

National Aeronautics and Space Administration



# NASA Helio Club

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## Session 6 Beyond the Heliosphere

NASA Heliophysics Education Activation Team



# Session 6: Beyond the Heliosphere

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## Time

**120 minutes** for the full progression of activities  
-or- three **25 minute** activities that stand alone

## Learning Goal

To show the interdisciplinary nature of science and how NASA missions work together to learn about the universe.

## Full Session Overview

This session starts with a Know, Want-to-know, Learned (KWL) strategy for finding out what learners already know about other stars. Learners start by exploring NASA's fleet of missions and will learn how different types of missions work together to learn about processes that occur across the universe. Learners then distinguish the difference between the life cycles of low-mass stars and high-mass stars, and model a supernova explosion. Learners analyze data from distant stars to determine which stars are more likely to have favorable conditions for exoplanets that could potentially host life. Learners expand their knowledge by further investigating how scientists find exoplanets around distant stars. Use the KWL to assess knowledge gains.

- **Prior Knowledge:** What do you already know about other stars? KWL (15 minutes)
- **Engage:** NASA's Science Fleet (15 minutes)
- **Explore: Activity 1:** Life Cycle of Stars (25 minutes)
- **Explain: Activity 2:** Finding Exoplanets (25 minutes)
- **Extend: Activity 3:** The Search for Extraterrestrials (25 minutes)
- **Evaluate:** KWL (15 minutes)



# Materials

[NASA Helio Club Youth Guide](#) (optional) includes all handouts for all six sessions.

Quantities are per learner.

## Basics

- Writing tools (pens or pencils)
- Art supplies (markers or crayons)
- (1) pair of scissors
- (1) roll of tape

## Prior Knowledge/Evaluate

- (1) [Handout KWL Session 6](#)

## Engage

- (1) [Handout NASA's Science Fleet](#)

## Explore: Activity 1

- (1) [Handout Lives of Stars](#)
- (1) [Handout Modeling a Supernova](#)
- (1) Tennis ball
- (1) Ping Pong ball

## Explain: Activity 2

- Digital Resources
- (optional) Poster Paper

## Extend: Activity 3

- [Set of Extremophile Cards](#)



## Digital Resources

- Educator Resource: [Educator Background Information](#)
- Educator Resource: [Slides Session 6](#)
- Video: [Exoplanets: Weird Wondrous Worlds](#)
- Video: [Exoplanet Types: Worlds Beyond our Solar System](#)
- Webpage: Engage: [Hubble Space Telescope](#)
- Webpage: Engage: [NASA/ESA Top 100 Images](#)
- Webpage: Engage: [James Webb Space Telescope \(JWST\)](#)
- Webpage: Engage: [International Space Station \(ISS\)](#)
- Webpage: Explore: [Chandra X-ray Observatory](#)
- Webpage: Explain: [Kepler Missions](#)
- Webpage: Explain: [TESS Mission](#)
- Webpage: Explain: [Spitzer Mission](#)
- Webpage: Explain: [Eyes on Exoplanet Interactive](#)
- Webpage: Explain: [Exoplanet Travel Bureau](#)

## Learning Objectives: At the end of the session, learners will be able to...

1. Describe how NASA missions work together to study the universe.
2. Compare the Sun to other stars in the universe.
3. Model how scientists look for stars with habitable zones.
4. Analyze NASA data about exoplanets.



## Key Vocabulary

- **Astrobiology** – A discipline of science dedicated to the study of the origins, evolution, distribution, and future of life in the universe.
- **Astrophysics** – A branch of space science dedicated to the study of the universe with a focus on how the universe and everything within it works, how the universe began and developed into its present form, and the search for life elsewhere.
- **Black Hole** – A place in space where gravity pulls so much that even light cannot get out. One way for black holes to form is during a supernova explosion.
- **Dark Matter** – An invisible form of matter that makes up a large fraction, 30%, of the universe's matter-energy composition.
- **Exoplanets** – Planets that orbit around other stars.
- **Extrasolar** – Outside of our Solar System.
- **Extremophile** - An organism that can survive in extreme environments, for example, environments that are extremely hot or cold, extremely acidic, or environments without sunlight.
- **Galaxy** – A large group of stars, gas, and dust bound together by gravity.
- **Gas Giant Planet** – A large planet mostly composed of helium and/or hydrogen.
- **Habitable Zone** – The area around a star where it is not too hot and not too cold for liquid water to exist on the surface of surrounding planets; also known as the **Goldilocks Zone**.
- **Light Year** – The distance light travels in 1 year; approximately 9.46 trillion kilometers (km) or 5.88 trillion miles.
- **Main-Sequence Star** – The phase in the life cycle of a star when the star is fusing hydrogen into helium in its core.
- **Milky Way Galaxy** – The name of the galaxy where the Solar System is located.
- **Neptune-like Planet** – Planets similar in size to Neptune and Uranus, typically having hydrogen- and helium-dominated atmospheres with cores of rock and heavier metals.
- **Neutron Star** – The dense, collapsed core of a massive star that exploded as a supernova.
- **Nuclear Fusion** – A process where two nuclei join to form a heavier nucleus.
- **Planetary Nebula** – A phase of stellar evolution that the Sun should experience several billion years from now (does not relate to a planet).
- **Protostar** – The beginning formation of a star that has not yet developed the energy-generating capabilities of a star, which fuses hydrogen into helium in its core.
- **Red Giant** – A star in the final stages of stellar evolution.
- **Stellar (star-forming) Nebula** – An enormous cloud of dust and gas occupying the space between stars and acting as a nursery for new stars.
- **Super Earth Planet** – A class of planets that are more massive than Earth, yet lighter than ice giants like Neptune and Uranus, and can be made of gas, rock, or a combination of both.
- **Supernova** – A large explosion that takes place at the end of a star's life cycle.



- **Supernova Remnant** – The remains of a supernova explosion.
- **Terrestrial Planet** – Planets with a compact, rocky surface.
- **Transits** – When one object crosses in front of another in space.
- **White Dwarf** – An extremely dense object formed from a dead Sun-like star, after the star has exhausted its nuclear fuel.

Review the [Educator Background Information](#) for more information on major concepts.



# Next Generation Science Standards (NGSS) Connections

**MS-ESS1-1. Space Systems:** [Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.](#) In this session, learners explore the cycles of other star systems and compare them to our Solar System.

**MS-PS4-2. Waves and Electromagnetic Radiation:** [Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.](#) In this session, learners explore how scientists use light to learn about exoplanets.

**MS-LS2-3. Matter and Energy in Organisms and Ecosystems:** [Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.](#) In this session, learners explore the habitable zones of stars and the capabilities of exoplanets to support life.

**MS-ETS1-4. Engineering Design:** [Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.](#) In this session, learners compare tools used to observe the Sun.

## Targeted STEM Skills

### Asking questions

In this session, learners ask questions using a KWL.

### Making predictions

In this session, learners make predictions about the forces involved in a supernova explosion.

### Developing and using models [MS-PS4-2] [MS-ESS1-1] [MS-ETS1-4] [MS-LS2-3]

In this session, learners model a supernova explosion.

### Recognizing patterns [MS-ESS1-1]

In this session, learners identify patterns in cause-and-effect relationships.

### Analyzing, organizing, and interpreting data

In this session, learners interpret data on exoplanets.



