Educator Guide

Science Activity 6: Beyond the Rainbow: Introducing Spectroscopy

Educator Preview

Activity Snapshot

Learners interpret the spectra of reflected light from various objects.

Timing | 45 minutes

Get Ready and Team Up	10 min.
Introduce Spectroscopy	25 min.
Reflect	10 min.
Total	**45 min.**

Level Up Activities 5–30 min. each

Prep Snapshot*

Prep Time 50 min.

At least two days ahead, create tactile spectra graphs and allow them to dry.

Determine how learners will access audio files.

**See Materials & Preparation for full info.*

21st Century Skills

Connection

- Critical Thinking

Science Practice

- Analyzing & Interpreting Data

Guiding Question

How can measuring reflected light help us identify different materials?

Learners Will Do

Interpret spectra to identify different materials.

Learners Will Know

Spectroscopy measures how much light of different colors (both visible and invisible) is coming from a material.

Connecting Across Activities

Activity 5: Topography on Mars	Activity 6: Introducing Spectroscopy	Activity 7: Using Spectroscopy to Understand Mars
Last time, learners interpreted topographic maps of Mars to locate interesting landforms and to determine the safest place for a rover to land. These maps are the second set of data they will use to choose a landing site.	**Today**, learners learn how to interpret spectra of light from various objects, which will later help them identify minerals from a distance.	**Next time**, they will interpret spectra to identify minerals at each of the different landing sites. These graphs are the third set of data they will use to choose a landing site.

Activity Resources

Access videos and digital resources using the link or QR code below. More information for teaching this curriculum is available in the Educator Guide Introduction, pgs. iii-xxvi. Access more PLANETS units, research, and pathways at https://planets-stem.org/.

QR Code for Activity Resources

weblink: https://hov.to/d728601d

Materials and Preparation

Materials

For the whole group

- *Our Ideas* poster (on paper or a shared digital document) in Prep & Setup Guide (PDF)
  Examples | Templates
- Assorted rocks and minerals, small, such as gravel mixture
- Science Activity 6 Audio Files (weblink)
- Audio player and speaker
- School glue or puff paint (optional)
- Sand or glitter (optional)
- Computer with internet access (optional)

Optional: Printed swell paper (webblink) or assembled tactile models, enough for half the groups:

- 3 copies of tactile model of *Electromagnetic Spectrum*, pg. 8 in the Science Notebook (PDF)
- 3 copies of tactile model of *Green Paint*, pg. 9 in the Science Notebook (PDF)
- 3 copies of tactile model of *Red Paint*, pg. 10 in the Science Notebook (PDF)
- 3 copies of tactile model of *Olivine*, pg. 11 in the Science Notebook (PDF)

For each learner

- Science Notebook (PDF)

Activity 6 Materials Preparation (60 min., at least two days ahead of time)

Ahead of Time

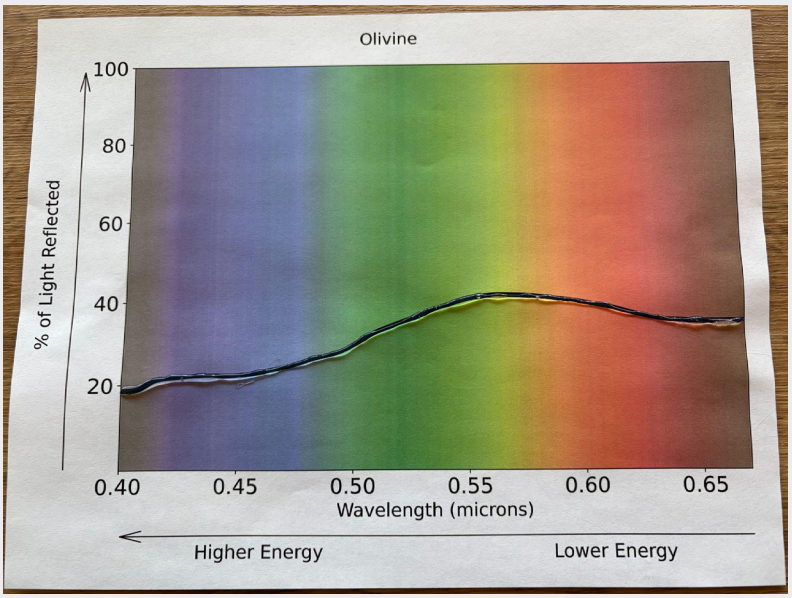
1. Review the *Our Ideas* poster "In-Use Example" in the Prep & Setup Guide - Examples (PDF) to help you think about what to add to the *Our Ideas* poster during the discussions in this activity.
2. Determine how you will share the audio files on the day of the activity with the whole group. You have the option to download the audio files or access audio files online (weblink).

