Why is the sky blue?

For Ages: 10-18, grades: 5-12

Description: This activity will demonstration the scattering effect of different wavelengths on small particles (~1/10th of the wavelength size).

Materials Needed

- A long, transparent water bottle
- A few drops of milk
- Red, Green, and Blue bulbs or LEDs
- Filters (OPTIONAL) – can be made from different color cellophane
- White bulb or LED (compact fluorescent bulb is preferred, OPTIONAL)

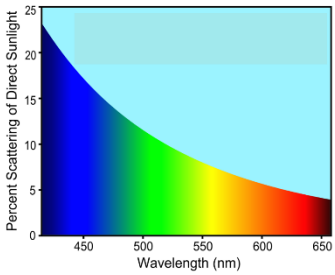
Background and Misconceptions

Reference for the above image: Diffraction Glasses – What's in Color? Mike McKee

White light, like the light from the sun, is composed of different colors. These colors each have a different wavelength that make up the electromagnetic spectrum. Red has the longest wavelength, green is near the middle and blue followed by violent has the shortest wavelength. When we look at the sky, which contains small molecules of water, oxygen and nitrogen, the question arises: Why is the sky blue? The spectrum of light emitted from the sun and the size of the molecules compared to the wavelength reveals a special phenomenon known as Rayleigh scattering. Here it was found that the rays of light interact and scatter off these small molecules, but with each wavelength experiencing a different amount of scattering that is described in the relationship:

$$I \propto \frac{1}{\lambda^4}$$

I is the intensity of the scattering and λ is the wavelength of light. This means that light with a shorter wavelength (like blue or violet) will be scattered more than light with a longer wavelength (like red). When sunlight passes through our atmosphere, some of the light is scattered with the shorter wavelengths being scattered more. As a result of this, more blue and violet light is scattered the most so when the sun is high in the sky, we are at the proper angle to see the scattered light. Even though violet light is scattered the most, our eyes are not very sensitive to the wavelength so what we see is a blue sky. By diluting milk in water, we are simulating the sky where the small fat molecules in the milk take the place of the molecules in our air and scatter the light we put through it in the same manner. It follows that the milk in our bottle should scatter the blue light more and the red light less.



How much of each wavelength is scattered in our atmosphere.

Reference for the above image: By Original uploader was User:Dragons flight at en.Wikipeda.derivative work:KES47 (talk) (converted to SVG). - File:Rayleigh sunlight scattering.png, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=10087273

Teacher Guided Questions to Inquiry

Use these questions to get the students started on their own inquiry.

1. **What color is sunlight?** (white)
2. **What colors make up white light?** (all the colors)
3. **What makes up our atmosphere?** (different molecules of oxygen, nitrogen, argon and carbon dioxide)
4. **What does sunlight interact with when it shines through our atmosphere?** (the molecules)
5. **What happens to the sunlight when it interacts with the molecules in our atmosphere?** (some the light is scattered by the molecules)

Guided Activity

1. Fill the clear bottle with water, leaving some room for the milk.

2. Add a few drops of milk to the water in the bottle, close and shake the bottle to evenly disperse the milk.

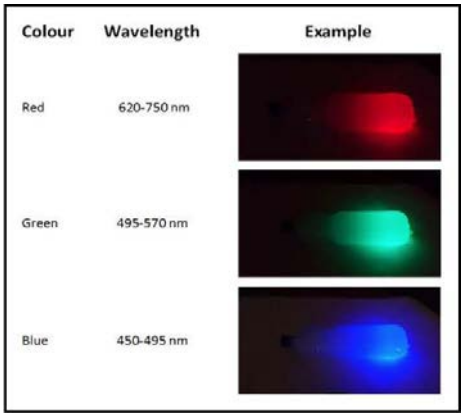
3. Place the bottle onto its side, shine the different colored LEDs from the bottom end and observe how much of the light is scattered with each wavelength or color.

4. Pair the different LED colors together and observe which scattered color dominates.

5. (optional) Shine the white light at the bottom of the bottle and place the different color filters between the bulb and bottle of diluted milk. Observe how the scattering changes for the different color arrays.

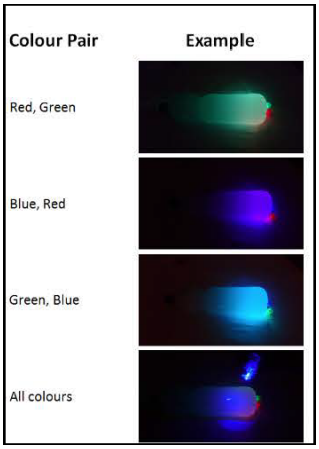
Guided Inquiry

1. Do you think the amount of light scattered changes for different colors/wavelengths? (Light with shorter wavelengths are scattered more than light with longer wavelengths) Shine the different light through the bottle from the end individually, and note which ones seem the most scattered/the most intense (Ours eyes are most sensitive to green so blue and green light might seem comparable even though blue light is scattered more intensely. Similarly, when taking images with the camera, the camera detectors are made to detect more green so that the images seem realistic to what we see.
   Note: the blue LED has some viloet wavelenghts in it, which may be seen near the end of the scattered light in the blue example.



2. How does the amount of light you see change with different colors you shine through the milky solution? (Blue and green light is much brighter than red.)

3. What happens when you pair the different color lights together? What colors did you see? (When green and red light are together, only green can be seen. When red and blue light are together, only blue can be seen. When green and blue light are together, only blue can be seen.)



4. Pair two different colors together and shine it into the bottle from the back end. Alternate the paired colors together until all the colors have been paired. (Blue outshines all the other wavelengths, indicating that it is scattered the most, and why the sky looks blue.)

Analysis Questions

1. Which light color is most scattered by the milk particles? (Blue) Think of light color in terms of wavelength; are longer or shorter wavelengths scattered more by the milk molecules? (Shorter wavelengths are scattered more: Green is scattered more/outshines the red light and the blue is scattered more/ outshines both green and red light.)

2. If the bottle is our atmosphere and the milk particles are the molecules making up our atmosphere, what do you think this means for the sunlight that shines through our sky? What happens to the different colors in our sunlight when they scatter off the molecules in the sky? (Rayleigh scattering happens. Shorter wavelengths are scattered more than the longer ones, so when we look into the sky we see the wavelength that is scattered the most. Blue light 'outshines' all the other scattered colors so we see the sky as blue.)