Grade 3--Light

Objective: Students will learn different properties of light.

NextGen Science Standards: An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2) Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)

Docent Lab Guidelines:

1. Schedule a date and time with your teacher to have the students come into the lab. Estimated time for this lab: 45 minutes
2. Input the day and time into the Science Lab Master Schedule. Please make sure you include your name and include time for set up and clean up.
3. This lab session consists of three experiments. Divide the class into three groups to rotate between the three experiments. Allow about 10 minutes at each station. You need at least one adult per station. One station takes place outside using sunlight.

<u>General Information about the Subject Matter:</u>

Vocabulary to Review with the Students:

Reflection—light waves bounce off an object (allows us to see images in a mirror)
Refraction—light waves bend when they pass through one medium to another
Light speed—186,000 miles (300 million meters) per second. It takes 8 minutes for sunlight to reach earth.
Internal reflection—light waves enter a material and reflect inside instead of going out again
Prism--a glass or other transparent object in prism form, especially one that is triangular with refracting surfaces at an acute angle with each other and that separates white light into a spectrum of colors.
Dispersion—breaking white light into the spectrum of colors (rainbow). Different wavelengths of light reflect at different lengths/angles. But they always appear in the same order.
Rainbow--an arch of colors formed in the sky in certain circumstances, caused by the refraction and dispersion of the sun's light by rain or other water droplets in the atmosphere.
Properties of Light—For Docent Reference (from physicsplanet.com)
Light is all around us. It is the primary way we come to know the universe, and thus is very important to physicists. Until the middle of 1800's, light was taken to be a stream of tiny particles. This was the stance advocated by Newton. However, by the late 1800's the particle theory was replaced by the wave theory. This was because light exhibited certain properties that could only be explained by the wave theory.

One of the properties of light is that it reflects off surfaces. Among other things, this reflection allows us to see images in mirrors. We see the images in mirrors as apparently coming from behind the mirror because our eyes interpret it in this manner. But when we see ourselves reflected in the mirror and raise our left arm, the image apparently raises its right arm.

Another property is the speed of light, which is the fastest anything has been observed to move. In a vacuum, the speed is 300 million meters per second. At that speed, it takes light one ten thousandth of a second to travel around the earth. When light enters a material, it slows down. The amount depends on the material it enters and it's density. For example, light travels about 30% slower in water than it does in a vacuum, while in diamonds, which is about the most dense material, it travels at about half the speed it does in a vacuum. This slowing down of light plays a role in another property, refraction.

Refraction means that light bends when it passes from one medium to another. When light enters a denser medium from one that is less dense, it bends toward a line normal to the boundary between the two media. The greater the density difference between the two media, the more the light bends. This property is used with respect to optical devices such as microscopes, corrective lenses for vision, magnifying lenses, and so on.

You may have noticed that, when you look into the surface of a lake or pond while fishing, the fish you catch seems larger when under the water than when you actually land it. This is due to refraction. Since the air is less dense than water, the light beds away from the normal as it emerges. Another common example is that your feel look larger and closer to the surface underwater than they really are.

Another property that combines both refraction and reflection is total internal reflection. This is an interesting concept. When light coming from the air strikes water, part is reflected and part is refracted. When the angle of incidence of the light striking the water is large enough, it gets totally reflected and in fact cannot leave the water. Fiber optics uses this property of light to keep light beams focused without significant loss, as long as the bending of the cable is not too sharp. TV and telephone cables use fiber optic cable more and more since it is much faster and more efficient than electrons in an electric current.

Dispersion is another property of light. This refers to the ability to break white light into its constituent colors. White light consists of all of the colors we are able to see. If white light enters a prism, what emerges from the other side is a spread out beam of multi-colored light. Blue light, with longer wavelengths, gets bent more by the different angles of the prism than red light, and the other colors are in between blue and red on the wave spectrum.

Rainbows are natural phenomena that exemplify all of the above properties of light. They use refraction, dispersion, and internal reflection to produce their amazing hues. White light enters raindrops from the sun and gets dispersed and refracted inside the raindrops. When the dispersed light hits the back of the raindrop, it gets internally reflected, and when it emerges it gets dispersed even more.

Because it refracts more, the blue is always at the top of the rainbow and the red on the bottom. The color you see most vividly depends on the angle of your eye. Generally, you must look higher in the sky to see the red, and lower to see the blue. What you actually see is the red on the top and the blue on the bottom, with all of the other colors in between. The arc of the rainbow depends on the angle that your line of sight makes relative to the sun behind you.

After the introductory videos and discussion, divide the class into 3 groups to rotate between the 3 stations. Allow 10 minutes at each station. One station takes place outside, using sunlight (if it's raining, you can try the experiment indoors with flashlights, but it's not as successful.

