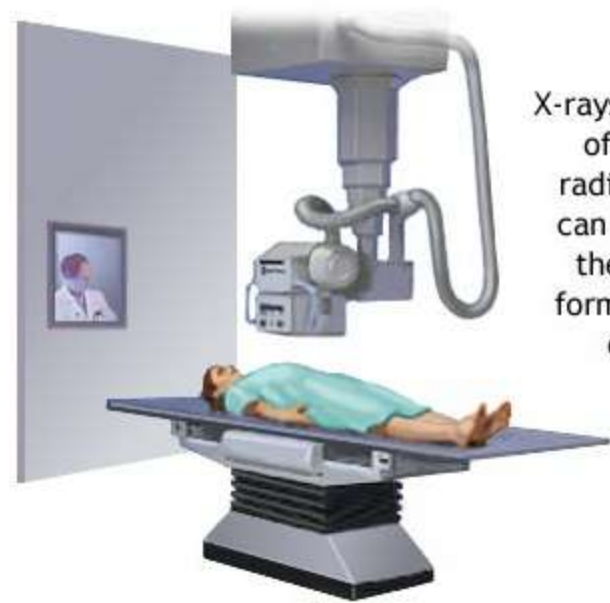
– Ultraviolet rays.

- EM waves with frequencies slightly higher than visible light
- Uses: food processing & hospitals to kill germs' cells
- Helps your body use vitamin D.
- Present in the sunlight and causes the skin to tan and to burn
- Over exposure kills cells

X-Ray

– X-Rays

- Def. - EM waves that are shorter than UV rays.
- Uses: Medicine
 - Bones absorb x-rays; soft tissue does not.
- Lead absorbs X-rays.



X-rays are a form of ionizing radiation that can penetrate the body to form an image on film

ADAM.



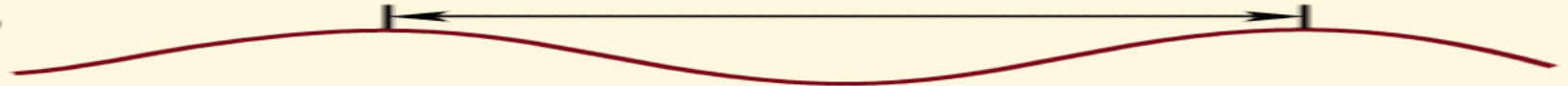
Gamma Ray

- Gamma rays
 - Def. Highest frequency EM waves; Shortest wavelength. They come from outer space.
 - Uses: cancer treatment.

LIGHT: Particles or Waves?

- Light as a wave
 - Wave Model of Light
 - Explains most properties of light
 - Light has interference pattern
- Light as a Particle
 - Particle Theory of Light
 - Photoelectric Effect – Photons of light produce free electrons

(a)

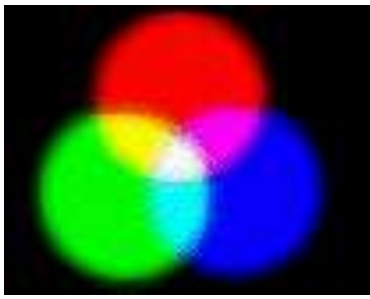


(b)



Light

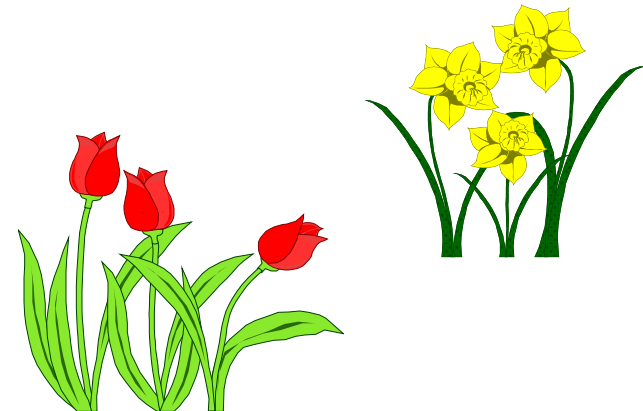
- Transparent Objects:
 - Light transmitted because the electron configuration allows light to pass through
 - Color transmitted is color you see. All other colors are absorbed.
- Translucent:
 - Light is scattered and transmitted some.
- Opaque:
 - Light is either reflected or absorbed.
 - Color of opaque objects is color it reflects.
 - Are opaque objects different colors?



