Driving Question: How can we tell if a planet is habitable without visiting that planet?

Middle School • Discipline: ESS and PS • Time: Two 50-minute class periods

Lesson Level Performance Expectation:
• Find patterns in data from the TRAPPIST-1 System and our solar system and use mathematical concepts to construct an explanation of why TRAPPIST-1e is classified as being in the habitable zone of its system.
• Use an understanding of patterns in light interactions to construct an explanation of how scientists can use telescopes to determine the presence of liquid water on distant planets.

What Students Will Figure Out
• The habitable zone is the range of distances from a star where liquid water might pool on the surface of an orbiting planet.
• Light interacts with different objects (substances) in characteristic ways. Light that travels through a planet’s atmosphere can reveal the composition of the atmosphere (spectroscopy).

Lesson Snapshot:
Students analyze and interpret data from our solar system and the TRAPPIST-1 System and look for patterns among the systems that can be used to identify a cause-and-effect relationship between star temperature and habitable zone location. Students engage with text and video to learn that the boundaries of the habitable zone are determined by the highest and lowest temperatures at which water can exist as a liquid.

Students use a model to help explain how TRAPPIST-1 (star) light transmitted through TRAPPIST-1e’s atmosphere and gathered by the James Webb Space Telescope reveals the composition of the atmosphere. Students use gathered evidence and scientific information from NASA-produced articles and videos to construct an explanation of how we can tell if TRAPPIST-1e is habitable without actually visiting that planet.
Phenomenon: TRAPPIST-1e is an exoplanet that could support life.

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
</table>
| **Analyzing and Interpreting Data** | **ESS1.A: The Universe and Its Stars**  
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2) | **Patterns**  
- Graphs, charts, and images can be used to identify patterns in data. |
| **Using Mathematics and Computational Thinking** | **ESS1.B: Earth and the Solar System**  
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3) |  |
| **Constructing Explanations** | **PS4.B: Electromagnetic Radiation**  
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) |  |
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2), (MS-PS1-3) |  |

This lesson could be one in a series of lessons building toward the following Performance Expectation:

**MS-ESS1-3.** Analyze and interpret data to determine scale properties of objects in the solar system.

[Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.]

[Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]

**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.]
Driving Question: How can we tell if a planet is habitable without visiting that planet?

Materials

Student Materials
Per Pair
- Tablet or computer
- NASA: Exoplanet Catalog TRAPPIST-1e
- NASA: Solar System Exploration
- NASA: What is the habitable zone or “Goldilocks zone”?

Per Small Group (2 to 4 students)
- Flashlight
- Red transparent film square (5.0 cm x 5.0 cm)
- Green transparent film square (5.0 cm x 5.0 cm)
- Blue transparent film square (5.0 cm x 5.0 cm)
- Additional colors of transparent film may be used, but are not necessary.
- Prism may be used but is not necessary.
- Sheet of white paper (8 ½ in x 11 in)

Teacher Materials
- Hunt for Planet B Slide Deck
- NASA: What Is the Habitable Zone? (video)
- NASA: The Search for Life (optional article)
- How Webb Will Study Atmospheres of Exoplanets (video)
- Prism (optional)
- Scholastic: Habitable Planet clip (from The Hunt for Planet B) found on the web page Scholastic Discovering the Universe (video)

Optional Teacher Resources
- CNN Films: The Hunt for Planet B
- NASA: What is a Light-Year?
- Scholastic: The Hunt for Planet B Video, Transcripts in English, Spanish, Arabic, Korean, Japanese, and Polish
- NASA: Is There Life on Other Planets?
- NASA: How Do We Use Spectroscopy to Search for Life?

Lesson Preparation

Previous Knowledge
This lesson builds on students' prior understanding of the following Disciplinary Core Ideas developed in previous units.
- PS3.B: Conservation of Energy and Energy Transfer
- PS4.A: Wave Properties
- PS4.B: Electromagnetic Radiation

Material Set-Up
- Cut transparent color film (blue, green, and red) into 3 cm x 3 cm squares.
- Create transparent color film sets (one each of blue, green, and red film squares) for each student group.

Pictured at right: Large squares of transparent film and smaller squares cut to fit inside 35 mm slide mounts (glassless). Use of slide mounts supports repeated use, but is not necessary.
Experience the Phenomenon

What Students are Doing:
In this section, students continue to investigate similarities and differences between our solar system and the TRAPPIST-1 system to determine how the boundaries of habitable zones are defined. From there, students investigate light transmitted through different substances. Students use their data and presented absorption data to build understanding of how light transmitted through atmospheres of exoplanets and collected by the James Webb Space Telescope are used to determine the presence of liquid water.

