Light Waves

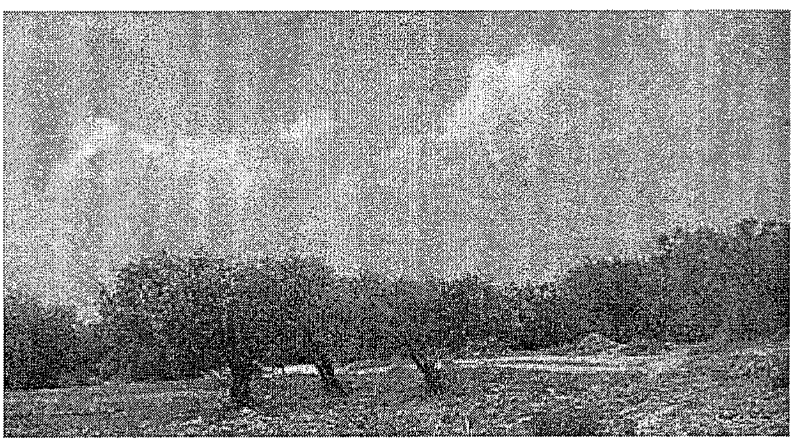
Visible Light Waves

Waves with a length of between 0.4 and 0.7 micrometers can be detected by the human eye. For these reason we call these waves visible light. As you look around the room everything you see has these waves bouncing off of them. If they didn't, you would not be able to see them. What your eyes pickup and turn into a picture in your brain, are these visible light waves.

Shorter visible light wavelengths, are bluer in color, while longer visible light wavelengths are redder in color. The wavelengths detectible by the human eye represent only about 3% of the total electromagnetic spectrum.

Light is made of billions of tiny particles called photons. These photons travel from one place to another in waves. Visible light is the subset of photons that move at a wavelength that we can see. Among the different photons that are in visible light, the ones that have the longest wavelength look red to us, and the ones that have the shortest wavelength look blue to us. All colors come from different wavelengths of light.

Most of the light on Earth comes to us from the Sun. The Sun shoots out billions of photons every second in all directions, and the ones that happen to be pointed toward the Earth come here. When these photons get to the Earth, they first run into Earth's atmosphere. Some of the photons get absorbed by the atmosphere itself, especially the ultraviolet ones whose wavelength is shorter.



Blue sky over Tunisia's olive orchards

This is a good thing for us, because too much ultraviolet light would kill us, and all other living things on the planet. (In fact, doctors sometimes use ultraviolet light to kill germs!). Because blue light has the shortest wavelength of the visible light photons, some of the blue light is also absorbed by the atmosphere. That's why the sky looks blue from the ground in the daytime, because you can see all that blue light up there. But when the light hits clouds instead, the clouds reflect all of the light down to Earth, so the clouds look white to us.

Most of the visible light does get through the atmosphere and comes down to the surface of the Earth.

In addition, a lot of infrared light also gets through the atmosphere. This is light that has a longer wavelength, so we can't see it.

Light is a complex phenomenon that is classically explained with a simple model based on rays and wavefronts.

Electromagnetic Radiation - Visible light is a complex phenomenon that is classically explained with a simple model based on propagating rays and wavefronts, a concept first proposed in the late 1600s by Dutch physicist Christiaan Huygens. Electromagnetic radiation, the larger family of wave-like phenomena to which visible light belongs (also known as radiant energy), is the primary vehicle transporting energy through the vast reaches of the universe. The mechanisms by which visible light is emitted or absorbed by substances, and how it predictably reacts under varying conditions as it travels through space and the atmosphere, form the basis of the existence of color in our universe.

Light: Particle or a Wave? - Many distinguished scientists have attempted to explain how electromagnetic radiation can display what has now been termed duality, or both particle-like and wave-like behavior. At times light behaves as if composed of particles, and at other times as a continuous wave. This complementary, or dual, role for the properties of light can be employed to describe all of the known characteristics that have been observed experimentally, ranging from refraction, reflection, interference, and diffraction, to the results with polarized light and the photoelectric effect.

Sources of Visible Light - A wide variety of sources are responsible for emission of electromagnetic radiation, and are generally categorized according to the specific spectrum of wavelengths generated by the source. Relatively long radio waves are produced by electrical current flowing through huge broadcast antennas, while much shorter visible light waves are produced by the energy state fluctuations of negatively charged electrons within atoms. The shortest form of electromagnetic radiation, gamma waves, results from decay of nuclear components at the center of the atom. The visible light that humans are able to see is usually a mixture of wavelengths whose varying composition is a function of the light source.