Color of Light

- Color of Objects

- White light is the presence of ALL the colors of the visible spectrum.
- Black objects absorb ALL the colors and no light is reflected back.



Color of Light

- Primary Colors of Light
 - Three colors that can be mixed to produce any other colored light
 - **Red** + **blue** + **green** = white light
- Complimentary Colors of Light
 - Two complimentary colors combine to make white light-**Magenta, Cyan, Yellow**

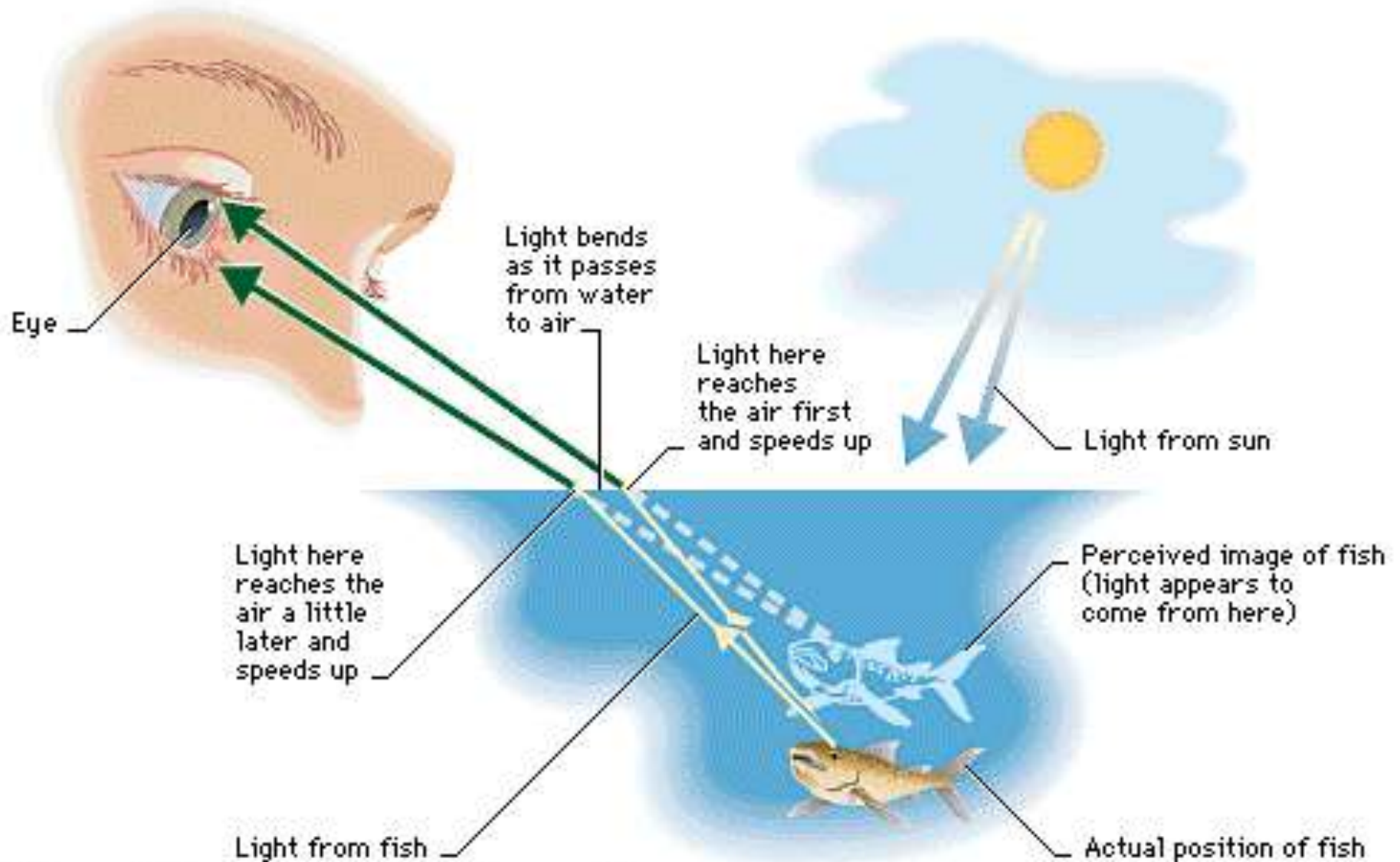


LIGHT: Refraction of Light



- Refraction – Bending of light due to a change in speed.
 - Index of Refraction – Amount by which a material refracts light.
 - Prisms – Glass that bends light. Different frequencies are bent different amounts & light is broken out into different colors.

