TATA CONSULTANCY SERVICES | Discovery EDUCATION

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)

CTV and CBC articles
about exoplanets
(teacher background only)

Canadian Space Agency
(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 climate change.

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 of 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.

IGNITE MY FUTURE
THINK SOLVE CREATE CONNECT

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 resource depletion and overpopulation, particularly in Earth's major cities. 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.

TATA Consultancy Services' goIT program in Canadian communities helps prepare our youth for STEM careers to help space research and exploration. Read more about this here.

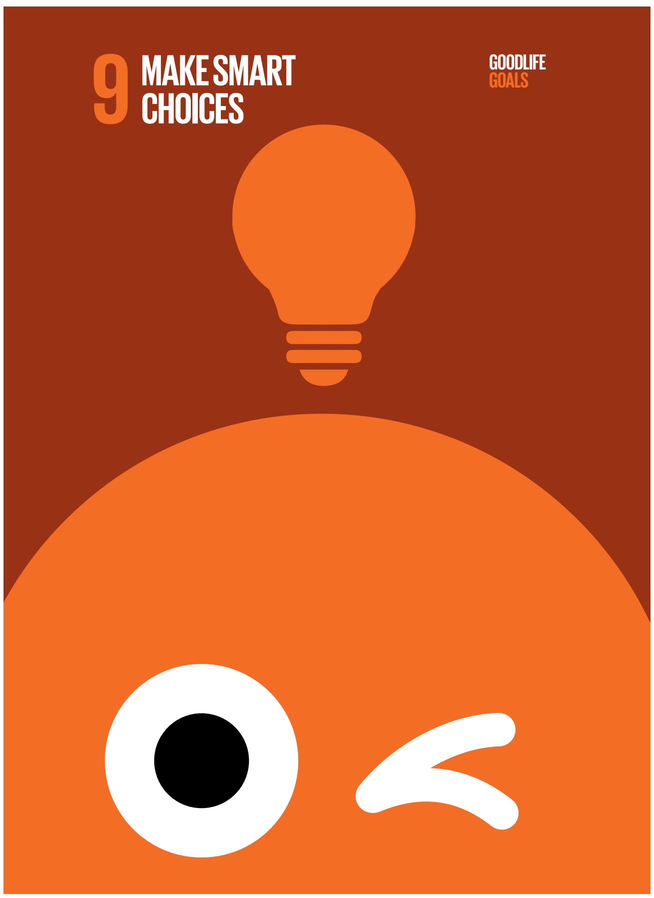
Curriculum Connections

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

"For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and **people like you**."
–The United Nations

"The Sustainable Development Goals are the blueprint for a better future. And together we can reach them. By following the Good Life Goals, we can all help make tomorrow better than today. Let's do this! #GoodLifeGoals"



MAKE SMART CHOICES 9
Actions

1 Learn about plans for progress in your country

2 Stay smart and kind online

3 Support construction that benefits people and protects the planet

4 Welcome innovations that make the world a better place

5 Demand the benefits from progress are shared

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE — Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. SUSTAINABLE DEVELOPMENT GOALS

Source:
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Global Competencies

CMEC (Council of Ministers of Education, Canada) Pan-Canadian Global Competencies Descriptions

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Collaboration	Collaboration involves the interplay of the cognitive (including thinking and reasoning), interpersonal, and intrapersonal competencies necessary to participate effectively and ethically in teams. Ever-increasing versatility and depth of skill are applied across diverse situations, roles, groups, and perspectives in order to co-construct knowledge, meaning, and content, and learn from, and with, others in physical and virtual environments.	Students participate in teams by establishing positive and respectful relationships, developing trust and acting co-operatively and with integrity. Students learn from and contribute to the learning of others by co-constructing knowledge, meaning, and content. Students assume various roles on the team, respect a diversity of perspectives, and address disagreements and manage conflict in a sensitive and constructive manner. Students network with a variety of communities/groups and use an array of technology appropriately to work with others.
Communication	Communication involves receiving and expressing meaning (e.g., reading and writing, viewing and creating, listening and speaking) in different contexts and with different audiences and purposes. Effective communication increasingly involves understanding both local and global perspectives, societal and cultural contexts, and adapting and changing using a variety of media appropriately, responsibly, safely, and with regard to one's digital footprint.	Students communicate effectively in different contexts in oral and written form in French and/or English through a variety of media. Students communicate using the appropriate digital tools and create a positive digital footprint. Students ask effective questions to acquire knowledge, listen to understand all points of view, voice their own opinions, and advocate for ideas. Students gain knowledge about a variety of languages and understand the cultural importance of language.

Global Competencies cont.

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Global Citizenship and Sustainability	Global citizenship and sustainability involve reflecting on diverse worldviews and perspectives and understanding and addressing ecological, social, and economic issues that are crucial to living in a contemporary, connected, interdependent, and sustainable world. It also includes the acquisition of knowledge, motivation, dispositions, and skills required for an ethos of engaged citizenship, with an appreciation for the diversity of people, perspectives, and the ability to envision and work toward a better and more sustainable future for all.	Students understand the ecological, economic, and social forces, their interconnectedness, and how they affect individuals, societies, and countries. Students take actions and responsible decisions that support quality of life for all, now and in the future. Students recognize discrimination and promote principles of equity, human rights, and democratic participation. Students understand Indigenous traditions and knowledge and its place in Canada, learn from and with diverse people, develop cross-cultural understanding, and understand the forces that affect individuals, societies, and nations. Students engage in local, national, and global initiatives to make a positive difference. Students contribute to society and to the culture of local, national, global, and virtual communities in a responsible, inclusive, accountable, sustainable, and ethical manner. Students as citizens participate in networks in a safe and socially responsible manner.