# Steps: Full Session

*\*Italics indicate recommended scripts to use with students.*

Use the accompanying slides to help keep learners engaged.



- **Prior Knowledge:** What do you already know about other stars? KWL (15 minutes)
- **Engage:** NASA's Science Fleet (15 minutes)
- **Explore: Activity 1:** Life Cycle of Stars (25 minutes)
- **Explain: Activity 2:** Finding Exoplanets (25 minutes)
- **Extend: Activity 3:** The Search for Extraterrestrials (25 minutes)
- **Evaluate:** KWL (15 minutes)

# Prior Knowledge: What do you already know about other stars?

## Overview

### (15 Minutes)

A KWL chart is an effective way to assess learners' prior knowledge, identify misconceptions, and measure growth. Use the guiding questions provided in the chart below to focus learners on the content that is explored in this session.

As students share their ideas and predictions, don't give them the answers just yet; rather, encourage them to investigate their questions throughout the session.

If you don't use the Youth Guide, have learners use a notebook to record their observations, draw diagrams, and collect data.

## Materials

- [Handout\\_KWL\\_Session\\_6](#)

## Instructions

- A. Direct learners to page 76 in the [NASA Helio Club Youth Guide](#), or print the [Handout\\_KWL\\_Session\\_6](#)
- B. Have learners complete the **K [Know Column]** and the **W [Wonder Column]** of the KWL chart. Instruct them to leave the L [Learn Column] blank until the end of the session. [Slide 4]



## KWL

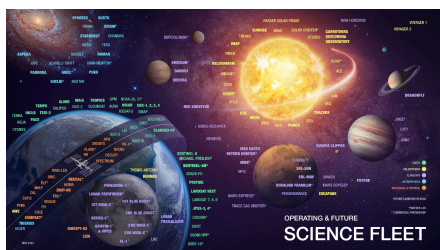
<b>[K] – What do you already know?</b>	<b>[W] – What do you wonder about?</b>	<b>[L] – What did you learn?</b>
<p><b>What do you already know about other stars?</b></p> <ul style="list-style-type: none"><li>• <i>Are all stars in the universe similar to the Sun?</i></li><li>• <i>Do other stars have planets around them? If so, what do you think those planets are like?</i></li><li>• <i>How do we learn about other stars?</i></li></ul>	<p><i>Record questions you have about other stars in this column.</i></p>	<p><i>Record what you learned about other stars in this column.</i></p>



# Engage: NASA's Science Fleet

## Overview (15 Minutes)

This activity introduces learners to NASA's science fleet of missions. This session focuses specifically on **astrophysics** missions, and how information from other stars helps us learn about the Sun and the heliosphere.



Operating and Future NASA Missions  
**Credit: NASA**

Learners identify their favorite Hubble image. The **Hubble Space Telescope** is an iconic **astrophysics** mission that has contributed to many NASA discoveries.

While **Hubble** is still in operation, and is still providing scientists with important data, the **James Webb Space Telescope (JWST)**, launched on December 25, 2021, is the newest space telescope. JWST is bigger and can see farther

## Materials

- [Handout NASA's Science Fleet](#)

## Instructions

- A. Examine:** Direct learners to page 77 of the [NASA Helio Club Youth Guide](#) or use the [Handout NASA's Science Fleet](#). *This graphic is not to scale and does not show actual orbits.* [Slide 5]

*This graphic is a visual representation of NASA's entire science fleet of missions, which includes the **heliophysics missions (shown in yellow)** that are explored in previous NASA Helio Club sessions.*

**Ask learners:** Which missions have we learned about during previous NASA Helio Club sessions? Which of the missions were most interesting to you? Why?

[The missions students explored in NASA Helio Club Sessions 1-5 include: **IBEX, Voyager, Parker Solar Probe, MMS, Artemis, ICON, SDO, and STEREO, Hubble**, and **ISS**.]

**Direct learners to the key on the [Handout NASA's Science Fleet](#).**

*NASA's missions are divided into five main categories, based on what they study. Together, all of these missions give NASA a better understanding of how the universe works.*

- **Earth Science missions in green**
- **Heliophysics missions in yellow**
- **Planetary Science missions in purple**
- **Astrophysics missions in blue**

than Hubble can. JWST collects different wavelengths of light than Hubble does. Hubble can see in the ultraviolet, visible, and near-infrared range; JWST focuses on the near-infrared and the mid-infrared wavelengths. The information gathered from both **Hubble** and **JWST** help scientists to better understand how the universe was formed.

Learners can discover more about the **Electromagnetic Spectrum** in NASA Helio Club Session 2: Observing the Sun and Session 5: Aurora: Seeing the Magnetosphere.

- **Biological and Physical Sciences missions in orange.**

*Many of the missions we have been learning about have been **heliophysics missions**, which are very important for understanding the effects of the Sun and space weather on our planet.*

***Earth science missions** are critical for monitoring the health of Earth, including gathering data on global temperatures, precipitation, ocean currents, forest health, wildfires, and the effects of climate change.*

***Planetary science missions** include missions to other planets and their moons, and even to asteroids and comets. Scientists are very interested in our neighbors, Venus and Mars, which hold clues about how Earth was formed.*

***Biological and Physical Sciences (BPS) missions** use the spaceflight environment to study phenomena in ways that cannot be done on Earth. [The International Space Station](#) (ISS) is a BPS mission.*

***Astrophysics missions** study everything beyond the heliosphere. This includes other stars, **exoplanets, galaxies, black holes**, the underlying structure of matter and energy in the universe and how it has evolved since the Big Bang. The [Hubble Space Telescope](#) is an astrophysics mission.*

*All of these missions work together to create a deeper understanding of the universe.*

- B. Favorite Hubble Image:** *The Hubble mission is a partnership between NASA and the European Space Agency (ESA). Hubble, launched in 1990, spends most of its time looking at objects very, very far away. Hubble is a space telescope, which means it orbits the Earth, just about 500 km (about 311 miles) above the surface of Earth. Because Hubble is above Earth's atmosphere,*

*it takes very clear pictures without the “fogginess” of Earth’s atmosphere. Remember that telescopes collect light. Light is information, and by using spectroscopes and other tools to analyze the light, we can learn information about objects very far away.*

***Astrophysics** missions, like Hubble, teach us more about the universe so we can better understand our local neighborhood, the heliosphere.*

**Direct learners to the [NASA/ESA Top 100 Images website](#).** Instruct learners to look through the images and choose their favorite. [Slide 6]

Optional: Have learners share their favorite image.

## Major Concepts

- ★ NASA has a variety of types of missions, which all work together to create a deeper understanding of the universe.
- ★ **Astrophysics** missions, like Hubble, teach us more about the universe so we can better understand our local neighborhood, the heliosphere.
- ★ Space telescopes, like Hubble, orbit Earth above Earth’s atmosphere. They take very clear pictures without the “fogginess” of Earth’s atmosphere.
- ★ Light is information, and by using telescopes, spectroscopes, and other tools to analyze the light, we can learn information about objects very far away.

## Featured NASA Missions

The [Hubble Space Telescope](#) is an **astrophysics** mission. Hubble’s domain extends from the ultraviolet through the visible and into the near-infrared. This range has allowed Hubble to deliver stunning images of stars, galaxies, and other astronomical objects that have changed our understanding of the universe. Hubble has made more than 1.5 million observations over the course of its lifetime.

