How Does a Habitable Planet Develop?

By Marvin Nationales

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Lesson Overview

Level: 6-12 Time: Two 55-minute class periods

Earth is just one of innumerable objects in the universe, but it is the only object known to be able to support life. How did the planet Earth develop into the life-bearing planet that it is today? Is it possible that other habitable worlds have also developed?

Students will research particular events in the history of Earth that have led to its present state, synthesize their findings and share them with the class, and contemplate the possible rarity of habitable planets.

**Educator Background Knowledge**

The teacher needs to have an understanding of the following key concepts:

* Formation of the solar nebula
* Formation of a rocky planet circling the Sun
* Formation of the Moon
* Development of liquid water on the planet
* Appearance of anaerobic life
* Development of aerobic life
* Significant accumulation of oxygen in the atmosphere
* First ice age
* Cambrian Explosion
* Mass extinction of dinosaurs and other forms of life

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**Learning Goals**

In this lesson, students will investigate the origin of the elements, the process of planet formation, the evolution of life on Earth, and the conditions necessary for life as we know it. In addition, students will also investigate if it is possible that other habitable worlds have also developed.

**Learning Objectives**

1. Students can identify and sequence the major events that caused Earth to develop into the planet we know.
2. Students can trace where the ingredients for Earth originated, including the conditions necessary for life.
3. Students can explain the seemingly unique conditions on Earth that make it habitable for life.
4. Students can consider the likelihood of other habitable worlds.
5. Students can use two-eyed seeing in understanding the origin of Earth and life.
6. Students can identify the central idea and provide text evidence upon reviewing scientific (informational) and mythological (literary/cultural) media.
7. Students can use NASA resources to explore the Sun’s atmosphere.

**Framework for Heliophysics Education**

NASA Question: How do the Earth, the solar system, and heliosphere respond to changes on the Sun? Big Idea:Life on Earth has evolved with complex diversity because of our location near the Sun. It is just right!

 **NGSS Performance Expectations**

* MS-ESS1-2: Earth’s Place in the Universe: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
* HS-ESS1-2: Earth’s Place in the Universe: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

**Disciplinary Core Idea**

* MS-ESS1.B: Earth and the Solar System: The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.
* HS-ESS1.A: The Universe and It’s Stars: The big-ang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)

**Targeted STEM Skills**

* Planning and Carrying Out Investigations
* Constructing Explanations and Designing Solutions

Materials

Internet connection, pen, notepad, reading texts, videos, 10 index cards

**Handouts**

* KWL Chart
* Student Observation Form
* Venn Diagram
* Multimedia Rubric
* Pre-Post Test (and Answer Key)

**Links to Digital Resources for Students**

* The Formation of the Solar System in 6 minutes: <https://www.youtube.com/watch?v=x1QTc5YeO6w&t=52s>
* NASA discovers Earth-like planet in a habitable zone: <https://www.nasa.gov/feature/goddard/2020/nasa-planet-hunter-finds-its-1st-earth-size-habitable-zone-world>
* NASA video: What makes a planet habitable?: <https://www.youtube.com/watch?v=J04YN9azln8>
* [The Elements: Forged in Stars](https://nm.pbslearningmedia.org/resource/ess05.sci.ess.eiu.fusion/) explains the role of stars in creating the elements found on Earth and throughout the universe.
* [The Origin of the Moon: The Giant-Impact Theory](https://nm.pbslearningmedia.org/resource/ess05.sci.ess.eiu.moon/)shows how samples of rock from the Moon led scientists to theorize that the Moon was formed from Earth materials.
* [Global Warming: The Physics of the Greenhouse Effect](https://nm.pbslearningmedia.org/asset/phy03_vid_greenhouse2/) explains how the greenhouse effect works on Earth and how humans are affecting it.
* [Life's Basic Ingredients](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.ingredients/) explains what astrobiologists consider to be the three basic ingredients of life—water, organic compounds, and energy.
* [Life Before Oxygen](https://nm.pbslearningmedia.org/resource/tdc02.sci.life.cell.stetteroxygen/) explains how our once oxygen-free atmosphere changed dramatically when primitive bacteria evolved the capacity to harness solar energy through photosynthesis, which produced oxygen as a byproduct. Thought-provoking questions are included in the resource and should help students grasp the enormity of this development.
* [Planet-Hunting | NOVA: Finding Life Beyond Earth](https://nm.pbslearningmedia.org/resource/flbe12.sci.ess.eiu.planethunt/),
* [Microbial Life in Antarctica](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.antarctica/)
* [Thriving on the Arctic Seafloor](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.hydrothermal/)
* [Caves: Extreme Conditions for Life](https://nm.pbslearningmedia.org/resource/ess05.sci.ess.eiu.lifecondtn/)
* Science-based (Our Story In One Minute - Evolution): <https://www.youtube.com/watch?v=ZSt9tm3RoUU>
* Culture-based (Navajo): Navajo Story of the Stars: <https://www.youtube.com/watch?v=gYWyIISAMGs>
* Eyes on Exoplanets: [https://exoplanets.nasa.gov/eyes-on-exoplanets/#/](https://exoplanets.nasa.gov/eyes-on-exoplanets/)
* Explore Mars: <https://spaceplace.nasa.gov/explore-mars/en/>
* [Exploring Evidence for the History of Early Earth Interactive Timeline](https://nm.pbslearningmedia.org/asset/buac19-int-earthtimeline/)