Refraction



The Human Eye

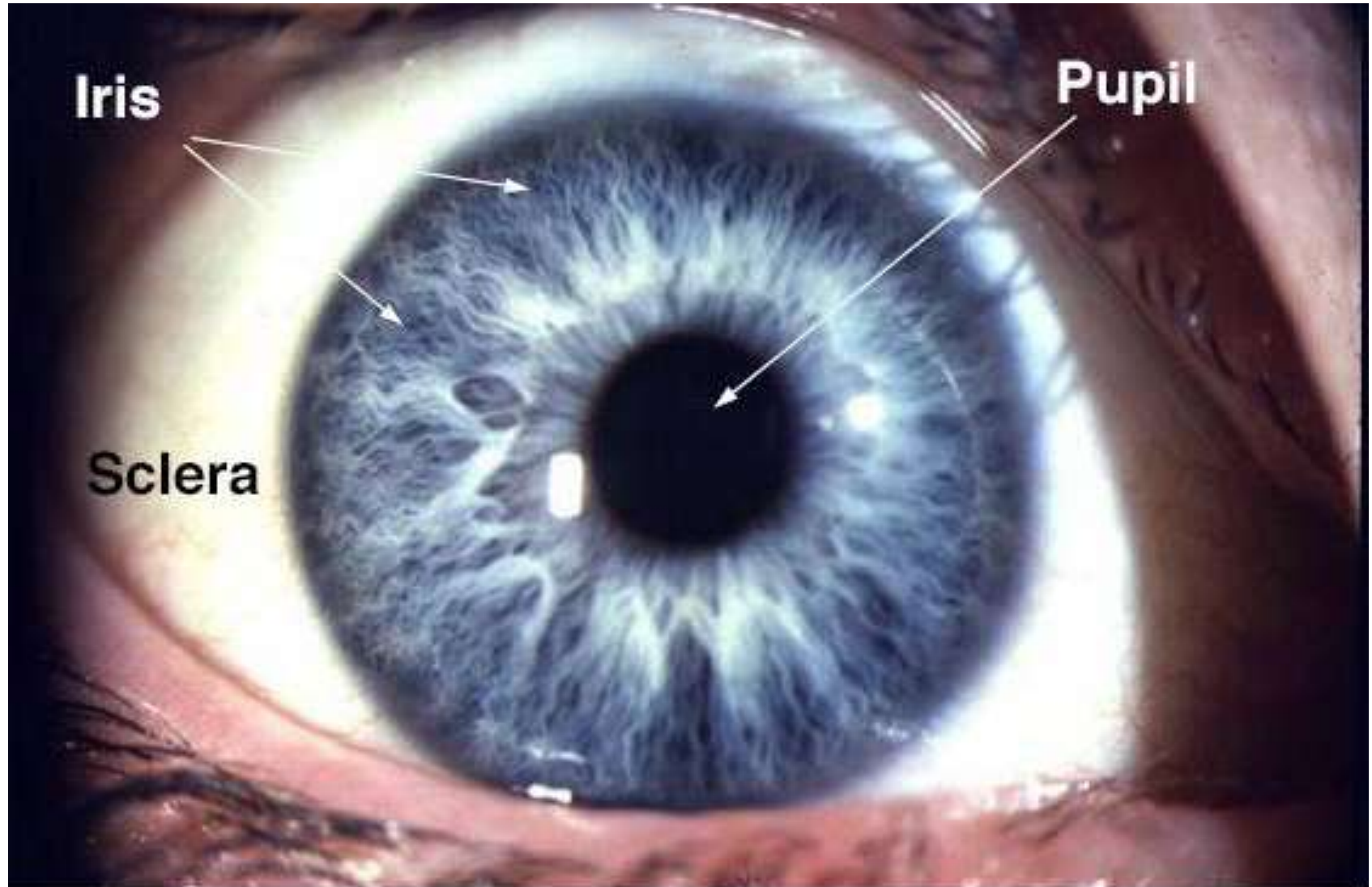