The [James Webb Space Telescope \(JWST\)](#), launched on December 25, 2021, is the premier observatory of the next decade, serving thousands of astronomers worldwide. It studies every phase in the history of our Universe, ranging from the first luminous glows after the Big Bang, to the formation of solar systems capable of supporting life on planets like Earth, to the evolution of our own Solar System.

# Explore: Life Cycles of Stars

## Overview of Activity 1 (25 Minutes)

In this activity, learners compare the life cycle of a Sun-like star to the life cycle of a massive star using an infographic.

Learners then model the directional forces of a **supernova** explosion using a tennis ball and Ping-Pong ball to represent the outer layers of a star.

The activity concludes with having learners examine images from NASA's Chandra Mission, which takes images of distant stars and entire galaxies of billions of stars.

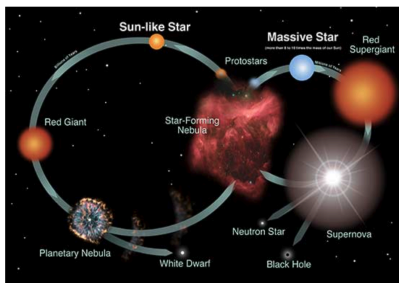


Diagram showing the lifecycles of Sun-like and massive stars. Click image for larger version. (Credit: NASA and the Night Sky Network)

## Materials

- (1) [Handout Lives of Stars](#)
- (1) [Handout Modeling a Supernova](#)
- (1) Tennis ball
- (1) Ping Pong ball

## Instructions

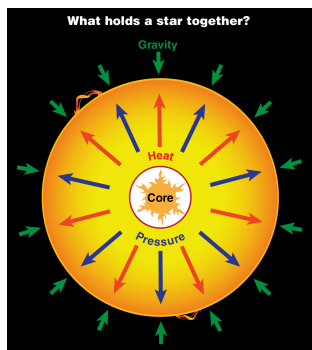
**A. Provide Context:** *We learned in Session 1 that the Sun is a star. Living next to a star gives scientists a unique chance to study a star up close. Studying the Sun can teach us a lot about other stars and about the fundamentals of how the universe works. In turn, learning about other stars can help us learn more about the Sun and the heliosphere.*

*NASA has many **astrophysics** missions that look at stars in the Milky Way Galaxy, as well as stars in distant **galaxies**. Scientists are interested in learning about other stars for a variety of reasons, one of which is the role they play in the evolution of matter in the universe.*

*There are lots of different types of stars! They come in different sizes; some stars are 100 times more massive than the Sun, while others may be a few tenths of the size of the Sun! The Sun is a very mild-mannered star. It has no strong winds, and relatively constant output, for which we can all be grateful.*

*Stars have different temperatures, which make them different colors. Blue stars are very hot! (The hotter the star, the shorter the wavelength of light it will emit; blue light has shorter wavelengths.)*

*Just like the water cycle or life cycles here on Earth, stars go through cycles. Some stars live longer than others, depending on their size. Stars fall into two main*



What Holds a Star Together?  
Credit: NASA Space Place

categories, smaller ones (or “low-mass” stars) and larger ones (or “massive” stars). Our Sun is a low-mass star.

**B. Examine:** Direct learners to page 78-79 of the [NASA Helio Club Youth Guide](#) or use the [Handout Lives of Stars](#). This graphic (not to scale) shows the life cycle of both a smaller star, like our Sun, and a star 10 times the mass of our Sun. [Slide 7]

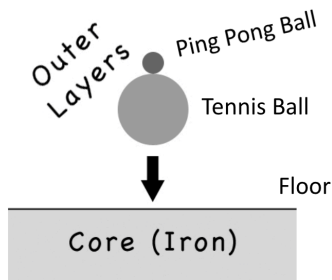
Guide learners through the graphic, exploring each phase using the educator notes below. Use the following questions to help learners engage with the handout.

- How do both low-mass stars and massive stars begin their life?
- Why is this process considered a cycle?
- What are the similarities and the differences between the red giant phase of a low-mass star and the red supergiant phase of a massive star?
- While a Sun-like (low-mass) star will slowly lose its material through the planetary nebula stage, eventually becoming a white dwarf - how will a massive star lose its material and what will it become?

**C. Model:** We learned that the elements in the star’s core go through many levels of **fusion**, which stops at fusing iron. It takes more energy to fuse iron than it would create. Fusion slows and stops, and the gravity of the star causes the outer layers of the star to fall into the core. The result of the collapse is a **supernova**. [Slide 8]

*A star is in balance between two opposite forces. The star’s gravity tries to squeeze the star into the smallest, tightest ball possible. But the nuclear fuel burning in the star’s **core** creates strong outward pressure. This outward push resists the inward squeeze of gravity.*

*When a massive star runs out of fuel, it cools off. This*



Modeling a Supernova

**Credit: NASA Afterschool Universe**

Help guide learners on the processes of science by having them think about how to make and record observations. Ask them to consider how they will measure results (height), how many times they think they should do the experiment (trials), and in what format they will collect their data (data table).

*causes the pressure to drop. Gravity wins out, and the star suddenly collapses. The collapse of the outer layers into the core of the star happens so quickly that it creates enormous shock waves that cause the outer part of the star to explode outward!*

**Direct learners to the diagram on page 80** of the [NASA Helio Club Youth Guide](#) or use the [Handout Modeling a Supernova Explosion](#). [Slide 9]

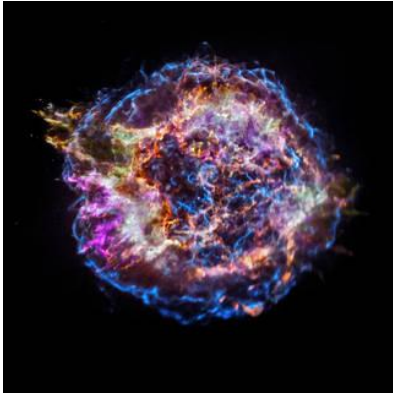
*We can model these directional forces by using a Ping-Pong ball and a tennis ball. The diagram shows how the tennis ball and Ping-Pong ball can be used to model the collapse of a star when fusion stops creating the outward pressure. The tennis and Ping-Pong balls represent the outer layers of the star. The floor represents the iron core of the star.*

**Direct learners using the procedure below:**

1. *First, make a prediction! How do you think each ball will behave?*
2. *Start by experimenting with bouncing each ball separately off the floor before dropping them together.*
3. *Drop the balls at the same time, with the balls in contact with one another. You have the option of using one or two hands. This may take a little bit of practice, so try it a few times and compare results.*
4. *Record your observations.*

As they experiment, have learners focus on the following questions:

- What happens to the tennis ball when it hits the floor by itself?
- What happens to the Ping-Pong ball when it hits the floor by itself?
- What happens to each ball when they hit the floor



This image of supernova remnant Cassiopeia A, captured by NASA's Chandra X-ray Observatory, reveals the location of silicon (red), sulfur (yellow), calcium (green) and iron (purple) in the debris. Cassiopeia A lies about 11,000 light-years from Earth. **Credits: NASA/CXC/SAO**

Chandra is an **X-ray telescope**. This provides another opportunity to revisit the **electromagnetic spectrum** with learners. Hubble sees the universe in mostly **visible light**, while JWST captures images farther into the **infrared** portion of the spectrum. Each type of light gives scientists different types of information.

