Activity*develop*

Habitable Conditions

What characteristics make a planet suitable for life?

Overview

Students use an interactive model to explore the zone of liquid water possibility around different star types and determine the characteristics of stars and planets that are most favorable for habitability.

For the complete activity with media resources, visit:
http://nationalgeographic.org/activity/habitable-conditions/

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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.

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 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

Science
- Earth science
- Space sciences

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

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

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: Habitable Conditions

Resources Provided: Images

- Kepler Planet Candidates Graph

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.
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.

For Further Exploration

Articles & Profiles

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

Images

- National Geographic: Illustration: Media Spotlight: Orbital plane

Reference

- National Geographic: Encyclopedic Entry: Planet
- Wikipedia: Astrobiology
- National Geographic: Encyclopedic Entry: Orbit

Video

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

Websites

- Wikipedia: Circumstellar Habitable Zone
- NASA Jet Propulsion Laboratory: PlanetQuest

None

- Habitable Zone - NASA Quest!

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