

5E Lesson Plan

Lesson Title: Exoplanets & Habitability (Explore/Explain 3)

Unit/Theme: Astronomy - Exoplanets

Subject/Grade Level: 9th/10th grade Earth & Space Science

Time Needed: 3-4 full class periods (45 min. each - designed for remote learning)

Driving Question(s)

- What types of planets exist in the Universe? How are they similar and different?
- Which characteristics of exoplanets make them more or less suitable for supporting life?
- Which exoplanet(s) outside our solar system could support life?

NGSS Performance Expectations working toward:

- **HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.**
- **HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system**

Learning Objectives

I can differentiate between terrestrial, Super Earth, Neptune-Like and Gas Giant exoplanets based on their characteristics.

I can 'discover' a new exoplanet, summarize its characteristics and evaluate its potential habitability based on my understanding of our solar system.

I can identify and explain important characteristics of planets that we should consider when looking for a habitable exoplanet.

I can interpret NASA exoplanet data to evaluate their potential habitability.

Prior Student Knowledge

At this point students have an understanding of some of the characteristics of habitable exoplanets. Students also should have learned about the solar system including terrestrial and Jovian planets in middle school so the pre-assessment helps to determine how much they remember and how much review may be necessary.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematical and Computational Thinking Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4) Constructing Explanations and Designing Solutions Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2) Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. Obtaining, Evaluating, and Communicating Information Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.	ESS1.A : The Universe and Its Stars The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) 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 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) PS3.D: Energy in Chemical Processes and Everyday Life Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1)	Patterns Empirical evidence is needed to identify patterns. Scale, Proportion, and Quantity The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1) Energy and Matter Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) Stability and Change Much of science deals with constructing explanations of how things change and how they remain stable.

Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3) Analyzing and Interpreting Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.		
Common Core State Standards Connections: <u>Math:</u> <i>MP.2 Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-3), (HS-ESS1-4)</i> <i>MP.4 Model with mathematics. (HS-ESS1-1), (HS-ESS1-4)</i> <i>HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS1-1), (HS-ESS1-4)</i> <i>HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-4)</i> <u>ELA/Literacy:</u> <i>CCSS.ELA-LITERACY.WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS1-3)</i> <i>CCSS.ELA-LITERACY.RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.</i> <i>CCSS.ELA-LITERACY.WHST.9-10.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.</i> <i>CCSS.ELA-LITERACY.RST.9-10.2 Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. (HS-ESS3-5)</i> <i>CCSS.ELA-LITERACY.RST.9-10.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.</i> <i>CCSS.ELA-LITERACY.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.</i>		

CCSS.ELA-LITERACY.SL.9-10.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

CCSS.ELA-LITERACY.SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. (HS-ESS1-3)

Possible Misconceptions:

When it comes to evaluating planet characteristics to determine habitability, students often struggle with the NASA data when it comes to interpreting data presented in decimals, for example an exoplanet with a mass of 0.98 Earths is often misinterpreted by students as being an exoplanet with a very large mass. Additionally, students sometimes think that in order for an exoplanet to be habitable its characteristics must be almost exactly the same as Earth in terms of planet type (terrestrial) and star type (G-type).

Differentiation of Instruction:

Students may need more or less review of our solar system depending on their prior knowledge, different videos and resources can be assigned to small subsets of students. In the Explore, Explain, Elaborate sections there are multiple opportunities where students may need to select only a few of the learning activities in order to develop their content understanding and can select between videos, articles, and visualizations. This lesson includes multiple opportunities for students to engage with the same information through mini-lessons, Edpuzzle videos, and Newsela articles. Embedded questions in the Edpuzzle questions prompt students to self-assess their comprehension and the Newsela articles are assigned at the students' demonstrated reading level. The final assessment can be modified to provide students with more or less support to interpret the NASA exoplanet data.

Lesson Procedure:

5E Model	5E Objectives
<u>Engage</u> <i>Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about</i>	<u>Guiding Question:</u> What are the other planets like in our solar system? In our universe? <u>Procedure:</u> Take students on a VR Field Trip to the surface of Mars using Nearpod VR and let them explore noting similarities and differences from Earth and/or Set the stage for exploring strange exoplanets in the universe with NASA's Exoplanet Travel Bureau posters (Prompt students to click through the Travel Bureau posters and click on the 'Explore the Surface' option and choose their favorite)