Teacher Guidance

1. **Tell students that you have a phenomenon you want to share with them.**
   The most studied planetary system, aside from our own solar system, is TRAPPIST-1, located about 40 light-years away from Earth. The exoplanet TRAPPIST-1e lies in the habitable zone of the TRAPPIST-1 planetary system.
   Project the top half of the What Is the Habitable Zone? diagram on slide 2 of the deck.
   Give students one minute in the alone zone to make and record observations and note questions that arise. Provide time for students to share their observations and questions with a partner. Invite students to share questions with the class.

   **Potential Student Questions**
   - How do we study our solar system?
   - How can you study a planetary system that is so far away?
   - How do we know this planetary system exists?
   - Why is it called TRAPPIST-1?
   - Why are we studying a planetary system that is so far away?
   - Has anyone traveled to these planets?
   - What does habitable zone mean? (What is a habitable zone?)
   - Do the planets in the habitable zone have life on them?
   - How do we know where a habitable zone starts and stops? Does it have a clear beginning and end?
   - Does our solar system have a habitable zone?

2. **Point out that many students have questions about the habitable zone.**
   Tell students that comparing our solar system with the TRAPPIST-1 System could provide answers to some of their habitable zone questions.

   **Additional Guidance: Specialized Language in Science**
   Habitable. Make sure all students understand the meaning of habitable.

   Light Years. If students are not familiar with the term light-year or are having a difficult time understanding how far the TRAPPIST-1 System is from Earth, consider showing them the What is a Light-Year video from NASA.

Investigate the Phenomenon

What Students Are Doing
In this section, students continue to investigate similarities and differences between Earth and TRAPPIST-1e to determine what it means for a planet to be located in the habitable zone of its star. From there, students watch videos and examine a picture of refraction to consider how scientists can use their understanding of light interactions with matter, telescopes, and spectroscopy to identify water on distant exoplanets.
Teacher Guidance

3. Project the diagram with the TRAPPIST-1 System and our solar system on slide 3.

Ask students to work with a partner to identify and record similarities and differences between the TRAPPIST-1 System and our solar system. Ask students to also note any questions that arise as they compare the two systems.

Ask student pairs to share similarities, differences, and questions with the class and build a class similarities and differences chart. A sample of a class chart is provided below.

<table>
<thead>
<tr>
<th>TRAPPIST-1 System and Our Solar System Similarities</th>
<th>TRAPPIST-1 System and Our Solar System Differences</th>
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</tr>
</thead>
<tbody>
<tr>
<td>• Both systems have a central star (planets orbit a star).</td>
<td>• The TRAPPIST-1 System is a lot smaller than our solar system. The whole TRAPPIST-1 System fits inside the orbit of Mercury.</td>
<td>• Does the planet need to be in the middle of the habitable zone to have life? (Earth is in the middle and has life; Venus and Mars don’t have life.)</td>
</tr>
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<td>• Both systems have more than one planet orbiting the central star.</td>
<td>• The planets in the TRAPPIST-1 System look closer to one another than the planets in our solar system do.</td>
<td>• Earth has life on it. Do scientists think TRAPPIST-1e has life on it?</td>
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<td>• Both systems have a habitable zone.</td>
<td></td>
<td>• Why does the habitable zone stop and start where it does in both systems? (How do you know where the edges are?)</td>
</tr>
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<td>• Both systems have more than one planet in its habitable zone.</td>
<td></td>
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</tr>
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<td>• Both planets (Earth and TRAPPIST-1e) are not the closest to the star in their solar system, but not the farthest away, either.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The habitable zone starts a little way away from the star and doesn’t go all the way out to the edge.</td>
<td></td>
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Ask students what they think a habitable zone is and which observations support their answer. You might have students do this individually or in pairs. Students do not need to share at this time. They will revisit their thinking later in the lesson.

SOURCE: NASA
4. Share that you have another source of data that could further support students’ ideas about habitable zones and address other questions about habitable zones and TRAPPIST-1e.

Direct students to NASA Exoplanet Catalog TRAPPIST-1e. Ask students to work with a partner to analyze the data and continue to add to their own similarities and differences chart. If there is time, students can also explore the NASA Solar System Exploration page.

Use the annotated image below to support students’ use of the NASA Exoplanet Catalog TRAPPIST-1e web page.

