NATIONAL GEOGRAPHIC

RESOURCE LIBRARY I LESSON

Is There Life in Space?

Students discover how scientists find planets and other astronomical bodies. They compare zones of habitability around different star types, discovering the zone of liquid water possibility around each star type and they explore how scientists use spectroscopy to learn about atmospheres on distant planets. Students will explain how scientists find distant planets and moons and how they determine whether those astronomical bodies could be habitable.

GRADES

7 - 12, Higher Ed

SUBJECTS

Earth Science, Astronomy

CONTENTS

6 Activities

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ACTIVITY 1: CONSTRUCTING AN ARGUMENT: SPACE I 10 MINS

DIRECTIONS

Tell students that Activity 1 (Constructing an Argument) of the lesson Is There Live in Space? introduces the structure of the scientific argumentation they will be asked to do in the rest of the lesson. Tell students that Activity 1 will give them practice with analyzing a data set and making a good scientific argument from the evidence. Encourage students to review the questions and example best answers provided in Activity 1 before starting on the current activity.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Astronomy

Learning Objectives

Students will:

- create a good scientific argument in the context of climate

Teaching Approach

- Inquiry-based learning

Teaching Methods

- Self-directed learning
- Self-paced learning
- Writing

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills
  - Creating

National Standards, Principles, and Practices

Preparation

BACKGROUND & VOCABULARY

Background Information

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
claim	*verb*	to state as the truth.
diameter	*noun*	width of a circle.
Earth	*noun*	our planet, the third from the Sun. The Earth is the only place in the known universe that supports life.
evidence	*noun*	data that can be measured, observed, examined, and analyzed to support a conclusion.
Mars	*noun*	fourth planet from the sun, between Earth and Jupiter.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
star	*noun*	large ball of gas and plasma that radiates energy through nuclear fusion, such as the sun.
Venus	*noun*	planet in the solar system, second from the sun.

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ACTIVITY 2: THE VASTNESS OF SPACE I 30 MINS

DIRECTIONS

1. Activate students' prior knowledge about our solar system.

Tell students that Earth is the only planet in our solar system known to have life. Ask:

- *What factors do you think are necessary for life to exist on a planet?* (Some commonly known factors for life include liquid water, an atmosphere, and having energy sources. Some students may say that oxygen is necessary. If this happens, you can point out that there are some organisms on Earth that do not require oxygen.)

Tell students that scientists are looking for planets and moons that might have characteristics necessary for supporting life. Explain that scientists have already found thousands of planets outside our solar system. Let students know that they will be learning how scientists search for planets and how they determine whether the planets they find have the potential to support life.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the concept of uncertainty in the scientific process. Explain that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Tell students that they can see examples of scientists' uncertainty in determining whether or not the data collected from telescopes show the presence of planets.

Show the **Kepler Planet Candidates graph** from the NASA Exoplanet Archive. Tell students that the red dots indicate potential planets the Kepler telescope has detected and the blue dots indicate the planets the Kepler telescope detected and have been confirmed by other means. Ask:

- *Why do you think there are more red dots than blue dots (more potential planets than confirmed planets)?* (The telescope may detect planets that are not there. The technology may not be good enough to tell the difference between a planet and some other phenomenon.)
- *Why do scientists need to independently confirm the presence of planets?* (Scientists need to check the accuracy of the telescope's predictions of a planet. If the telescope shows a planet and the scientists confirm that it is a planet, then the scientists can spend more time trying to learn about the planet.)

Let students know that they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Have students launch the interactive The Vastness of Space.

Provide students with the link to the interactive The Vastness of Space. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer workstations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 2 in the **Is There Life in Space?** lesson.

4. Discuss the issues.

After students have completed the activity, bring the groups back together and lead them in a discussion focusing on these questions:

- *How do scientists detect planets?* (Scientists use light from stars to detect planets.)
- *Why do scientists have to use stars to find planets?* (Planets don't give off their own light so they are difficult to see in the darkness of space. Stars are bright, so they are easier to see.)
- *How do scientists use light from stars to find planets?* (Scientists can use light from stars in two ways: [1] they can look at the movement of the light towards and away from Earth to find a wobble in the star's orbit, and [2] they can look for dimming of the light from the star.)
- *What factors are necessary for life to exist on a planet?* (Scientists think that liquid water is necessary for life. Living things also need a source of energy and a place to exist [rocky body, such as a planet, moon, or asteroid].)

