Taking apart the Light
Spectroscopy Reading

Read the following article. Underline key points and answer the 4 questions at the end. I want you to summarize the article in paragraph form, while answering the 4 questions. Documents will be prepared in Google Docs and will be shared with me: cgaupp@ga.hiltoncsd.net.

What is the name of that big, grassy planet in our solar system that has the bright, beautiful rings? If you are interested in space and astronomy, you probably know it is Saturn. And if you are really an astronomy buff, you might know that Saturn is mostly hydrogen and helium and that Saturn’s rings are mostly solid water (ice).

How do scientists know what Saturn is made of? How do they also know that the Sun is three-fourths hydrogen and one-fourth helium? How do they know what other stars, planets, comets, and gas clouds in space are made of?

How they know is by use a technique called spectroscopy (spek-TROSS-koh-pee). Spectroscopy is a way of studying the light coming from some material (like a star) or passing through some material, like a gas. For example, as the light passes through the gas, the atoms in the gas change the light somewhat so that the light is different when it comes out from when it went in. What makes this technique so interesting is that every different kind of matter produces or changes the light in a different way. So, just by examining the light that comes from something that is burning or has passed through a cold gas, scientists can figure out what the burning material or gas is. Or, if two or more kinds of materials are mixed together, they can tell in what proportions they are mixed - like figuring out the recipe by tasting the stew.

How does this work? Why do different materials all change the light in different ways?
Quantum Mechanics Made Easy (Really!)

All ordinary matter is made up of atoms. Atoms are the smallest particles of an element. Elements are the simplest substances that can’t easily be separated into other substances. For example, oxygen is an element and hydrogen ins an element. Water is one oxygen atoms and two hydrogen atoms combined. However, water can fairly easily be separated back into oxygen and hydrogen.

Atoms themselves are made up of even smaller particles, but when you start breaking those apart, you don’t have the element anymore. You have something else, but we won’t get into that here.

An atoms is made of a nucleus (containing protons and neutrons, also called nucleons), with electrons buzzing around it. What kind of atom it is depends on how many protons (the number defines which element it is), neutrons, and electrons there are. Hydrogen, which is the most abundant element in the universe, has just one proton and one electron (and most often no neutrons). The nucleus is just a few quadrillionths (that is, an unimaginably small part) of the total size of the atom, yet a nucleon is nearly 2000 times heavier than an electron. What does this mean? IT means atoms are mostly empty space! Yes, even the most solid-looking matter - the chair that is holding you up, the floor you are standing upon - is almost all empty space.

Although electrons do not exactly go around the nucleus like the planets orbit the Sun, it sometimes helps to think of electrons that way in order to understand how they behave. But unlike planets orbiting the Sun, electrons cannot orbit at just any orbits that the electrons can occupy. (These ‘orbits’ are sometimes called shells, since the electrons can be anywhere on an imaginary sphere a certain distance from the nucleus.) The electrons can jump from one orbit to the next, however, If a little packet of energy comes their way, they may use it to jump from one orbit to the next, however. If a little packet of energy comes their way, they may use it to jump to the next higher orbit (that is, farther away from the nucleus). Or, they may fall back to a lower orbit (closer to the nucleus), and give up a little packet of energy. For this reason, these orbits or shells the electrons occupy are also called energy levels.
These packets of energy the electrons are grabbing or giving up are called photons. Photons are the smallest units of light energy (that we know of). Each kind of atom prefers photons of certain colors, or wavelengths. For example, in the range of light that we can see with human eyes, hydrogen atoms like a certain shade of red, a certain shade of blue, and a certain shade of violet.

**Everyone has a Favorite Color**
What makes light different colors? It is the wavelength of the light.

Like energy passes through the ocean and breaks in waves upon the shore, light energy also travels in waves. Some waves are long and slow and lazy. Other are short, choppy, and energetic. When it comes to waves of light energy, our eyes are sensitive to only a very small range of these wavelengths. This range we call **visible light**, because it is the light that is visible to us.

Whoa! Haven’t we been talking about photons of light being little packets? so how can little packets travel in waves? Good question! Well, the universe is a strange and wondrous place. Light seems to be both particles and waves.

Normally, light from the Sun doesn’t seem to be any particular color - it’s just white light. But sometimes we are lucky enough to see a rainbow. A rainbow is formed when water droplets in the air act like little prisms and bend the sunlight so that the different wavelengths get separated out. Then we see that sunlight is really made up of all these different colors. when we see all the different colors separated, like a rainbow, we call it a spectrum.
Now you know where the word spectroscopy comes from. It is the study of spectra (which just means more than one spectra).

If all the colors are present in the spectrum, it is called a continuous spectrum. However, if you had a particular kind of prism that was very, very good at separating out all the different wavelengths in the light, you might notice that some of the wavelengths were missing! Even the light coming from the Sun would have some wavelengths missing. Where are these missing photos? Most likely, they were absorbed by atoms or molecules of the gases in Earth’s atmosphere. Electrons in those gases used their favorite wavelengths of photos to boost themselves to a higher orbit. The missing wavelengths in their spectra are called absorption lines.

While looking for absorption lines is a good way to find out what kind of stuff the light has passed through (like gas clouds), we can also use spectroscopy to examine the source of the light - like a star. When the star burns, the electrons in the star’s atoms are jumping from higher to lower orbits, releasing photons like mad. If we use a particular kind of prism that is very, very good at separating out the wavelengths of light coming from the star, we will see bright bands at certain wavelengths. This bright bands are called emission lines. They allow scientists to identify what’s cooking on the star.

Questions:
1. How does the title of this article (Taking Apart the Light) relate to spectroscopy?

2. Why is spectroscopy important to astronomers?

3. Use the movement of electrons to help explain how elements emit certain colors of light.

4. Discuss whether light is generally thought of as a particle or a wave?