NVACSS Lesson Plan Template	
Grade Level: 4th	**Topic: Waves- Light and the eye**
General Lesson Description: (Include Estimated Time to Complete the Lesson) **Students will follow the story of how they use their senses (eyes and brain) to processes electromagnetic waves (light) so that we can see. Students will engage in learning by listening to a story and watching a couple of videos about their eyes and how we see. Students will then explore how light reflects by completing FOSS Energy Investigation 5 Part 2 Light Travels. Next students will explain their learning in a sense making circle, followed by reading multiple science stories to elaborate their learning. Lastly, they will develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. This lesson will take 6 to 10 sessions.**	
Performance Expectation: **4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.**	
Clarification Statement:	**Assessment Boundary:** *Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.*
Big Question: **How do we use waves to see objects?**	**Specific Learning Targeted Outcomes:** 1. **Students will engage in scientific discourse about how we use waves to see and that our brains process the information.** 2. **Students will develop various types of models throughout the lessons.** 3. **Students can identify and explain that our vision is a system and that each part has a function.**
NGSS Anchor Phenomena: https://www.ngssphenomena.com/#/iris-wiggle/	
Background Information	
Prior Student knowledge to teach this lesson: This lesson is designed as an extension to FOSS. Energy Investigations 1-4. Most importantly Investigation 5 Part 1 Forms of Waves. **If not using FOSS students need to know that energy is everywhere and always moving. It can be transferred by moving from place to place. Energy moves in waves and there are various types of waves.**	
Teacher background information around big ideas: Copied from FOSS Energy Investigation 5-Waves **Light is the flash, the glare, the colored sparkle, the bright twinkle, and the soft glow that fills our space. Light is electromagnetic radiation. The primary source of light is a radiant object. The most pervasive radiant object is the Sun, but all the other stars, lamp filaments, flames, flashes of electricity, and fireflies are also sources of light. Light sources radiate light.** **In order for any object to be visible, it must either produce light or reflect it. Objects such as the Sun, a candle flame, and a lightbulb produce light. Objects such as the Moon, a candlestick, and people reflect light.**	

The human eye has evolved specialized neurons called photoreceptors (rods and cones) that turn visible light into electric pulses, which are processed in the brain to create what we know as vision. Vision is a direct response to light interacting with photoreceptors. Contrary to a widely held misconception, our eyes never "get used to" the dark. Our eyes accommodate to very low levels of light, but in the total absence of light, vision is impossible.

Light starts with a vibrating charge, like an electron. The vibration creates waves of energy that radiate out in all directions. They are called electromagnetic waves. (They are also called light rays.) The properties of the wave depend on the rate of vibration of the source charge. Rapidly vibrating charges have lots of energy, and the high–frequency waves they radiate are very energetic.

All electromagnetic waves, regardless of their vibrational frequency, travel through space at the speed of light, 299,792 kilometers (km) per second. And they travel in straight lines, until they hit something. When a light wave hits matter, one of four things can happen. It can transmit (pass through). It can reflect (bounce off) and continue, possibly in a new direction. It can refract (change speed and direction of travel as it passes through the material) and continue in a new direction, or absorb (get taken into the material) and cease to be a light wave. In this module students will learn about the effects of reflection and absorption and be introduced to refraction.

The different frequencies of light waves, also called wavelengths, are organized into the electromagnetic spectrum. The longest wavelengths are the low–energy radio frequencies. A single radio wave can be a meter or more in length between peaks.

At the other end of the spectrum are the high–energy X–rays and gamma rays, with tiny wavelengths that are mere billionths of a centimeter (cm) in length.

Right in the center of the spectrum is a narrow slice of wavelengths known as visible light. The wavelengths of visible light range from 0.00004 cm (violet) to 0.00007 cm (red). It is this small range of wavelengths that we humans exploit for vision. We don't have the neural equipment to detect longer (infrared and longer) or shorter (ultraviolet and shorter) wavelengths.

A mirror is an extremely smooth surface that reflects light. Car bumpers, store windows, soup spoons, and the surface of calm water are all mirrors. The object that we most often call a mirror is a piece of glass or plastic with a thin layer of silver plated on the back. The mirror is the highly ordered arrangement of silver atoms on the smooth glass surface.