Tip

The Vastness of Space activity is part of a sequence of activities in the Is There Life in Space? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Tip

You can save student data for grading online by registering your class for free at the High-Adventure Science portal page.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- Why do scientists use stars to find planets?
- What factors are necessary for life?
- Why is it difficult to figure out if there is life on other planets?
- Why are some scientists confident that they will find life on another planet?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science
- Astronomy

Learning Objectives

Students will:

- explain how scientists use light from distant stars to find planets
- describe the factors scientists look for to determine if life could be possible on distant planets
- explore the probability of scientists finding a habitable planet or moon

Teaching Approach

- Learning-for-use

Teaching Methods

- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard G-1:**
Science as a human endeavor
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard G-1:**
Science as a human endeavor
• **(9-12) Standard G-2:**
Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

- **Standard 3:**
Research and Information Fluency
- **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

- **Crosscutting Concept 1:**
Patterns
- **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
- **Crosscutting Concept 3:**
Scale, proportion, and quantity
- **Crosscutting Concept 4:**
Systems and system models
- **Science and Engineering Practice 1:**
Asking questions and defining problems

• **Science and Engineering Practice 4**:
Analyzing and interpreting data
• **Science and Engineering Practice 5**:
Using mathematics and computational thinking
• **Science and Engineering Practice 6**:
Constructing explanations and designing solutions
• **Science and Engineering Practice 7**:
Engaging in argument from evidence
• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information

Preparation

BACKGROUND & VOCABULARY

Background Information

As of February 2016, Earth is the only planet known to have life. Whether there is life beyond Earth is an important and compelling question in science. With billions of galaxies each containing billions of stars, scientists think at least one of them is likely to have a planet like Earth. Scientists use the light from stars to find planets and other celestial bodies. The light from stars is visible, while the dark planets, moons, asteroids, etc. are invisible in the darkness of space.

As a planet orbits a star, the star moves (Newton's Third Law of Motion). Scientists use telescopes to detect the movement of stars, and infer the presence of planets. Scientists can also look for dimming of the star's light, which would indicate that a celestial body is orbiting the star.

Life on other planets does not need to be like life on Earth, however. Even on Earth, there is life in unlikely places. So-called extremophiles live in extreme conditions: high acid, high heat, extreme cold, extreme dry, and high radiation areas. Extremophiles broaden the range of planets that could be habitable for some form of life.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
asteroid	*noun*	irregularly shaped planetary body, ranging from 6 meters (20 feet) to 933 kilometers (580 miles) in diameter, orbiting the sun between Mars and Jupiter.
carbohydrate	*noun*	type of sugar that is an important nutrient for most organisms.
celestial	*adjective*	having to do with the sky or heavens.
celestial body	*noun*	natural object in space, such as a planet or star. Also called an astronomical object.
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.
galaxy	*noun*	collection of stars, planets, gases, and other celestial bodies bound together by gravity.
lipid	*noun*	one of a large group of organic compounds including fats, oils, waxes, sterols, and triglycerides.
moon	*noun*	natural satellite of a planet.
organic compound	*noun*	chemical substance that contains the element carbon.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
protein	*noun*	one of many complex compounds, made of chains of amino acids, that make up the majority of all cellular structures and are necessary for biological processes.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
telescope	*noun*	scientific instrument that uses mirrors to view distant objects.
universe	*noun*	all known matter, energy, and space.

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ACTIVITY 3: MOVING STARS AND THEIR PLANETS | 1 HR

DIRECTIONS

1. Activate students' prior knowledge about Newton's Third Law of Motion.

Tell students that for every action, there is an equal and opposite reaction. Ask:

- *Imagine you have a dog on a leash. When the dog pulls on the leash, what do you feel?* (When the dog pulls on the leash, you feel a pull towards the dog.)
- *What does the dog feel?* (The dog feels an equal force pulling it back towards you. The force is equal to and opposite of the force that you feel in the leash.)

Explain to students that scientists use this concept to find planets orbiting around stars. Tell students that the gravitational pull of planets can move their stars as they orbit.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the concept of uncertainty in the scientific process. Explain that science is a process of learning how the world works and that scientists do not know the "right" answers when they start to investigate a question. Tell students that they can see examples of scientists' uncertainty in determining whether or not the data collected from telescopes show the presence of planets.

Show the **Kepler Planet Candidates graph** from the NASA Exoplanet Archive. Tell students that the red dots indicate potential planets the Kepler telescope has detected and the blue dots indicate the planets the Kepler telescope detected and have been confirmed by other means. Ask:

- *Why do you think there are more red dots than blue dots (more potential planets than confirmed planets)?* (The telescope may detect planets that are not there. The technology may not be good enough to tell the difference between a planet and some other phenomenon.)
- *Why do scientists need to independently confirm the presence of planets?* (Scientists need to check the accuracy of the telescope's predictions of a planet. If the telescope shows a planet and the scientists confirm that it is a planet, then the scientists can spend more time trying to learn about the planet.)

Let students know that they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models. Explain the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the NOAA Weather Forecast Model, which provides a good example of a computational model. Tell students that scientists use planetary models to predict the motion and apparent brightness of stars if planets are present and to predict the habitability of planets. Explain that there are many different types of models and that they will be using simple models of planetary motion in this activity.