<i>what students already know and want to know.</i>	Pre-assessment: Determine students' prior knowledge of our solar system using a Kahoot quiz (remote) or Plickers (in-person) to ascertain students' prior knowledge of geocentric vs heliocentric model, types of planets, differences between the inner and outer planets, etc. Resources NASA Solar System Exploration Review of our Solar System #360video: Explore The Solar System: 360 Degree Interactive Tour!
Explore <i>Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.</i>	Guiding Questions: • What types of planets exist in our solar system? How are they similar and different? • How was our solar system formed and how is it organized? • Which characteristics of planets make them more or less suitable to life? Procedure: - Edpuzzle Video: Watch the assigned video "The Solar System" (3:51) and answer the multiple choice questions in the video. Replay any sections if you are stuck on the questions. Create 4+ bullet points in your own words to describe the important differences between the inner terrestrial planets and the outer Jovian planets in our solar system. - Edpuzzle Video: Watch the assigned video "The Habitable Zone" (5:29) and answer the multiple choice questions in the video. Replay any sections if you are stuck on the questions. In your own words, describe the characteristics of the stars and exoplanets that the travelers use to determine if each of the exoplanets they explore could be habitable or not. (minimum of 4 characteristics, summarized in at least 3 complete sentences) - Learning Activity: Strange New Worlds Exploration Modifications: The Strange New Worlds Exploration requires a lot of processing power to run the visualizations so sometimes students can't get the site to load. Students can be provided with the authentic space data to compare and contrast the new planetary system with our solar system if needed. Formative Assessments: The questions in the Strange New Worlds Exploration learning activity assess students' understanding of the characteristics of Earth and our Sun and how their characteristics make Earth habitable. Additionally they assess students' ability to apply the characteristics of habitability in a new context by assessing the habitability of their chosen exoplanet. Resources NASA Exoplanet Catalog section featuring 'Strange New Worlds'

<u>Explain</u> <i>Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.</i>	Guiding Questions: • What are the characteristics that differentiate terrestrial, Super Earth, Neptune-Like and Gas Giant exoplanets? • Which characteristics of planets make them more or less suitable to life? Procedure: - Newsela Article: Read the assigned article about our solar system and how it was formed, answer the four multiple choice comprehension questions at the end in the Newsela Quiz, & Summarize the main idea of the article in the box below. <u>In your own words</u>, how are the inner planets (Mercury, Venus, Earth and Mars) different from the outer planets (Jupiter, Saturn Uranus, and Neptune) in our solar system? What are the characteristics of the inner terrestrial planets like Earth that make them better candidates to be habitable than the outer Jovian planets like Jupiter? (Summarize in 3 - 4 complete sentences. You should not use quotations in your summary, but summarize the important ideas and evidence from the Newsela article in your own words.) - Watch Exoplanets 101 National Geographic (YouTube) and provide students with a digital chart to document the four different types of exoplanets in the Universe (Gas Giant, Neptune-like, Super Earth, Terrestrial) including their similarities, differences, and characteristics that determine their habitability (size, composition, atmosphere, etc.). Students share ideas in chat to fill out the chart. Formative Assessment: Review students summaries of the Newsela article and their charts. Resource NASA's What is an Exoplanet? Planet Types
<u>Elaborate</u> <i>Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.</i>	Guiding Questions: • Has NASA already discovered Earth-like planets in the Universe? • What telescopes do NASA use to discover exoplanets light-years away? Procedure: - Have students read the article "NASA Planet Hunter Finds its 1st Earth-size Habitable-zone World" as introduction to NASA's telescopes including Transiting Exoplanet Survey Satellite (TESS), Spitzer Space Telescope and Kepler Space Telescope. - Have students (re-)watch the NASA video "Q and Alien: What's in an Exoplanet Name?" and explain the significance of the name of the exoplanet they explored in the <i>Learning Activity: Strange New Worlds</i>.

	- Ask students to then research the telescope/mission that discovered their selected exoplanet including when the telescope or mission started identifying exoplanets, where it is located, and when it may be decommissioned. Modifications: For students who need an additional challenge or enjoy doing art, they could additional or in place of another activity create an illustration imagining the view of the planetary system from the surface of their selected exoplanet. Formative Assessment: Review students explanations of their chosen exoplanet's name and the telescope or mission responsible for its discovery.
Evaluate <i>Assess students' knowledge, skills and abilities.</i>	Guiding Question: Based on our current knowledge, which of the following exoplanets could be good candidates for habitable Earth-like planets? Why? Procedure: Provide students with a data table of different exoplanets from the NASA Exoplanet Catalog (see below) including the planet type, mass, star type, orbit around the host star, etc. and have them determine for each exoplanet whether or not it could be habitable and support their answer with data from the table. Modifications: The chart has an example row that all students may not need as a support. Additional examples can be completed for additional scaffolds as well as guiding questions to help students think through how to approach the chart. Information in parentheses could also be removed for students who need less support interpreting the star type and eccentricity data. Formative/Summative Assessment: Assess students' understanding based on their responses in the chart and their written response to the question, "Based on the information in the chart above, which exoplanet have you identified as the best possible candidate to be habitable? Use the data above and your knowledge of relevant science concepts from class to explain your answer." Resources NASA's Exoplanet Catalog

(Mastery Skill Assessment) Visual Interpretation:

Based on our current knowledge, which of the following exoplanets could be good candidates for habitable Earth-like planets? Why?