Global Competencies cont.

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Critical Thinking and Problem Solving	Critical thinking and problem solving involve addressing complex issues and problems by acquiring, processing, analysing, and interpreting information to make informed judgments and decisions. The capacity to engage in cognitive processes to understand and resolve problems includes the willingness to achieve one's potential as a constructive and reflective citizen. Learning is deepened when situated in meaningful, real-world, authentic experiences.	Students will solve meaningful, real-life, complex problems by taking concrete steps to address issues and design and manage projects. Students will engage in an inquiry process to solve problems as well as acquire, process, interpret, synthesize, and critically analyse information to make informed decisions (i.e., critical and digital literacy). Students will see patterns, make connections, and transfer what they have learned from one situation to another, including in real world applications. Students will construct, relate, and apply knowledge to all domains of life such as school, home, work, friends, and community. Students will analyze the functions and interconnections of social, economic, and ecological systems.
Innovation, Creativity and Entrepreneurship	Innovation, creativity, and entrepreneurship involve the ability to turn ideas into action to meet the needs of a community. The capacity to enhance concepts, ideas, or products to contribute new-to- the-world solutions to complex economic, social, and environmental problems involves leadership, taking risks, independent/unconventional thinking and experimenting with new strategies, techniques, or perspectives, through inquiry research. Entrepreneurial mindsets and skills involve a focus on building and scaling an idea sustainably.	Students formulate and express insightful questions and opinions to generate novel ideas. Students contribute solutions to complex economic, social, and environmental problems or to meet a need in a community in a number of ways including; enhancing concepts, ideas, or products through a creative process, taking risks in their thinking and creating, making discoveries through inquiry research, and by hypothesizing and experimenting with new strategies or techniques. Students demonstrate leadership, initiative, imagination, creativity, spontaneity, and ingenuity in a range of creative processes and motivate others with an ethical entrepreneurial spirit.

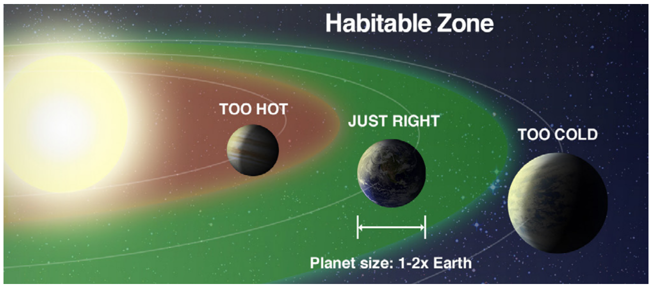
Global Competencies cont.

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Learning to learn and to be self-directed and self-aware	Learning to learn and to be self-directed and self-aware, means: becoming aware and demonstrating agency in one's process of learning, including the development of dispositions that support motivation, perseverance, resilience, and self-regulation. Belief in one's ability to learn (growth mindset), combined with strategies for planning, monitoring and reflecting on one's past, present, and future goals, potential actions and strategies, and results. Self-reflection and thinking about thinking (metacognition) promote lifelong learning, adaptive capacity, well-being, and transfer of learning in an ever-changing world.	Students learn the process of learning (metacognition) (e.g., independence, goal-setting, motivation) and believe in their ability to learn and grow (growth mindset). Students self-regulate in order to become lifelong learners and reflect on their thinking, experience, values, and critical feedback to enhance their learning. They also monitor the progress of their own learning. Students develop their identity in the Canadian context (e.g., origin and diversity) and consider their connection to the environment. They cultivate emotional intelligence to understand themselves and others. They take the past into account to understand the present and approach the future. Students develop personal, educational, and career goals and persevere to overcome challenges to reach these goals. They adapt to change and show resilience to adversity. Students manage various aspects of their lives: physical, emotional (relationships, self-awareness), spiritual, and mental well-being.

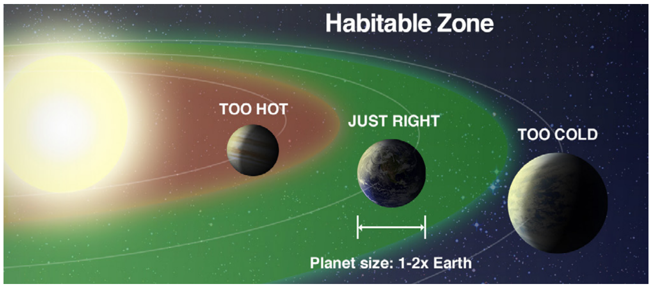
Conditions of Life on Earth Part I

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/m^3	Atmospheres trap heat and shield the planet from radiation.	Atmosphere denser than 0.007302 kg/m^3
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 = 5.972×10^{24} 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

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

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

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							

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

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. (Visit the planet by clicking here.)
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 (Learn more about me here.)
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 (Learn more about me here.)
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 (Learn more about me here.)
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.