Because no light can escape a **black hole** the images of **black holes** are of the event horizon, which is basically the edge of the **black hole**.

together?

Allow time for learners to experiment and have them share their observations.

- D. Analyze Data:** *Many of NASA's space telescopes, along with Hubble, that look at distant stars and have captured images of supernovae and even **black holes**. The image on the [Handout Modeling a Supernova Explosion](#) (page 80) is an image of a supernova remnant, taken by [NASA's Chandra X-ray Observatory](#).*

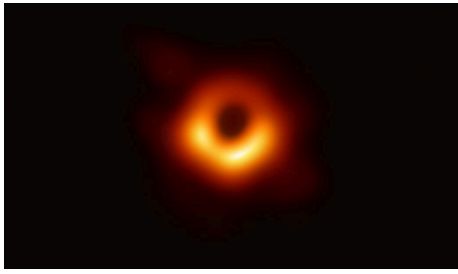
*Chandra is the world's most powerful **X-ray** telescope (telescope designed to detect X-rays). **X-rays** are produced in the universe when matter is heated to millions of degrees, like **supernova remnants** and the event horizon of a **black hole**.*

**Direct learners to the [Chandra Stories](#)** and have them complete the Chandra Image Scavenger hunt. [Slide 10]

**Scavenger Hunt Items:**

- Spiral Galaxy
- Supernova Remnant
- Black Hole
- Nebula

*Many of the images in the Chandra gallery are composite images, meaning multiple images laid over top of one another. This is so scientists can see the features of the image in multiple wavelengths of light. For example the image of the spiral galaxy, Messier 74 (M74), shown below, combines Chandra's X-rays with infrared data from JWST images, both of which are invisible to the unaided eye, along with data from NASA's Hubble Space Telescope (visible light). [Slide 11]*



An image of the **black hole** at the center of the galaxy M87. The **black hole** is outlined by emission from hot gas swirling around it under the influence of strong gravity near its event horizon. **Credit: Event Horizon Telescope**



### Galaxy M74

**Credits:** X-ray: Chandra: NASA/CXC/SAO, XMM: ESA/XMM-Newton; IR: JWST: NASA/ESA/CSA/STScI, Spitzer: NASA/JPL/CalTech; Optical: Hubble: NASA/ESA/STScI, ESO; Image Processing: L. Frattare, J. Major, and K. Arcand

*JWST outlines gas and dust in the **infrared** while Chandra data spotlights high-energy activity from stars at **X-ray** wavelengths. Hubble optical data showcases additional stars and dust along the dust lanes. These cosmic wonders and details are made available by mapping the data to colors that humans can perceive (**X-ray**: purple; optical: orange, cyan, blue; **infrared**: green, yellow, red, magenta).*

## Activity 1 Major Concepts

- ★ Scientists are interested in learning about other stars for a variety of reasons, one of which is the role they play in the evolution of matter in the universe.
- ★ Stars come in different sizes; some stars are 100 times more massive than the Sun, while others may be a few tenths of the size of the Sun!
- ★ The Sun is an average-sized, very mild-mannered star. It has no strong winds, and relatively constant output of energy.
- ★ Stars are born in a **stellar nebula**, which is made of mostly hydrogen and dust.
- ★ The **main sequence** phase of the life cycle of a star is when the star is actively making energy through **nuclear fusion**.
- ★ Our Sun is currently in the **main sequence** phase of its life and will continue to do so for about 5 billion more years.
- ★ Sun-like stars end their lives as a **white dwarf**; massive stars end their lives either as a **neutron star** or a **black hole**, depending on the mass of the star.
- ★ Material from dead stars is recycled into new stars.

- ★ A star is in balance between two opposite forces: The outward pressure caused by nuclear fusion, and the inward pressure of gravity. A **supernova** explosion occurs when the star runs out of fuel and the force of gravity causes the star to collapse in on itself.
- ★ The Sun will not become a **supernova**.

**Featured NASA Mission:** [NASA's Chandra Mission](#) is the world's most powerful X-ray telescope (telescopes designed to detect X-rays). X-rays are produced in the cosmos when matter is heated to millions of degrees. Such temperatures occur where high magnetic fields, extreme gravity, or explosive forces exist. X-ray telescopes can also trace the hot gas from an exploding star or detect X-rays from matter swirling as close as 90 km from the event horizon of a stellar black hole. This increased clarity can help scientists answer fundamental questions about the origin, evolution, and destiny of the universe.



## Educator's Notes: Lives of Stars Infographic

**(1) Nebula:** As you can see, both a smaller star and a more massive star begin their life in what is called a **star-forming nebula**, or a **stellar nebula**, and it is where stars are born; it's like a nursery for infant stars. A **stellar nebula** is made of mostly hydrogen and dust.

**(2) Protostar:** At the next phase, gravity is pulling all of the star material together and the material is spinning and beginning to heat up. Scientists call this a **protostar**.

**(3) Main Sequence:** (Not labeled on the infographic) Next, both a low-mass star and a massive star will enter the main phase of a star's life, the **main-sequence** phase, in which the star is actively consuming hydrogen to make energy through a process called **nuclear fusion**. Our Sun is currently enjoying the **main-sequence** phase of its life and will continue to do so for about 5 billion more years. The size of the star determines how long the **main-sequence** phase is. Larger stars burn much hotter and faster than lower-mass stars and run out of fuel much more quickly.

<b>Sun-like Star (low mass)</b>	<b>Massive Star (8-10 times the mass of the Sun)</b>
<p><b>(4) Red Giant:</b> The next phase our Sun will go through is the <b>red giant</b> phase. This phase begins when the star runs out of hydrogen, which is the fuel that makes the star's energy for most of its life. In the <b>red giant</b> phase, the Sun will use helium for fuel, which burns hotter than hydrogen, causing the Sun to expand. This will be bad news for any life forms on Earth during that time, because the <b>red giant</b> will expand so far that it will envelop the Earth. But you don't have to worry because that won't happen for another 5 billion years. But, our Sun will steadily increase in luminosity before then so that in 'only' another billion years, Earth will be uninhabitable for life. It is important to emphasize that our Sun will not explode!</p>	<p><b>(4) Red Supergiant:</b> The next phase a massive star will go through is the <b>red supergiant</b> phase, which like a supergiant, occurs when the star runs out of hydrogen and begins to fuse helium, causing the star to expand. While our Sun doesn't have enough mass or energy to fuse helium into carbon, massive stars are able to go through many phases of fusion. This causes the star to expand and contract several times over millions of years, as each new phase of fusion occurs. Helium fuses into carbon, until all the helium is gone; then carbon fuses into oxygen, etc.).</p>
<p><b>(5) Planetary Nebula:</b> This term can be misleading because it doesn't really have anything to do with planets. A <b>planetary nebula</b></p>	<p><b>(5) Supernova:</b> Fusion stops when the core of the star is made of iron, because fusing iron requires more energy than it produces. The star</p>

is simply the leftover gas and dust from the shell of the dying star that may become part of another **(1) stellar nebula** one day, which can eventually become part of a new planetary system! That is what makes it a cycle.

is now out of fuel and is left with a heavy iron core. Without the inner pressure created by fusion inside the core, the force of gravity overpowers the balance of forces, causing the star to collapse in on itself. This collapse creates a **supernova explosion**. The outer layers of material are shot outward in the explosion and form what scientists call a **supernova remnant**, which is also material that can be recycled into a (1) planetary nebula one day, which can eventually become part of a new star system! That is what makes it a cycle.