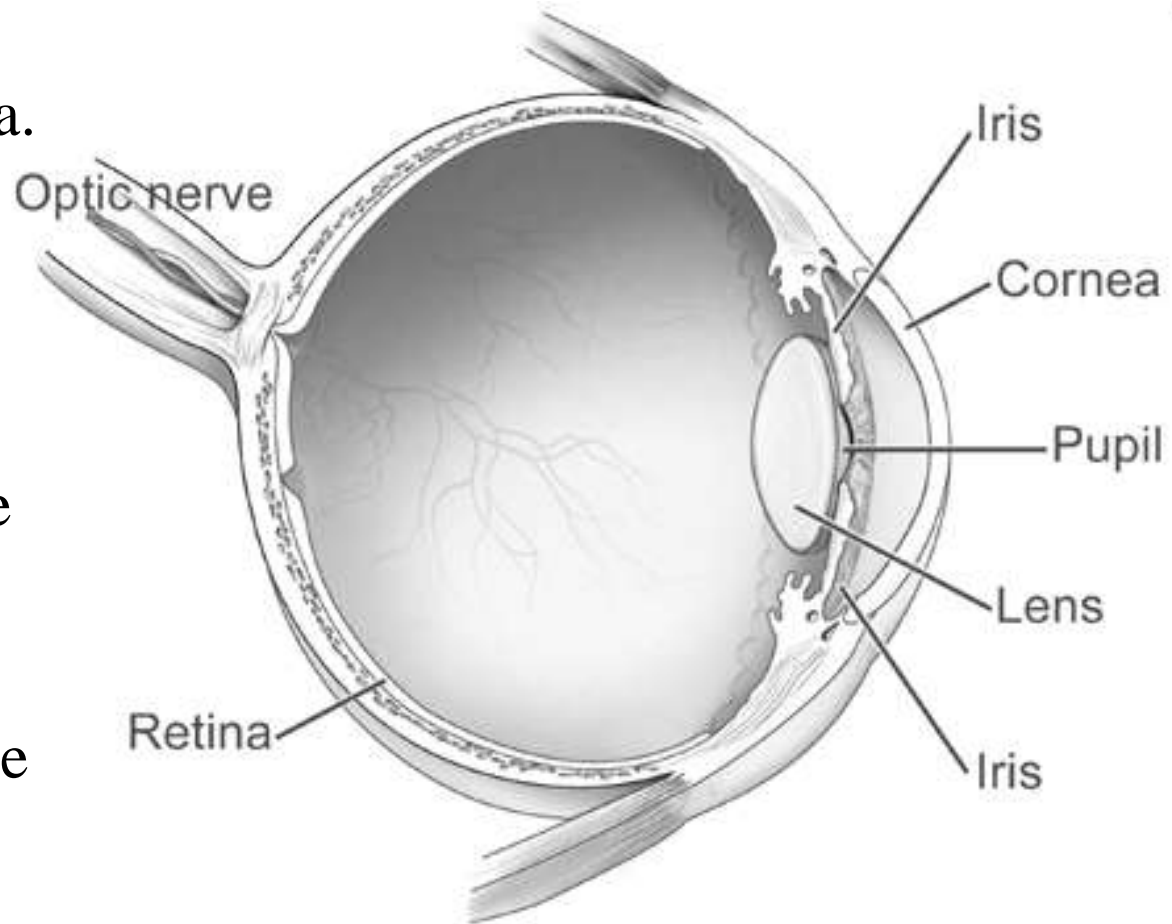
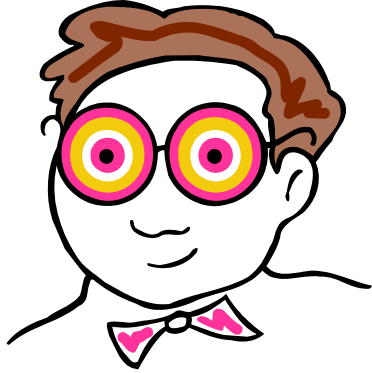


