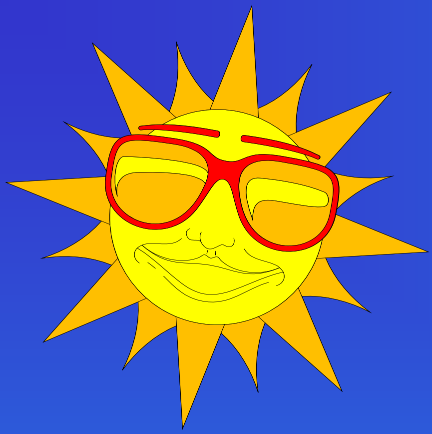
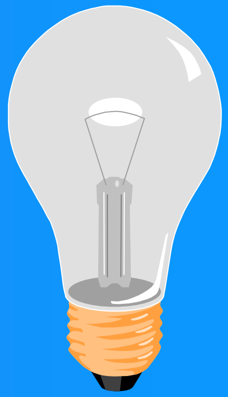
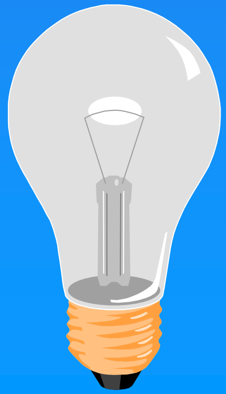
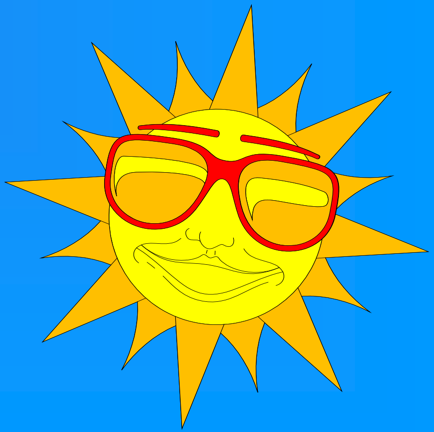




Let there be ...

Light





The Nature of Light

What is Light?

By the 17th century,
light had been observed to…

1. travel in straight lines
2. reflect
3. refract
4. transmit energy from one place to another

Two theories could explain these phenomena.

The **WAVE THEORY**, advocated by Christian Huygens and Robert Hooke, said that light was a wave.

The **PARTICLE** (corpuscular) **THEORY**, advocated by Isaac Newton and later by Pierre Laplace, said that light was made up of a stream of tiny particles called corpuscles.

The more popular theory was the particle theory because of the reputation of Isaac Newton.

Newton's particle theory could easily explain the straight line travel of light, reflection, and energy transmission, but had trouble explaining refraction.

Newton's explanation of refraction required that light must travel faster in water than in air.

Huygen's wave theory could easily explain reflection, energy transmission, and refraction, but had difficulty explaining the straight line travel of light.

The wave theory's explanation of refraction required that light must travel slower in water than in air.

The debate among the two sides continued through the mid 1800's.

1801 - **interference** of light was discovered
1816 - **diffraction** of light (actually observed in the 1600's but not given much significance) was explained using interference principles

Neither phenomena could be explained satisfactorily by the particle theory.

The final blow to the particle theory came in 1850 when Jean Foucault discovered that light traveled faster in air than in water.