**Key Vocabulary**

Solar Nebula, Anaerobic life, Aerobic life, Cambrian Explosion

**Material Preparation**

If possible, arrange computer access for all students to work individually or in pairs. Write each of the following events on an index card:

* Formation of the solar nebula
* Formation of a rocky planet circling the Sun
* Formation of the Moon
* Development of liquid water on the planet
* Appearance of anaerobic life
* Development of aerobic life
* Significant accumulation of oxygen in the atmosphere
* First ice age
* Cambrian Explosion
* Mass extinction of dinosaurs and other forms of life
* Access to the video: The Formation of the Solar System in 6 minutes! <https://www.youtube.com/watch?v=x1QTc5YeO6w&t=52s>

5E Steps

**Engage**

* Show a [video on NASA discovers Earth-like planet](https://www.nasa.gov/feature/goddard/2020/nasa-planet-hunter-finds-its-1st-earth-size-habitable-zone-world) in a habitable zone. You can use [Mentimeter](https://www.mentimeter.com/app) to ask students if they think there are other habitable planets like Earth in the universe? Have students share their ideas in pairs, groups, or with the whole class.
* Use the KWL chart to assess what students know about the origin of the Earth.
* Explain to the class that they will be learning about how a habitable planet like the Earth develops.
* Show the video on [what makes a planet habitable](https://www.youtube.com/watch?v=J04YN9azln8). Have students share their ideas on what makes a planet habitable.
* Have students share their ideas in pairs, groups, or with the whole class. Ask students to describe the key ideas they saw in the video. They can use a KWL Chart (see Handouts).



Credit: <https://exoplanets.nasa.gov/resources/323/goldilocks-zone/>

**Explore**

1. Divide the class into 10 groups and hand each group an index card with the name of an event. Explain that each group will conduct their own research for their assigned event and that they should be prepared to discuss their findings with the class. You may want to remind them that the answers are not always clearly defined. They should be able to answer, to the best of their ability:
2. The conditions prior to the event.
3. The event itself: What happened? What caused it? When and how did it happen?
4. The conditions after the event and its impact on the future of Earth.
5. Before having the students disperse to do their research, show the class the following video segments to introduce them to some history of the evolution of Earth and life. These videos do not directly relate to one another and do not have to be shown in order. Use as time allows. As students watch the video segments, ask them to record one thing that they learned from each video and one thing that they would like to find out more about. If there is time, have students share their thoughts with the class.

Video segments to introduce some history of the evolution of Earth and life:

* [The Elements: Forged in Stars](https://nm.pbslearningmedia.org/resource/ess05.sci.ess.eiu.fusion/) explains the role of stars in creating the elements found on Earth and throughout the universe.
* [The Origin of the Moon: The Giant-Impact Theory](https://nm.pbslearningmedia.org/resource/ess05.sci.ess.eiu.moon/)shows how samples of rock from the Moon led scientists to theorize that the Moon was formed from Earth materials.
* [Global Warming: The Physics of the Greenhouse Effect](https://nm.pbslearningmedia.org/asset/phy03_vid_greenhouse2/) explains how the greenhouse effect works on Earth and how humans are affecting it.
* [Life's Basic Ingredients](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.ingredients/) explains what astrobiologists consider to be the three basic ingredients of life – water, organic compounds, and energy.
* [Life Before Oxygen](https://nm.pbslearningmedia.org/resource/tdc02.sci.life.cell.stetteroxygen/) explains how our once oxygen-free atmosphere changed dramatically when primitive bacteria evolved the capacity to harness solar energy through photosynthesis, which produced oxygen as a byproduct. Thought-provoking questions are included in the resource and should help students grasp the enormity of this development.
1. Cultural Activity: Have students watch these two videos and complete the Venn Diagram activity.