Fig. 1. View of the human eye

How You See

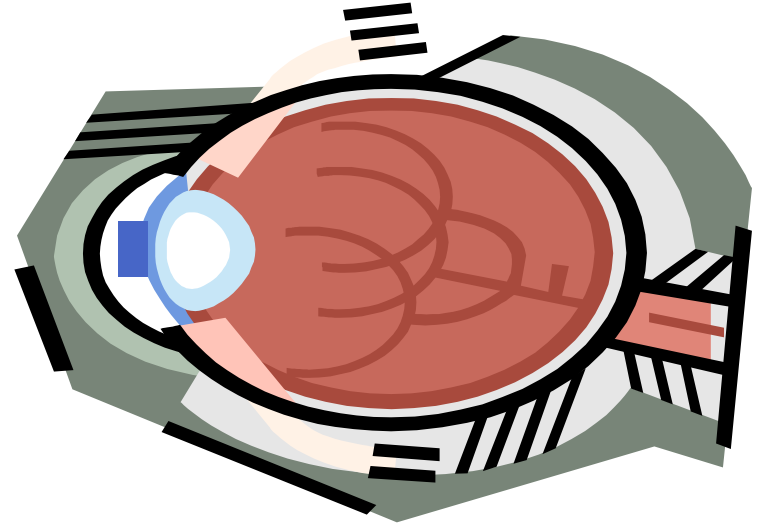
- Retina –
 - Lens refracts light to converge on the retina. Nerves transmit the image
- Rods –
 - Nerve cells in the retina. Very sensitive to light & dark
- Cones –
 - Nerve cells help to see light/color



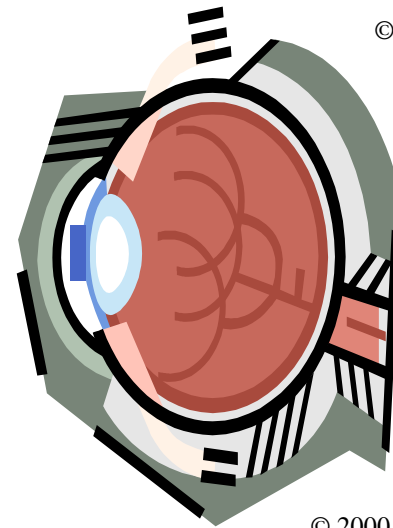


How You See

- Near Sighted – Eyeball is too long and image focuses in front of the retina
- Far Sighted – Eyeball is too short so image is focused behind the retina.



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Paint Pigments

- Pigments absorb the frequency of light that you see
- Primary pigments
 - **Yellow** + **Cyan** + **Magenta** = **black**
 - Primary pigments are compliments of the primary colors of light.

Reflection

- Reflection – Bouncing back of light waves
 - Regular reflection – mirrors smooth surfaces scatter light very little. Images are clear & exact.
 - Diffuse reflection – reflected light is scattered due to an irregular surface.

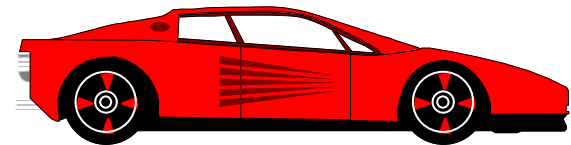
Mirrors

- Plane Mirrors – Perfectly flat
 - Virtual – Image is “Not Real” because it cannot be projected

Mirrors

- Reflection & Mirrors (Cont.)
 - Convex Mirror
 - Curves outward
 - Enlarges images.
 - Use: Rear view mirrors, store security...

CAUTION! Objects are closer than they appear!

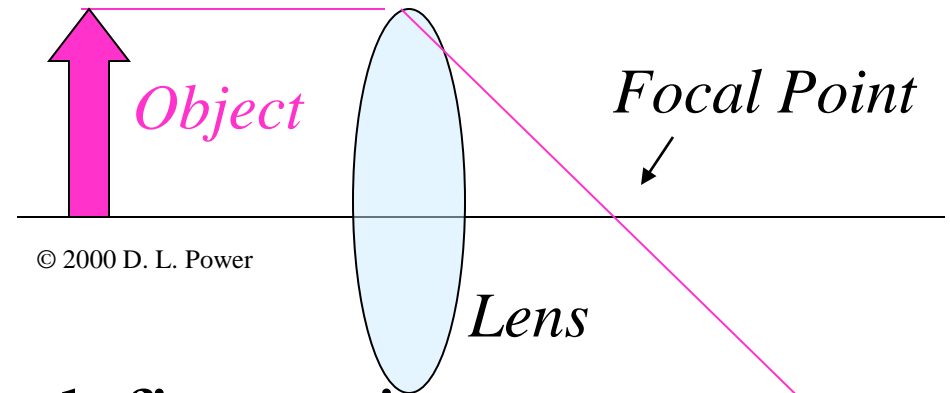


Lenses

- Convex Lenses
 - Thicker in the center than edges.
 - Lens that converges (brings together) light rays.
 - Forms real images and virtual images depending on position of the object