Support Learner Differences

Although it is listed as optional, all learners will benefit from interacting with a tactile version of the spectra, and it will make for a more enriching experience. Learners trace the reflectance lines with their fingers as they listen to the audio files, making them active participants versus passive listeners. This will strengthen their connection to understanding the changes in the light that comes from the materials.

Print these on swell paper with Braille at this weblink or prepare a tactile model by adding a line of glue or puff paint to the data line, to each of the axes, and on either side of the visible spectrum of *Electromagnetic Spectrum, Red Paint, Green Paint,* and *Olivine*, pgs. 8-11 in the Science Notebook (PDF). Ensure you have a space to let the graphs dry.

Consider sprinkling the glue with a bit of fine sand or glitter to add additional texture (see photo below). Make enough for half the learners in your program to access the tactile graphs at once.



A tactile version of the visible portion of olivine's spectrum

Teaching Tip

If you are planning to make the tactile graphs, consider also preparing the tactile graphs for Activity 7 at the same time. See Activity 7 Materials Preparation, pg. 80.

In Your Space

3. Place the *Our Ideas* poster in a visible place in your learning setting or prepare to share it digitally.

Activity Guide

Get Ready and Team Up (10 min.)

1. Ask: **If you did the last activity, what did you do and why?** (*We interpreted topographic data to find interesting landforms and to determine the safety of each landing site*). Draw learners' attention to their findings about landforms and topography on the *Our Ideas* poster.
2. Say: **Our challenge is to choose the best landing site to search for past liquid water.**
3. Say: **Today we'll focus on what Mars is made of to determine whether water was once there.** Refer to the questions on the *Our Ideas* poster about what the planet is made of, what rocks and minerals are present, and the presence of past water needed for life. If learners do not mention water, ask them what types of things NASA is interested in learning about Mars and why. It is important they focus on water for the rest of the activity. Share the Guiding Question or a similar question from the *Our Ideas* poster with learners aloud and in writing (using multiple languages as needed): **How can measuring reflected light help us identify different materials?**
4. Organize learners into groups of four and distribute Science Notebooks.

Support Learner Differences

If new learners are joining you, lead an inclusion activity (pgs. xx-xxi) and use other engagement strategies as necessary (pgs. iii-xxvi).

Teaching Tip

Learners may not have asked questions about minerals directly, but they may have asked related questions. For example, "Was there life on Mars?" can be answered by looking for minerals that form in water. Reinforce the connection between evidence for past water on Mars and the possibility of past life.

Introduce Spectroscopy (25 min.)

5. Give each group some rocks and minerals to examine for several minutes. Write the word *minerals* on the *Our Ideas* poster. Say: **There are not any plants on Mars, but there are a lot of rocks and minerals. Where have you heard the word *mineral*?** *(Precious minerals, minerals in our diet, etc.)* **What do you already know about minerals?** *(Minerals occur naturally and form crystals, including quartz, salt, and diamond.)* Have learners discuss in groups and add their answers to the *Our Ideas* poster.
6. Say: **Each kind of mineral forms in a certain way. Some minerals form only in water, so knowing which minerals are at each landing site can help us understand whether that site once had water.** Ask: **How might we figure out what kinds of rocks and minerals these are?** *(Weighing them, shining light on them, showing them to someone, etc.)*

Teaching Tip

Learners may know the terms *hardness*, *crystal structure*, *luster*, and *streak*, but it is not important to introduce these terms. Focus on the ways someone can collect evidence if they physically have a mineral.