4. Have students launch the Moving Stars and Their Planets interactive.

Provide students with the link to the Moving Stars and Their Planets interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer workstations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 3 in the **Is There Life in Space?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead them in a discussion focusing on these questions:

- *What is the Doppler effect?* (The Doppler effect is the apparent change in wavelength as an object moves. As the object moves closer, the wavelength decreases, and as the object moves away, the wavelength increases.)
- *How do scientists use the Doppler effect to find planets around a star?* (Planets pull on their stars as they orbit, thus moving the star. If the star is in the same plane as the observer, the observer can see that the light coming from the star appears to become redder as the star moves away and bluer as the star moves closer. The changing wavelengths indicate that the star is moving. If this movement is regular, it is likely that a planet is causing the star to move.)

Tip

The activity is part of a sequence of activities in the Is There Life In Space? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Tip

You can save student data for grading online by registering your class for free at the High-Adventure Science portal page.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- How are planets found via the wobble method?
- How does a planet's mass affect its star's wobble?
- How does the angle of orbit affect whether a planet will be detected?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science
- Astronomy

Learning Objectives

Students will:

- explain how changes in the light coming from a star allow scientists to detect its motion
- describe how planets are found using the wobble method
- describe the effect of planetary mass on a star's wobble
- explain how the angle of a planets' orbit around a star determines whether the planet might be found

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-2:**
Motions and forces
• **(5-8) Standard E-2:**

Understandings about science and technology

• **(5-8) Standard F-5**:

Science and technology in society

• **(5-8) Standard G-1**:

Science as a human endeavor

• **(9-12) Standard A-1**:

Abilities necessary to do scientific inquiry

• **(9-12) Standard A-2**:

Understandings about scientific inquiry

• **(9-12) Standard B-4**:

Motions and forces

• **(9-12) Standard E-2**:

Understandings about science and technology

• **(9-12) Standard F-6**:

Science and technology in local, national, and global challenges

• **(9-12) Standard G-1**:

Science as a human endeavor

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Craft and Structure, RST.6-8.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Key Ideas and Details, RST.11-12.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Key Ideas and Details, RST.6-8.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Key Ideas and Details, RST.9-10.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Key Ideas and Details, RST.6-8.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Craft and Structure, RST.9-10.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Key Ideas and Details, RST.11-12.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Key Ideas and Details, RST.9-10.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3:**
Research and Information Fluency

• **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1:**
Patterns

• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction

• **Crosscutting Concept 3:**
Scale, proportion, and quantity

• **Crosscutting Concept 4:**
Systems and system models

• **ESS1.A: The Universe and Its Stars (Disciplinary Core Idea):**
The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)

• **ESS1.A: The Universe and Its Stars (Disciplinary Core Idea):**
Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

• **ESS1.B: Earth and the Solar System (Disciplinary Core Idea):**
Kepler’s laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

• **PS2.A: Forces and Motion (Disciplinary Core Idea):**
For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).

• **PS2.B: Types of Interactions (Disciplinary Core Idea):**
Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4)

- **Science and Engineering Practice 1:**
Asking questions and defining problems
- **Science and Engineering Practice 2:**
Developing and using models
- **Science and Engineering Practice 3:**
Planning and carrying out investigations
- **Science and Engineering Practice 4:**
Analyzing and interpreting data
- **Science and Engineering Practice 5:**
Using mathematics and computational thinking
- **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
- **Science and Engineering Practice 7:**
Engaging in argument from evidence
- **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientists use the Doppler effect to detect star motion. As a star moves towards you, the wavelengths appear to get shorter (blue shift). As the star moves away from you, the wavelengths appear to get longer (red shift). Scientists use these shifts in wavelength to determine the motion of stars relative to their telescopes.

Stars' motion is caused by gravitational interactions with other celestial bodies. As a planet orbits a star, the planet “tugs on” the star. This demonstrates Newton’s Third Law of Motion, which states that for every action, there is an equal and opposite reaction. Depending on the sizes of the planet and star, the planet may cause the star to visibly move. Thus, star motion can indicate an orbiting planet. (Even if it can't be seen, all planets have an effect on their stars' motions.)

Planetary mass affects the amount of star movement. The more gravity that the planet has, the more it will move its star. Rocky planets are denser than gaseous planets, so a large rocky planet will have more effect on star motion than a large gaseous planet.

The angle of a planet's orbit will affect whether or not scientists can detect the planet. If the planet's orbit is in the same plane (line-of-sight) as the telescope, the movement of the star will be most readily detected. But if the planet orbits at a right angle to the telescope, the motion of the star will not be detected by the telescope because the star will not be moving toward or away from the telescope. Whether or not a telescope will detect an obliquely orbiting planet depends on the planet’s mass.