On the NASA Solar System Exploration web page, tell students to focus on the inner solar system for our solar system if they are struggling to make comparisons between the two planetary systems.

Ask students to share with the class the similarities, differences, and questions they recorded. Add to the class similarities and differences chart. Anticipated additions to the chart are in **boldface** text.

**Revised Class Similarities and Differences Chart**

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<td>• Both systems have a habitable zone.</td>
<td>• TRAPPIST-1e only takes 6.1 days to orbit its star; Earth takes 365 days.</td>
<td>• Why does the habitable zone stop and start where it does in both systems? (How do you know where the edges are?)</td>
</tr>
<tr>
<td>• Our solar system has three planets in the habitable zone. The TRAPPIST-1 System has three planets in the habitable zone (1e, 1f, and 1g).</td>
<td>• TRAPPIST-1e is much closer to its star than Earth is to the Sun. (Earth is 1 AU from its star; TRAPPIST-1e is .02925 AU from its star.)</td>
<td>• What are the blue parts of TRAPPIST-1e? Is that water/ocean?</td>
</tr>
<tr>
<td>• Both planets (Earth and TRAPPIST-1e) are not the closest to the star in their solar system, but not the farthest away, either.</td>
<td>• TRAPPIST-1e is almost the same size as Earth (radius 0.92 x Earth)</td>
<td></td>
</tr>
<tr>
<td>• Earth and TRAPPIST-1e both have blue areas (oceans?).</td>
<td>• The habitable zone starts a little way away from the star and doesn’t go all the way out to the edge.</td>
<td></td>
</tr>
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<td>• TRAPPIST-1e is almost the same size as Earth (radius 0.92 x Earth)</td>
<td>• TRAPPIST-1 is redder, cooler, and dimmer than the Sun.</td>
<td></td>
</tr>
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<td>• The habitable zone starts a little way away from the star and doesn’t go all the way out to the edge.</td>
<td></td>
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5. Revisit students’ initial thinking about habitable zones.

Give students time to individually add to and/or change their thinking about habitable zones. If students do not have additions/changes, ask them to circle ideas that are further supported by new observations. Pair students and ask them to share what they added/changed or circled and the observations the revisions or supported ideas are based on.

Ask students to share their ideas about the characteristics of a habitable zone. (What makes a habitable zone *habitable*?) Support students in reaching a tentative conclusion. The following prompts may be helpful.

- What ideas do we have about the characteristics of habitable zones? What makes a habitable zone *habitable*?
- How did you arrive at that conclusion?
- Does it always work that way? (Push students to think deeper about why the habitable zone size/location of our planetary system is different from the habitable zone size/location of the TRAPPIST-1 System.)
- Can you clarify what you mean by _______? (Press students to clarify what they mean by “not too close and not too far from the star” or “not too hot or not too cold” —not too close/too far or not too hot/too cold for what? You might reference students’ earlier observation/question about TRAPPIST-1e depicted with what looks like water/oceans on the surface.)
- What can we conclude? What new questions do we have?
Driving Question: How can we tell if a planet is habitable without visiting that planet?

**Middle School • Discipline: ESS and PS**

6. **Tell students to read the short article What is the habitable zone or “Goldilocks zone”?** and/or show the video *What Is the Habitable Zone?*
   Consider providing students a thinking routine like Connect, Extend, Challenge to scaffold students in supporting and/or revising their current understanding of what makes a habitable zone habitable.

   If time permits, give students an opportunity to compare their thinking in small groups. Ask groups to share connections; after each share, ask remaining groups to indicate if they made similar connections (thumbs up/thumb down, for example). When all connections have been shared, move on to extensions. Students may share that life on Earth started in water, all stars have habitable zones, and some habitable zones are empty (no planets exist within the habitable zone).

   Before inviting new questions, return students’ attention to their questions posted on the class similarities and differences chart. Ask students to identify which questions have been answered and which questions remain. Ask students if they have new questions or would like to revise the remaining questions.

   Summarize what students have figured out so far about habitable zones. Use students’ observations and/or questions about TRAPPIST-1e depicted with surface oceans/waters or other questions about the potential for water on TRAPPIST-1e to coherently transition to the next day of the lesson: We know liquid water can exist on TRAPPIST-1e because it’s in the habitable zone, but many of us are wondering how we can figure out if water exists on a planet 40 light-years away from Earth.

**Additional Guidance: Alternative Text**
Depending on time, reading level, and students’ interest, you might use the article *The Search for Life* instead of the shorter What is the habitable zone or “Goldilocks zone”?