7. Say: **Because we cannot touch the surface of Mars, we cannot use most of the ways scientists identify minerals on Earth. We must rely on cameras and other technologies on spacecraft orbiting Mars and on rovers on the surface. One useful way to learn about the world remotely is through color. That's why humans and many animals have color vision. Let's explore this idea a bit, before we come back to identifying minerals.**

8. Invite learners to review the colors marked "visible spectrum" on *Electromagnetic Spectrum*, pg. 8 in their Science Notebooks. Say: **This diagram describes all types of light, visible and invisible, in a range of colors, or a spectrum.** Write the word *spectrum* on the *Our Ideas* poster. Say: **Notice that the part marked "visible spectrum" is only a small portion of the diagram. Most light cannot be seen by human eyes.** Ask: **What does this visible spectrum remind you of?** *(It looks like a rainbow).* **What do you know about rainbows?** *(They come out after rainstorms and when light passes through prisms.)*

9. Say: **When humans see a rainbow we are actually seeing all the visible colors of light.** Ask: **Besides rainbows, what other kinds of light listed here are familiar to you? What kinds are unfamiliar?** *(Ultraviolet light might be familiar because of sunscreens and blacklights; infrared light can be felt as warmth from heat lamps, etc.)*

10. Invite learners to notice the area marked "energy" on *Electromagnetic Spectrum*, pg. 8. Say: **Light's color is a measure of its energy. In the visible spectrum, violet light has the most energy and red light has the lowest energy.** Point out ultraviolet, x-rays, gamma rays to the left of violet and infrared, microwaves, and radio to the right of red as you say: **Light with more energy than violet and light with less energy than red is invisible to humans.**

11. Say: **To identify different materials, scientists worked with engineers to design a technology that measures the colors of light coming from those materials. Because this technology measures a range of colors, or a spectrum, it is called a *spectrometer*.** Write the word *spectrometer* on the *Our Ideas* poster.

Support Learner Differences

If prepared, distribute the tactile model of *Electromagnetic Spectrum*, pg. 8 in the Science Notebook (PDF).

Support Thinking

Play the video The Electromagnetic Spectrum to support understanding of spectra and spectroscopy.

Level Up!

Tell learners that many planets and moons are exposed to gamma rays and other types of radiation, or light energy from the Sun, that would be hazardous to humans. But just as we can learn information from visible and infrared data, we can learn things from gamma ray and x-ray data. The Mars Odyssey GRS (Gamma Ray Spectrometer) instrument detects gamma rays and other types of radiation to learn about the chemistry of the surface of Mars. The Radiation Assessment Detector on the Curiosity rover on Mars monitors radiation from space and will let us know how much shielding from radiation future Mars astronauts will need to be protected. (<5 min.)

12. Point to the source of light in the room as you say: **When all of the colors in the spectrum come from the same place at about the same brightness, such as from the sun or a light bulb, human brains interpret that as white light. But, when more of one color than the others bounces off or is reflected back from an object, humans perceive it differently. For example, when humans see a stop sign, a lot of red light is reflected back, so we perceive it as red.**

13. Say: **Scientists often display data collected by spectrometers in a graph that is also called a *spectrum*. If we have more than one spectrum, we say *spectra*. We are going to study some spectra now.**

14. Say: **Look at *Green Paint*, page 9 in your Science Notebooks. The graphed line, or spectrum, shows how much light of each color bounces off, or is reflected from, paint. If the sun shines on green paint, the paint absorbs most colors but reflects green light. Where the line is high, that color of light is reflected.** Ask**: Where on the graph does the green paint reflect the most visible light?** *(The peak in the graph is in the green band of light, so the green paint reflects the most visible light in the green range).* **Human eyes perceive objects as being different colors based on how much of each color of visible light they reflect. What color will the paint be to human eyes?** *(You can tell from the peak in the graph on the green band of light that it will appear green).*

Support Thinking

To support understanding of the word spectrometer, display the word and explain that it comes from roots spec, meaning "to observe," and meter, meaning "measure." Have learners think of other words that come from similar roots, such as spectator (someone who observes), spectacle (something people observe), thermometer (a tool for measuring temperature), and pedometer (a tool for measuring steps).

Level Up!

If time permits, allow learners to explore electromagnetic radiation through experience with prisms or heat lamps and explore how wavelength and frequency change based on the amount of energy put into a system using Slinkys. (20 min.)

Learners may also view the NASA Science Activation Network's e Clips videos that talk about and use the electromagnetic spectrum. Based on your group, consider replacing or adding to the above explanation with the video *Using Light to Find Out What Things are Made of (Spectroscopy)*. (5 min.)

Support understanding of spectrometers by having learners build their own spectrometers using the first activity in the PLANETS Remote Sensing @ Home Activity (weblink) or explore resources about spectrometers before introducing the term *spectrometer*. (30 min.)