Telescopes used to detect star motion are imprecise. Interference from our atmosphere, as well as space dust and gases (sometimes referred to as “noise”), also blur the telescopes' vision. The data from these telescopes are “noisy,” and it can be difficult to detect star motion beyond the background noise. If a planet does not cause a large change in star motion, current telescopes may not detect it. However, with technological advances, scientists will be able to detect smaller star motions, and, therefore, smaller planets.

Prior Knowledge

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Recommended Prior Activities

- The Vastness of Space

Vocabulary

Term	Part of Speech	Definition
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.
orbit	*verb*	to move in a circular pattern around a more massive object.
orbital plane	*noun*	flat space in which a body orbits.

Term	Part of Speech	Definition
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
telescope	*noun*	scientific instrument that uses mirrors to view distant objects.
velocity	*noun*	measurement of the rate and direction of change in the position of an object.

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ACTIVITY 4: HUNTING FOR PLANETS | 45 MINS

DIRECTIONS

1. Engage students in a discussion about eclipses.

Explain to students that in a solar eclipse, the Moon moves directly between the Earth and Sun. Tell them that an eclipse may be total, in which the Moon appears to block the entirety of the Sun, or partial, in which the Moon blocks only a part of the Sun. Ask:

- *What happens to the Sun's brightness, as seen from Earth, during a solar eclipse?* (When the Moon moves between the Sun and Earth, the Sun appears to dim.)
- *Which type of eclipse causes more dimming effect, as seen from Earth: a partial eclipse or a total eclipse?* (A total eclipse will cause more dimming because the entire face of the star is

blocked. During a partial eclipse, there is less dimming because the Moon does not completely obscure the Sun.)

Tell students that scientists use planetary eclipses to find planets around stars. As the planets move around their stars, they can block some of the light from that star, just as our Moon can block light coming from our Sun during a solar eclipse.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the concept of uncertainty in the scientific process. Explain that science is a process of learning how the world works and that scientists do not know the "right" answers when they start to investigate a question. Tell students that they can see examples of scientists' uncertainty in determining whether or not the data collected from telescopes show the presence of planets.

Show the **Kepler Planet Candidates graph** from the NASA Exoplanet Archive. Tell students that the red dots indicate potential planets the Kepler telescope has detected and the blue dots indicate the planets the Kepler telescope detected and have been confirmed by other means. Ask:

- *Why do you think there are more red dots than blue dots (more potential planets than confirmed planets)?* (The telescope may detect planets that are not there. The technology may not be good enough to tell the difference between a planet and some other phenomenon.)
- *Why do scientists need to independently confirm the presence of planets?* (Scientists need to check the accuracy of the telescope's predictions of a planet. If the telescope shows a planet and the scientists confirm that it is a planet, then the scientists can spend more time trying to learn about the planet.)

Let students know that they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Explain the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the NOAA Weather Forecast Model, which provides a good example of a computational model. Tell students that scientists use planetary models to predict the motion and apparent brightness of stars if planets are present and to predict the habitability of planets. Explain that there are many different types of models and that they will be using simple models of planetary motion in this activity.

4. Have students launch the Hunting for Planets interactive.

Provide students with the link to the Hunting for Planets interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer work stations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 4 in the **Is There Life in Space?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How does a planet's size affect its ability to be discovered via the transit method?* (The transit method relies on detecting dimming of a star as planets orbit. If the planet is very large, it can block more of the light coming from the star. A high level of dimming is easier

to detect than a smaller level of dimming. Therefore, larger planets are more likely to be detected than smaller planets.)
- *How does the angle of orbit affect a planet's ability to be detected?* (A planet needs to orbit in the same plane as the scientists' telescopes to be able to be detected reliably. This is particularly important when using the transit method. If the telescope is even slightly out of the orbital plane, the dimming will not be detected. The wobble (radial velocity) method is more robust, since that depends on detecting motion (wavelength shift) of the star, not the brightness of the star.)
- *How does telescope "noise" affect planet hunting?* (Scientists are more likely to discover larger, heavier planets than smaller, lighter ones because of the effect of telescope noise. The signals from smaller, less massive planets are smaller than the signals from larger, more massive planets. The smaller signals can get lost in the data "noise," making it difficult to determine whether a planet is present.)

TipTeacher Tip

To save your students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

The activity is part of a sequence of activities in the Is There Life In Space? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- How are planets found via the transit method?
- Why can't scientists use the transit method to find planets orbiting at a 45-degree angle?