Fluorescence - The phenomenon of fluorescence was known by the middle of the nineteenth century. British scientist Sir George G. Stokes first made the observation that the mineral fluorspar exhibits fluorescence when illuminated with ultraviolet light, and he coined the word "fluorescence". Stokes observed that the fluorescing light has longer wavelengths than the excitation light, a phenomenon that has become to be known as the Stokes shift. Fluorescence microscopy is an excellent method of studying material that can be made to fluoresce, either in its natural form (termed primary or auto fluorescence) or

when treated with chemicals capable of fluorescing (known as secondary fluorescence). The fluorescence microscope was devised in the early part of the twentieth century by August Köhler, Carl Reichert, and Heinrich Lehmann, among others. However, the potential of this instrument was not realized for several decades, and fluorescence microscopy is now an important (and perhaps indispensable) tool in cellular biology.

Speed of Light - Starting with Ole Roemer's 1676 breakthrough endeavors, the speed of light has been measured at least 163 times by more than 100 investigators utilizing a wide variety of different techniques. Finally in 1983, more than 300 years after the first serious measurement attempt, the speed of light was defined as being 299,792.458 kilometers per second by the Seventeenth General Congress on Weights and Measures. Thus, the meter is defined as the distance light travels through a vacuum during a time interval of 1/299,792,458 seconds. In general, however, (even in many scientific calculations) the speed of light is rounded to 300,000 kilometers (or 186,000 miles) per second.

Reflection of Light - Reflection of light (and other forms of electromagnetic radiation) occurs when the waves encounter a surface or other boundary that does not absorb the energy of the radiation and bounces the waves away from the surface. The incoming light wave is referred to as an *incident* wave and the wave that is bounced away from the surface is called the *reflected* wave. The simplest example of visible light reflection is the glass-like surface of a smooth pool of water, where the light is reflected in an orderly manner to produce a clear image of the scenery surrounding the pool. Throw a rock into the pool, and the water is perturbed to form waves, which disrupt the image of the scene by scattering the reflected light in all directions.

Refraction of Light - As light passes from one substance into another, it will travel straight through with no change of direction when crossing the boundary between the two substances head-on (perpendicular, or a 90-degree angle of incidence). However, if the light impacts the boundary at any other angle it will be bent or refracted, with the degree of refraction increasing as the beam is progressively inclined at a greater angle with respect to the boundary. As an example, a beam of light striking water vertically will not be refracted, but if the beam enters the water at a slight angle it will be refracted to a very small degree. If the angle of the beam is increased even further, the light will refract with increasing proportion to the entry angle. Early scientists realized that the ratio between the angle at which the light crosses the media interface and the angle produced after refraction is a very precise characteristic of the material producing the refraction effect.

Diffraction of Light - Depending on the circumstances that give rise to the phenomenon, diffraction can be perceived in a variety of different ways. Scientists have cleverly utilized diffraction of neutrons and X-rays to elucidate the arrangement of atoms in small ionic crystals, molecules, and even such large macromolecular assemblies as proteins and nucleic acids. Electron diffraction is often employed to examine periodic features of viruses, membranes, and other biological organisms, as well as synthetic and naturally occurring materials. No lens exists that will focus neutrons and X-rays into an image, so

investigators must reconstruct images of molecules and proteins from the diffraction patterns using sophisticated mathematical analysis. Fortunately, magnetic lenses can focus diffracted electrons in the electron microscope, and glass lenses are very useful for focusing diffracted light to form an optical image that can easily be viewed.

Polarization of Light - The human eye lacks the ability to distinguish between randomly oriented and polarized light, and plane-polarized light can only be detected through an intensity or color effect, for example, by reduced glare when wearing polarized sun glasses. In effect, humans cannot differentiate between the high contrast real images observed in a polarized light microscope and identical images of the same specimens captured digitally (or on film), and then projected onto a screen with light that is not polarized. The first clues to the existence of polarized light surfaced around 1669 when Erasmus Bartholin discovered that crystals of the mineral Iceland spar (more commonly referred to as calcite) produce a double image when objects are viewed through the crystals in transmitted light. During his experiments, Bartholin also observed a quite unusual phenomenon. When the calcite crystals are rotated about their axis, one of the images moves in a circle around the other, providing strong evidence that the crystals are somehow splitting the light into two different beams.

Name:____Date:____________Period:_____

Light Waves

1. Why can you see things?

2. How much of the total electromagnetic spectrum can the human eye see?

3. What is light made up of?

4. How do the photons move?

5. Why is the sky blue?

6. Visible light is also know as?

7. What is the visible light that humans are able to see composed of?

8. What is reflection of light?

9. What is refraction of light?

10. What is diffraction of light?