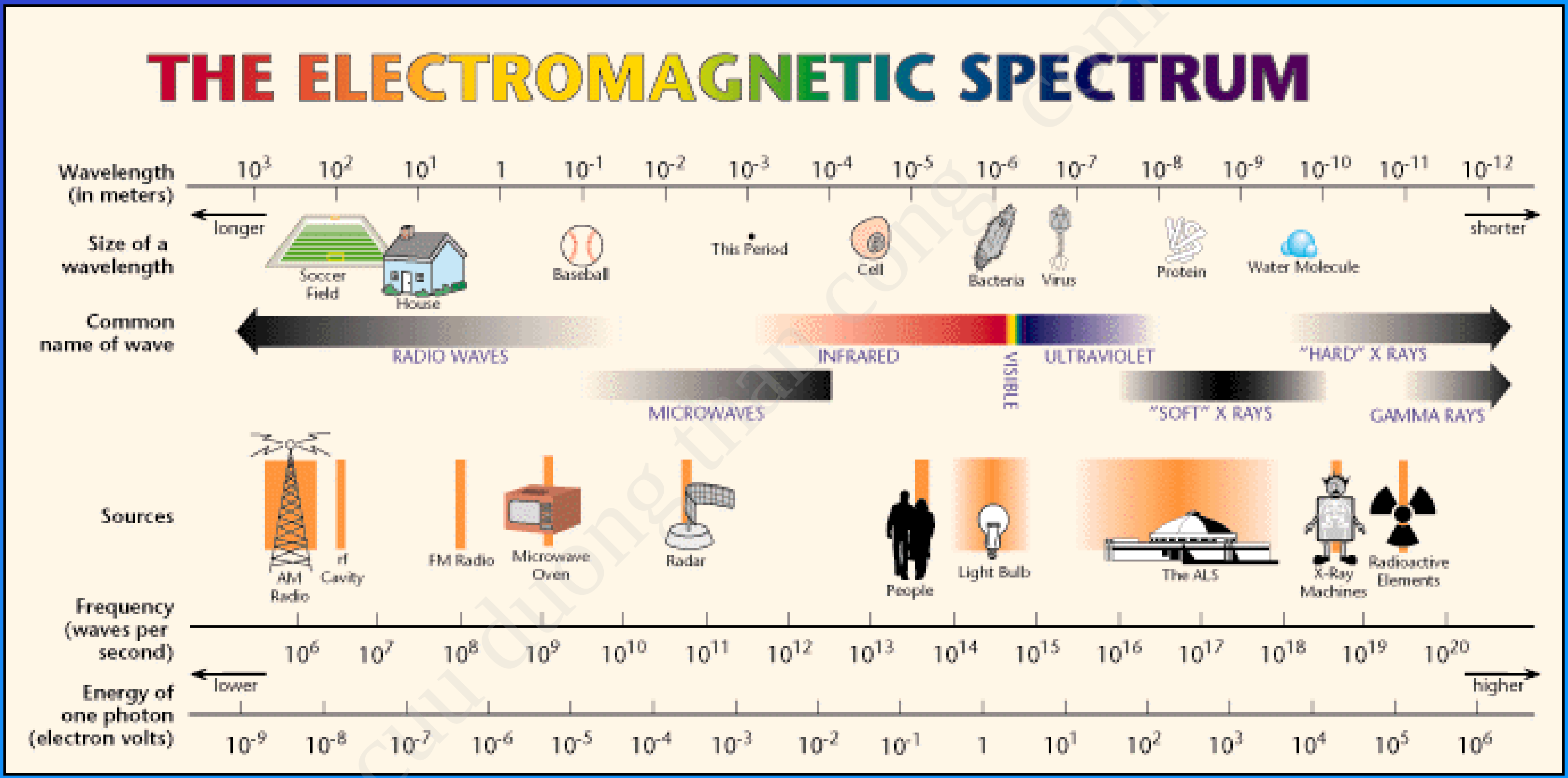
It was then widely accepted that light was a wave, ***but what kind of wave?***

In 1865, James Maxwell developed ideas began by Michael Faraday into a series of equations that

proposed the **electromagnetic wave theory**. It said that light was a type of e/m wave: **a periodic disturbance involving electric and magnetic forces.**

In **1885**, Heinrich Hertz experimentally confirmed the e/m theory.

Click here and here to view simulations of electromagnetic waves.



Click here to explore a tutorial on the production of e/m waves.

At the end of the century, many physicists felt that all the significant laws of physics had been discovered. Hertz even stated, “The wave theory of light is, from the point of view of human beings, a certainty.”

That view was soon to change.

Around 1900,

the **photoelectric effect** was observed.

“the emission of electrons by a substance when illuminated by e/m radiation”

Careful study of the photoelectric effect was performed by many scientists.

The wave theory could not totally explain the photoelectric effect, but a variation of the old particle theory could!

Max Planck and Albert Einstein subsequently proposed the **QUANTUM THEORY**.

THE QUANTUM THEORY

The transfer of energy between light radiation and matter occurs in discrete units called quanta, the magnitude of which depends on the frequency of radiation.

Although we still commonly characterize light as a wave, it is actually **neither** a wave nor a particle. It seems to have characteristics of both.

The modern view of the nature of light recognizes the dual character:

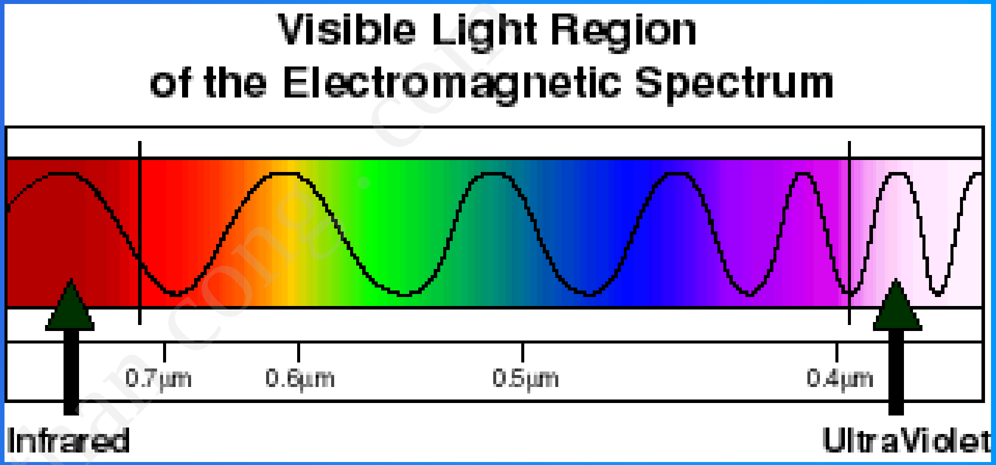
Light is radiant energy transported in photons that are guided along their path by a wave field.