This unit's engineering pathway activities (PDF) challenge learners to design technologies similar to spectrometers that will help scientists distinguish between different materials.

Support Learner Differences

If prepared, distribute tactile models of Green Paint and Red Paint, pgs. 9-10 in the Science Notebook (PDF).

15. Say: **Now look at the spectrum of *Red Paint,* page 10. Where on the graph does this paint reflect the most visible light?** *(In the red band).* **What color will human eyes see?** *(Red)*.

16. Say: **The amount of reflected light can be represented by lines on a graph, but it can also be represented using sounds. I will play audio files of the spectra for the two colors of paint.** Use hand gestures and your voice to indicate changes as you say: **Before I play them you must know that**

    - The pitch, or how high or low the sound is, matches how much light is reflected as you go from left to right on the graph.
    - As the pitch goes down, less light is reflected. As the pitch goes up, more light is reflected.
    - Beeps represent the wavelengths on the bottom of the graph.

Support Thinking

To help learners understand what they will be doing next, show the translatable video RS Science How To (from 1:08).

Green Paint: https://hov.to/a1f474fc

Red Paint: https://hov.to/91f10b77

17. Say: **Compare the audio file of the green paint spectrum to the audio file of the red paint spectrum (links or QR codes above) while exploring the graphs in your Science Notebooks. Trace the graphs with your fingers as you listen to the sounds.** Play the two files a few times. Ask: **What differences do you notice between the sound of the green paint spectrum and the sound of the red paint spectrum?** Encourage learners to use gestures and voice to illustrate their ideas. *(The red paint audio is higher in pitch and is fairly steady. The green paint audio is lower in pitch and fluctuates.)*

18. Say: **Planetary scientists use spectrometers to identify minerals on other planets. Look at the spectrum of a common volcanic mineral called *Olivine* on page 11 of your Science Notebooks.**

Support Learner Differences

If prepared, distribute the tactile model of Olivine, pg. 11 in the Science Notebook (PDF).

19. Say: **Now I will play the audio file of the spectrum of olivine, so you can compare it to the sounds of the paint color spectra. Listen to the audio while exploring the graphs.** Play the audio file of olivine visible only (QR code and link below).

Olivine Visible Only: https://hov.to/1de476a4

20. Ask: **What do you notice about the spectrum of light reflected by olivine? Is olivine's spectrum more like the green paint or the red paint? What color will olivine be to human eyes?** *(In the colors visible to humans, olivine reflects more green than other colors. Its spectrum is more like the green paint's spectrum, so it will appear green to human eyes.)*

Teaching Tip

To learn more about spectroscopy, see this webpage for the Educator Background.

Support Thinking

Contrast LiDAR and spectroscopy. Explain that while LiDAR measures the *time* it takes for light of one energy to bounce between the aircraft and the surface of a planet, spectrometers measure the *intensity* (or *brightness*) of the light the surface reflects at many different energies/colors.

Reflect (10 min.)

21. Revisit the Guiding Question on the *Our Ideas* poster: **How can measuring reflected light help us identify different materials?** *(We can tell what color something is by how much light it reflects.)* Remind learners of the terms *minerals*, *spectrum*, and *spectrometer*. Ask: **What questions do you still/now have?** Allow time for learners to add questions.

22. Ask: **When might it be useful to know about light beyond the visible spectrum?** *(Studying ultraviolet light helps us to develop sunscreens, x-rays help us see broken bones, NASA shields astronauts from gamma rays, etc.)* Consider returning to learners' ideas at the start of the next activity.

23. Say: **Good job working as scientists today! Now you are prepared for next time, when you will use spectra to identify minerals at each of the potential landing sites. Remember, the process you are following is like the process NASA uses to choose landing sites.**

After the Activity

1. Clean up:
   - Keep the *Our Ideas* poster for Activity 7.
   - Collect the Science Notebooks and tactile spectra.
2. Plan ahead for Science Activity 7. See Activity 7 Materials Preparation, pg. 80.
3. Take time to reflect on the following educator prompts: **How did you connect the topics in this activity, such as colors and types of light, to learners' prior knowledge and experiences? What strategies can you use again in the future?**

Remote Sensing Additional Resources

QR code leads to resources available for this unit.

weblink: https://hov.to/248cf0d9