- If there is no dip in a star's light intensity, does that mean that there is not a planet orbiting that star?
- How does a planet's diameter affect scientists' ability to detect it via the transit method?
- How does a planet's size affect whether it can be discovered via the transit method?
- How does the angle of orbit affect whether a planet will be detected via the transit method?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Astronomy

Learning Objectives

Students will:

- explain how planets can be detected using the transit method
- describe how a planet's diameter affects its ability to be detected via the transit (light-intensity) method
- describe how the tilt (orbiting angle) of a planet affects its ability to be detected via the transit method
- explain how technological advances can result in new scientific discoveries

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction

- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NCTM PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS

• **Algebra (9-12) Standard 1:**
Understand patterns, relations, and functions
• **Algebra (9-12) Standard 2:**
Represent and analyze mathematical situations and structures using algebraic symbols
• **Algebra (9-12) Standard 3:**
Use mathematical models to represent and understand quantitative relationships

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-2:**
Motions and forces
• **(5-8) Standard E-2:**

Understandings about science and technology

• **(5-8) Standard F-5**:
Science and technology in society

• **(5-8) Standards 8AI1.3**:
Use appropriate tools and techniques to gather, analyze, and interpret data

• **(9-12) Standard A-1**:
Abilities necessary to do scientific inquiry

• **(9-12) Standard A-2**:
Understandings about scientific inquiry

• **(9-12) Standard B-4**:
Motions and forces

• **(9-12) Standard E-2**:
Understandings about science and technology

• **(9-12) Standard G-2**:
Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **CCSS.ELA-LITERACY.RST.9-10.1.**:
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:

Craft and Structure, RST.9-10.4

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:
Research and Information Fluency
• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

• **Crosscutting Concept 1**:
Patterns
• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3**:
Scale, proportion, and quantity
• **Crosscutting Concept 4**:
Systems and system models
• **Crosscutting Concept 7**:
Stability and change
• **ESS1.A: The Universe and Its Stars (Disciplinary Core Idea)**:
The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
• **ESS1.B: Earth and the Solar System (Disciplinary Core Idea)**:
Kepler’s laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)
• **PS2.A: Forces and Motion (Disciplinary Core Idea)**:
For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).
• **PS2.B: Types of Interactions (Disciplinary Core Idea)**:
Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4)
• **Science and Engineering Practice 1**:
Asking questions and defining problems

• **Science and Engineering Practice 2**:
Developing and using models
• **Science and Engineering Practice 3**:
Planning and carrying out investigations
• **Science and Engineering Practice 4**:
Analyzing and interpreting data
• **Science and Engineering Practice 5**:
Using mathematics and computational thinking
• **Science and Engineering Practice 6**:
Constructing explanations and designing solutions
• **Science and Engineering Practice 7**:
Engaging in argument from evidence
• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientists can use the light from stars to detect orbiting planets. The light from the star appears to dim when the planet crosses between the star and the telescope. This is similar to a solar eclipse when the Moon moves between the Sun and the Earth. This results in an apparent dimming of the light from the Sun.

The easiest planets to detect via the transit method are those that cause the most dimming of the star. The larger the planet size, the more it will dim the light from the star.

The angle of a planet's orbit will affect whether or not scientists can detect the planet. If the planet is in the same plane as the telescope, the dimming will be most readily detected. But if the planet orbits at a right angle to the telescope, the dimming of the star will not be detected by the telescope. Whether or not an obliquely orbiting planet will be detected by a telescope depends on its size. The transit method is more sensitive to angle of orbit than the wobble method.

Prior Knowledge

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Recommended Prior Activities

- Moving Stars and Their Planets
- The Vastness of Space

Vocabulary

Term	Part of Speech	Definition
eclipse	*noun*	an event where one heavenly body obscures the light of another.
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.
mass	*noun*	measure of the amount of matter in a physical object.
outer space	*noun*	space beyond Earth's atmosphere.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
precision	*noun*	exactness.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
telescope	*noun*	scientific instrument that uses mirrors to view distant objects.

PARTNER

The Concord Consortium

FUNDER

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

ACTIVITY 5: HABITABLE CONDITIONS | 45 MINS

DIRECTIONS

1. Engage students in a discussion about conditions that are necessary for life.

Introduce the idea that there is a variety of living things on Earth that live in a wide variety of environments—from organisms that live in hot springs to organisms that live in the Antarctic ice. Ask:

- *What conditions are necessary for life to exist on a planet?* (Scientists think that liquid water is necessary for life. They also think that a habitable planet should have an atmosphere.)
- *Do you think that a planet should be exactly like Earth to be able to support life?* (Student answers will vary. Students should recognize that there is a wide variety of conditions on Earth that have life, so there could be planets that are very different from Earth that still have some habitable regions. Humans would not survive at the bottom of the ocean, but there are many organisms that thrive there. Some organisms use sulfur compounds for respiration, instead of oxygen; humans would die without oxygen.)

Tell students that scientists look for certain characteristics of planets to assess their potential habitability.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the concept of uncertainty in the scientific process. Explain that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Tell students that they can see examples of scientists' uncertainty in determining whether or not the data collected from telescopes show the presence of planets.

