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Activity Sheet

How can we better model the interactions between light and matter?

SAFETY NOTE: *Lasers are not toys. Laser light can damage tissue, especially in the eye. Take care to not point the laser at any people in the room, whether within your group or not.*

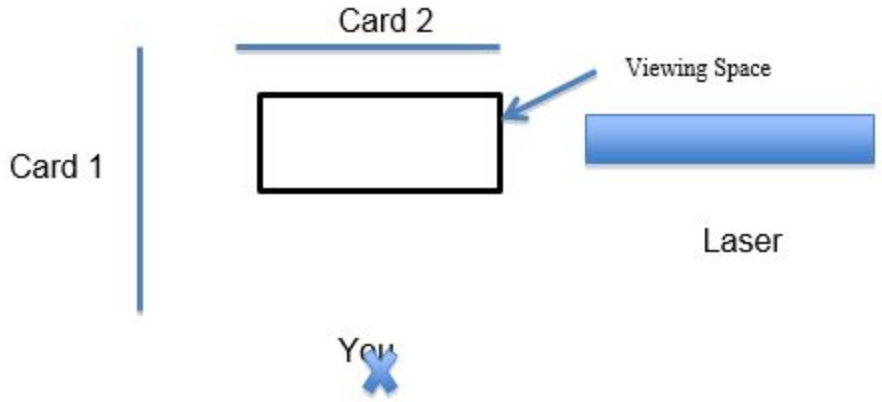
Part I: *In this section, you will observe light as it interacts with matter to operationally define various phenomena. At each step, we will ask three questions:*

1. *Did the **color** of the incident light **change**?*
2. *Did the **direction** of the velocity of the light **change**?*
3. *Did the **brightness (intensity)** of the light **change?***

We will not concern ourselves with an explanation (or model) of why light behaves as it does until Part II.

Experiment 1:

Set up the green laser and an index card (Card 1) as in the diagram below so that you can see a dot of laser light on the card. Then place yourself so that you can look into the "viewing space" from the location marked "X." Your view is now at right angles to the direction of the laser beam. Observe and record in the data chart what you see in the viewing space. Now place a second index card (Card 2) in the viewing space, so that the card follows the same line as the laser light (i.e., make a line of green light appear across card 2). Observe and record what the card looks like.



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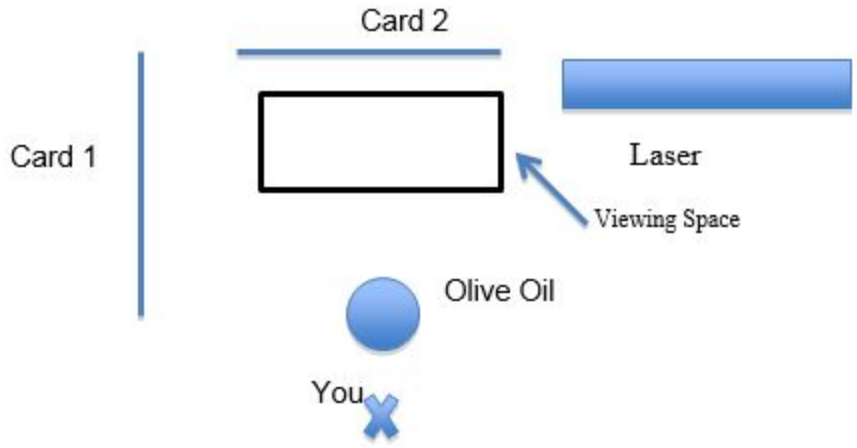
When light strikes matter, it can undergo a process known as scattering, in which the direction of the light changes, but not the color. That set of conditions operationally defines scattering. Convince yourself that the direction the scattered light moved changed from the time it left the laser until the time it reached your eye. The remaining experiments ask you to operationally define other light-matter interactions.

