IGNITE MY FUTURE

THINK SOLVE CREATE CONNECT

LESSON TITLE

Earth 2.0

Guiding Question: Why should we continue to explore?

SUBJECTS

Science
Language Arts

COMPUTATIONAL THINKING PRACTICE

Find Patterns

COMPUTATIONAL THINKING STRATEGIES

Developing and Using Abstractions

MATERIALS

Conditions of Life on Earth
student capture sheet

Conditions on Exoplanets
student handout

What Makes an Exoplanet Habitable?
student capture sheet

Evaluating Exoplanets
student capture sheet

What Makes a Planet Habitable?
(teacher background only)

Exoplanet Exploration
(teacher background only)

Ignite Curiosity

- Could humans live on another planet?
- What would that planet have to be like?
- How can we determine whether a planet is enough like Earth for us to live on?

In this lesson students will develop their own rating scales for determining whether an exoplanet (a planet outside our solar system) can sustain human life. In **THINK**, students will act as planetary scientists challenged to identify the purpose of finding “another Earth” and to consider the scenarios in which identifying a planet would be beneficial. In **SOLVE**, students will utilize the computational thinking strategy of finding patterns to evaluate conditions on four provided exoplanets. Students will build rubrics to compare the exoplanets’ conditions with information provided about Earth. In **CREATE**, students will write a brief report in which they make a case for which one of the four planets would make the most suitable “Earth 2.0.” In this report, they will analyze the habitability of their chosen planet, attaching their rubric evaluating the planet’s conditions. In **CONNECT**, students will assess how close we are to finding an Earth-like planet and consider how finding such a planet would help us address problems ranging from resource depletion to global warming.

Students will be able to:

- **Identify** the conditions that make Earth habitable for humans,
- **Analyze** living conditions on other planets and identify which exoplanets might support human life, and
- **Evaluate** how close we are to finding an Earth-like planet.

Students act as planetary scientists challenged to find another planet on which humans could potentially survive.

1 **Read** the following scenario to students:

Imagine that you are on a team of planetary scientists challenged to find "Earth 2.0"—another planet on which humans could live. To do this, you will first examine why we might want to find another Earth. Then, you will use the question "what are the basic building blocks of human life?" to hypothesize whether or not humans could survive on another planet.

2 **Lead** students to consider the importance of finding planets that are similar to Earth. Ask the following guiding questions:

- Why would we want to find another Earth? (to learn more about our own planet, to gain a better understanding of our universe, to investigate clues to Earth's past or future [depending on the age of the exoplanet], to live on if Earth became inhospitable or overcrowded)
- Why would it be significant if we found life forms on an exoplanet? (It would help us learn more about different patterns and building blocks of life.)
- What kinds of life are we most likely to find on an exoplanet? (Microbial; explain to students that even most life forms on Earth are microbial.)

3 **Elicit** from students a few of the characteristics of Earth that allow human life to flourish. Write these in one column on the board. In a separate column, ask students to identify what the opposite of those conditions would be. Explain that life on Earth is sustainable due to a specific set of conditions, including its distance from the sun and material composition. To support human life, other planets would have to be at a similar distance from their stars and have a similar composition (a gaseous planet, for example, would be uninhabitable for humans).

4 **Distribute** the Conditions of Life on Earth student capture sheet to familiarize students with the specific conditions that allow humans to live on our planet. Guide students through Part I of the handout, in which they review these conditions. Highlight Part II the Conditions of Life on Earth student capture sheet. Review with students that to complete this part of the handout, they will use their knowledge of necessary conditions from Part I of the handout and hypothesize about the conditions on another habitable planet.

5 **Students should work** through Part II of the Conditions of Life on Earth student capture sheet in teams of four, with each student leading discussion on one of the four questions:

- If a planet had cold temperatures but a thick atmosphere, could it be habitable for humans? (Possibly, if the atmosphere could trap enough heat to warm the planet sufficiently.)
- Beyond practical considerations of human passage on the surface of a planet, why is it important for an exoplanet to have rocky terrain (Nutrients, which are necessary to support life, reside in the soil.)?
- When a planet is in the Habitable Zone, how large can it be in terms of R (1-2R)?
- What would be significant about discovering water vapor on an exoplanet (Water vapor would indicate the presence of water, which suggests that the planet meets at least some of the criteria for supporting human life.)?

6 **When they have finished,** regroup as a class and ask students to share and find patterns in their responses.

Students will create a rubric to evaluate conditions on four exoplanets, comparing them to conditions on Earth. They will identify the exoplanet most likely to support human life.

1 **In their teams of four,** have students brainstorm responses to the following guiding questions:

- How could we evaluate whether another planet could sustain life?
- What would we need to consider before exploring the planet as a potential home?

Return to the larger group to discuss students' responses to these questions.

2 **Guide** students to return to the Conditions on Life on Earth student capture sheet and invite them to work in their groups to create a rubric to determine how likely an exoplanet would be to sustain life. Their rubric should include at least six criteria, as well as gradations for each criterion. For example: "Climate" could be rated from 1, most appropriate, to 3, least appropriate). You may choose to have students use the What Makes an Exoplanet Habitable? student capture sheet to guide their work. Ask students to turn to a neighbor and discuss their rubrics. Clarify with students that this process is called abstraction. Abstraction is using the details of phenomena to make generalizations that allow a solution to work in a variety of scenarios. By removing detail and reducing the complexity in a collection of data, computers can not only find patterns more easily, but also make a solution work for a variety of situations.

Students will use the abstract categories from their rubrics to rate each of the four exoplanets and select their best choice for "Earth 2.0." They will then write a report analyzing the habitability of their chosen exoplanet.

Teacher note: Not all information about all four exoplanets is included in the descriptions of the planets. This is to encourage students to include questions in their report that would need to be answered before making further determinations.

1. **Tell students** that they will now use their rubric to rate the habitability of the four planets listed on the Conditions on Exoplanets student handout using their Evaluating Exoplanets student capture sheet. Explain that they will use the information they have abstracted about a planet's habitability to evaluate which planet would be the most likely candidate for hosting human life.

2. **Convene** as a larger group to discuss students' choices. Have students defend their choices with specific examples and details.

3. **Individually,** students should write a brief report. In this report, students should work with the following guiding questions:
   - Which exoplanet did you select as most likely to sustain human life?
   - Why is this exoplanet a good candidate for sustaining human life?
   - What do we not know about the planet that is important to know?
   - What are next steps could we take to explore whether the exoplanet could sustain human life?
   - How did abstracting information about Earth help you to evaluate exoplanets?

4. **Students should submit** their reports along with their completed What Makes an Exoplanet Habitable? and Evaluating Exoplanets student capture sheets.

Select one of the strategies listed below to help students answer these questions:

- **How do this problem and solution connect to me?**
- **How do this problem and solution connect to real-world careers?**
- **How do this problem and solution connect to our world?**

1. **Write** the three questions on PowerPoint or flip chart slides and invite students to share out responses.
2. **Display** pieces of chart paper around the room, each with one question written on it. Ask students to write down their ideas related to the questions on each sheet.
3. **Assign** one of the questions to three different student groups to brainstorm or research, and then share out responses.
4. **Invite** students to write down responses to each question on a sticky note, and collect them to create an affinity diagram of ideas.

How does this connect to students?

Students are likely familiar with the effects of climate change in science and social science contexts. They are likely also familiar with the phenomena of overpopulation, particularly in Earth's major cities, and resource depletion. By exploring exoplanets and the possibility of identifying an exoplanet that could be habitable for humans, students will understand that by continuing to push the boundaries of planetary sciences, we may be able to address some of these issues—by studying the exoplanets and potentially by living there.

How does this connect to careers?

Astronomers study the origin and composition of the universe by focusing on different bodies (such as planets) or events (such as black holes).

Astrophysicists study the characteristics and behavior of celestial objects in terms of physics: for example, the amount of light stars emit, or the size and mass of various planets.

Engineers create new technologies that allow us to keep exploring planets farther from Earth.

Geoscientists explore the composition, structure, and processes of Earth. They are particularly concerned with understanding Earth's past, present, and future.

How does this connect to our world?

The exploration of exoplanets has potentially significant consequences for the future of life on earth. As humanity faces climate change, overpopulation, and resource depletion, exoplanets may provide a snapshot into how conditions elsewhere have evolved in the face of similar pressures (such as the greenhouse effect). Though it is unlikely that scientists will discover intelligent life forms, the discovery of microbial life forms on exoplanets is possible and would lead to a greater understanding of Earth's geological history. This may in turn help solve the problems humans confront today.

NASA scientists claim that the discovery of planets that could (and especially those that do) support life outside our solar system would lead to a new conception of our universe: one that is less Earth-centered and that views our planet as one among many. This shift in perspective could be as significant as that which occurred when Copernicus hypothesized that Earth orbited the sun, rather than vice versa.

National Standards

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data ▪ Analyze and interpret data to provide evidence for phenomena. ▪ Developing and Using Models	**ESS1.A: The Universe and Its Stars** ▪ 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) ▪ Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)	**Patterns** ▪ Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1) ▪ Systems and System Models ▪ Models can be used to represent systems and their interactions. (MS-ESS1-2)

COMMON CORE STATE STANDARDS CONNECTIONS

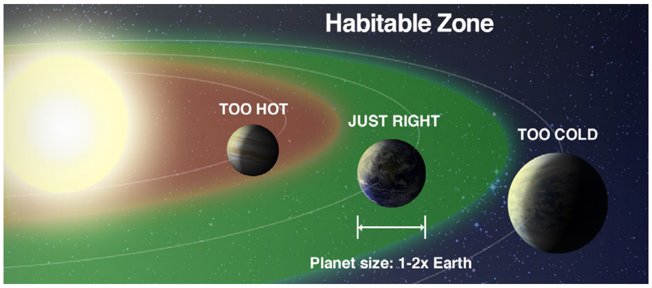
- **CCSS.ELA-LITERACY.W.6.1** Write arguments to support claims with clear reasons and relevant evidence.
- **CCSS.ELA-LITERACY.W.6.1.A** Introduce claim(s) and organize the reasons and evidence clearly.
- **CCSS.ELA-LITERACY.W.6.1.B** Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.
- **CCSS.ELA-LITERACY.W.6.1.C** Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.
- **CCSS.ELA-LITERACY.W.6.1.D** Establish and maintain a formal style.
- **CCSS.ELA-LITERACY.W.6.1.E** Provide a concluding statement or section that follows from the argument presented.
- **CCSS.ELA-LITERACY.W.6.2** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
- **CCSS.ELA-LITERACY.W.8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

K-12 COMPUTER SCIENCE FRAMEWORK

Practice 4. Developing and Using Abstractions
Abstractions are formed by identifying patterns and extracting common features from specific examples to create generalizations. Using generalized solutions and parts of solutions designed for broad reuse simplifies the development process by managing complexity.

Conditions of Life on Earth Part I

Review the following table of facts about Earth. When you have finished, answer the questions following the table.

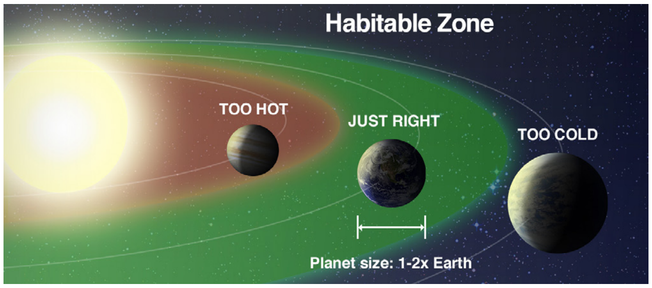


Characteristic	Earth	Why It's Important	Potential Range or Acceptable Variations
Temperature	Average annual temperature of 57.2°C	Temperature influences how quickly atoms and molecules move.	From −15°C to 115°C
Water	Percentage of the Earth's surface covered by water: 71%	Water moves chemicals in and out of cells.	Surface liquid water between 50% and 150% of Earth's surface (510.1 million square kilometers)
Atmosphere	Density (quantity of material in a given space): 1.217 kg/m3	Atmospheres trap heat and shield the planet from radiation.	Atmosphere denser than 0.007302 kg/m3
Energy (Sunlight or Chemical)	Sunlight	Energy, in the form of light or chemicals, allows organisms' life processes to function.	Sufficient light from solar system's star or appropriate chemical conditions
Nutrients	Sufficient nutrients to sustain life	Nutrients build bodies and keep them healthy.	Sufficient nutrients to sustain life
Composition	Rocky; terrestrial	Only rocky planets could support life; rocky terrain is capable of containing nutrients.	Rocky; terrestrial
Mass	Mass = 5.972 × 1024 kg	A planet with too low mass has lower gravity and different atmospheres; high mass often produces a magnetic field, which also affects the atmosphere.	Mass can be up to 6 times the mass of Earth.
Radius	Radius = 6,371 km	The size of a planet influences the temperature, tides, and light available.	Radius can be up to 1.6 times Earth's radius
Distance from Sun	Within the habitable zone of the sun	According to NASA, the habitable zone is "a range of distance from a star where liquid water might pool on the planet's surface."	Within the habitable zone of its star

Find more easy-to-implement resources to integrate computational thinking practices into your classroom by visiting **ignitemyfutureinschool.org**

Conditions of Life on Earth Part II

Review the following table of facts about Earth. When you have finished, answer the questions following the table.



1 **If a planet had cold temperatures but a thick atmosphere, could it be habitable for humans?**

2 **Beyond practical considerations of human passage on the surface of a planet, why is it important for an exoplanet to have rocky terrain?**

3 **When a planet is in the Habitable Zone, how large can it be in terms of R?**

4 **What would be significant about discovering water vapor on an exoplanet?**

What Makes an Exoplanet Habitable?

Complete the table below, listing the criteria that make an exoplanet habitable and the different point values you would assign to different levels of each criterion.

Criterion	Point Value and Description	Point Value and Description	Point Value and Description	Point Value and Description

Evaluating Exoplanets

Planet	Criterion and Point Value	Criterion and Point Value	Criterion and Point Value	Criterion and Point Value	Criterion and Point Value	Criterion and Point Value	Criterion and Point Value
Kepler 186-f							
Proxima b							
Kepler 62-f							
Kepler 452-b							

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Conditions of Exoplanets

The following describes four exoplanets that scientists have identified as potentially habitable for humans. M is Earth's mass, and R is Earth's radius.

1 Kepler 186-f.
Kepler 186-f is an exoplanet with a mass of 0.6 to 4.7M. It has a radius of 1.17R. It is within its solar system's habitable zone. It is 1.1 times the size of Earth, but it receives only about 30% of the sunlight Earth receives, so it is colder than Earth. The conditions of its atmosphere are unknown. The surface of Kepler 186-f receives infrared light as energy, which has the potential to change human perception of color. Kepler 186-f faces the same direction constantly, meaning that one side of it is hot and the other is in a deep freeze.

2 Proxima b
Proxima b has a mass of 1.3M or less and a radius of 0.8 to 1.4R. It is within its solar system's habitable zone. It is the closest exoplanet to Earth at 4.2 light years away. Proxima b receives 70% of the light energy Earth does. It is uncertain whether Proxima b's orbit around its star would make an Earth-like atmosphere possible. The star is an M-dwarf, which has the potential to live billions of years beyond our sun.

3 Kepler 62-f
Kepler 62-f has a mass of 1.2 to 10.2M and a radius of 1.41M. It is within its solar system's habitable zone. Scientists believe that it is most likely rocky, though it could be covered in water. It receives approximately 40% of the light energy that Earth does. It orbits a K-dwarf star, which has a very long lifespan.

4 Kepler 452-b
Kepler 452-b has a mass of 1.9 to 19.8M and a radius of 10.50 to 1.63R. It is within its solar system's habitable zone. It orbits a star like our sun, and it receives about 110% of the energy Earth does from our sun's light. Scientists do not know whether it is rocky or a mini gas giant. Furthermore, temperatures may have risen to be closer to those of Venus than Earth.