Mirrors and white materials both reflect all the light that falls on them. Mirrors, however, clearly reflect light differently than, say, a sheet of white paper. You just can't use a piece of paper to see if you have a piece of spinach stuck between your teeth. The difference is the surface characteristics of the two objects. It is like the difference between a tennis court and the Grand Canyon. If you fire a tennis ball hard onto the surface of the tennis court (angle of incidence), it will bounce away from you predictably at the same angle (angle of reflection). If you fire the ball into the Grand Canyon, it might ricochet off a thousand surfaces before leaving the canyon. And there is no telling what direction it will be heading. Light reflecting off a mirror surface reflects true, replicating the image of the object from which the light emanated. Light reflecting off the paper is chaotic. The image is fragmented and the light scattered in a zillion directions. You see random white light.

Mirrors can reflect light from an object, such as your face. When you look into a mirror, you see light in many colors exactly as it is reflected from your face. The reflected light forming a perfect likeness of your face is called an image. But is a mirror image a perfect likeness of an object? The answer is yes and no. Every detail of the object is reflected accurately, but it is reversed left to right. For instance, when you look at yourself in a mirror, your hair seems to be parted on the right. But when you look at your image in a photograph (the view the rest of the world gets of you), that image has the hair parted on the left. This characteristic of mirrors is fascinating and opens a fertile subject for inquiry. Optics (the science of manipulating light) and the study of images will not be pursued in this module, except in the take–home and extension activities. But be aware that these introductory experiences open the door to many opportunities for enthusiastic learners to extend their understanding of light and imagery.

Because mirrors reflect true, they can be pressed into service in a couple of ways. The most common use is redirecting light into our eyes that would otherwise not find its way there. Without a mirror, you could go through your whole life not knowing what you look like. The light reflected from your face is directed just about every direction except into your eyes. A mirror remedies that. The light can be turned around and sent into your eyes. Oh, that's what I look like...

The other thing we never see is everything behind us. Our visual field, that is, the space from which light can enter our eyes, is somewhat less than a hemisphere out in front of us. If you were inside a giant sphere, you could see half of the inside of the sphere; half would be invisible. A mirror strategically placed can reflect light rays coming from behind you so as to redirect them into your eyes. Almost as good as having eyes in the back of your head. We call such a device a rearview mirror.

The other interesting thing you can do with a mirror is redirect a beam (a column of rays) of light into a dark place. It has been speculated that mirrors were used to deliver sunlight to the Pharaoh's subjects laboring in the dark interior of the pyramids. Because the angle of reflection is true, light can be herded through convoluted pathways to illuminate a dark space or to achieve an interesting optical stunt. Students will have opportunities to develop their skill of reflection by directing beams of light in interesting ways.

Light coming from the Sun (and other white–light sources) is a hodgepodge of frequencies of light. The flood of light includes red, yellow, green, blue, orange, and every other color of light mixed together. The net result is white light. We can use a prism to separate white light into its rainbow spectrum.

Light can come from a primary source (radiant object) or a secondary source (an object that reflects light). Reflected light is a little different from what we usually consider a reflection, like the flash from a window or mirror. Reflected light hits an object and is not absorbed, but bounces off in a new direction. Trees, books, people, oranges, shoes, and every other nonluminous object we see reflects at least some light.

Light is essential for vision. Without light, our eyes could not detect objects. When white light falls on a red apple, the apple absorbs wavelengths of light selectively, and reflects the rest. The apple reflects red light, so that is what enters our eye. Leaves of trees reflect only green light, school buses absorb everything but yellow, and so on. That's what happens when white light falls on an object.

What happens when only selected wavelengths of light fall on an object? The result can be startling. This is a good extension activity for students. Place a sheet of blue cellophane over a flashlight, and the plastic will absorb all wavelengths of light except the blue, which will pass through. You now have a blue flashlight. If you go into a darkened room and shine a regular white light on an orange, it looks orange. It absorbs all colors of light except orange. But when you shine the blue light on the orange, what do you see? A black orange! The orange absorbs the blue light and reflects nothing.

