Name:____Date:_______________Period:__________

The Nature of Light Reading

Reading Objectives:

- Recognize that light has both wave and particle characteristics
- Relate the energy of light to the frequency of electromagnetic waves.

Most of us see and feel light almost every moment we're awake, from the first rays of dawn to the warm glow of a campfire. Even people who cannot see can feel the warmth of the sun on their skin, which is a form of infrared light, but how much do we understand about what light really is?

WAVES AND PARTICLES

It is difficult to describe all the properties of light with a single scientific model. The two most commonly used models describe light either as a wave or as a stream of particles.

Wave Evidence: Light produces interference patterns like water waves

Light has always been very mysterious to scientists, and, only just into the nineteeth century did we start to get some answers to the question: What is light? In 1801, the English scientist Thomas Young devised an experiment to test the nature of light. He passed a beam of light through two narrow openings and then onto a screen on the other side. He saw that the light produced a striped pattern on the screen. This pattern reminded him of the pattern he saw when two water waves (mechanical waves) bumped into each other creating an interference pattern.

Wave Evidence: Light can be modeled as a wave

Because the light in Young's experiment produced an interference pattern, Young concluded that light must consist of waves. The model of light as a wave is still used today to explain many of the basic properties of light and its behavior.

We have talked about light (or electromagnetic radiation) being a transverse wave that does not require a medium in order to travel. Light waves are called ***electromagnetic waves*** because they consist of changing electric and magnetic fields. The properties of transverse waves that you have already learned are some of the same properties that help explain light within the wave model.

The wave model of light helps explain much of the observed behaviors for light. For example, light waves may reflect when they meet a mirror, refract when they pass through a lens, or diffract when they pass through a narrow opening. These are all properties that are used to help describe how waves act, and light waves act this way too.

⃠STOP: Complete the summary on the wave model before reading on!!!

Evidence that doesn't fit: The wave model of light cannot explain some observations

In the early part of the twentieth century, physicists began to realize that some observations could not be explained with the wave model of light. For example, when light strikes a piece of metal, electrons (negatively charged particles of an atom) may fly off the metal's surface. Experiments show that in some cases, *dim* blue light (high frequency light) may knock some electrons off a metal plate, while very *bright* red light (low frequency light) cannot knock off any electrons.

According to the *wave model*, very *bright* red light should have more energy than *dim* blue light because the waves in bright light should have greater amplitude. But this does not explain how the blue light can knock electrons off the plate while the red cannot.

Particle Evidence: Light can be modeled as a stream of particles

One way to explain the effects of light striking a metal plate is to assume that the energy of the light is contained in small packets. A packet of blue light carries more energy than a packet of red light, enough to knock an electron off the plate. *Bright* red light contains many packets, but no single one has enough energy to knock an electron off the plate.

In the particle model of light, these packets are called ***photons***, and a beam of light is considered to be a stream of photons. Photons are considered particles, but they are not like ordinary particles of matter. Photons do not have mass; they are more like bundles of energy. But unlike the energy in a wave, the energy in a photon is located in a particular place.

⃠STOP: Complete the summary on the particle model before reading on!!!

The model of light used depends on the situation

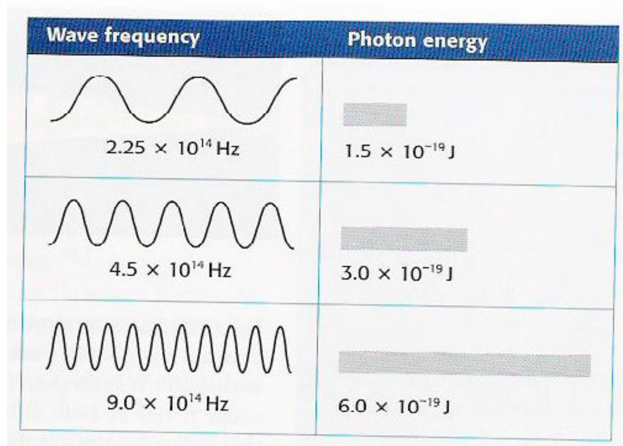
Light can be modeled as either waves or particles; so which explanation is correct? The success of any scientific theory depends on how well it can explain different observations. Some effects, such as the interference of light, are more easily explained with the wave model. The particle model explains other cases, like light knocking electrons off a metal plate better. The particle model also easily explains how light can travel across empty space without a medium.