Experiment 2:

Use the same set up as before, but now place the container of olive oil between your eye and the viewing space as shown below. Can you view light that scatters off an index card transmitting through the olive oil? Record the color of the transmitted light. Use your observations to operationally define transmission. Record.



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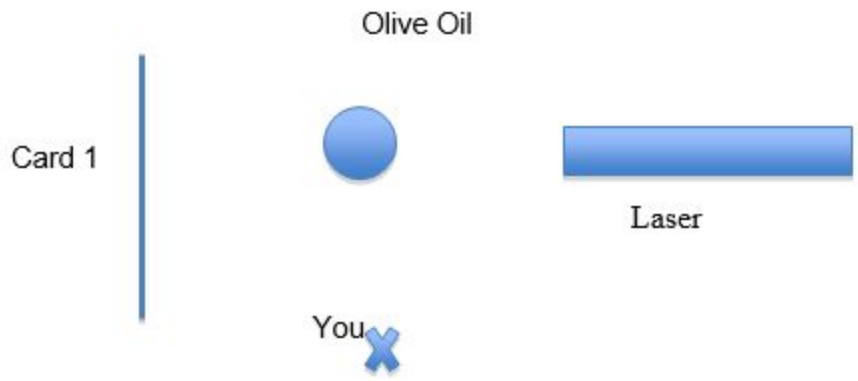
Experiment 3:

For this experiment, place the container of olive oil into the viewing space so that laser light passes through the container on its way to striking Card 1. What color is the light on the index card? What color does the light take as it passes through the olive oil? Record your observations.



The new phenomenon is known as fluorescence. Write an operational definition for fluorescence. The light passing through your oil exhibited both transmission and fluorescence, but the fluorescence was much brighter.

Experiment	*Does the **direction** of the light change?*	*Does the color of the light change?*	*Does the intensity (brightness) change?*	*Name of Behavior*
1a				
1b				
2				
3				
4 (card 1)				

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Experiment 4:

Obtain red and blue/violet laser pointers. Repeat Experiment 3 with the new colors. Make a chart in which you record how the light of each laser (red, green, and violet) behaves. Don't forget to observe card 1. Which laser behaves differently?

Laser Color	*Color of Transmitted Light (on Card 1)*	*Fluorescence Color (through the oil)*
Red		
Green		
Blue/Violet		

When light enters a liquid, it may interact with it in such a way that the molecules in the liquid absorb the photons. If so, then light energy is converted to another form, such as added kinetic energy of the particles (internal energy or heat). Write an operational definition for the process of absorption.

Be sure to discuss your findings with your teacher before moving to part II.

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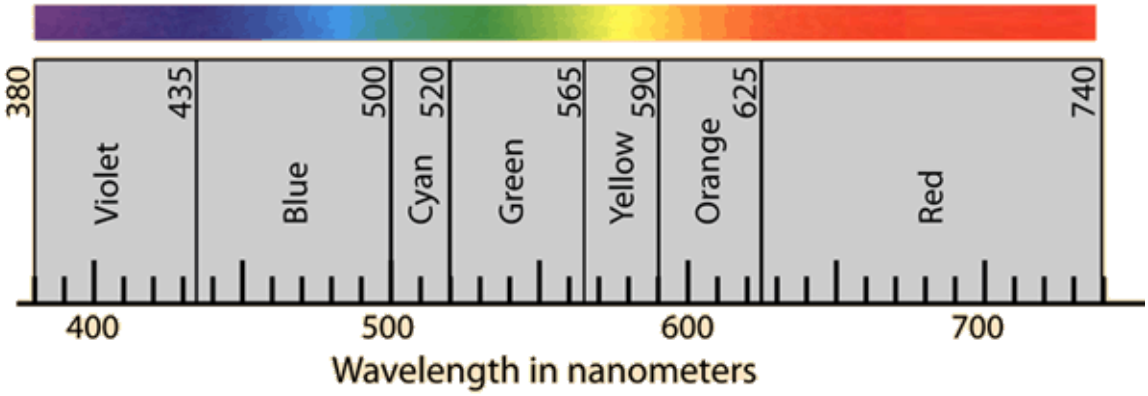
Part 2:

In this part of the lesson, you will build a simple model that assumes that when particles of light (photons) interact with particles of matter (molecules), electrons in the molecules can (quantum) jump between energy levels.