**Additional Guidance: Exit Ticket**
A possible exit ticket task could be to ask students to choose one question they posed earlier in the lesson and consider if they can answer it using observations and/or scientific information from the texts and media they explored.

**Additional Guidance: Suggested End of Day 1**
This lesson is estimated to take two 50-minute class periods to complete. If possible, we suggest ending the first day after Step 6. It is a moment when students reflect on what they have figured out so far and focus on a new question: How can we figure out if water exists on a planet 40 light-years away from Earth?

7. **Remind students we are wondering how to figure out if water exists on TRAPPIST-1e without visiting the planet.**
   Tell students that the use of telescopes is required when studying objects very far from Earth. Telescopes are designed to receive and concentrate light. Different types of telescopes are designed for looking at different types of light (x-ray, ultraviolet, visible, infrared, etc.).

8. **Project the video How Webb Will Study Atmospheres of Exoplanets.**
   Tell students that the James Webb Space Telescope is gathering light from the TRAPPIST-1 System (as well as many other planetary systems). Say that you have a video, *How Webb Will Study Atmosphere of Exoplanets*, that provides information about how gathered light can reveal the presence of water and other substances in a planet’s atmosphere.
Show the video. Ask students to record ideas and information that will help answer their question about how we can figure out if water exists on TRAPPIST-1e without visiting the planet.

Ask students to work individually or with a partner to use ideas and information presented to answer this question: How can we figure out if water exists on TRAPPIST-1e without visiting that planet? If students work individually, allow two minutes for students to exchange their thinking with a partner.

Invite a few students to share their initial answers with the class. The following prompts are provided to support students in sharing and listening to one another.

• What do you mean by that? Can you give an example?
• Who can repeat what [student’s name] just said or put it into their own words?

Listen for students to share ideas about “different wavelengths being absorbed” and “wavelengths of starlight are missing” in response to the question.

Use these ideas or new student questions that arose during their shares to move students to think about what missing wavelengths of starlight might look like (that is, how you know when some of the light from a star has been absorbed/is missing).

Suggest that the class investigate what light looks like when some of that light is absorbed (goes missing). If students offer terms and/or descriptions of absorption or emission spectra, consider saying, “That’s interesting. Let’s see if we can gather evidence to support your claim(s).”

9. Prepare students to investigate absorption and transmission of light shined through different substances (color transparent films).

Tell students you have materials available to model light passing through an atmosphere, and that they will use the model to collect data to test their ideas about what it looks like when some of the light passing through the atmosphere is absorbed (goes missing).

Show students the flashlight, transparent color films, and white paper. Shine the flashlight through one of the color films and onto the paper. Ask students what each component of the model represents in the real world. Students will likely easily recognize that the flashlight represents a star (starlight) and the paper represents the James Webb Space Telescope (or simply, telescope). Students may need help recognizing that the color film represents a substance in the atmosphere (like water, oxygen, and carbon dioxide are substances in Earth’s atmosphere).

If you have a prism available, show students that the white light from the flashlight is composed of red, yellow, orange, green, blue, and violet light. If no prism is available, remind students that white light is a combination of these colors.

10. Students investigate absorption and transmission of light shined through different substances (color transparent film).

Place students in small groups of three or four and distribute the materials.

Investigation Option 1 (no prism)

Direct students to use the model to collect data about light passing through different substances (color films). Ask them what they think they should include in their observations of the light that passes through the color film and onto the white paper.

Make sure to let students know that later they will use their observations to determine which color film (or films) the light passed through. The color film(s) will be hidden from their view.

As you move around the room, use the following prompts to move students to think deeper.

• Which colors do you think are being transmitted through the [color] film? Which colors do you think are being absorbed (or partially absorbed) by the [color] film?
• What happens when light passes through two color films held together? Three films? Make sure to record your observations.
Driving Question: How can we tell if a planet is habitable without visiting that planet? 

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• Can you think of other ways (besides color) to describe the light transmitted through the color film(s)?
• How might you quantify the amount of light passing through the color film? How might you quantify the amount of each color of light transmitted?

Investigation Option 2 (with prism)

Show students how to separate white light with the prism; project the “rainbow” onto the white paper (the paper may be on the floor or taped to a wall). Place the filter between the flashlight and the prism. Conduct the investigation as described under Option 1.

The benefit of using a prism is that students can clearly see the color film transmits a lot of the same color as the film, but also a small amount of other colors. The changes in absorbed/transmitted light from one to two stacked color films also become easier to describe/identify.

