

**Title:** Visible Light: Why is the Sky Blue?

**Time:** 40 min

**Grade level:** 4<sup>th</sup> and 5<sup>th</sup>

**Synopsis:** In an effort to teach wavelength and frequency in the electromagnetic spectrum, students will look at the visible light spectrum through the color of the sky. This lab would be introduced with the wave spectrum, discussing the wavelength and frequency of the different colors of the rainbow. They would look into the scattering of light through the atmosphere and the effects of the angles of the earth.

**Purpose:** The purpose of this lab is to not only answer why the sky is blue but to discuss prisms, scattering, different gases in the atmosphere and to give an introduction to the wave spectrum.

**Next Generation Science Standards:**

Students who demonstrate understanding can:

**4-PS4-1.** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]

**MS-PS4-1.** Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

**PS4.A: Wave Properties** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)

A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

**MS-PS4-2.** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

**Objectives:**

Students should be able to:

- Identify frequency and wavelength of the colors of the visible light spectrum.
- Connect wavelength and frequencies properties to the different waves on the electromagnetic spectrum.
- Name atmospheric elements that affect visible light.

**Vocabulary:**

Wavelength- the distance between successive crests or troughs of a wave

Frequency- number of waves that pass a fixed point in a given interval

Scattering- the process in which a wave of particles is diffused by collision with particles of the medium that it traverses (in our case, the light waves are being diffused or separated by particles in the air such as nitrogen and oxygen)

A physical process where light, sound, or particles are forced to deviate from a straight trajectory. It occurs when light encounters a rough surface, causing it to be sent off in many different directions, and does not change in frequency.

ROYGBIV- Red, Orange, Yellow, Green, Indigo, Violet

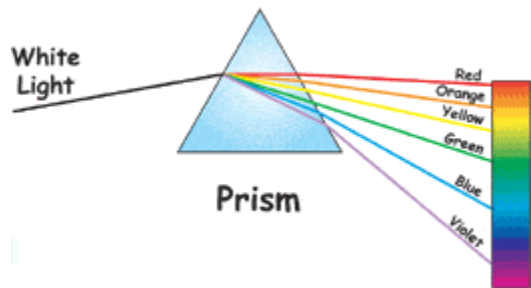
Prism- a glass or other transparent object that separates white light into a spectrum of color

Electromagnetic Spectrum- the entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and including visible light

## Introduction/Teacher information:

It is easy to see that the sky is blue. Have you ever wondered why? A lot of other smart people ave

The light from the Sun looks white. But it is really made up of all the colors of the rainbow.

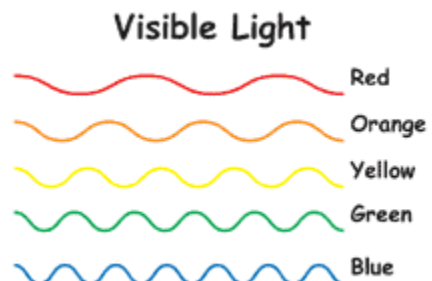


A prism is a specially shaped crystal. When white light shines through a prism, the light is separated into all its colors.

*The light from the Sun looks white. But it is really made up of all the colors of the rainbow.*

If you visited [The Land of the Magic Windows](#), you learned that the light you see is just one tiny bit of all the kinds of light energy beaming around the Universe--and around you!

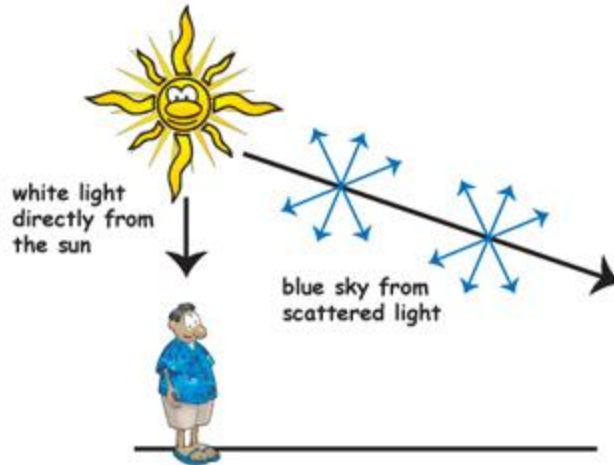
Like energy passing through the ocean, light energy travels in waves, too. Some light travels in short, "choppy" waves. Other light travels in long, lazy waves. Blue light waves are shorter than red light waves.