Exercise 1:

When photons (particles of light) pass through the oil, they may interact with molecules in such a way that those molecules emit light in not only a new direction, but also with a new color. This process is known as fluorescence. The light passing through your oil exhibited both transmission and fluorescence, but the fluorescence was much brighter. The color of the fluoresced light is such that the wavelength of the light always increases. Did your light behave in such a way? (Hint: You may refer to the color chart below) Why does an increased wavelength for the fluoresced photons make sense from an energy perspective?



Source: http://hyperphysics.phy-astr.gsu.edu/hbase/vision/specol.html

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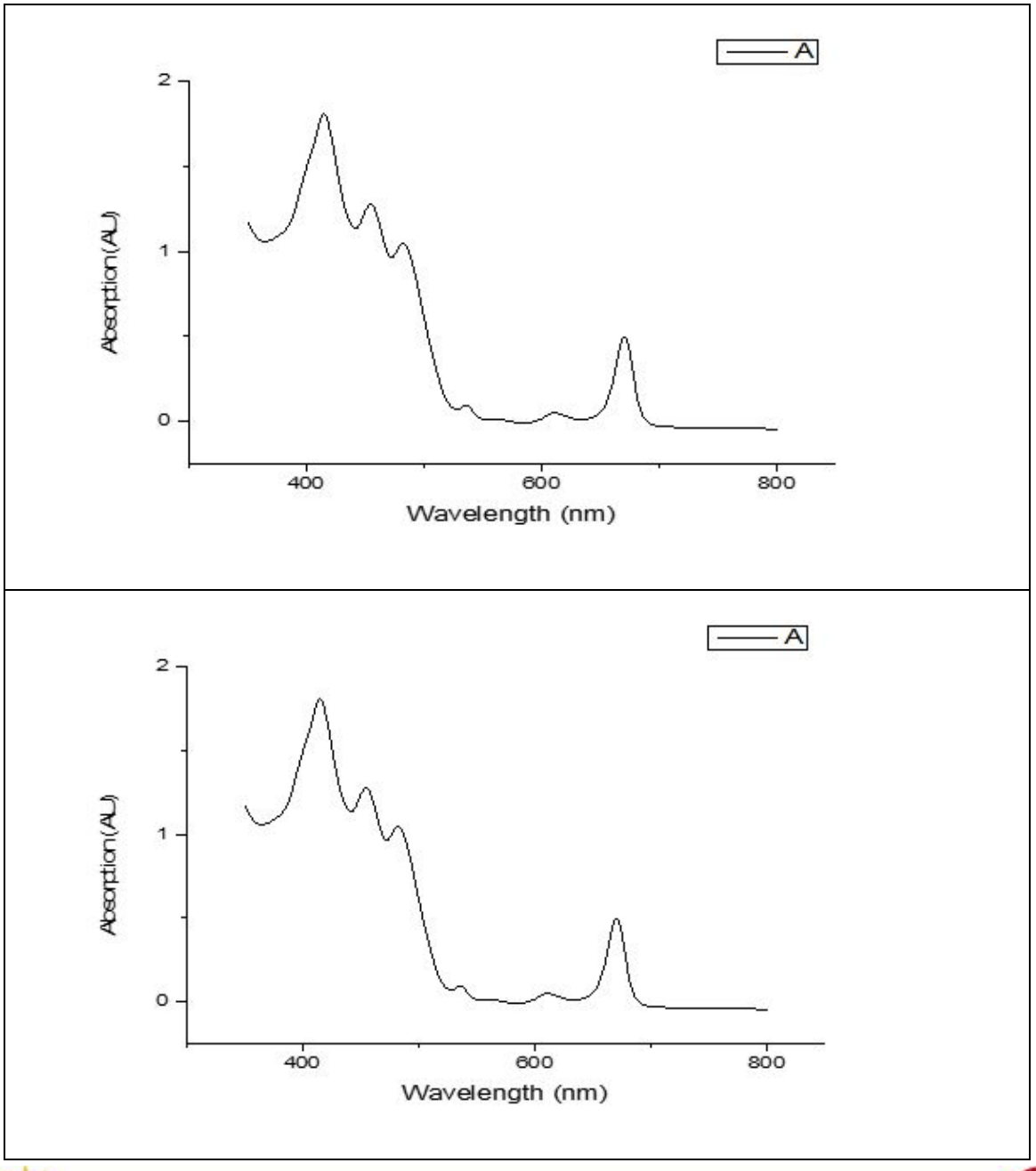
Exercise 2:

The below graphs illustrate absorption spectra (singular: spectrum). The y-axis represents the amount of light absorbed (don't worry about the units) while the x-axis shows the wavelength of the light in nanometers. Based on your previous observations (and the color chart above), which graph best represents the absorption of light in olive oil? Explain.



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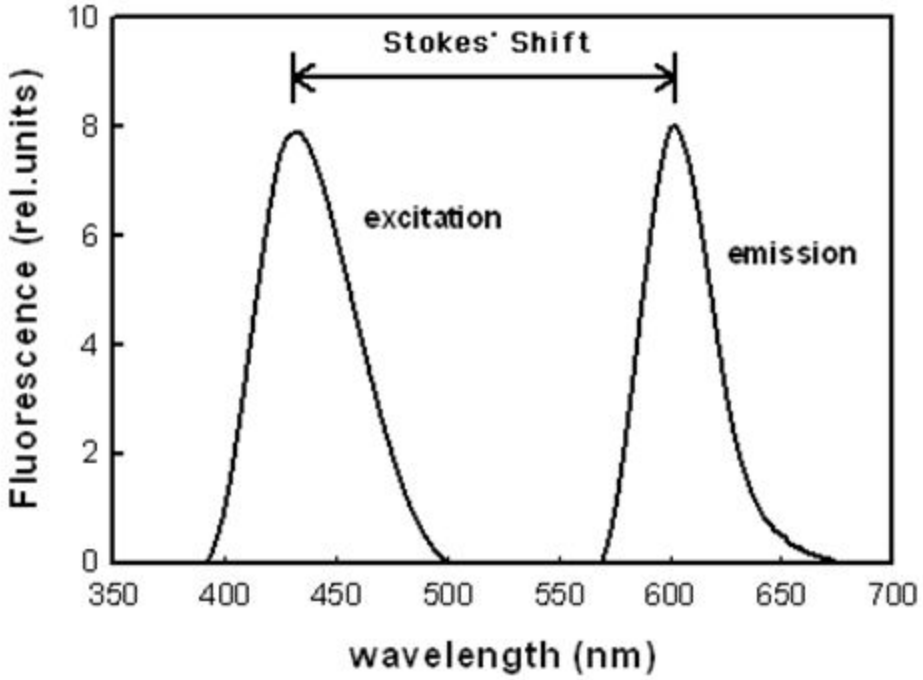
Exit Ticket: *The below graph shows both absorbance (or excitation) and fluorescence (emission) for light interacting with a solution. Use it to answer the questions below.*



Source: http://www.photobiology.info/Berg.html

1) Does this graph correspond to your observations of light in olive oil? Explain.

2) What color is the incident photon in this graph? What color is the emitted photon?

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3) How do the (chlorophyll) molecules in the olive oil become excited?

4) In your own words, describe what you think is meant by a "Stoke's Shift." Be sure to include the concept of energy in your description