Lenses

- Convex Lenses
- Ray Tracing



– Two rays usually define an image

- Ray #1: Light ray comes from top of object; travels parallel to optic axis; bends thru focal point.

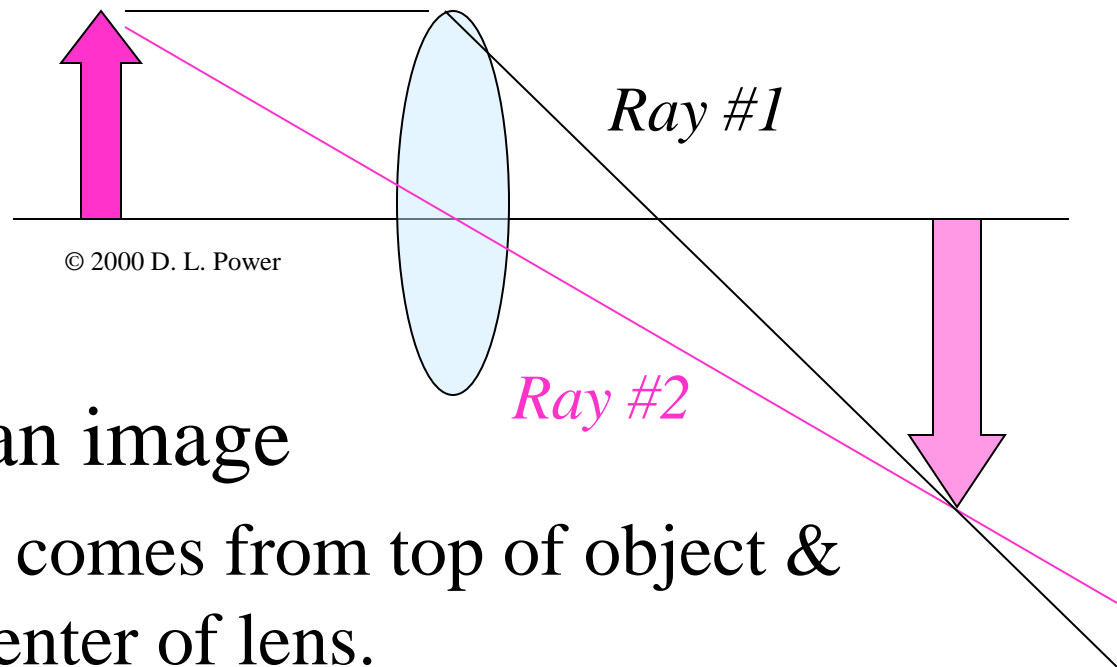
Lenses

- Convex Lenses

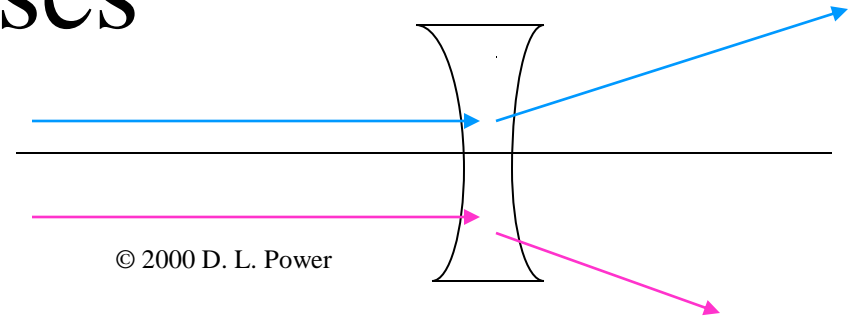
- Ray Tracing

- Two rays define an image

- Ray 2: Light ray comes from top of object & travels through center of lens.