All light travels in a straight line unless something gets in the way to—

- reflect it (like a mirror)
- bend it (like a prism)
- or scatter it (like *molecules* of the gases in the atmosphere)

Sunlight reaches Earth's atmosphere and is scattered in all directions by all the gases and particles in the air. Blue light is scattered in all directions by the tiny molecules of air in Earth's atmosphere. Blue is scattered more than other colors because it travels as shorter, smaller waves. This is why we see a blue sky most of the time.



Closer to the horizon, the sky fades to a lighter blue or white. The sunlight reaching us from low in the sky has passed through even more air than the sunlight reaching us from overhead. As the sunlight has passed through all this air, the air molecules have scattered and rescattered the blue light many times in many directions. Also, the surface of Earth has reflected and scattered the light. All this scattering mixes the colors together again so we see more white and less blue.

### **What Makes a Red Sunset?**

As the Sun gets lower in the sky, its light is passing through more of the atmosphere to reach you. Even more of the blue light is scattered, allowing the reds and yellows to pass straight through to your eyes.

<http://spaceplace.nasa.gov/blue-sky/en/>

What causes the beam of light from the flashlight to look blue from the side and orange when viewed head on? Light usually travels in straight lines, unless it encounters the edges of some material. When the beam of a flashlight travels through air, we cannot see the beam from the side because the air is uniform and the light from the flashlight travels in a straight line. The same is true when the beam travels through water, as in this experiment. The water is uniform and the beam travels in a straight line. However, if there should be some dust in the air or water, then we can catch a glimpse of the beam where the light is scattered by the edges of the dust particles. When you added milk to the water, you added many tiny particles to the water. Milk contains many tiny particles of protein and fat suspended in water. These particles scatter the light and make the beam of the flashlight visible from the side. Different colors of light are scattered by different amounts. Blue light is scattered much more than orange or red light. Because we see the scattered light from the side of the beam, and blue light is scattered more, the beam appears blue from the side. Because the orange and red light is scattered less, more orange and red light travels in a straight line from the flashlight. When you look directly into the beam of the flashlight, it looks orange or red. What does this experiment have to do with blue sky and orange sunsets? The light you see when you look at the sky is sunlight that is scattered by air molecules and particles of dust in the atmosphere. If there were no scattering, and all of

the light travelled straight from the sun to the earth, the sky would look dark as it does at night. The sunlight is scattered by the air molecules in the same way as the light from the flashlight is scattered by particles in milk in this experiment. Looking at the sky is like looking at the flashlight beam from the side: you're looking at scattered light that is blue. When you look at the setting sun, it's like looking directly into the beam from the flashlight: you're seeing the light that isn't scattered, namely orange and red. What causes the sun to appear deep orange or even red at sunset or sunrise? At sunset or sunrise, the sunlight we observe has traveled a longer path through the atmosphere than the sunlight we see at noon. Therefore, there is more scattering, and nearly all of the light direct from the sun is red.

<http://www.optics4kids.org/home/content/classroom-activities/easy/blue-sky-%E2%80%94-red-sunset/>

Activity Procedure Copyrighted by The Optical Society

### **Materials:**

- Flashlight
- Glass box (some kind of small fish tank, transparent container with parallel sides)
- Milk
- Water

### **Procedures:**

Before Demonstration, go through powerpoint and work through first half of worksheet.

1. Set the container on a table where you can view it from all sides.
2. Fill it  $\frac{3}{4}$  full with water.
3. Light the flashlight and hold it against the side of the container so its beam shines through the water. Try to see the beam as it shines through the water. You may be able to see some particles of dust floating in the water; they appear white. However, it is rather difficult to see exactly where the beam passes through the water.
4. Add about 60 milliliters ( $\frac{1}{4}$  cup) of milk to the water and stir it. Hold the flashlight to the side of the container. Notice that the beam of light is now easily visible as it passes through the water. Look at the beam both from the side and from the end, where the beam shines out of the container. From the side, the beam appears slightly blue, and on the end, it appears somewhat yellow.
5. Add another  $\frac{1}{4}$  cup of milk to the water and stir it. Now the beam of light looks even more blue from the side and more yellow, perhaps even orange, from the end.
6. Add the rest of the milk to the water and stir the mixture. Now the beam looks even more blue, and from the end, it looks quite orange. Furthermore, the beam seems to spread more now than it did before; it is not quite as narrow.