Directions:

1. **Examine** the information in the table below **carefully**.
2. Each **row** contains important **data** (information) about **one** of the thousands of **exoplanets** that NASA has detected in the universe.
3. For each exoplanet, **determine if the exoplanet could potentially be habitable** by interpreting the data we have for each exoplanet in the chart.
4. **Complete** in the first empty column '**Could this exoplanet be habitable?**' with '**Yes**' or '**No**.'
5. Then, complete the second empty column: '**Identify & explain at least 2 pieces of information from the chart to show why this exoplanet could or could not be habitable.**'
6. Based on your interpretation of the information, determine which of the exoplanets presented in the chart has the **best possibility of being habitable** and answer the final question in the blue table below.
7. Resources:
 - a. [NASA's Exoplanet Glossary](#)
 - b. [NASA's Frequently Asked Questions about Exoplanets](#)

Exoplanet Name	Planet Type	Planet Mass	Star Type	Orbital Shape <i>Eccentricity</i>	In host star's habitable zone?	Light Years from Earth	Could this exoplanet be habitable? <i>Yes or No</i>	Identify & explain at least 2 pieces of information from the chart to show why this exoplanet could or could not be habitable.
EXAMPLE (we'll do this in class together): YZ Ceti c	Terrestrial	0.98 Earths	M-type (red dwarf)	0.04 (circular)	no	12		
1. Kepler-1001 c	Super Earth	3.11 Earths	G-type (yellow dwarf)	0.0 (circle)	no	3,291		
2. GJ 163 b	Neptune-like	10.6 Earths	M-type (red dwarf)	0.07 (circular)	no	49		
3. K2-136 b	Terrestrial	0.937 Earths	K-type star (orange)	0.1 (circular)	no	194		

			<i>dwarf)</i>					
4. HD 62509 b	Gas Giant	2.3 Jupiters	K-type star (<i>orange dwarf</i>)	0.02 (<i>circular</i>)	no	34		
5. Kepler-452 b	Super Earth	3.29 Earths	G-type (<i>yellow dwarf</i>)	0.0 (<i>circle</i>)	yes	1,829		

Based on the information in the chart above, which exoplanet have you identified as the best possible candidate to be habitable? Use the data above and your knowledge of relevant science concepts from class to explain your answer.

Your response:

Mastery Skill Rubrics

Visual Interpretation I can identify, interpret, apply and synthesize relevant information presented visually.			
<i>Professional (4)</i>	<i>Practitioner (3)</i>	<i>Apprentice (2)</i>	<i>Novice (1)</i>
I can synthesize the relevant information with outside knowledge to address a question or solve a problem.	I can accurately identify, interpret and apply relevant information presented visually (in a chart, graph, diagram, image, etc.).	I can identify relevant information and make basic interpretations of the relevant information presented visually (in a chart, graph, diagram, image, etc.).	I can identify relevant information related to a question or problem.

Scientific Communication I can clearly, accurately, and completely communicate scientific ideas using scientific language.			
Professional (4)	Practitioner (3)	Apprentice (2)	Novice (1)
Fluently and accurately communicates complex scientific information or ideas in a professional manner with consistent scientific language.	Clearly and accurately communicates detailed scientific information or ideas with consistent scientific language.	Communicates mostly accurate scientific information or ideas with some minor errors in scientific language.	Communicates general scientific ideas that are mostly accurate.

Reflection & Revision I can revise and improve my own work through reflection and incorporating feedback.			
Professional (4)	Practitioner (3)	Apprentice (2)	Novice (1)
I can thoroughly revise my own work using the criteria in the mastery rubrics and feedback I receive. I can show detailed evidence of reflection and revision to improve the quality of my work.	I can revise my own work using the criteria in the mastery rubrics and feedback I receive. I can show evidence of reflection and revision to improve the quality of my work.	I can revise parts of my own work using the criteria in the mastery rubrics and feedback I receive. I can show some evidence of reflection and revision to improve the quality of my work.	I can revise parts of my own work using the criteria in the mastery rubrics and feedback I receive.

References

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