Lenses



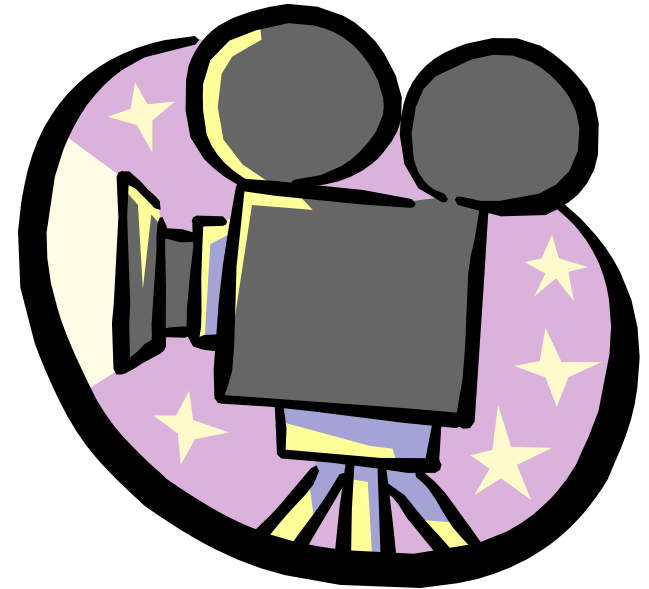
- Concave Lenses –
 - Lens that is thicker at the edges and thinner in the center.
 - Diverges light rays
 - All images are erect and reduced.

Lenses

- Concave Lenses –
 - Vision – Eye is a convex lens.
 - Nearsightedness – Concave lenses expand focal lengths
 - Farsightedness – Convex lenses shortens the focal length.

Optical Instruments

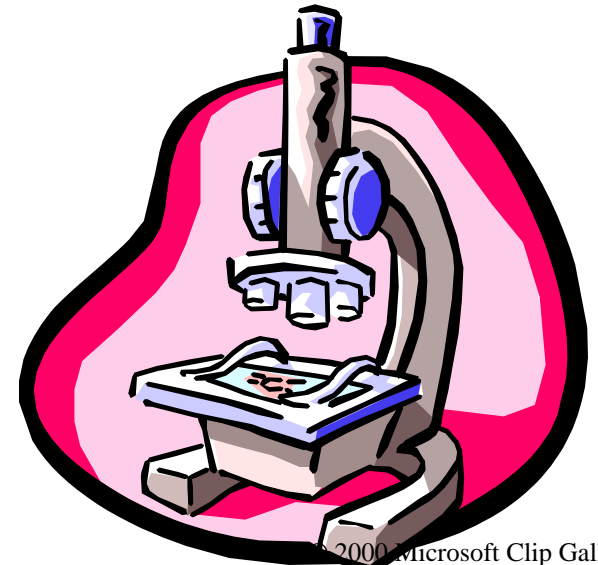
- Cameras
- Telescopes
- Microscopes



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Optical Instruments

- LASERS
 - Acronym: *L*ight *A*mplification by *S*timulated *E*mission of *R*adiation
 - Coherent Light – Waves are in phase so it is VERY powerful & VERY intense.