After demonstration, work through second half of the worksheet.

**Helpful Hints/ Discussion Materials:**

Use a smaller container (fish tank/clear container) to conserve materials. Flash lights onto a blank wall or white board if possible to get the clearest color possible. If possible to get a prism, it might be a good demonstration to first see the different possibilities with light but not necessary for the activity. Circulate when students are measuring to offer additional assistance in measuring.

**Accommodations/Modifications:**

Some students may have difficulties with measuring or even seeing some of the smaller numbers on the ruler and may need a magnifying glass or additional assistance in reading numbers- students could work in pairs on some measuring and be given the option to discuss the worksheet

During the simulation of light, a student who is having trouble staying engaged could be given a job (pouring milk, pouring water, holding flashlight etc.)

**Questions to Engage the Students/Analysis:**

Think of why we would angle the flashlight differently for the blue and red sky color, what is happening during the day that would cause these different angles.

Think of when you see a rainbow, what is acting like a prism?

What is the milk simulating?

**Career Connection:**Environmental Engineer

Environmental engineering is the integration of science and engineering principles to improve the natural environment, to provide healthy water, air, and land for human habitation and for other organisms, and to clean up pollution sites.

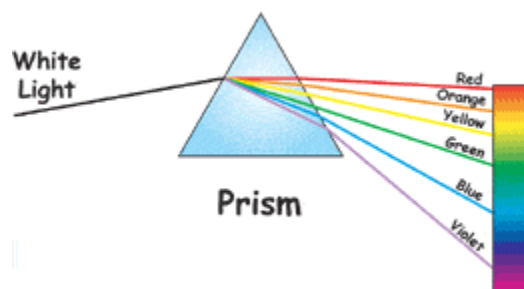
Occupational Health and Safety Specialist

Review, evaluate, and analyze work environments and design programs and procedures to control, eliminate, and prevent disease or injury caused by chemical, physical, and biological agents or ergonomic factors.

## Why is the Sky Blue?

### Exploring Visible Light

Not everything is as it appears. White light is really made up of all the colors that can be seen through a prism. But what is light made of and how do we measure the energy of light? Light is made of waves and we measure light by the wavelength and the frequency.








Wavelength- the distance between two peaks or troughs

Frequency- number of waves that pass a fixed point in a given interval

#### Part I

In the chart below, measure the wavelength and count the frequency. For this exercise we will assume that this is the amount of wavelengths that pass by a fixed point in one second.

	Wavelength (in mm)	Frequency (#of peaks or troughs)
 <span style="float: right;">Red</span>		
 <span style="float: right;">Orange</span>		
 <span style="float: right;">Yellow</span>		
 <span style="float: right;">Green</span>		
 <span style="float: right;">Blue</span>		

Use the Chart and Answer the following questions.

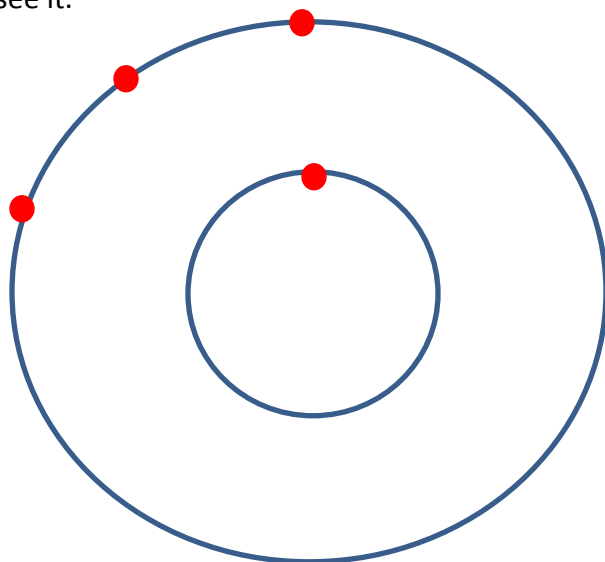
Which color has the longest wavelength?

Do larger or smaller wavelengths have a higher frequency? Why?

Describe blue light, how does it compare to the other colors? Why do we think the daytime sky appears blue? Why does the sun appear white when it is super bright?

## Part II

Measure the distance between each of the dot on the outside circle to the dot on the inside circle. Depending on where the sun is on the sky determines how much atmosphere is passes through before we see it.



How much milk was added before there was red light in the tank? What does this tell us about the light at sunset?