This leads us to the **Duality Principle**:

Light is ...

- a wave when it acts like a wave
- a particle when it acts like a particle

Visible light is that portion of the electromagnetic spectrum which stimulates the retina of the human eye.



Visible spectrum wavelengths range from about 400 nm (violet) to 760 nm (red).

Light travels at about 3×10^8 m/s through empty space and slightly slower through air.

Remember that for all waves, $v = f\lambda$.

COLOR

Materials may be classified as:

transparent - readily transmits light;
can clearly see objects through them

translucent - transmits, but diffuses, light;
cannot see objects clearly through them

opaque - transmits no light;
cannot see through them

WHITE light is composed of all colors.

Red, **orange**, **yellow**, **green**, **blue**, **violet**
is the order of
increasing frequency
or **decreasing wavelength**.

Frequencies directly above this spectrum are **ultraviolet**.

Frequencies directly below this spectrum are **infrared**.

The color of an **opaque** object depends on the **colors** (*frequencies*) of light **incident** upon it and on the **colors** (*frequencies*) of light **reflected**.

The color of a **transparent** object depends on the **colors** (*frequencies*) of light **incident** upon it and on the **colors** (*frequencies*) of light **transmitted**.

Complimentary colors are two colors that combine to form white light.

Red and **cyan**,

blue and **yellow**,

green and **magenta**

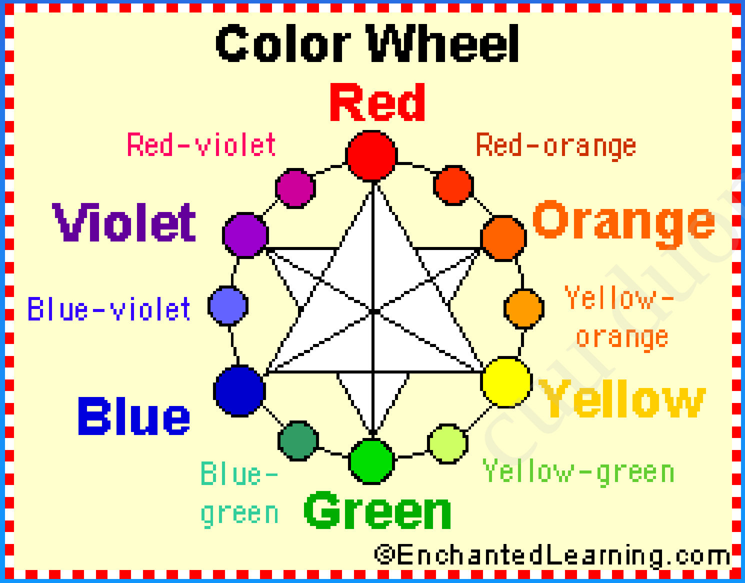
are pairs of complimentary colors.

Red, blue, and green are called **primary colors** or **secondary pigments**.

Cyan, yellow, and magenta are called **primary pigments** or **secondary colors**.

These sites let you simulate mixing colors and pigments of light: link1, link2, link3

Learn more about color mixing here.

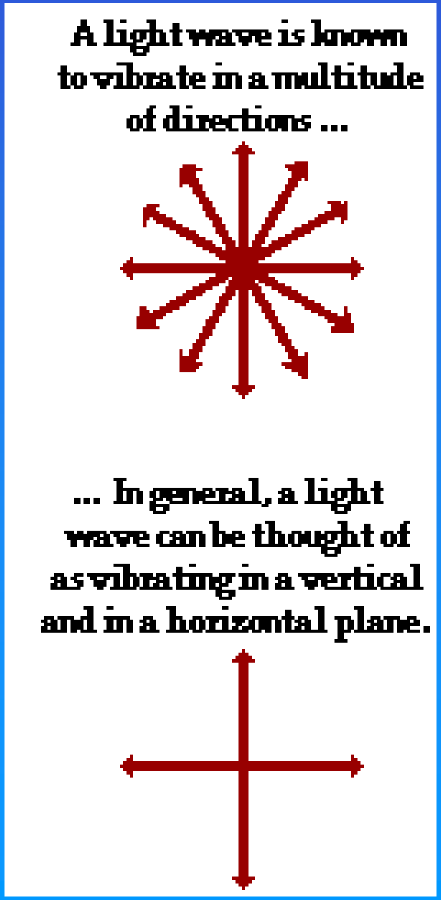


"But I learned that the primary colors are red, blue, and yellow – not red, blue, and green."

Read about it here.

POLARIZATION

Only transverse waves may become polarized.



A pair of Polaroid filters are capable of blocking all light.

Click here, here, here, and here to explore polarization of light.