11. Ask students to use their data to determine the color film(s) light has passed through.

Shine light through different color films and onto a white surface (whiteboard, white paper hung on wall, etc.). Make sure the color film is not visible to students. Ask students to identify the color film using their data.

Make the connection that astronomers also make and record observations of light passing through known substances—for example, water, oxygen, carbon dioxide, and methane—and then use their data to identify an unknown substance based on the light received by a telescope. Tell students that this understanding is used across the sciences to identify substances, from forensic science to studying distant exoplanets.

12. Move the conversation from qualitative to more quantitative thinking about light absorbed and transmitted by different substances.

Ask two or three students to share the different ways they described the light transmitted through the color films and onto the white paper. Consider quickly polling the class (thumbs up/thumbs down) after each sharing to see if other students used similar or different methods/strategies to describe the transmitted light. Invite students who responded “thumbs down” to all sharings to tell the class their method/strategy for describing transmitted light.

Next, ask if anyone tried to quantify how much light was transmitted through each color film. Did they try to quantify each color of light that was transmitted? Some students may have tried using a light meter app. Students who conducted the investigation using prisms may have tried using relative scales (for example, mostly red, then orange, then little bits of green and blue).

Tell students that instruments that measure the intensity (amount) of transmitted light do exist; these tools are able to measure the intensity of each color of white light or wavelength. Intensity of transmitted light at different wavelengths outside the visible spectrum can also be measured.

Project slide 4. Point out that these data are measurements of the amount of light absorbed by the red film at different wavelengths. Make sure students understand the relationship between measurements of absorbed and transmitted light before continuing.

Ask students to compare their observations of light transmitted through the red filter to the data presented on the graph. How is their data similar to the data presented on the graph?
Different? After a minute, ask students to share their patterns of similarities and differences with a partner. Students may identify that they described light transmitted through the red color film and the graph describes light absorbed by the red film (pattern of difference). Similarities may include that student data and the data presented in the graph indicate red film transmits mostly red light (or doesn’t absorb much red light). Students who used prisms in their investigations will likely notice that the other colors that make up white light were transmitted “a little bit” (or absorbed “a lot,” but not completely).

Project slide 5. Tell students that the data presented on this graph was collected by shining visible light (and near-infrared) through liquid water. Like the previous graph, the data are measurements of the amount of light absorbed by liquid water at different wavelengths. Make sure to tell students that the interaction of light with a substance (absorption, transmission, reflection) is a characteristic property of that substance. At similar temperatures, liquid water will reflect, absorb, and transmit the same way no matter where the water is found.

Help students make the connection between the data presented in the graph and the information presented in the How Webb Will Study Atmosphere of Exoplanets video. What would students (scientists) expect to see when they look at light transmitted through an atmosphere that contains liquid water?

13. Share the video clip Habitable Planet from the film The Hunt for Planet B.

Play the Habitable Planet video clip from The Hunt for Planet B (housed on the Scholastic Discovering the Universe web page). Students will likely recognize features of the “spectrum of a habitable planet” presented in the video. The absence of x- and y-axes make it impossible to interpret the graph. However, it does provide an opportunity to show that characteristic absorption/transmission of light by different substances can be recognized in the light received by a telescope (as students observed when light was transmitted through stacked color film and onto the white paper).

Additional Guidance: NASA’s James Webb Space Telescope

To continue exploring NASA’s James Webb Space Telescope and telescopes with your students, consider sharing the following resources.

- CNN Films: The Hunt for Planet B film
  The Habitable Planet clip is part of a documentary called The Hunt for Planet B. The film outlines the work behind NASA’s James Webb Space Telescope launch. In doing so, it introduces viewers to a wide variety of scientists and engineers who contributed to the launch or who will use the telescope to study exoplanets.
- NASA: James Webb Space Telescope (JWST)
- NASA: First Images from the James Webb Space Telescope
- NASA: How Do Telescopes Work?
Explain the Phenomenon

What Students Are Doing
In this section, students explain how we can tell if TRAPPIST-1e is habitable without visiting the planet.

Teacher Guidance

14. **Tell students that they will use gathered evidence and scientific information to explain how we can tell if TRAPPIST-1e is habitable without visiting the planet.**

Review the sources of data and scientific information students can use to support their explanation.