Many of the elements essential for life on Earth are manufactured through the life and death of massive stars, including oxygen, nitrogen, calcium, sodium, and magnesium.

**(6) White Dwarf:** When a low-mass star like the Sun runs out of fuel and **nuclear fusion** stops, the core of the star collapses and becomes a **white dwarf**, while the outer shell of the star gently drifts away and can become a **planetary nebula**. A **white dwarf** slowly cools and dims over time, until eventually it stops radiating any light. The material that makes up a **white dwarf** is very dense. One teaspoon of the material would weigh as much as an entire school bus.

**(6) Neutron Star or Black Hole:** When a massive star runs out of fuel and **nuclear fusion** stops, the core of the star collapses, causing the shell of the star to explosively bounce off the dense iron core, projecting star material and elements far out into space with tremendous energy (**supernova**). Because the core collapse is even more dramatic than in a low-mass star, it creates an even denser object than a white dwarf; the remaining core becomes a **neutron star** or a **black hole**, depending on how big the original star was. **Black holes** are only created from the largest stars in the universe that are more than 20-times more massive than our Sun.

# Explain: Finding Exoplanets

## Overview of Activity 2 (25 Minutes)

In this activity, learners apply their knowledge of stars to looking for planets around other stars, which are called **exoplanets**. Learners will explore how these exoplanets are discovered and why scientists are interested in looking for exoplanets that could potentially host life.

**Exoplanets** roughly around the same size and composition as Earth, orbiting around a Sun-like star, are good candidates for potential life.

Learners begin by gathering background knowledge on how transits are used to find exoplanets and then examine data from NASA's Eyes on **Exoplanets** interactive to learn more about the types of exoplanets that have been discovered so far.

Emphasize that the knowledge we have about our own Sun and the Solar System helps us to learn about other star systems. Other star systems

## Materials

- Digital Resources

## Instructions

- A. Provide Context:** *The Sun has eight official planets orbiting it, as well as many other objects. It turns out that other stars have planets orbiting around them, too. We call these **extrasolar planets**, or **exoplanets**.*

**Show learners the following videos:** [Exoplanet Types: Worlds Beyond our Solar System](#) and [Exoplanets: Weird and Wondrous](#). [Slide 12]

**After the video, review the planet types:**

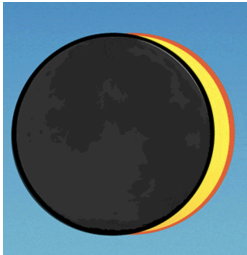
- Earth is an example of a **terrestrial planet**, which is rocky.
- Jupiter is an example of a **gas giant**, which is made of gas.
- **Neptune-like planets** are bigger than terrestrial planets, but smaller than gas giants.
- A **Super Earth** is bigger than Earth, but smaller than Neptune-like planets. We don't have any Super Earths in our Solar System, but they are quite common in the galaxy.

*There are two NASA missions dedicated to finding **extrasolar planets**, or **exoplanets**: [Kepler and K2 Missions](#) and [TESS](#) (Transiting Exoplanet Survey Satellite). Along with TESS and Kepler, Hubble has also made **exoplanet** discoveries, as well as another **astrophysics** mission: [Spitzer Space Telescope](#). As of 2023, NASA missions have discovered more than 5,000 **exoplanets**!* [Slide 13]

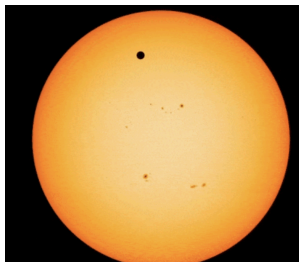


can, in turn, help us to learn about our own.

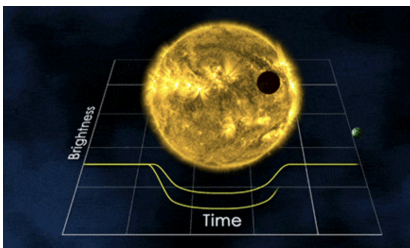
### NASA Space Place Graphics



Graphic 1: Solar Eclipse  
Credit: NASA/JPL-CalTech



Graphic 2: Venus Transit  
Credit: NASA



Graphic 3: Brightness vs. Time  
Credit: NASA GSFC

Finding **exoplanets** can be pretty hard because stars are gigantic and bright and, comparatively, planets are small and dim. In most cases, scientists can't just point a telescope at a star and see planets orbiting it. But there are other methods that scientists can use to find them.

There are multiple methods that scientists use to find **exoplanets**. NASA does not confirm the discovery of an **exoplanet** until it has been confirmed by at least two different methods.

The Kepler and TESS missions use a specific method to discover **exoplanets** by looking for **transits**. A **transit** is when an object passes between a star and its observer. More **exoplanets** are discovered this way than any other method.

**B. Examine: Direct learners to the transit resources on [NASA Space Place](#).** Guide learners through the graphics as they scroll down the page.

**Graphic 1:** We can experience **transits** here on Earth. One example of a transit is a **solar eclipse**, when the Moon passes between Earth and the Sun, and all three objects are perfectly aligned. [Slide 14]

**Graphic 2:** We can also view **transits** of Venus and Mercury from Earth, during the right time, when these inner planets pass between Earth and the Sun. Seeing a **transit** of Venus or Mercury from Earth requires special equipment. But just like a **solar eclipse**, all of the participating parts need to be lined up in just the right way.

**Graphic 3:** There is a star on a graph with the y-axis labeled "brightness" and the x-axis labeled "time." Because telescopes often can't directly see the **transit** of an **exoplanet**, they look for a change in light from the star as the **exoplanet** passes between the star and the

telescope. More **exoplanets** are discovered this way than any other method.

Watch how the light output dips on the graph as the planet passes between the star and the telescope. The amount of light blocked by the planet tells us how big the planet is compared to its star. The amount of time between each **transit** tells us about the planet's orbit.

**C. Analyze Data:** Direct learners to [NASA's Eye on Exoplanets Interactive](#) to analyze data gathered about the **exoplanets** NASA has discovered so far. Emphasize that new data is being gathered by NASA missions every day. [Slide 15]

**Use the educator notes below to guide learners through the features of the interactive webpage.**

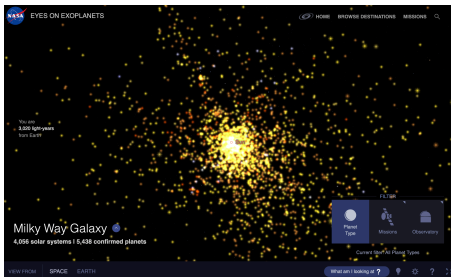
Encourage learners to explore multiple data points and to record their observations about the star, the planets, and the entire system.

- *What are the characteristics of the star? How does the star compare to the Sun?*
- *What are the characteristics of the planet? How do the planets compare to the planets in our solar system?*
- *What are the characteristics of the system? How does the system compare to our solar system?*
- *Do you notice any patterns across the data points you explored?*

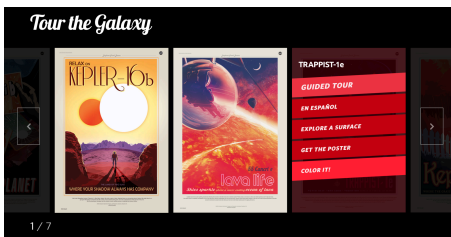
**Give time for learners to explore the data and share their observations.**

**D. Extend:** Point learners to the [Exoplanet Travel Bureau](#), which includes seven **exoplanets** that have been further imagined by a collaboration of scientists and artists.

