Outline for the Colors Lab

Part 1. Observation
(1) Each group needs a sheet of white paper and a box of crayons. Make a solid, blue circle. Then color over the blue circle with yellow.

What is the new color?

(2) Make a solid blue circle. Write over the blue circle with red.

What is the new color?

You have now made observations about a phenomenon. You have noticed that when you mix crayons with different colors, a new color is formed. Why does a new color form? What causes the new color for form? Why don't you just see a mix of blue and yellow?

Part 2. Theory

Does anyone have a theory (explanation) about what causes this?

What causes color (handout)?

Revisit the theories.

Part 3. Testing the Theories. (Handout)

Part 4. Conclusions, or further testing
Overlay the printouts of "Blue" and "Yellow". Compare them to the green spectrum. What colors are not being absorbed by the green spectrum? Does it make sense that this solution was green?

Repeat for the "Blue". "Red", and "Purple" spectra.

Background Information on Light

Visible spectroscopy investigates the absorbtion of visible light by a sample. Students are often interested in visible-region spectroscopy because of the correlation to color vision. You can guess the visible spectrum of an object by looking at tits color.

The Nature of Light

Light is composed of tiny, massless particles called photons. The properties of photons are very wavelike, so photons can be characterized by their frequency (ν) and wavelength (λ). The wavelength is the distance from one peak to the other peak in the oscillating wave (see below). The frequency is the number of times the "peak" passes a stationary point every second. Wavelength is usually expressed in nm (10^{-9} m) and frequency is expressed in Hz (1/s) or MHz (10^{6} Hz). Wavelength and frequency are related by the equation

$$\lambda\nu = c \quad (c = 3.00 \times 10^{8} \text{ m/s}) \qquad (1)$$

Every time one peak passes the stationary point, it moves one wavelength, therefore $\lambda\nu$ is equal to the velocity of the photon (the speed of light, c).

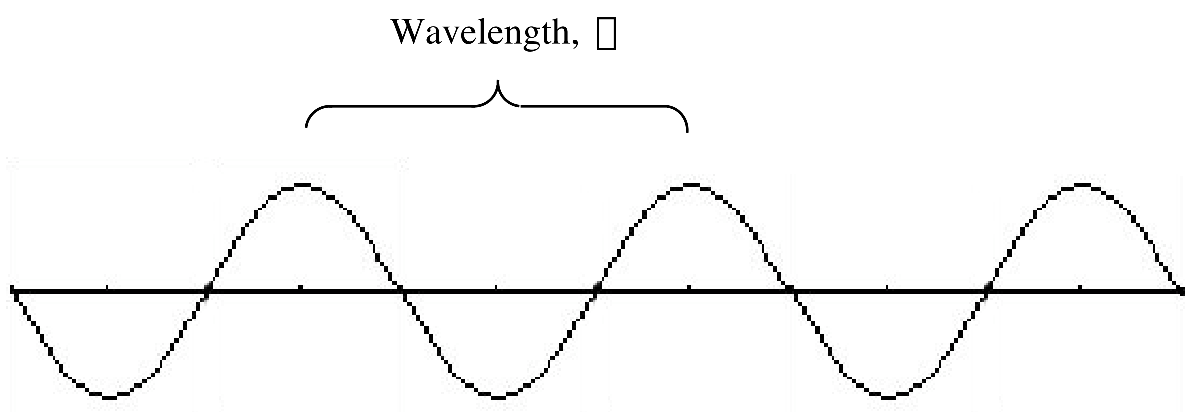


Figure 1. Depiction of a wave and the definition of the wavelength.

As stated before, light exists as particles called photons. Since photons have no mass, it might be better to describe them as energy packets. A photon with frequency, ν has the same amount of energy as any other photon with the same frequency. The energy for a photon is given below and is dependent on the wavelength :

$$h\nu = E \quad (2)$$

$$h = \text{Plank's constant, } 6.626 \times 10^{-34} \text{ Joule} \bullet \text{s} \quad (3)$$

$$E = \text{energy} \quad (4)$$

The higher the frequency, the more energy each photon has. Therefore, the two ways to increase the amount of energy from a beam of light are to increase the frequency (change the color) of the light while keeping the number of photons the same, or increase the number of photons (make the light brighter).

The Visible Spectrum

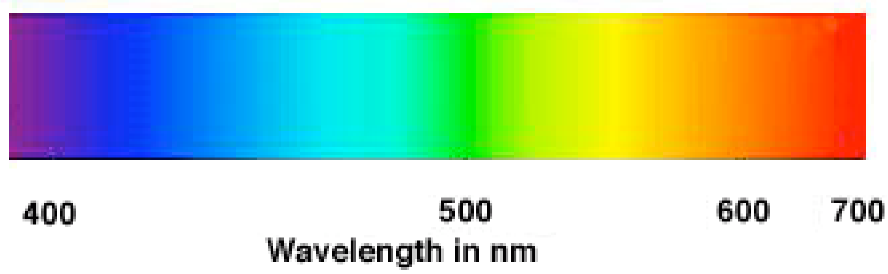


Figure 2. The visible spectrum

The visible spectrum includes photons with wavelengths from ~400 to 780 nm. The blue region has the shortest wavelengths and therefore, the highest energy. The region with wavelengths from ~200 - 400 nm is the ultraviolet (above violet). With shorter wavelengths than the visible, ultraviolet light is more energetic than visible light and this accounts for it's damaging effects on skin and DNA. Light having wavelengths from ~780 nm to 300,000 nm is inthe infrared region(below the red). Light in the infrared has less energy than visible light.