- Class similarities and differences chart
- NASA Exoplanet Catalog TRAPPIST-1e
- NASA article *What is the habitable zone or “Goldilocks zone”?*
- NASA video *What is the Habitable Zone?*
- NASA video *How Webb Will Study Atmosphere of Exoplanets*
- Light investigation with color transparent film

15. **Direct students to write an explanation of how we can tell if TRAPPIST-1e is habitable without going to the planet.**

If students are struggling to begin a written explanation, encourage them to first create a model using words, pictures, symbols, colors, etc. to explain how we can tell if TRAPPIST-1e is habitable without going there. Students can use their model to construct a written explanation. Consider having students present their model for peer feedback (next step) before writing their explanation.

16. **Facilitate peer review.**

Ask students to form groups of four. Have the students bring their individual explanation (or model) to the group. Consider providing sentence starters to support students in giving specific and actionable feedback. A few examples of sentence starters appear below.

- We like how you _____. It would be more complete if you added ________.
- We agree that _______. We think you should add more evidence from the _______ investigation.
- We agree with your claim that _______. We disagree that the __________ (evidence) you used matches your claim.

Direct students, working in pairs, to provide feedback to the other two student explanations. They can use adhesive notes to communicate their feedback and can post them on the explanations.

17. **Direct students to use the feedback to revise their explanations.**

Sample Student Explanation

TRAPPIST-1e is in the habitable zone of its planetary system because it is at a distance from its star where the temperature is neither too hot nor too cold for water to exist as a liquid. TRAPPIST-1e is a lot closer to its star than Earth is to the Sun, but the TRAPPIST-1 star is a lot cooler than our Sun, so it ends up being the right temperature.

Just because TRAPPIST-1e is in the right place for the right temperature for liquid water doesn’t mean that water exists on the planet. To figure out if water exists on TRAPPIST-1e, scientists will need to use the James Webb Space Telescope. The telescope will allow us to study TRAPPIST-1e without making the 40 light-year trip to the planet. The telescope will collect light from TRAPPIST-1 that went through TRAPPIST-1e’s atmosphere. Scientists will look to see if some light is missing. If the missing light is the light that water absorbs, they’ll know water is there.
Extension

STEM Careers: Explore the Universe

STEM Career Awareness is an important part of educating and preparing our students for the future workforce. Students can explore the challenging and rewarding careers of planetary scientist, astrobiologist, and systems engineer by watching and discussing the videos below.

1. **Play the videos below for students.**

   **Day at Work: Planetary Research Scientist**
   NASA Ames planetary research scientist Natasha Batalha was featured in the film *The Hunt for Planet B* (*Hunt for Planet B Clip: TRAPPIST-1e*). In this video, her colleague Margarita Marinova, also a planetary research scientist at NASA Ames Research Center, takes us to Antarctica to talk about her research on extreme environments.

   **Astrobiology: The Search for Life Beyond Earth | Marta Filipa Cortesão**
   What other environments are there in our solar system and beyond? Could they support life? What would that life look like? Like Maggie Turnbull, an astrobiologist from the SETI Institute in *The Hunt for Planet B*, Marta Filipa Cortesão tells us more about the science of astrobiology and what we can expect in the next space missions to Mars or Jupiter’s moon, Europa.

   **Systems Engineer: Looking Back in Time With the James Webb Space Telescope**
   Amy Lo, Northrop Grumman systems engineer, was featured in *The Hunt for Planet B*. In this video, she relates more about the unique systems that are key to the functioning of the JWST in deep space.
   - More about what a systems engineer does can be found in the ThinkTV/PBS video *Systems Engineering*.
   - Amy Lo uses a LEGO model to explain the JWST sunshield in *The Hunt for Planet B* clip *The Webb Telescope Sunshield*.

2. **After watching the videos, elicit student’s noticings and wonderings about each career.**

   **Suggested Prompts**
   - What do you think are the most important aspects of their work, and why?
   - What skills, science and engineering practices, and science ideas were applied in their work?
   - What do you admire about them, and why?
   - What sparks your interest about these careers?
   - What hobbies, interests, or passions of yours may relate to the work of these STEM careers, and why?

3. **Show students The Hunt for Planet B clip How Diversity Powers Teams with Gregory L. Robinson, director of the James Webb Space Telescope Program.**

   After watching the video clip, encourage student discussion around other STEM careers that have and will continue to contribute to the JWST mission.

   **Suggested Prompts**
   - Read the following quotation from Jon Arenberg, Chief Mission Architect for Science and Robotic Exploration, Northrop Grumman, and discuss it with a partner: “Webb used almost every engineering specialty imaginable.”
   - In science class, we often work in groups or teams. What are the benefits of working in a team?
   - What is something that your partner helped you understand in today’s lesson? What is something you helped your partner understand in today’s lesson?