Show the **Kepler Planet Candidates graph** from the NASA Exoplanet Archive. Tell students that the red dots indicate potential planets the Kepler telescope has detected and the blue dots indicate the planets the Kepler telescope detected and have been confirmed by other means. Ask:

- *Why do you think there are more red dots than blue dots (more potential planets than confirmed planets)?* (The telescope may detect planets that are not there. The technology may not be good enough to tell the difference between a planet and some other phenomenon.)
- *Why do scientists need to independently confirm the presence of planets?* (Scientists need to check the accuracy of the telescope's predictions of a planet. If the telescope shows a planet and the scientists confirm that it is a planet, then the scientists can spend more time trying to learn about the planet.)

Let students know that they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Explain the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the NOAA Weather Forecast Model, which provides a good example of a computational model. Tell students that scientists use planetary models to predict the motion and apparent brightness of stars if planets are present and to predict the habitability of planets. Explain that there are many different types of models and that they will be using simple models of planetary motion in this activity.

4. Have students launch the Habitable Conditions interactive.

Provide students with the link to the Habitable Conditions interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer workstations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 5 in the **Is There Life in Space?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on the following questions:

- *Why does the habitable zone change around different star types?* (The habitable zone, roughly defined as the area where liquid water can exist on a planet's surface, is different around different star types because different stars have different temperatures. Around a cool star, the habitable zone will be closer to the star. Around a hot star, the habitable zone will be farther from the star.)
- Show the model on page 4 of the activity.

According to this model, what characteristics make a planet suitable for life? (A planet should be rocky, orbit entirely in the liquid water zone, and orbit a M, K, G, or F class star.)

- *Do you think that a planet needs to orbit completely within the zone of liquid water possibility to be able to have life?* (Student answers will vary. Students should note that the zone of liquid water possibility means that water can be liquid on the planet's surface. There can still be liquid water below the surface that could support living things. In this case, with liquid water under the surface, life could exist on a planet that orbits in-and-out of the zone of liquid water possibility.)

TipTeacher Tip

To save your students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

The activity is part of a sequence of activities in the Is There Life In Space? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- Why is the habitable zone around an F-class star different than the habitable zone around an M-class star?
- What type of planet is most suitable for life: a rocky planet, or a gaseous planet?
- Which type of planet and solar system would you want to explore further for life?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Astronomy

Learning Objectives

Students will:

- compare the zone of liquid water possibility around different star types
- describe what conditions make a planet suitable for life
- evaluate solar system characteristics to decide whether a planet is worth further investigating for evidence of life

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NCTM PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS

• **Algebra (9-12) Standard 1:**
Understand patterns, relations, and functions
• **Algebra (9-12) Standard 2:**
Represent and analyze mathematical situations and structures using algebraic symbols

NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
- **(5-8) Standard A-2:**
Understandings about scientific inquiry
- **(5-8) Standard E-2:**
Understandings about science and technology
- **(5-8) Standard F-5:**
Science and technology in society
- **(5-8) Standards 8AI1.3:**
Use appropriate tools and techniques to gather, analyze, and interpret data
- **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
- **(9-12) Standard A-2:**
Understandings about scientific inquiry
- **(9-12) Standard E-2:**
Understandings about science and technology
- **(9-12) Standard G-2:**
Nature of scientific knowledge

NATIONAL STANDARDS FOR ARTS EDUCATION

- **Music (5-8) Standard 6:**
Listening to, analyzing, and describing music
- **Music (9-12) Standard 6:**
Listening to, analyzing, and describing music

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

- **CCSS.ELA-LITERACY.RST.9-10.1.:**
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3

• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3**:
Research and Information Fluency
• **Standard 4**:
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

• **3-LS4 Biological Evolution: Unity and Diversity**:
3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well. Some less well, and some not at all.
• **Crosscutting Concept 1**:
Patterns
• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3**:
Scale, proportion, and quantity
• **Crosscutting Concept 4**:
Systems and system models
• **Crosscutting Concept 7**:
Stability and change
• **Science and Engineering Practice 1**:

Asking questions and defining problems

• **Science and Engineering Practice 2:**
Developing and using models

• **Science and Engineering Practice 3:**
Planning and carrying out investigations

• **Science and Engineering Practice 4:**
Analyzing and interpreting data

• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions

• **Science and Engineering Practice 7:**
Engaging in argument from evidence

• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

BACKGROUND & VOCABULARY

Background Information

One consideration for habitability is that the stars must exist long enough that life can evolve on the planet. Longer-lived stars are therefore more likely to have planets with life, just because more time is allowed for life to develop and fill ecological niches. Cooler stars have longer lifespans than hotter stars.