Most scientists currently accept *both* the wave model and the particle model of light, and use one or the other depending on the situation that they are studying. Some believe that light has a "dual nature," so that it actually has different characteristics depending on the situation. In many cases, using either the wave model or the particle model of light gives good results.

The energy of light is proportional to frequency

Whether modeled as a particle or as a wave, light is also a form of energy. Each photon of light can be thought of as carrying a small amount of energy. The amount of this energy is proportional (the same) to the frequency of the corresponding electromagnetic wave.

A photon of red light, for example, carries an amount of energy that corresponds to the frequency of waves in red light, 4.5×10^{14} Hz (450,000,000,000,000 Hz). A photon with twice as much energy corresponds to a wave with twice the frequency, which lies in the ultraviolet range of the electromagnetic spectrum. Likewise, a photon with half as much energy, which would be a photon of infrared light, corresponds to a wave with half the frequency.



⃠STOP: Complete the summary on wave frequency and energy before reading on!!!

The speed of light depends on the medium

In a vacuum, all light travels at the same speed. The speed of light, called *c*, is very large, 3×10^8 m/s (about 186,000 miles per second). Light is the fastest signal in the universe. Nothing can travel faster than the speed of light.

Light also can travel through transparent ("see through") mediums, such as air, water, and glass. When light passes through a medium, it travels slower than it does in a vacuum. The table on the right shows the speed of light in several different mediums.

Medium	Speed of light
Vacuum	2.997925×10^8 m/s
Air	2.997047×10^8 m/s
Ice	2.29×10^8 m/s
Water	2.25×10^8 m/s
Quartz (SiO_2)	2.05×10^8 m/s
Glass	1.97×10^8 m/s
Diamond	1.24×10^8 m/s

⃠STOP: Complete the summary on the speed of light before reading on!!!

The brightness of light depends on intensity

You have probably noticed that it is easier to read near a lamp with a 100 W bulb than near a lamp with a 60 W bulb. That is because a 100 W bulb is brighter than a 60 W bulb. The quantity that measures the amount of light illuminating a surface is called ***intensity***, and it depends on the amount of light—the number photons or wave—that passes through a certain area of space.

Like the intensity of sound, the intensity of light from a light source decreases as the light spreads out in spherical wave fronts. Imagine a series of spheres centered around a source of light. As light spreads out from the source, the number of photons or waves passing through a given area on a sphere, say 1 cm^2, decreases. An observer farther away from the light source will therefore see the light dimmer than an observer closer to the light source.

⃠STOP: Complete the summary on brightness and intensity !!!

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The Nature of Light Summaries

Directions: Read through "The Nature of Light" text. Then, go back a second time and read through each section underlining information useful in creating a summary for each of the different topics. Follow the instructions on your text page (shown where it says ⦸ **STOP**). All summaries should be completed in the below boxes.

Wave Model Summary	
Topic Sentence	
Supporting Details (include 3 points)	• • •
Conclusion	

Particle Model Summary	
Topic Sentence	
Supporting Details (include 3 points)	• • •
Conclusion	

Wave Frequency and Energy Summary	
Topic Sentence	
Supporting Details (include 2 points)	• •
Conclusion	

Speed of Light Summary	
Topic Sentence	
Supporting Details (include 2 points)	• •
Conclusion	

Brightness and Intensity Summary	
Topic Sentence	
Supporting Details (include 2 points)	• •
Conclusion	