*Artist Tyler Nordgren worked with scientists to create an illustration of what these **exoplanets** might be like, based on the available data gathered by missions like Kepler and*



Eyes on Exoplanets  
**Credit: NASA**



Exoplanet Travel Bureau  
**Credit: NASA**



A global ocean of lava under sparkling, silicate skies reflecting the lava below: What better choice for an extreme vacation? **Credit: Tyler Nordgren**

TESS. These creatively crafted travel posters include some of the sites and attractions a visitor may encounter on one of these exoplanets. Would you like to visit a planet with two Suns? How about a planet with red grass?

Each **exoplanet** featured in the Travel Bureau includes a travel poster, a tour of the poster details, and an interactive feature that allows you to explore the imagined surface of the **exoplanet**. Print your favorites or color your own!

**Ask learners:** Which one would you like to visit? Why?

- E. Optional:** Instruct learners to choose one of the exoplanets that they explored in [NASA's Eye on Exoplanets Interactive](#) (in Part A) to create their own *Exoplanet Travel Bureau* poster. Remind learners that they can be creative, but that they should consider the available data when creating their own travel poster.

**To complete Part E,** budget more time for this activity, or use it as a homework extension, or a culminating unit project.

## Activity 2 Major Concepts

- ★ **Extrasolar planets**, or **exoplanets** are planets found outside of the Solar System, usually orbiting around other stars.
- ★ Finding **exoplanets** can be pretty hard because stars are gigantic and bright and, comparatively, planets are small and dim.
- ★ As of 2022, NASA missions have discovered more than 5,000 **exoplanets**!
- ★ There are multiple methods that scientists use to find exoplanets. NASA does not confirm an exoplanet find until it has been confirmed by at least two different methods.
- ★ The Kepler and TESS missions use a specific method to discover exoplanets by looking for **transits**. A **transit** is when an object passes between a star and its observer. More planets are discovered this way than any other method.
- ★ Missions looking for **exoplanets** are very interested in looking at stars similar to the Sun, which are the best candidates for hosting **exoplanets** with potential biological life.

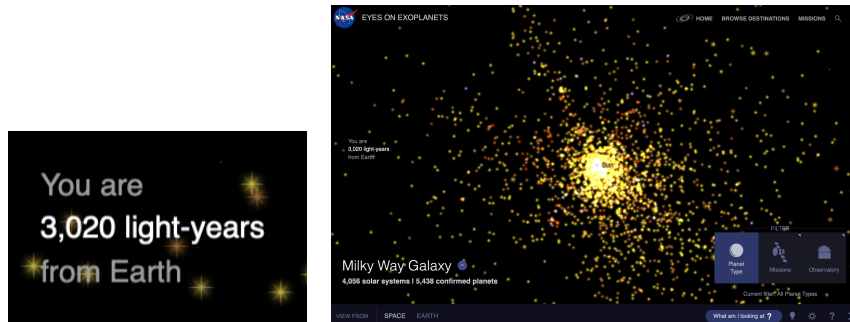
- ★ Sun-like stars have conditions that can host planets where there could be potential for biological life. These conditions include long life cycles and temperatures similar to the Sun.
- ★ When scientists find Sun-like stars, they look around the star in an area called the **habitable zone**, or the **Goldilocks Zone**, which is the distance from a star that a planet could exist with liquid water on the surface.
- ★ Life is most likely to exist on a **terrestrial planet**, roughly the size of Earth.

### Featured NASA Missions:

- The [Kepler Mission](#) is specifically designed to survey our region of the Milky Way galaxy to discover hundreds of Earth-size and smaller planets in or near the habitable zone and determine the fraction of the hundreds of billions of stars in our galaxy that might have such planets.
- The [TESS Mission](#) will find exoplanets that periodically block part of the light from their host stars, events called transits. TESS will survey 200,000 of the brightest stars near the Sun to search for transiting exoplanets.
- The [Spitzer Space Telescope](#)'s highly sensitive instruments allowed scientists to peer into cosmic regions that are hidden from optical telescopes, including dusty stellar nurseries, the centers of galaxies, and newly forming planetary systems. Spitzer's infrared eyes also allowed astronomers to see cooler objects in space, such as failed stars (brown dwarfs), extrasolar planets, giant molecular clouds, and organic molecules that may hold the secret to life on other planets.

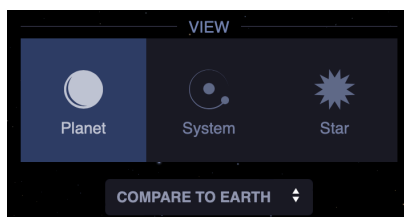
## Educator's Notes: NASA's Eyes on Exoplanets Interactive

- **Each plot on the screen is a star** where an **exoplanet** has been discovered. You can see the Sun labeled at the center of the data plots. You can zoom in and out and it will display the distance the plot is from Earth.

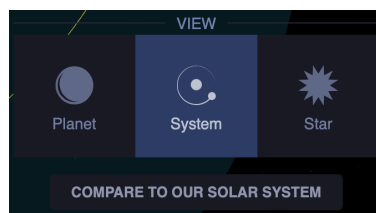


Each point is a star with a confirmed exoplanet.

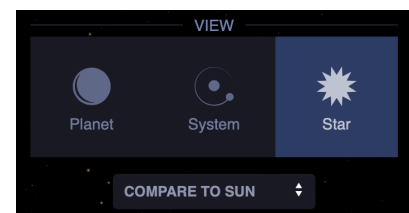
- **When you click on a data point, it zooms in on the star and its orbiting planets.**
- **Choose to view the planet, the star, or the whole system (the star and planets).** The data includes an artist's conception of what the **exoplanet** may look like, based on data about the exoplanet, including the size of the planet and the distance of the planet to its star. Because stars are so much brighter than planets it is hard to directly view these planets, so scientists and artists collaborate and use data to come up with an illustration of what the planet might look like.
- You can also **COMPARE** each one to our Solar System, the Sun, and to familiar planets like Earth and Jupiter.



View Planet



View System



View Star

- You can refine your search by clicking on **BROWSE DESTINATIONS** to search by planet type, by the mission or observatory that discovered the exoplanet, or by the detection method.



- Hit the **HOME** button in the top menu at any time to return to the view of all of the data points. Or navigate to **MISSIONS** to learn more about exoplanet hunting missions.

## Extend: The Search for Extraterrestrials

### Overview of Activity 3 (25 Minutes)

In this activity learners will extend their knowledge of other stars and exoplanets by looking for planetary systems that could potentially have planets with life.

**Astrobiology** is the study of the origin, evolution, distribution and future of life in the universe. When astrobiologists search for extraterrestrial life they look for planets like Earth, because Earth is the only place we know of that can support life.

Learners will reexamine the data on the Eyes on Exoplanets Interactive and search for planets in the habitable zone of the star.

Learners then explore extremophiles that live on Earth and transfer that knowledge to determine what life would most likely look like on another planet.