Introductory Videos to Show the Class:

Bill Nye the Science Guy on the Eyeball (2:13)
https://www.youtube.com/watch?v=cFVbLnXWn6A

How Human Brain Sees Light (1:10)
https://www.youtube.com/watch?v=SMJbUmVrgao

*Discuss two videos of how we are actually seeing objects and light.

Revealing harmful light from the sun (1:09)
https://www.youtube.com/watch?v=FAUyBH_ER_U&t=5s

*Discuss how instead of the beads, to think about the sun's rays on our skin. How if we didn't wear protection, we would look and feel like a steamed lobster. LIght comes in all forms. Today, we will be using light from laser pointers, lights from the ceiling, sunlight or flashlight depending upon the outside weather.

Station 1: Bending Light Fountain

Docent tip: Watch a demo of this experiment: https://www.youtube.com/watch?v=ifbCsha7Syc

Materials needed:

- Empty plastic water bottle with small hole poked into the side about halfway up
- Water
- Shallow bowl or pan
- Laser pointer

Procedure:

1. Put the empty water bottle inside the bowl or pan.
2. Pour water into the bottle. Notice how it will start to flow out of the hole in the side.
3. Place the laser pointer next to the bottle directly opposite of the hole and turn on the light.
4. The light will appear to go straight across the bottle and then bend with the flow of the water. Doesn't light travel in straight lines? What is happening? (The water is reflecting the light, both on the surface and underneath the surface, so it appears as though the light is bending. This is an example of internal refraction.)

Station 2: Optical Illusions

Docent tip: Watch a demo of this amazing water trick: https://www.youtube.com/watch?v=G303o8pJzls

Materials needed for each pair of students:

- Glass drinking glasses or beakers
- Pre-printed black and white cards
- Pitcher of water
- Ipad (Check out from the front office. Students can play on the Color Uncovered app after experiencing the optical illusions. 2-3 students per Ipad.)

Procedure:

1. Place the cards upright for viewing, and place an empty glass or beaker in front of them. Make observations about what the pictures look like as they are looking through the glass.
2. Now fill the glass/beaker with water. What happens? Why?

When the arrow is moved to a particular distance behind the glass, it looks like it reversed itself. When light passes from one material to another, it can bend or refract. In the experiment that you just completed, light traveled from the air, through the glass, through the water, through the back of the glass, and then back through the air, before hitting the arrow. Anytime that light passes from one medium, or material, into another, it refracts.

Just because light bends when it travels through different materials, doesn't explain why the arrow reverses itself. To explain this, you must think about the glass of water as if it is a magnifying glass. When light goes through a magnifying glass the light bends toward the center. Where the light all comes together is called the focal point, but beyond the focal point the image appears to reverse because the light rays that were bent pass each other and the light that was on the right side is now on the left and the left on the right, which makes the arrow appear to be reversed. (from home science)

After looking at all the optical illusions, students can play on the Color Uncovered app on the Ipad (2-3 students per Ipad).

Station 3: Create your own Rainbow

Materials needed for each pair of students:
•A plastic jar (or clear shallow pan)
•Water
•Sunlight (or a flashlight if it's raining)
•A white surface or piece of posterboard
•A small mirror
•Prisms

Procedure:
•Fill the jar or pan about half way full with water. Take the materials outside into sunlight.
•Place the mirror in the water at an angle.
•Turn the mirror towards the sun to shine the light into the water where the mirror is under water (This is much more difficult to do with a flashlight indoors.)
•Hold the white paper above the mirror; adjust the angle until you see the rainbow appear!
•Try the same process with the prism. Hold the prisms up into the sunlight and move it until you find a rainbow appear. How does it compare to the rainbow created by the mirror?

What happens? Why?
Okay, so this doesn't look exactly like the rainbow you see in the sky after a storm, but it shares the same general characteristics of colors and order — but why? This demo and the rainbows that appear in the sky share the same principles: refraction & reflection.

We've heard about refraction before — this is the concept of how light bends when it passes through different mediums, like glass or water. Refraction can even make arrows appear to reverse directions when viewed through a glass of water!

When you shine the white light of your flashlight (or the white light coming from the sun) into the water, the light bends. But white light isn't just one color; instead, it's a combination of all the visible colors. So when white light bends, all of its components (red, orange, yellow, green, blue, and indigo light) also bend. Each of these colors bends at a different angle because each color travels at a different speed inside water or glass.

When you reflect the light back out of the water using the mirror, you're reflecting the white light that has been broken up (from refraction) into the full rainbow of colors, and a rainbow appears!

When a rainbow forms in the sky, the same principle applies. Many little water droplets refract the sun's light. The angle at which we view these water droplets determines which color we see from them. (By Aliya Merali, http://www.physicscentral.com/experiment/physicsathome/rainbow.cfm)