Possible Student Misconceptions:

That you can see without light. That you can't see anything that doesn't omit light. How we see things is how everyone sees it.

Evidence Statements: How do students show mastery?

Students develop a model to make sense of a phenomenon involving the relationship between light reflection and visibility of objects. In the model, students identify the relevant components, including: light, objects, the path light follows, the eye

Students identify and describe casual relationships between the components, including: light enters the eye, allowing objects to be seen; light reflects off of objects, and then can travel and enter the eye; objects can be seen only if light follows a path between a light source, this object, and the eye.

Students use the model to describe that in order to see objects that do not produce their own light, light must reflect off the object and into the eye.
Students use the model to describe the effects of the following on seeing an object: removing, blocking, or changing the light source; closing the eye; changing the path of the light.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and using models Obtaining, evaluating, and communicating information	**PS4.B: Electromagnetic Radiation** An object can be seen when light reflected from its surface enters the eyes. **LS1.D Information Processing** 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.	Cause and effect: Mechanism and explanation Systems and system models Structure and function

Lesson Plan: 5E Model
ENGAGE: 1 Session **Begin lesson by reading The Eye Book by Dr. Seuss.** **Then show one or both of the short videos.** **Bill Nye on the Eyeball** https://www.youtube.com/watch?v=cFVbLnXWn6A **The Visual System** https://www.youtube.com/watch?v=i3_n3Ibfn1c **If possible post them on Google Classroom, so the students can watch them again at their pace to take notes and draw a draw a model of their eye.**(Developing and using models & Obtaining, evaluating, and communicating information)
Assessment **Formative:** Notes and model of eye in their science notebooks **Summative:**
Engage Materials Needed and Website/Other Resources: **The Eye Book by Dr. Seuss** If you don't have the book you can use this link and watch a video https://www.youtube.com/watch?v=dE6RKmyN_AQ **Bill Nye on the Eyeball** https://www.youtube.com/watch?v=cFVbLnXWn6A **The Visual System** https://www.youtube.com/watch?v=i3_n3Ibfn1c **The National Eye Institute** https://nei.nih.gov/kids
EXPLORE: 2-3 Sessions Review yesterday's activities. Explain that today we will learn more about how light travels in order for us to better understand how we can see things using our eyes. Complete FOSS Energy Investigation 5 Part 2 Light Travels. In this part of the investigation, students use mirrors to experience reflecting light. They start by using mirrors outdoors to see objects behind them and to reflect a bright image of the Sun onto walls. In the classroom, they determine that a mirror can be used to reflect light. Students then use flashlights, mirrors, and water to observe light in numerous ways, reinforcing the idea that light can reflect and refract. Students build a conceptual model about how light travels. The focus question is **How does light travel?** **After the investigation watch the FOSS video All About Light.**
Assessment **Formative:** Models in science notebook/ 3,2,1 about the video **Summative:**
Explore Materials Needed and Website/Other Resources: **FOSS Energy Investigation 5 Part 2 Light Travels** **See investigation for the materials needed and step by step instructions** **All About Light video from FOSS**
EXPLAIN: 1 Session **Have a sense making circle:** Ask these questions to lead the students on a path of discussion • What is light? [A form of energy.] • What is the most important source of light for Earth? [The Sun.] • How can light energy change into heat energy? [When light is absorbed by matter, it can be converted into heat. Light can be absorbed by plants, which is converted into food and fuel, which can be converted into heat.] • How is reflection different from absorption? [Reflected light bounces off matter and continues on as light. Light that is absorbed by matter is converted into another form of energy.] • Describe an object that can block sunlight to create shadows. [An opaque object reflects or absorbs light, making a dark place (shadow) behind it.] • Describe how light travels. [As wavelike rays, in straight lines.] **Review any vocabulary, especially if not addressed in the sense making circle.** **Have students revise their models to include how light changes direction when it travels from water into air.** **Then have students answer the focus question in their notebooks. How does light travel?**

Prompt students to provide evidence from their investigations with different materials.

Explain Materials Needed and Website/Other Resources:

FOSS Energy Investigation 5 Part 2 Light Travels
Vocabulary cards
Sentence stems for sense making circle
Students notebooks and notes

ELABORATE: 1-2 Sessions (ELA Connection can be done during reading)

Review and connect past lessons to today. Today we will further our learning about how light travels to understand how we can see with our eyes. Read the following stories using reading strategies of your choice.