### Materials

- [Set of Extremophile Cards](#)

### Instructions

- A. Provide Context:** *How do scientists decide what stars to look for **exoplanets** around?*

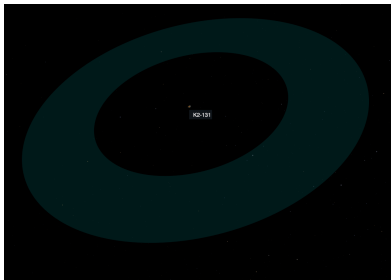
*One of the main questions that drives the research into exoplanets is, “can we find evidence that life exists elsewhere in the universe?” **Astrobiology**, another discipline of science that NASA explores, is the study of the origin, evolution, distribution and future of life in the universe.*

*We have already learned that there are small stars and big stars. Missions looking for **exoplanets** are very interested in looking at stars similar to the Sun, which are the best candidates for hosting **exoplanets** with potential biological life.*

*Sun-like stars have conditions that can host planets where there could be potential for biological life. These conditions include:*

- *Long life cycles (enough time for life to evolve on the exoplanet). Massive stars burn hot and quick, not allowing enough time for life to evolve on an orbiting planet.*
- *Temperatures similar to the Sun (to allow for liquid water on the surface of the planet).*

*When scientists find Sun-like stars, they look around the star in an area called the **habitable zone**, or the **Goldilocks Zone**, which is the distance from a star that a planet could exist with liquid water on the surface. The*



Eyes on Exoplanets  
'Habitable Zone'  
Credit: NASA

**Educator Note:**

Finding exoplanets similar to Earth in the habitable zone of a Sun-like star is rare. Kepler-452b is the first near-Earth-size world to be found in the habitable zone of a star that is similar to our Sun. Until its discovery in 2015, the Kepler telescope had only detected 12 Earth-size planets (smaller than twice the size of Earth) in the habitable zone of their smaller and cooler stars.

planets in this zone aren't too hot, or too cold, they are just right! Planets in the **habitable zone** are the best places to look for life.

**B. Analyze Data:** Instruct students to go back to [NASA's Eye on Exoplanets Interactive](#), from the previous activity, to use the “habitable zone” feature of the interactive. Instruct learners to click the “habitable zone” box to indicate that you want to view the habitable zone. Depending on the size of the star, the habitable zone can be different distances from the star.


**Ask learners:**

- Were you able to find many planets within the habitable zones of different stars?
- Based on your sampling of data, are planets found in habitable zones rare?

**C. Provide Context:** *If scientists found a planet in the habitable zone, they don't expect to find evidence of human life, or of any complex organism. Instead, scientists expect to find the simplest kind of life, for example bacteria.*

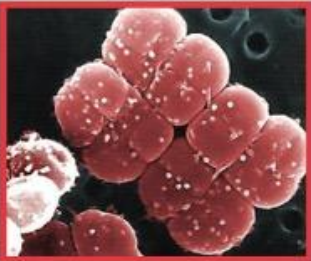
*Scientists also expect that the conditions on the planet (or moon) would be extreme, potentially too hot or too cold, or maybe the planet is covered in an ocean of acid. It can be assumed that any organism living in those conditions would be adapted to the extreme environment, similar to how some organisms have adapted to the harshest environments on Earth.*

*Organisms that can survive in extreme environments are known as extremophiles. These extreme environments include boiling pools of acid, underwater thermal vents, inside of glaciers, or in the deepest rocks on Earth. Scientists study extremophiles and the environments they live in to learn more about how to find evidence for potential extraterrestrial life.*

National Aeronautics and Space Administration 

# CONAN THE BACTERIUM

*Deinococcus radiodurans*





Peggy A. O'Callan and Margaret C. Heink, Louisiana State University


the "terrible grain"


### Conan the Bacterium Environment


Conan is so tough, it can even survive high levels of radiation.


**Temperature** 

**Sunlight** 

**Pressure** 

**Water Need** 

**Acidity** 

**Can be found**  all over the world

**Fun Fact** *Deinococcus radiodurans* is listed as the world's toughest bacterium in The Guinness Book Of World Records.

www.nasa.gov

Extremophile Cards  
**Credit: NASA**

**D. Interpret Data:** Pass out the Extremophile cards. There are 14 cards, so depending on the number of learners, you can group them as pairs.

*Each card has a different organism on it. The front of the card is the common name and the scientific name of the organism, and a picture of the organism. The back of the card has more detailed information on what the organism needs to survive, including the required temperature, amount of sunlight, pressure, water and acidity.*

*Take a minute to discuss with your partner exactly what part of the scale on the card you consider a condition to be extreme in each category. How is the organism on your card extreme? Some organisms will fit into more than one category. They may survive in places with extreme temperatures and unusual chemistry, for example.*

- **Extreme Temperatures:** *What is an example of an environment that has extreme temperatures, either hot or cold?*

*If your organism likes extreme hot environments, stand on my left. If your organism likes extreme cold environments, stand on my right. [HOT: Conan the Bacterium, Hot Sulfur Springer, Iron Eaters, Pompeii Worm, Rushing Fireberry, Strain 121, Water Bear COLD: Penguin, Rocky Lichen, Watermelon Snow, Wood Frogs]*

**SUGGESTION:** Write the words, 'Hot and Cold,' up on opposite ends of the board, if you are able to. Or consider putting a sticky note with the words on them on opposite walls. You can even just hold the sticky notes in each hand, as a visual cue to help participants sort themselves.

Instruct learners to hold up their cards and have them take turns sharing a fun fact about the extremophile on the card.

- **Extreme pH:** *What is an example of an environment with high pH (alkaline) or low pH (acidic)?*

*If your organism likes environments that are not acidic (high pH or alkaline) stand on my left. If your organism likes environments that are very acidic (low pH or acidic) stand on my right. [ALKALINE: Spirulina, Rushing Fireberry ACIDIC: Hot Sulfur Springer, Iron Eaters, Pompeii Worm, Snottites, Maybe Yeti Crab and Strain 121]*

Instruct learners to hold up their cards and have them take turns sharing a fun fact about the extremophile on the card.

- **High Pressure:** *What is an example of an environment that has high pressure?*

*If your organism likes environments with high pressure, stand up. [Pompeii Worm, Rocky Lichen, Strain 121, Water Bear, Yeti Crab]*

Instruct learners to hold up their cards and have them take turns sharing a fun fact about the extremophile on the card.

- **Low Sunlight:** *What is an example of an environment with very little or no sunlight?*

*If your organism needs very little sunlight to survive, stand up. [Yeti Crab, Snottites, Water Bears, Strain 121, Rocky Lichen, Pompeii Worm, Iron Eaters, Hot Sulfur Springers]*

Instruct learners to hold up their cards and have them take turns sharing a fun fact about the extremophile on the card.

- **Little Water:** *What is an example of an environment that has very little water?*

*If your organism needs very little water to survive, stand up. [Rocky Lichen, Water Bears, Watermelon Snow]*

*“Of those of you standing, if your organism needs absolutely no water at all, come up and stand on either side of me.”*

No one should come up. If they do, ask them to look at the water requirements of their organism one more time and ask them if it says the organism needs little water, or no water at all? The answer should be little water.

*That’s right. So far, every single organism we have discovered on this Earth needs water to survive, even if it is just a little bit. When we look for extraterrestrial life, we assume that it will need water, which is why we look in the habitable zone around a star. The habitable zone is where water can exist on the surface of the planet in liquid form. There could be life that doesn’t rely on water, but we haven’t discovered it yet.*

Instruct learners to hold up their cards and have them take turns sharing a fun fact about the extremophile on the card.