Origin of Life Videos:

* Science-based (Our Story In One Minute - Evolution): <https://www.youtube.com/watch?v=ZSt9tm3RoUU>
* Culture-based (Navajo): Navajo Story of the Stars: <https://www.youtube.com/watch?v=gYWyIISAMGs>

Student Directions: Complete the Venn diagram by Comparing and Contrasting Scientific from Culture-Based Origin of Earth and Life. Write a compare and contrast essay after completing the Venn diagram (see Handouts).

1. Explore NASA Resources
2. Go to this website: [https://exoplanets.nasa.gov/eyes-on-exoplanets/#/](https://exoplanets.nasa.gov/eyes-on-exoplanets/)
3. Navigate the Earth and other exoplanets.
4. Gather evidence about what makes the Earth habitable.
5. Identify other exoplanets that could become habitable.
6. Play Explore Mars: <https://spaceplace.nasa.gov/explore-mars/en/>

**Explain**

Concepts discussed and vocabulary defined:

1. Have students study the [Exploring Evidence for the History of Early Earth Interactive Timeline](https://nm.pbslearningmedia.org/asset/buac19-int-earthtimeline/). The interactive will help students develop an understanding of their event and how it fits in with geologic time.
2. Have each group present their findings. Using the information they have gathered as a class, students should be able to piece together their own geologic timeline without help from the teacher. This can be done with students standing in front of the room and arranging themselves in the correct order, or by taping a representation of their event on a timeline wall in the classroom.

Note: Because of the complexity of these events and the interpretation of evidence, there may be several different "correct" versions of the timeline that the students create. Those who have collected the most evidence and have the most persuasive arguments may dictate the final result.

1. Ask students to consider the seemingly unique conditions on Earth. Allow time at the computers to look at the [Planet-Hunting | NOVA: Finding Life Beyond Earth](https://nm.pbslearningmedia.org/resource/flbe12.sci.ess.eiu.planethunt/), [Microbial Life in Antarctica](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.antarctica/), [Thriving on the Arctic Seafloor](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.hydrothermal/), and the [Caves: Extreme Conditions for Life](https://nm.pbslearningmedia.org/resource/ess05.sci.ess.eiu.lifecondtn/)videos. Discuss the following:
2. Why do most scientists think that water is necessary for life to exist?
3. How did the discovery of extremophiles change views about life?
4. Do you think that there are other habitable planets in the universe? What about habitable moons?
5. Did you find any answers to the questions that you had posed when watching the video segments earlier (in step 3)? Which of your questions did these resources answer?

4. Have the students discuss the following:

* What conditions are necessary for life as we know it?
* How does solar system formation affect whether or not life will develop on a planet?
* How does Earth's atmosphere impact life?
* What do you think would happen if a giant asteroid hit Earth now?

**Extend**

Directions: Lead a debate about the search for extraterrestrial life. Now that we understand that there are billions of galaxies in the universe, with hundreds of billions of stars in each, it seems quite probable that there may be other life or other planets similar to Earth. And now that we have found extreme forms of life in places on Earth that were previously thought unlivable, it seems possible that life may be thriving in other non-Earthlike worlds.

1. Divide the class into teams for and against further research to answer the question of whether or not humans are alone in the universe.
2. Issues to address may include the following: the timescale for life to develop, the limitations of space exploration, the conditions necessary for life, methods to search for life as we know it, methods to look for life NOT as we know it, and the search for extraterrestrial intelligence.
3. Write a persuasive essay about the search for extraterrestrial life. (See Multimedia Rubric in Handouts)

**Evaluate**

* Pre-Post Test in Handouts.