Short wavelength = high frequency = high energy (5)

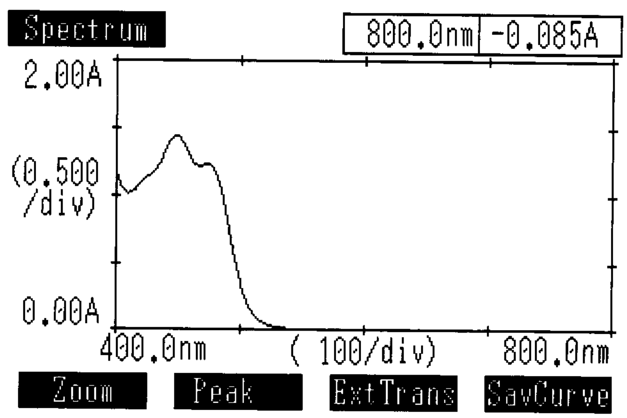
Long wavelength = low frequency = low energy (6)

Color

Many objects around us are colored. The light we see as color originates as sunlight. Sunlight contains all the colors of the visible spectrum and therefore appears to be white (incandescent light bulbs act the same way). When the light reflects off of a surface or passes through a solid, some of the light is absorbed (removed). When photons of specific wavelengths are removed, we see the remaining colors (the ones not absorbed). If we see a blue object, it is blue because it absorbs the red, yellow, orange, and green light. After white light hits the object, only the blue light is not removed and we see the object as blue.

The Absorption Spectrum of Flower Pigments

Flowers are a convenient source of colored compounds. Preferential absorption results in the colors seen in the flower petal. The amount of light of a certain frequency that is absorbed (removed) by a compound can be measured by an instrument called a spectrometer. By measuring the amount of light absorbed at different frequencies of visible light an absorption spectrum can be constructed. Such a spectrum describes which frequencies of light are absorbed and to what extent. An example of an absorption spectrum for a yellow flower is shown below.



The pigments in the flower absorb the blue and green light between 400 and 500 nm (the y-axis is absorption) leaving the yellow, orange, and red light to be reflected. This gives the flower it's color.

Instructions for the Experiment

Each group needs to each make three cuvettes.

Green Group

(1) Fill two cuvettes 1/2 way with water

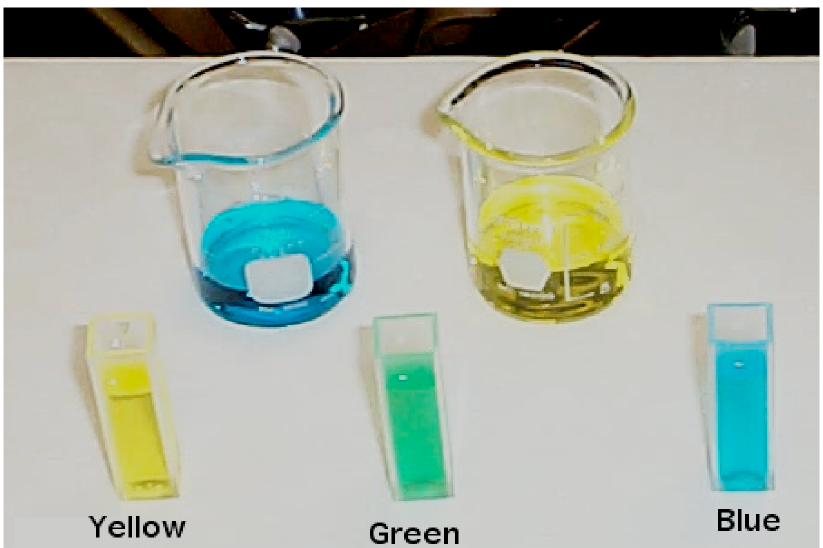
(2) Fill two 25 mL beakers with 15 mL of water

(3) Place one drop of blue in the first 25 mL beaker and three drops of yellow in the second beaker

(4) Fill each of the two cuvettes the rest of the way with one of the solutions from the beakers (you should have one blue and one yellow cuvette)

(5) Fill a third cuvette 1/2 way with the yellow solution from the beaker and the other 1/2 way with the blue solution.

(6) Take a spectrum of each of the three solutions and print them out. Label the printouts "yellow", "blue", and "green".



Purple Group

(1) Fill two cuvettes 1/2 way with water

(2) Fill two 25 mL beakers with 15 mL of water

(3) Place one drop of blue in the first 25 mL beaker and one drop of the red in the second beaker

(4) Fill each of the two cuvettes the rest of the way with one of the solutions from the beakers (you should have one blue and one red cuvette)

(5) Fill a third cuvette 1/2 way with the red solution from the beaker and the other 1/2 way with the blue solution.

(6) Take a spectrum of each of the three solutions and print them out. Label the printouts "red", "blue", and "purple".