### Activity 3 Major Concepts

- ★ **Extrasolar planets**, or **exoplanets** are planets found outside of the Solar System, usually orbiting around other stars.
- ★ Finding **exoplanets** can be pretty hard because stars are gigantic and bright and, comparatively, planets are small and dim.
- ★ As of 2022, NASA missions have discovered more than 5,000 **exoplanets!**
- ★ There are multiple methods that scientists use to find exoplanets. NASA does not confirm an exoplanet find until it has been confirmed by at least two different methods.
- ★ The Kepler and TESS missions use a specific method to discover exoplanets by looking for **transits**. A **transit** is when an object passes between a star and its observer. More planets are discovered this way than any other method.

- ★ Missions looking for **exoplanets** are very interested in looking at stars similar to the Sun, which are the best candidates for hosting **exoplanets** with potential biological life.
- ★ Sun-like stars have conditions that can host planets where there could be potential for biological life. These conditions include long life cycles and temperatures similar to the Sun.
- ★ When scientists find Sun-like stars, they look around the star in an area called the **habitable zone**, or the **Goldilocks Zone**, which is the distance from a star that a planet could exist with liquid water on the surface.
- ★ Life is most likely to exist on a **terrestrial planet**, roughly the size of Earth.
- ★ Organisms that can survive in extreme environments are known as **extremophiles**. These extreme environments include boiling pools of acid, underwater thermal vents, inside of glaciers, or in the deepest rocks on Earth. If we discover extraterrestrial life, they most likely will be a type of **extremophile**.

# Evaluate: What did you learn about other stars?

## Overview of Activity (15 Minutes)

At the end of the session, learners complete the KWL chart, adding what they learned to the L [Learn] column.

Encourage learners to look through Session 6 in the NASA Helio Youth Guide, and to review the activities and the observations they recorded during the activities, to help them summarize what they learned during the session.

## Materials

- [Handout\\_KWL\\_Session\\_6](#)

## Instructions

- Direct learners to page 76** in the [NASA Helio Club Youth Guide](#), or print the [Handout\\_KWL\\_Session\\_6](#)
- Have learners complete the **L [Learn Column]** of the KWL chart.

Emphasize to learners that they should also be correcting any misconceptions they had prior to the session, from the K [Know] column, and answering any questions from the W [Wonder] column, if they are able to.



## Session 6 Major Concepts

- ★ Stars come in different sizes; the Sun is an average-sized, very mild-mannered star.
- ★ Stars are born in a **stellar nebula**, which is made of mostly hydrogen and dust.
- ★ The **main-sequence** phase of the life cycle of a star is when the star is actively making energy through **nuclear fusion**.
- ★ Our Sun is currently in the **main-sequence** phase of its life and will continue to burn fuel for about 5 billion more years.
- ★ Sun-like stars end their lives as a **white dwarf**; massive stars end their lives either as a **neutron star** or a **black hole**, depending on the size of the star.
- ★ A star is in balance between two opposite forces: The outward pressure caused by nuclear fusion and the inward pressure of gravity. A **supernova** explosion occurs when the star runs out of fuel and the force of gravity causes the star to collapse in on itself.
- ★ The Sun will not become a **supernova**.
- ★ **Extrasolar planets**, or **exoplanets**, are planets found outside of the Solar System, usually orbiting around other stars.
- ★ There are multiple methods that scientists use to find exoplanets. NASA does not confirm an exoplanet find until it has been confirmed by at least two different methods. As of 2022, NASA missions have discovered more than 5,000 **exoplanets**!
- ★ The Kepler and TESS missions use a specific method to discover exoplanets by looking for **transits**. A **transit** is when an object passes between a star and its observer. More planets are discovered this way than any other method.
- ★ Sun-like stars have conditions that can host planets where there could be potential for biological life. These conditions include long life cycles and temperatures similar to the Sun.
- ★ When scientists find Sun-like stars, they look around the star in an area called the **habitable zone**, or the **Goldilocks Zone**, which is the distance from a star that a planet could exist with liquid water on the surface.
- ★ Organisms that can survive in extreme environments are known as **extremophiles**. These extreme environments include boiling pools of acid, underwater thermal vents, inside of glaciers, or in the deepest rocks on Earth. If we discover extraterrestrial life, they most likely will be a type of **extremophile**.



## References

- NASA. (2023, May 24). *Chandra X-ray Observatory*. Retrieved on June 20, 2023 from <https://science.nasa.gov/mission/chandra/>
- NASA. (2019, December 12). *Kepler and K2*. Retrieved on June 20, 2023 from <https://science.nasa.gov/mission/kepler/>
- NASA. (2023, June 1). *Hubble Space Telescope*. Retrieved on June 20, 2023 from <https://science.nasa.gov/mission/hubble/>
- NASA. (2023, March 7). *International Space Station*. Retrieved on June 20, 2023 from <https://www.nasa.gov/international-space-station/>
- NASA. (2018, July 24). *Spitzer Space Telescope*. Retrieved on June 20, 2023 from <https://science.nasa.gov/mission/spitzer/>
- NASA. (2023, May 16). *TESS Exoplanet Mission*. Retrieved on June 20, 2023 from <https://science.nasa.gov/mission/tess/>
- NASA/Afterschool Universe. (2018, September 5). *Lives of Stars*. Retrieved on June 20, 2023 from <https://imagine.gsfc.nasa.gov/educators/programs/au/resources/curriculum.html>
- NASA/ESA. *Top 100 Images*. Retrieved on June 20, 2023 from <https://esahubble.org/images/archive/top100/>
- NASA/Goddard Space Flight Center. *James Webb Space Telescope*. Retrieved on June 20, 2023 from <https://science.nasa.gov/mission/webb/>
- NASA GSFC. (2023, June 2). *Operating and Future Science Fleet*. Retrieved on June 9, 2023 from <https://svs.gsfc.nasa.gov/31162>
- NASA/JPL. Exoplanet Travel Bureau. Retrieved on June 20, 2023 from <https://science.nasa.gov/exoplanets/immersive/exoplanet-travel-bureau/>
- NASA/JPL. *Eyes on Exoplanets*. Retrieved on June 20, 2023 from <https://eyes.nasa.gov/apps/exo/#/>
- NASA/JPL-Caltech. (2021, April 13). *Exoplanet Types: Worlds Beyond our Solar System*. Retrieved on June 20, 2023 from <https://www.youtube.com/watch?v=k1UcseLVNVc>
- NASA/JPL-Caltech. (2021, May 4). *Exoplanets: Weird, Wondrous Worlds*. Retrieved on June 20, 2023 from <https://www.youtube.com/watch?v=4IXYp9Fse44>



NASA/JPL-Caltech/Night Sky Network. (2011, June). *Extremophiles: Life in the Extreme*. Retrieved on June 20, 2023 from <https://nightsky.jpl.nasa.gov/news/360/>

NASA Space Place. (2021, June 15). *What is a Transit?* Retrieved on June 20, 2023 from <https://spaceplace.nasa.gov/transits/en/#:~:text=A%20transit%20is%20when%20one,is%20%E2%80%9Ctransiting%E2%80%9D%20the%20Sun.>

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