LASER CLASSROOM
Bringing STEM to light®

FLOURESCENCE: LIGHT AS ENERGY

A simple activity that makes the abstract concepts of light is energy and energy varies with wavelength, clear and understandable.

DISCUSSION & BACKGROUND

First described as early as the sixteenth century, fluorescence was documented and so named in 1852 by George Gabriel Stokes. But it wasn't until the twentieth century that the quantum nature of light, and thus fluorescence was finally understood.

Here's why - by the nineteenth century, Newton's idea that light was composed of particles had been replaced by Huygen's wave theory of light. The wave theory, as with most classical physics, assumes that change occurs as a continuous process. Embarrassingly, fluorescence could not be explained by the wave theory of light.

Enter Max Plank, who suggested that energy changes might actually occur in a stepwise manner, and "jump" from one state to another, rather than proceed as a continuous process. When Einstein applied this idea to light energy he re-introduced the idea that light is made of particles (which we now call photons).

Plank then formalized this understanding of light energy by relating the frequency of

light to its energy.

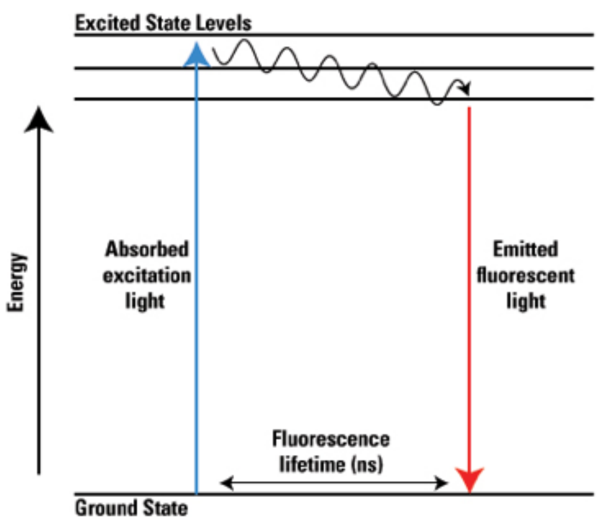
Mathematically: $\mathbf{E= hn}$
Where: **E** = energy **h** = a constant, and **n** = the frequency of light.

The take away here is that the frequency of light is directly related to its energy – and that the energy of light is quantized, or occurs as definitely defined "steps" or values, rather than as a continuous flow. It is by understanding light in this way that we can understand what is happening when something fluoresces.

When light hits a material, the light is either transmitted or absorbed by

RELATED PRODUCTS

Laser Blox



the material. Certain materials are fluorescent, which means that they contain molecules whose electrons may become excited – and excited electron "jumps" energy levels.The electrons in fluorescent materials become excited when exposed to light of a high enough frequency (light with enough energy) to cause the excitation.

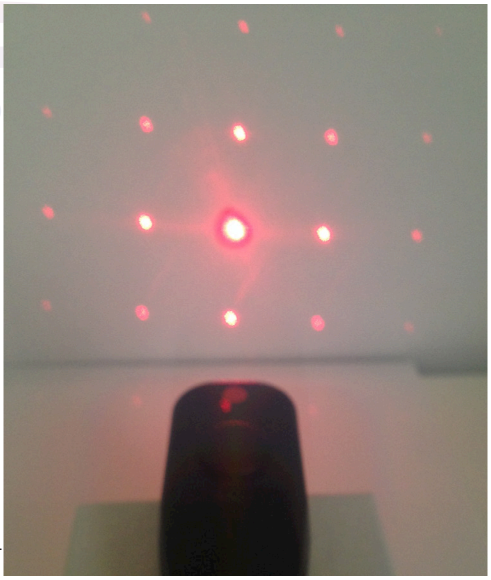
But the excited state is not maintainable for very long – a tiny fraction of a second, actually – before it falls back down to its original state. When it does this, it releases the energy it gained in order to "jump" as LIGHT of a different frequency from the original light.

UV light has a very short wavelength, and therefore has a high frequency and plenty of energy to fluoresce lots of materials. But some fluorescent materials are sensitive enough to fluoresce with visible light.

FLOURESCENCE: ACTIVITY

MATERIALS (EACH GROUP OF 4-5 STUDENTS)

- Set of 3 LASER Blox
- Three fluorescent markers
- A piece of plain white paper
- A pair of rainbow glasses for each student



PROCEDURE

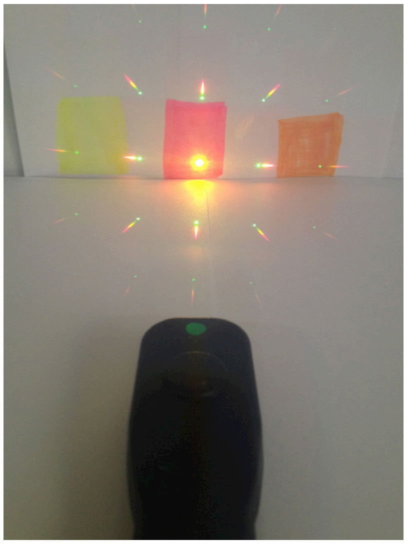
1. Distribute materials to students
2. Review LASER safety guidelines
3. Instruct students to put on the glasses and look around the room at the "white lights"
4. Explain that the glasses are Diffraction Film and break the white light up into its constituent wavelengths so that they see a spectrum.
5. With the glasses still on, have them turn on and point the RED LASER Blox at the white paper to observe the diffraction of monochromatic light. (for more see our lesson about the properties of LASER Light) Note that monochromatic light does not produce a spectrum of color -

it "splits" the light into a diffraction pattern.

6. Repeat step 5 with the GREEN LASER Blox
7. Repeat step 6 with the VIOLET LASER Blox - and notice the spectrum! While the green and the red LASER Blox are not of sufficient energy to cause fluorescence upon hitting the white paper, the VIOLET LASER Blox is! The spectrum is caused not by the diffraction grating, but by the light's interaction with the molecules in the paper. The energy of the 405nm violet laser light "knocks" electrons out of orbit - when they fall back down, they release energy in the form of light. The released light is not 405nm -- It is released at several other wavelengths. The diffraction grating allows us to see the spectrum of wavelengths released by the phenomenon of fluorescence! See background for a more thorough explanation.
8. Now color three squares with fluorescent markers.
9. Start with the RED LASER Blox - with the glasses still on, point the beam at each square. What do you see? Does it fluoresce on the fluorescent colors? NO. Because the red laser, at 635nm, does not generate enough energy to cause the electrons to "jump" out of orbit
10. Now try the GREEN LASER Blox. Notice that it fluoresces with the pink and orange, but not with the yellow. Discuss.
11. Finally try with the VIOLET LASER Blox. Discuss.

Diffraction of a Green Laser

Diffraction reveals the spectrum created by 405nm laser on white paper



Fluorescence spectrum with 532nm laser on fluorescent marker.