Optical Instruments

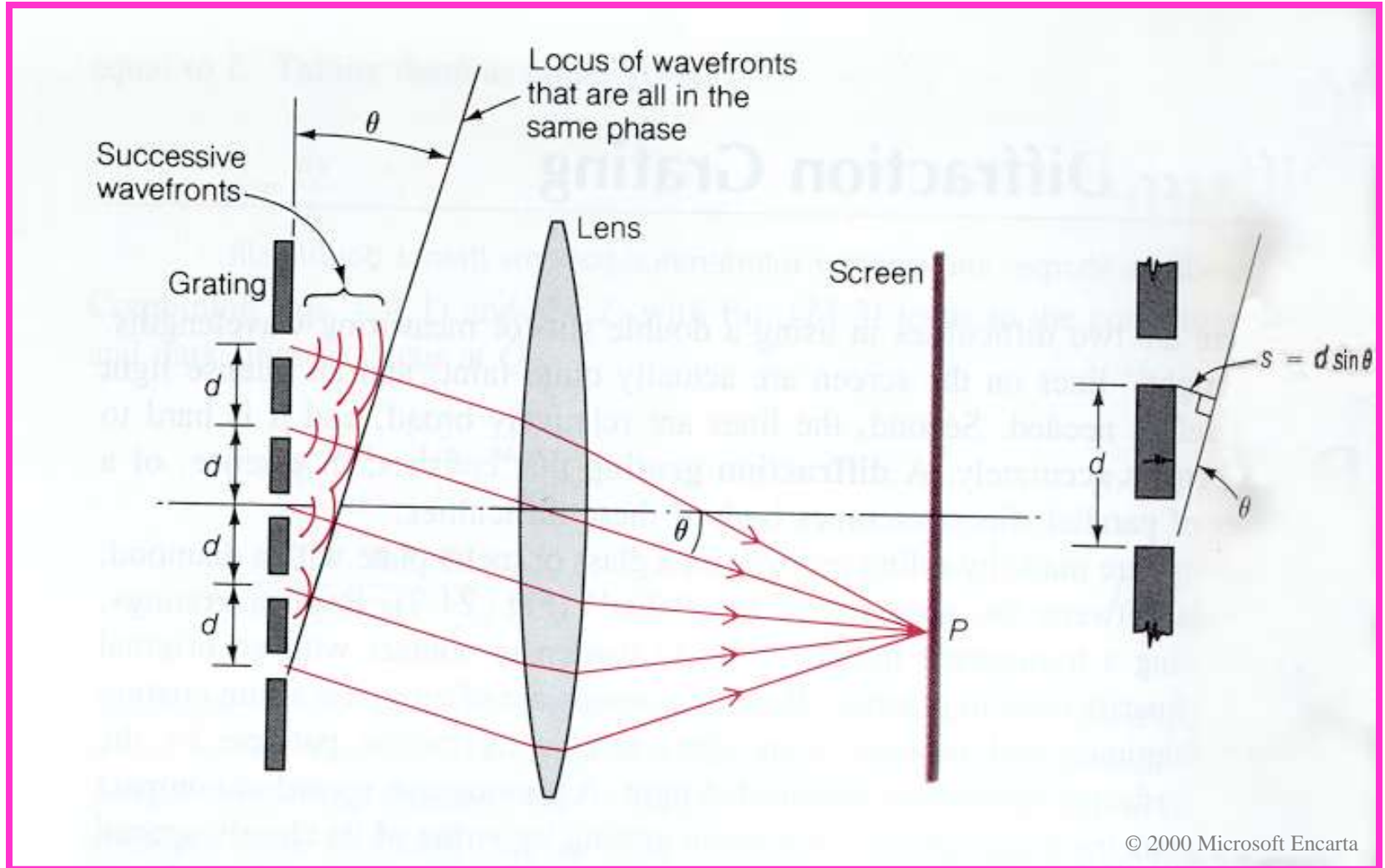
- LASERS

- Holography – Use of Lasers to create 3-D images
- Fiber Optics – Light energy transferred through long, flexible fibers of glass/plastic
- Uses – Communications, medicine, t.v. transmission, data processing.

Diffraction

- Diffraction – Bending of waves around the edge of a barrier. New waves are formed from the original. breaks images into bands of light & dark and colors.
- Refraction – Bending of waves due to a change in speed through an object.

Diffraction



- A diffraction grating. Each space between the ruled grooves acts as a slit. The light bends around the edges and gets refracted.

Light & Color

- Light and matter
- Materials
 - Opaque materials are materials that absorb or reflect light
 - Translucent materials are materials that let some light through but you can't see clearly through it
 - Transparent means allows light to pass through so that you can see clearly through it

Vision and seeing color

- We have cones in our eyes that see red green and blue
 - When the colors are focused on our retina we are able to see things in the right shape and color
 - Color Blindness is the lack of the proper cones in your eye

Brightness of light

- a. SI unit of brightness is the lux
- b. 1000 lux is needed for comfortable reading
 - 1) 0.2 joules of light energy/second
- c. The energy of the lux depends on the color of the light

Models of light

- A. *Isaac Newton* 1672 said that light is a stream of tiny particles
- B. *Christian Huygen* found that light is a wave, because one beam of light can pass through another without disturbance
- C. *Thomas Young* in 1804 showed that light has constructive and destructive interference which proved it to be a wave
- D. *Albert Einstein* in 1905 said that energy from light comes out in tiny packages of energy called photons
- E. It is now known that light is photons that travel in a wave pattern