Liquid water is necessary for life. For a planet/moon/asteroid to be considered habitable, it must orbit in a zone where liquid water is possible. The planet needs to be far enough away from the star that the surface water does not evaporate and close enough to the star that the surface water does not remain perpetually frozen.

The zone of liquid water possibility (habitable zone) is different for different star types. For the hottest (blue) stars (O-class), the habitable zone is far from the star. For the coolest (red) stars (M-class), the habitable zone is close to the star.

Even if it is impossible for liquid water to be present on the surface of the planet, liquid water may be possible beneath the surface. If the inside of the planet is hot enough, liquid water beneath ice or the ground may be possible. Larger planets are more likely to be habitable than smaller ones because they have enough gravity to hold onto an atmosphere and because they are more likely to be tectonically active. Tectonic activity allows recycling of the rocks to bring new nutrients to the surface. Tectonically active planets also have internal heat that can allow for liquid water beneath the surface.

Planets that orbit their stars too closely can become tidally locked, meaning that the rotational period matches the revolutionary period (like our Moon). This results in the same side of the planet always facing the star. This can lead to a very hot side facing the star and a very cold side facing away from the star. Tidally-locked planets are unlikely to be able to be habitable because of the extreme conditions.

Prior Knowledge

["There are different star classes, categorized by the star's temperature. Hotter stars are brighter and shorter-lived than cooler stars."]

Recommended Prior Activities

- Hunting for Planets
- Moving Stars and Their Planets
- The Vastness of Space

Vocabulary

Term	Part of Speech	Definition
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.
habitability	*noun*	suitability to support life.
liquid	*noun*	state of matter with no fixed shape and molecules that remain loosely bound with each other.
mass	*noun*	measure of the amount of matter in a physical object.

Term	Part of Speech	Definition
outer space	*noun*	space beyond Earth's atmosphere.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
telescope	*noun*	scientific instrument that uses mirrors to view distant objects.

FUNDER

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PARTNER

NATIONAL GEOGRAPHIC
ENTERTAINMENT

ACTIVITY 6: LOOKING FOR SIGNS OF LIFE | 45 MINS

DIRECTIONS

1. Activate students' prior knowledge about atmospheres.

Tell students that Earth's atmosphere is a mixture of gases, 78% nitrogen, 21% oxygen, and 1% all other gases, including carbon dioxide, water vapor, argon, etc. Ask:

- *What gases do you think are necessary for life?* (Students may state that oxygen is necessary for life, but there are many forms of life on Earth that do not need oxygen.)
- *How do you think scientists determine if a planet has an atmosphere and what gases are in its atmosphere?* (Students may state that scientists have to send probes to the planets to sample their atmospheres. Tell students that most planets are too far away to send probes to get information directly.)

Let students know that scientists use light from planets' stars to analyze the atmospheres of the planets.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the concept of uncertainty in the scientific process. Explain that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Tell students that they can see examples of scientists' uncertainty in determining whether or not the data collected from telescopes show the presence of planets.

Show the **Kepler Planet Candidates graph** from the NASA Exoplanet Archive. Tell students that the red dots indicate potential planets the Kepler telescope has detected and the blue dots indicate the planets the Kepler telescope detected and have been confirmed by other means. Ask:

- *Why do you think there are more red dots than blue dots (more potential planets than confirmed planets)?* (The telescope may detect planets that are not there. The technology may not be good enough to tell the difference between a planet and some other phenomenon.)
- *Why do scientists need to independently confirm the presence of planets?* (Scientists need to check the accuracy of the telescope's predictions of a planet. If the telescope shows a planet and the scientists confirm that it is a planet, then the scientists can spend more time trying to learn about the planet.)

Let students know that they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Explain the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the NOAA Weather Forecast Model, which provides a good example of a computational model. Tell students that scientists use planetary models to predict the motion and apparent brightness of stars if planets are present and to predict the habitability of planets. Explain that there are many different types of models and that they will be using simple models of planetary motion in this activity.

4. Have students launch the Looking for Signs of Life interactive.

Provide students with the link to the Looking for Signs of Life interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer workstations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

NOTE: You can access the Answer Key for students' questions—and save students' data for online grading—through a free registration on the High-Adventure Science portal page.

Tell students this is Activity 6 in the **Is There Life in Space?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on the following questions:

- *How can scientists tell what elements are in a mixture of gases?* (Scientists use spectroscopy to detect which elements are in a mixture of gases. Each element absorbs light in a unique pattern. By analyzing the light going into the atmosphere and the light coming out of the atmosphere, scientists can determine what elements are in the atmosphere.
- *How can scientists use planetary spectra to search for life on other planets?* (Scientists can analyze the composition of the planet's atmosphere. If the planet has gases that are

conducive to life or indicate that life may be present, they can then investigate further for life.)

