Activity*develop*

Looking for Signs of Life

How do scientists determine whether a planet has life?

Overview

Students explore how scientists determine the atmospheric composition of distant planets. They use a model to explore how elements in a gaseous mixture can be identified through absorption spectroscopy. Finally, students explore what compounds are most likely to reflect the presence of, or favorability to, life on other planets.

For the complete activity with media resources, visit:
http://nationalgeographic.org/activity/looking-signs-life/

Content Created by

The Concord Consortium

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.

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:

- *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.)

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 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

Science

- Earth science
- Space sciences

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.
• **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.9-10.3
• **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.11-12.1
• **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.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3

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**:

Preparation

What You'll Need

Materials You Provide

- Computers (either one per student or one per group of two students)
- Internet access

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per small group, Interactive whiteboard, Projector

Physical Space

- Classroom
- Computer lab
- Media Center/Library

Grouping

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

Resources Provided: Handouts & Worksheets

- Answer Key: Looking for Signs of Life

Resources Provided: Images

- Kepler Planet Candidates Graph

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.
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.

Term	Part of Speech	Definition
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.

For Further Exploration

Articles & Profiles

- National Geographic: This Day in Geographic History: November 27, 2001 Atmosphere on Extrasolar Planet Detected

Reference

- National Geogarphic: Encyclopedic Entry: atmosphere
- National Geographic: Encyclopedic Entry: Planet

Video

- TED Talk: Tabetha Boyajian: The most mysterious star in the universe

Websites

- Wikipedia: Extraterrestrial atmospheres
- NASA Jet Propulsion Laboratory: PlanetQuest

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