Resources

* KWL Chart
* Student Observation Form
* Venn Diagram
* Multimedia Rubric
* Pre-Post Test (and Answer Key)
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* NASA discovers Earth-like planet in a habitable zone: <https://www.nasa.gov/feature/goddard/2020/nasa-planet-hunter-finds-its-1st-earth-size-habitable-zone-world>
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* [Thriving on the Arctic Seafloor](https://nm.pbslearningmedia.org/resource/nvfl.sci.space.hydrothermal/)
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* Eyes on Exoplanets: [https://exoplanets.nasa.gov/eyes-on-exoplanets/#/](https://exoplanets.nasa.gov/eyes-on-exoplanets/)
* Explore Mars: <https://spaceplace.nasa.gov/explore-mars/en/>
* [Exploring Evidence for the History of Early Earth Interactive Timeline](https://nm.pbslearningmedia.org/asset/buac19-int-earthtimeline/)

Handouts

These begin on the next page.

**Pre-Test: How Does a Habitable Planet Develop?**

1. In order for life as we know it to exist, a planet must have:
2. Heat
3. Animals
4. Solar energy
5. Liquid water

2. Which one helps protect the Earth from radiation?

1. Atmosphere
2. Water
3. Gravity
4. Mantle

3. To offset the effects of the low-gravity space environment on the body, astronauts must:

1. Shower twice a day
2. Eat high-fat meals
3. Exercise regularly
4. Take naps every day

4. Earth’s atmosphere contains water vapor and carbon dioxide. These greenhouse gases are important because they:

1. Protect against magnetic particles
2. Are substances animals need to breath
3. Trap thermal energy in the atmosphere
4. Create Earth’s gravitational field

5. All of the extreme conditions in space that challenge manned space exploration are listed EXCEPT:

1. Space vacuum
2. Vast temperature ranges
3. High air pressure
4. Microgravity

6. What happens if a planet is too hot?

1. The water will boil away
2. The water will freeze and make ice
3. The water will be nice and warm
4. The water will be too cold

7. What happens if a planet is too cold?

1. The water will boil away
2. The water will freeze and make ice
3. The water will be nice and warm
4. The water will be too cold

8. What is the habitable zone? Select one.

1. A zone where life cannot be sustained
2. A zone with the correct distance away from a star
3. A zone in space where water is frozen
4. A zone in space where water turns into vapor

9. The habitable zone is determined by the:

1. Mass and temperature of the star
2. Mass of the planet
3. Mass and brightness of the planet
4. Gravity of the star

10. As our Sun increases in age, it also increases in size. What will happen to the habitable zone as time goes on?

1. The habitable zone will grow in size
2. The habitable zone will move further away from the Sun
3. The habitable zone will shrink in size
4. The habitable zone will move closer to the Sun

Pre-Test Answer Key: 1. D 2. A 3. C 4. C 5. C 6. A 7. C 8. B 9. A 10.B

**Post-Test: How Does a Habitable Planet Develop?**

1. In order for life as we know it to exist, a planet must have:

A. Heat

B. Animals

C. Solar energy

D. Liquid water

2. Which helps protect the earth from radiation?

A. Atmosphere

B. Water

C. Gravity

D. Mantle

3. To offset the effects of the low-gravity space environment on the body, astronauts must:

A. Shower twice a day

B. Eat high-fat meals

C. Exercise regularly

D. Take naps every day

4. Earth’s atmosphere contains water vapor and carbon dioxide. These greenhouse gasss are important because they:
A. Protect against magnetic particles

B. Are substances animals need to breath

C. Trap thermal energy in the atmosphere

D. Create Earth’s gravitational field

5. All of the extreme conditions in space that challenge manned space exploration are listed EXCEPT:

A. Space vacuum

B. Vast temperature ranges

C. High air pressure

D. Microgravity

6. What happens if a planet is too hot?
A. The water will boil away

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C. The water will be nice and warm

D. The water will be too cold

7. What happens if a planet is too cold?
A. The water will boil away

B. The water will freeze and make ice

C. The water will be nice and warm

D. The water will be too cold

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9. The habitable zone is determined by the:
A. Mass and temperature of the star

B. Mass of the planet

C. Mass and brightness of the planet

D. Gravity of the star

10. As our Sun increases in age, it also increases in size. What will happen to the habitable zone as time goes on?

A. The habitable zone will grow in size

B. The habitable zone will move further away from the Sun

C. The habitable zone will shrink in size

D. The habitable zone will move closer to the Sun

Post-Test Answer Key: 1. C 2. D 3. B 4. C 5 .A 6. B 7. C 8. A 9 .C 10. A

**Name: Date: Class Period:**

**KWL Chart**

**Topic:** How Does a Habitable Planet Develop?

| What I **Know** | What I **Want** to Know | What I **Learned** |
| --- | --- | --- |
|               |   |  |

**Student Observation Notes**

Directions: Students use this worksheet for all sources they view or read.

| Date/Time | Observation/Notes |
| --- | --- |
| 9/27/22 @ 2:07 p.m. | Type your observations here . . . |
| 9/29/22 @ 10:47 am |   |
|   |   |
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|  |  |

**Explore: Compare and Contrast the Origin of Earth and Life**

**Directions:** Complete the Venn diagram by comparing and contrasting scientific and culture-based origin of life on Earth. Write a compare and contrast essay after completing the Venn diagram that draws conclusions about the differences and commonalities.

**Scientific Origin of Earth and Life**   **Culture-Based Origin of Earth and Life**

****

 **Compare and Contrast Essay:**

**Multimedia/Essay Rubric**Copyright © Texas Education Agency, 2006. All rights reserved.
Task Description: Use this rubric to plan your work and review it before submitting.

| **Criteria** | **%** | **Exemplary** | **Admirable** | **Acceptable** | **Attempted** |
| --- | --- | --- | --- | --- | --- |
| **Research of Topic** | 20% | * Use of three or more sources, including at least two Internet and one print source; use of two search engines
* Variety of domain name suffix (.com, .edu, .net)
* Factual information is accurate
* Narrow focus of topic
 | * Use of two sources, including, including at least one Internet source; use of one search engine
* Most information can be confirmed
* Topic could be more narrowly focused
 | * Use of one Internet source
* Some errors in information
* Topic somewhat broad
 | * Use of only one source
* Numerous errors in information
* Topic too general
 |
| **Organization (Outline or Story board for Planning)** | 15% | * Logical sequencing
* Menus and paths are clear
* Original; inventive; creative
 | * Somewhat logical sequencing
* Menus and paths are mostly clear
* Original
 | * Sequencing is poorly planned
* Menus and paths are sometimes confusing
* Little originality
 | * Sequencing is confusing
* Menus and paths are confusing
* Inconsistent
* Rehash of other people’s ideas
 |
| **Content** | 20% | * Covers topic completely and in depth
* Content is readily understandable
* Media used contributes to understanding of topic
 | * Covers topic
* Content is mostly understandable
* Media used mostly contributes to understanding of topic
 | * Barely covers topic
* Content is somewhat understandable
* Media used somewhat contributes to understanding of topic
 | * Does not adequately cover topic
* Content is confusing
* Media used does not contribute to understanding of topic
 |
| **Graphic Design** | 25% | * Effective combination of multimedia and persuasive design elements
* Excellent use of navigational tools and buttons
* Graphics effectively entice audience; accurately convey message
 | * Good combination of multimedia and design elements
* Adequate navigational tools and buttons
* Visuals and images are attractive; adequately conveys message
 | * Some use of multimedia and design elements
* Some buttons and navigational tools work properly
* Use of visuals and images is limited; message is conveyed
 | * 0-1 media used
* Buttons and navigational tools are absent or confusing
* Use of visuals and images is confusing or absent; message is confusing
 |
| **Mechanics** | 10% | * Correct grammar, usage, mechanics, and spelling
* All sources are correctly cited
 | * Few grammar, usage, mechanics, or spelling errors
* Most sources are correctly cited
 | * Several grammar, usage, mechanics, or spelling errors
* Some sources are incorrectly cited
 | * Obvious grammar, usage, mechanics, or spelling errors
* Sources are not cited
 |
| **Teamwork****(optional)** | 10% | * Workload is divided and shared equally
 | * Some members contribute
 | * Few members contribute
 | * One or two people do all of the work
 |

**Assignment Score \_\_\_\_\_\_\_\_\_\_\_\_\_\_ + Beyonder/Bonus \_\_\_\_\_\_\_\_\_\_\_\_\_\_ =**

**Final Score \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