Tip

The activity is part of a sequence of activities in the Is There Life In Space? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Tip

You can save student data for grading online by registering your class for free at the High-Adventure Science portal page.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- How can you use light to determine which elements are in a mixture?
- Would the spectrograph of a planet's atmosphere have more, fewer, or the same number of lines as the spectrograph of the planet's star? Why?

2. Use the answer key to check students' answers on embedded assessments.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Astronomy

Learning Objectives

Students will:

- describe how matter can absorb and emit light of different frequencies
- interpret visible light emission spectra
- explain how planetary spectra can be used to search for life on other planets

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1**:
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2**:
Understandings about scientific inquiry
• **(5-8) Standard E-2**:
Understandings about science and technology
• **(5-8) Standard F-5**:
Science and technology in society
• **(5-8) Standards 8AI1.3**:
Use appropriate tools and techniques to gather, analyze, and interpret data
• **(9-12) Standard A-1**:
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2**:
Understandings about scientific inquiry
• **(9-12) Standard B-1**:
Structure of atoms
• **(9-12) Standard G-1**:
Science as a human endeavor
• **(9-12) Standard G-2**:
Nature of scientific knowledge

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **CCSS.ELA-LITERACY.RST.9-10.1.**:
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
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Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Craft and Structure, RST.9-10.4

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 3:**
Research and Information Fluency
• **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

NEXT GENERATION SCIENCE STANDARDS

• **3-LS4 Biological Evolution: Unity and Diversity:**
3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well. Some less well, and some not at all.
• **4-ESS2-2:**
Analyze and interpret data from maps to describe patterns of Earth's features.
• **Crosscutting Concept 1:**
Patterns
• **Crosscutting Concept 2:**
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3:**
Scale, proportion, and quantity
• **Crosscutting Concept 4:**
Systems and system models
• **Crosscutting Concept 7:**
Stability and change
• **ESS1.A: The Universe and Its Stars (Disciplinary Core Idea):**
The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)

• **PS4.B: Electromagnetic Radiation (Disciplinary Core Ideas):**
Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)

• **Science and Engineering Practice 1:**
Asking questions and defining problems

• **Science and Engineering Practice 2:**
Developing and using models

• **Science and Engineering Practice 3:**
Planning and carrying out investigations

• **Science and Engineering Practice 4:**
Analyzing and interpreting data

• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions

• **Science and Engineering Practice 7:**
Engaging in argument from evidence

• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

BACKGROUND & VOCABULARY

Background Information

Spectroscopy is a powerful tool for identifying atoms and molecules in gaseous mixtures.

By shining a known light source on a mixture and measuring the light that comes out of the gaseous mixture, scientists can determine the elements and molecules in the mixture. This is known as absorption spectroscopy.

This is used to determine the makeup of planetary atmospheres. The light from the star is measured to know what wavelengths there are, and then scientists measure the light from the star after it goes through a planet's atmosphere. The lines on the spectrometer tell the scientists which elements and molecules are present in the planet's atmosphere.

Determining which elements and molecules reflect the presence of or likelihood for life is more difficult. Scientists can look for evidence of life under the assumption that life on other planets is similar to Earth. That would mean looking for oxygen, which on Earth is produced by photosynthetic organisms.

Or scientists could look for gases that would protect life on the surface, such as ozone, which absorbs UV radiation, and greenhouse gases, such as carbon dioxide and methane, that would help to stabilize the temperature of the planet.

Finding planets that could be habitable is an ongoing search!

Prior Knowledge

["Elements absorb and emit radiation at distinct frequencies. The pattern of absorption of radiation can give information about the composition of a mixture."]

Recommended Prior Activities

- Habitable Conditions
- Hunting for Planets
- Moving Stars and Their Planets
- The Vastness of Space

Vocabulary

Term	Part of Speech	Definition
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
electromagnetic spectrum	*noun*	continous band of all kinds of radiation (heat and light).
emission	*noun*	discharge or release.

Term	Part of Speech	Definition
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.
greenhouse gas	*noun*	gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
methane	*noun*	chemical compound that is the basic ingredient of natural gas.
nitrogen	*noun*	chemical element with the symbol N, whose gas form is 78% of the Earth's atmosphere.
outer space	*noun*	space beyond Earth's atmosphere.
oxygen	*noun*	chemical element with the symbol O, whose gas form is 21% of the Earth's atmosphere.
photosynthesis	*noun*	process by which plants turn water, sunlight, and carbon dioxide into water, oxygen, and simple sugars.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
respiration	*noun*	breathing.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
spectrograph	*noun*	machine that transcribes sound waves into visible lines.
spectroscopy	*noun*	science of the measurement of light that is reflected, absorbed, or emitted by different materials.
telescope	*noun*	scientific instrument that uses mirrors to view distant objects.
water vapor	*noun*	molecules of liquid water suspended in the air.

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