Habitable Exoplanets Unit Plan

Unit/Theme: Astronomy - Exoplanets

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

Time Needed: At least 10 full class periods (45 min. each - designed for remote learning)

Unit Essential Questions:

- Are there other Earth-like planets in the universe?
- Which type(s) of star(s) would be the best candidates for having habitable, Earth-like planets orbiting them?
- How does orbit shape and location affect if an exoplanet can be habitable?
- 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-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements**
- **HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system**

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	**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) Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy . Heavier elements are produced when certain massive stars achieve a	**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) Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth v s. exponential growth). (HS-ESS1-4) **Energy and Matter** Energy cannot be created or destroyed–only moved between one place and another place,

data support the explanation or conclusion. **Engaging in Argument from Evidence** Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. **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. 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.	supernova stage and explode. (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) **PS4.B Electromagnetic Radiation** 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)	between objects and/or fields, or between systems. (HS-ESS1-2) In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3) **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable.

Common Core State Standards Connections:

Math:

MP.2 Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-3), (HS-ESS1-4)

MP.4 Model with mathematics. (HS-ESS1-1), (HS-ESS1-4)

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)

HSN-Q.A .2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-4)

ELA/Literacy:

CCSS.ELA-LITERACY.WHST.9-10.1 Write arguments focused on discipline-specific content

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)

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.

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.

CCSS.ELA-LITERACY.WHST.9-10.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

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. (HS-ESS1-1)

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.

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.

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.

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)

CCSS.ELA-LITERACY.SL.9-10.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

5E Model	5E Objectives
Engage *Is there another Earth? (1-2 sessions)*	**Guiding Questions:** ● Are there other Earth-like planets in the universe? **Objective:** I can brainstorm at least 3 topics we need to investigate in order to find an exoplanet that could support life.

	Learning Activities: - Jamboard Opener: "Is it probable that another planet similar to Earth exists somewhere in the universe? Why or why not?" - Discussion of Anchor Phenomenon Resources: ● BuzzFeed YouTube Video: 200 Seconds that will make you question your entire existence ● Astronomic YouTube Video: How Many Planets Are In The Milky Way? ● Space.com article "Exoplanets: Worlds Beyond Our Solar System" ● NASA's Mission overview for Kepler & K2 ● Q and Alien: What's in an Exoplanet Name? Video - Jamboard Brainstorm & Discussions: ● Why is Earth a great place for life? ● What do we need to investigate in order to find an Earth-like planet where humans and other species might be able to live? *Additional Resources:* NASA Exoplanet Exploration NASA What is an Exoplanet?
Explore 1 & Explain 1 The Sun *(1-2 sessions)*	**Guiding Questions:** ● How does the Sun work? ● What is going to happen to our Sun at the end of its life? **Objective:** I can explain how the Sun produces energy and why this is important to life on Earth. **Jamboard Pre-assessment:** "What is one thing you already know about the Sun?" **Learning Activities:** - Video: Sun 101 | National Geographic While watching the video, students jot down: ● What is the Sun made of? ● What is the main force that is responsible for creating energy in the Sun? ● How long do scientists calculate the Sun will 'live' for? - What does NASA know about the Sun? Explore the different resources on: https://solarsystem.nasa.gov/solar-system/sun/overview/ - On the Jamboard: Describe two new things you learned about the Sun from the video and the NASA website. - Video: How does the Sun make energy? Show (0:00-3:10) - While watching the video, students jot down: ● Any misconceptions/confusions you hear. ● What happens during nuclear fusion? ● Where does the energy come from? **Independent Learning Activities & Formative Assessments:**

	- Newsela Article: Read the assigned article about The Sun, answer the multiple choice comprehension questions at the end in the Newsela Quiz. Describe in detail TWO new things you learned about the SUN after reading the Newsela article. (Summarize your learnings in 3 - 4 complete sentences.) - Edpuzzle Video: Watch the assigned video "How does the Sun work?" (1:50) and answer the multiple choice questions in the video. In your own words, how does the Sun produce heat and light energy? (minimum of 2 complete sentences) **Extension Activity:** *Play a Game:* Fe[26] Activity & Questions
Explore 2 & Explain 2 *Types of Stars & Goldilocks zone (2-3 sessions)* ***SEE DETAILED LESSON PLAN***	**Guiding Questions:** ● Which type(s) of star(s) would be the best candidates for having habitable, Earth-like planets orbiting them? ● How does orbit shape and location affect if an exoplanet can be habitable? **Objectives:** ● I can explain what the Goldilocks (habitable) zone is and why it is important. ● I can describe the best orbit shape in order for a planet to be habitable. ● I can categorize different types of stars based on shared characteristics. ● I can predict which stars would be the best candidates for having habitable, Earth-like exoplanets orbiting them. **Formative Assessment:** CER Scientific Explanation ***Additional Resources:*** NASA What is an Exoplanet? - Stars NASA The Search For Life (Habitable Zone)
Explore 3 & Explain 3 *Exoplanets & Habitability (3-4 sessions)* ***SEE DETAILED LESSON PLAN***	**Guiding Questions:** ● 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? **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. **Formative Assessment:** Interpretation of Exoplanet Data Table
Elaborate *Exoplanet detection methods*	**Guiding Questions:** ● What methods does NASA use to identify exoplanets outside our solar system? ● Which characteristics of exoplanets can NASA currently determine and what is still left to discover? ● How has NASA's ability to detect and observe exoplanets changed over time?

& Atmospheres (2 sessions) ***SEE DETAILED LESSON PLAN***	• Why do terrestrial planets have much thinner atmospheres than Jovian planets? • What are the unique characteristics of Earth's atmosphere that make our planet habitable? **Objectives:** • I can describe two ways that NASA detects exoplanets and the advantages and the limitations of these methods. • I can explain the important characteristics of an exoplanet's atmosphere that we should consider when looking for a habitable exoplanet. **Formative Assessment:** Paragraph explaining the important characteristics of an exoplanet's atmosphere that we should consider when looking for a habitable exoplanet
Evaluate *Exoplanet Project*	**Summative Assessment CER Scientific Question:** Based on current scientific evidence, which exoplanet in the NASA Exoplanet Catalog has a high probability of being habitable by humans and should be investigated further? **Project Template (version A - more scaffolded)** **Project Template (version B - less scaffolded)** NASA Exoplanet Catalog How do exoplanets get their names? ***Additional Resources:*** NASA's Exoplanet Glossary NASA's Frequently Asked Questions about Exoplanets

Mastery Skill Rubrics

Visual Interpretation **I can identify, interpret, apply and synthesize relevant information presented visually.**			
Professional (4)	***Practitioner (3)***	***Apprentice (2)***	***Novice (1)***
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.

Claim & Evidence **I can state a detailed claim to answer a scientific question and provide relevant and sufficient scientific evidence to support that claim.**			
Professional (4)	***Practitioner (3)***	***Apprentice (2)***	***Novice (1)***

States specific, detailed claim regarding complex relationships that accurately and completely answers the scientific question. AND Supports claim with extensive relevant and varied scientific evidence.	States detailed claim that accurately and completely answers the scientific question. AND Supports claim with sufficient relevant scientific evidence.	States basic claim that answers the scientific question. AND Supports claim with some appropriate, but insufficient scientific evidence; may include some inappropriate evidence.	States basic claim that answers part of the scientific question; may provide non-scientific or unrelated evidence.

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.

This unit was inspired by Unit 1: Origin of the Universe & Solar System created by New Visions for Public Schools but this unit sequence and all materials were created by Ariadne Prior-Grosch.

References

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