Read "Light Interactions" and discuss the following questions: (Cause and Effect)

- What must happen for you to see an object? [Light from a light source or reflected from an object must enter your eye.]
- What happens when light reflects? [Light hits an object and bounces off. The light continues in a straight line in a new direction.]
- What kinds of surfaces reflect light? [Shiny surfaces like mirrors, and most other objects that can be seen.]
- What can you use a mirror for? [To change the direction of rays of light, to direct light into your eyes to see things behind you, to reflect beams of light around corners.]
- What happens when light refracts? [Light changes direction so it doesn't travel straight from an object to your eye.]

Read "Throw a Little Light on Sight" and discuss the following questions.
(Obtaining, evaluating, and communicating information)

- Why couldn't Sara see anything when she first went into the exhibit at the Lawrence Hall of Science? [Objects can only be seen when light enters an eye. The exhibit room was completely dark. There was no light to enter Sara's eyes.]
- Why did Sara's orange appear black in blue light? [The orange absorbs all colors of light except orange. Blue light contains no orange light, so the orange did not reflect any light. Objects that don't reflect any light are black.]
- Why did Sara's lime appear green in white light? [White light is a mixture of all colors of light. The lime absorbs all colors except green light. The reflected green light enters the eye and makes the lime appear green.]
- How will Sara's lime look in red light? Explain why. [Black, because the green lime reflects only green light. A red light has no green light to reflect.]

Read "More Light on the Subject" and discuss the following questions: (Cause and effect & Systems and system models)

- Why does a green leaf appear green in sunlight? [Sunlight is white light, containing all colors of light. Green leaves reflect only green light, making them appear green.]
- How does vision work? [Light from a light source or reflected from an object enters an eye. The object is seen when light enters the eye.]
- How do mirrors work, and what can they do? [Mirrors reflect all light that hits them. They can be used to direct light into an eye to see things that are otherwise not visible. Mirrors can direct beams of light around corners.]

Have students turn to their shoulder partner and discuss. Is this a system? Explain using evidence.

Students will then complete FOSS Response Sheet 28
What to Look For:

- Explains that Model 1 is incorrect because the light has to shine on the object first, then that light is reflected into the eye.
- Explains that Model 2 is incorrect because the arrow going from the object to the eye needs to be reversed. Light reflects off of objects and into our eyes in order for us to see.

Assessment

Formative: Revisit answer to focus question in science notebook and add any new information or change any incorrect information

Summative: FOSS Energy Response Sheet 28

Elaborate Materials Needed and Website/Other Resources:

FOSS Energy Reading in Science Resources

FOSS Energy Response Sheet 28

<u>EVALUATE:</u> 1-3 Sessions

Start lesson by reading the Eyes section in Eyes and Ears by Seymour Simon.

Tell students that today they are going to develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen (4-PS4-2) and how the eye with help from the brain process light so that we can see objects (LS1.D). Have another sense making circle to make connections about all content learned in the previous days and this section of the book about the eye as review.
Students will then create a 3D model of the eye of the eye showing how light reflecting from objects and entering the eye allows us to see the objects upside down and our brain processes the information and turns the image right side up. Depending on your class and resources you can choose to have them bring their own various supplies to use or you can make it as simple as needed. If supplies and/or time are an issue they can also just draw a final model in their science notebook.
Writing connections: Students then write and informational/explanatory essay explaining how we use waves to see objects.

Assessment

Formative:
Summative: Developed Model of Eye, Informational/Explanatory Essay

Evaluate Materials Needed and Website/Other Resources:

<u>Eyes and Ears</u> by Seymour Simon

Possible materials for the 3D Eye Model:
Foam ball
Foam square
Foam sheet
Wooden stick
Googly eye
Toilet paper roll
Acrylic paints
Glue
Sting
Object
Paper

Model magic (eyeball & brain)
String or pipe cleaners
Black paper (pupil)
Colored paper (iris)

Paper Plates
Makers
Paper
Object

Comments/Teacher Tips: