



Life in the Universe

Outreach ToolKit Manual

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JPL's [Exoplanet Exploration Program](#) and the



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The nonprofit Astronomical Society of the Pacific (ASP), one of the nation's leading organizations devoted to astronomy and space science education, is managing the Night Sky Network in cooperation with NASA and JPL. Learn more about the ASP at <http://www.astrosociety.org>.



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Introduction: Life in the Universe

"I believe in evidence. I believe in observation, measurement, and reasoning, confirmed by independent observers. I'll believe anything, no matter how wild and ridiculous, if there is evidence for it. The wilder and more ridiculous something is, however, the firmer and more solid the evidence will have to be."

~ Isaac Asimov

Life in the Universe: Are we alone?

Aliens are a favorite topic for many visitors to public astronomy events. This ToolKit is designed to take science fiction questions and direct them toward scientific facts and the exciting discoveries constantly being made in the search for life outside Earth.



Astrobiology is the study of the origin, evolution, distribution, and future of life in the universe. This multidisciplinary field encompasses the search for habitable environments in our Solar System and habitable worlds outside our Solar System, the search for evidence of prebiotic chemistry and life on Mars and other bodies in our Solar System, laboratory and field research into the origins and early evolution of life on Earth, and studies of the potential for life to adapt to challenges on Earth and in space.

The three big questions we address with this ToolKit are:

- What makes an environment hospitable for life?
- Life in our Solar System -- What are we looking for, and where are we looking?
- Life outside our Solar System -- What are the chances that it exists, and how are we looking?

Many amateur astronomers feel unfamiliar with or unprepared to talk about these big topics. These tools give you the background, tools, and confidence to discuss the idea of life beyond Earth with your audiences.

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Summary of Activities and Resources:

The Life in the Universe ToolKit focuses on the study of Astrobiology. Using activities, demonstrations, and presentations, it covers topics including what makes an environment habitable, as well as the possibilities of life within our own Solar System and beyond. Included in this ToolKit are two bags, containing the following materials:

1. Media & Resources Bag

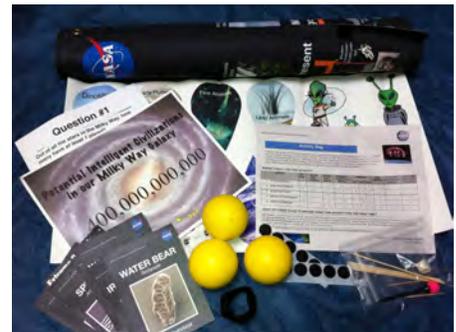
- Training Video DVD is for training your club members on the ToolKit
- Background Materials on NASA Missions for sharing with club members
- Manual & Resources CD contains the ToolKit Manual and a variety of other resources, including a folder called Masters with master copies of all materials. The CD also includes:
 - The Astrobiology Primer, a great reference and overview of the field written by leading scientists and included with permission from the journal *Astrobiology*, *Volume 6, Number 5*
 - PowerPoint: Anyone Out There? along with a script
 - "Where Are the Distant Worlds?" Star Map sample. *Master copies can be found in the folder titled Masters.* You can also find the most updated versions of these masters here:

http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=320



2. Activity Bag

- Life In the Extreme cards introduce your visitors to the variety of extremophiles found on Earth and lets them discover a common trait that is helping us search for life on other worlds – water.
- Earth Timeline Banner shows the progression of life on Earth from single-celled organisms to current human civilization. The back shows the Watery Worlds of our Solar System.
- Anyone Out There? is an interactive version of the Drake Equation that can be used with or without the PowerPoint found in the Manual & resources CD.
- How Do We Find Planets Around Distant Stars? uses models of stars to show the "wobble" and "transit" methods of exoplanet detection.
- Keys to the Rainbow is an investigation into spectroscopy, highlighting how we learn about the atmospheres of exoplanets.



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Life In the Extreme

What's this activity about?

Big Questions:

- What characteristics are common to all life on Earth?
- What are we looking for when we search for evidence of life on other worlds?

Big Activities:

Participants are each given one of 14 examples of extremophiles -- organisms found in some of the toughest conditions on Earth. They sort themselves into groups according to the various preferences of their organisms. Finally, they discover that all known life on Earth requires liquid water to survive and grow.



Participants:

From the club: A minimum of one person

Visitors: This activity works best with a group of at least 10 participants so that each person gets a card. With more participants, they can form "colonies." With fewer participants, this activity can be a simple sorting game spread out on a table. Ages 7 to adult will enjoy this activity at different levels.

Duration:

5 to 15 minutes

Topics Covered:

- All life that we have found on Earth needs liquid water to survive.
- Life is found in a variety of extreme environments on Earth.
- Science is using these facts to explore the possibility of life beyond Earth.

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Life In the Extreme		√	√	√	√	√	√		√	

What do I need to do before I use this activity?

What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set-Up
The 14 Extremophile Cards (Optional) Presenter's Cue sheet	Nothing	None

Background Information

What is an Extremophile? (from Microbial Life Educational Resources)

<http://serc.carleton.edu/microbelife/extreme/extremophiles.html>

An extremophile is an organism that thrives under "extreme" conditions. The term extremophile is relatively anthropocentric. We judge habitats based on what would be considered "extreme" for human existence. Many organisms, for example, consider oxygen to be poisonous. While oxygen is a necessity for most life as we know it, some organisms flourish in anoxic environments. We call them extremophiles... but that is only one perspective. If they could think, what would they think of our environment?

Types of Extremophiles

(adapted from NASA's Astrobiology Institute)

<http://astrobiology.nasa.gov>

There are many different classes of extremophiles that range all around the globe, each corresponding to the way its environmental niche differs from moderate conditions. These classifications are not exclusive. Many extremophiles fall under multiple categories.

Acidophile: An organism with optimal growth at pH levels of 3 or below. That's as acidic as lemon juice. They are mostly found in mines and caves. Venus has toxic clouds that may be the perfect environment for something that loves acidic environments, though we have not discovered any life there yet. *Examples found in this activity: Hot Sulfur Springer, Iron Eaters, Snottites*

Alkaliphile: An organism with optimal growth at pH levels of 9 or above; that is, the least acidic (most basic) environments. They can be found in caves, some hot springs, and waste dumps and are used in making paper and recovering spilled oil. *Examples: Rushing Fireberry, Spirulina*

Barophiles: These microbes thrive under high pressure. Most are found on the ocean floor. Most have a waxy cell layer that protects them against crushing pressures and very cold temperatures. *Examples: Pompeii Worm, Rocky Lichen, Yeti Crab, Water Bear*

Endoliths: This broad category of organisms makes their home inside of rocks. They can live for hundreds of years by feeding on minerals such as iron, potassium, and sulfur in their host rocks. Many scientists think that endoliths are a good candidate for the types of life most likely to be discovered living on Mars now or in the past. *Example: Endolith*

Polyextremophile: An organism that qualifies as an extremophile under more than one category. *Examples: Conan the Bacterium, Water Bear*

Psychrophile: An organism capable of survival, growth or reproduction at temperatures of $-15\text{ }^{\circ}\text{C}$ ($5\text{ }^{\circ}\text{F}$) or lower for extended periods. These can be found on Earth in very cold temperatures, such as frozen soils, permafrost, polar ice, cold ocean water, and in or under alpine snowpack. Scientists are trying to determine if Jupiter's icy moon Europa harbors cold-loving microbes. *Examples: Penguins, Water Bear, Watermelon Snow, Wood Frogs*

Radioresistant: Organisms resistant to high levels of ionizing radiation, most commonly ultraviolet radiation, but also including organisms capable of resisting nuclear radiation. They have been found in nuclear reactors, using the radioactive energy to produce food. *Examples: Conan the Bacterium, Water Bear*

Thermophile: An organism that can thrive at temperatures between $60\text{--}80\text{ }^{\circ}\text{C}$ ($140\text{--}176\text{ }^{\circ}\text{F}$) they have developed special enzymes and proteins that allow them to survive in a broad range of temperatures. *Examples: Conan the Bacterium, Hot Sulphur Springer, Strain 121, Water Bear*

Xerophile: An organism that can grow in extremely dry, desiccating conditions; such as the soil microbes of the Atacama Desert. They can even grow in dried foods such as nuts. *Examples: Rocky Lichen, Water Bear, Watermelon Snow*

Detailed Activity Description

Life In the Extreme

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> Who thinks there might be life elsewhere in our galaxy? –or– What kinds of worlds do you think aliens might live on?</p> <p>To get some clues to these questions, scientists are studying organisms that survive in extreme environments right here on Earth to see all of the amazing ways life has adapted on our planet. This broadens the kinds of planets we are looking at where life might exist. If aliens exist, they might look very different from us and live in different environments. Let's see what kinds of organisms they are finding here on Earth. Everyone take a card.</p> <p><u>To Do:</u> Hand out the Extremophile Cards to your visitors.</p>	<p>I do! Worlds like Earth?</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>Presentation Tip:</u> If there are more than 14 visitors, have them form "colonies" of organisms around each card. If there are fewer than 14, you can run the activity with as few as 10 of the cards. With just 1-4 participants, have them sort all of the cards together.</p> <p>The first few times you use this activity, it might be useful to have the Presenter's Cue sheet to remind you of the categories.</p> <p><i>Alternative activity for small groups:</i> If there are only a few participants, use the small environment cards also titled "Life in the Extremes" and found in the Media and Resources bag or online here: http://astrobiology.nasa.gov/nai/education-and-outreach/products-and-resources/life-in-the-extremes-trading-cards/</p> <p>Visitors can try to pair the large organism cards with the environments described on the smaller cards. Again, you can sort them by many categories, laying the small cards out one at a time. Or allow them to explore the cards on their own and make their own categories.</p>	



Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> What are some of the organisms you all have?</p> <p>Great. Now look on the back. There you will find information about your organism's environment. To start with, who has an organism that likes a hot environment? If your organism likes it really hot, come over to my left side. Everyone else to my right.</p> <p><u>To Do:</u> Sort the groups 3-5 times in this fashion. After each sorting, ask a participant to tell about their organism. Younger groups usually have shorter attention spans, but ages 10 through adult like running through this more times. Use categories such as Hot, Cold, and Acidic, or organisms that like Sunlight, Darkness, and High pressure.</p> <p><u>To Say:</u> Which of your organisms can live without water? Come over here.</p> <p>Ahh! Interesting. Did you know that every single living organism we've discovered on Earth needs liquid water to survive, grow, and reproduce?</p> <p>That has some interesting implications for our search for aliens. When we look for possible habitable planets, we are actually looking for planets with evidence of liquid water. Did you know that there are other worlds right here in our Solar System that likely have liquid water on them?</p> <p><u>To Do:</u> Either show the group the Watery Worlds banner or direct them to telescopes showing Jupiter's moons or Mars as examples of potentially watery worlds. The front of the Presenters Cue Card also has images of possible watery worlds in our Solar System with more information on the back.</p>	<p>Snottites! Penguins...</p> <p>No one goes to that side</p>

Materials

What do I need to prepare?

- If you are using the pre-printed cards, there is nothing to prepare.
- If you are printing your own cards, you will need to fold each 1-sided piece of paper in half and glue the halves together to create 2-sided cards. See example, right.
- You may want to have the Presenter Cues nearby if you ever need help thinking of categories.



Where do I get additional materials?

Master copies of the cards are found in the Manual & Resources CD in the file named Masters. You may want to take these to a professional printer because they are ink-intensive for home printers.

You can also find them on the Night Sky Network website by searching the Astronomy Activities for "Extreme"
<http://nightsky.jpl.nasa.gov>

Earth Timeline

What's this activity about?

Big Questions:

- When in Earth's history did life develop?
- How long did it take for complex life to develop?
- What can these answers tell us about the type of life we might find on other planets?



Big Activities:

Participants guess when various kinds of organisms first developed in the history of Earth. Then the actual timeline of life is revealed, usually to great surprise. The early development of simple life and the relatively late development of complex life changes many people's ideas of what alien life may look like.

Participants:

From the club: A minimum of one person.

Visitors: The Earth Timeline is appropriate for families, the general public, and school groups ages 10 and up. One to 30 visitors at a time may comfortably participate.

Duration:

10 to 15 minutes

Topics Covered:

- Life on Earth developed soon after oceans formed.
- Complex life developed recently (in the last ½ billion years) in the Earth's history.
- Scientists expect most life in the Universe to be simple. If any life is found in our Solar System beyond Earth, it is likely to be simple.

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Earth Timeline		√	√	√		√	√	√		√

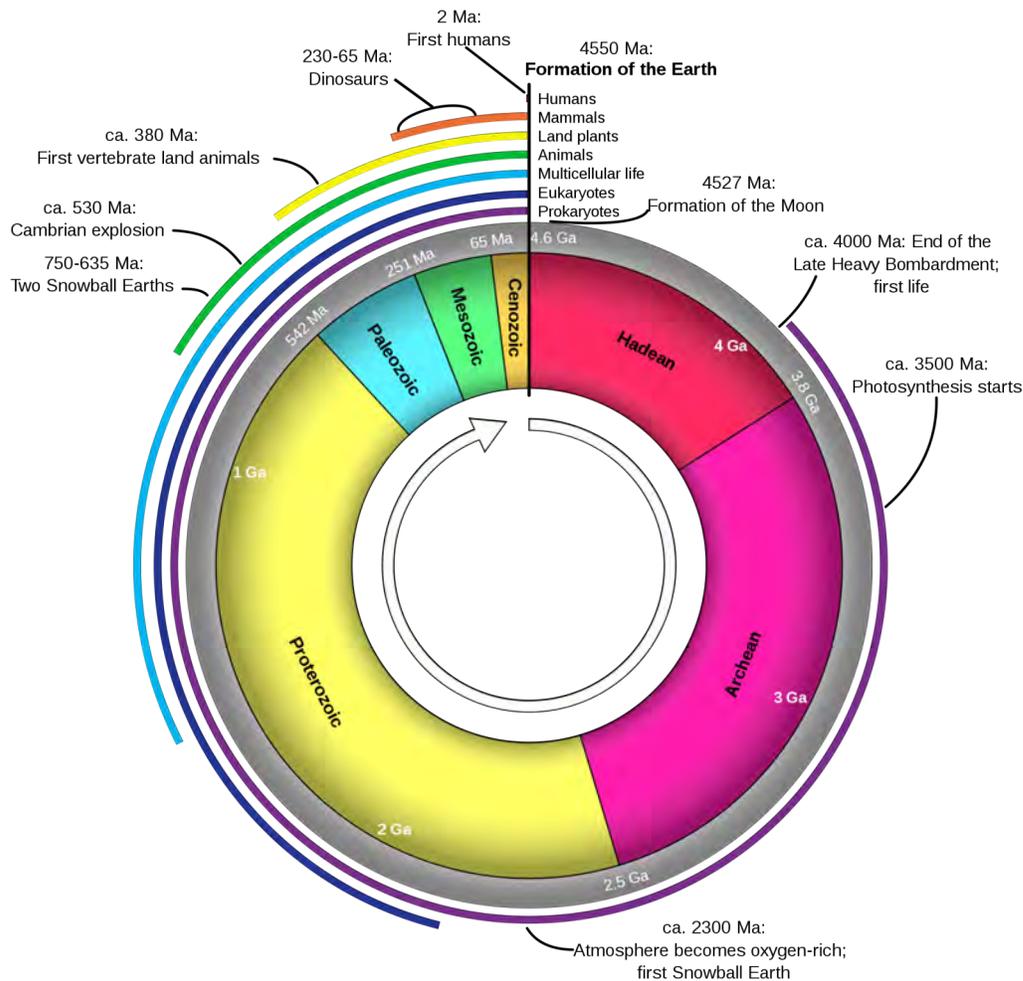
What do I need to do before I use this activity?

What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set-Up
<ul style="list-style-type: none"> • Earth Timeline banner • 7 Life Form cards with Glue Dots or other temporary adhesive • One Alien card 	A flat surface (table, fence, or car) to present the banner	<ul style="list-style-type: none"> • Use the Velcro strips to attach the banner to a fence or car. • Fold the bottom of the timeline and attach using the Velcro to hide the life forms.

Background Information

Origins of Life

The Earth formed about 4.6 billion years ago. The earliest life formed on Earth around one billion years later. This is when we have undisputed fossils of microbe-like organisms. It seems likely that these developed from even more primitive organisms that did not leave fossils. We do not know the earliest life, but estimates from rocks show changes in the atmosphere possibly indicating life around 3.8 billion years ago.



Further Activities

A brief, interactive history of life on Earth can be found here:
<http://www.pbs.org/wgbh/nova/evolution/brief-history-life.html>

If you would like a longer, more detailed timeline activity, there are models here:
<http://serc.carleton.edu/quantskills/activities/calculatortape.html>
and here:
<http://www.worsleyschool.net/science/files/toiletpaper/history.html>

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Detailed Activity Description

Earth Timeline

Leader's Role	Participants' Role (Anticipated)
<p><u>Presentation Tip:</u> There is silhouette of a person on the bottom of the banner and many points from this activity can be made even if you do not have the banner. Face your audience and set up the scale for them so that the Solar System formed at the tip of your right hand and today is at the tip of your left hand. Then the scale is:</p> <ul style="list-style-type: none"> • The first life developed at some point on the earliest (right) forearm. • Complex life did not occur until almost the "most recent" wrist. • Dinosaurs occupied from the end of the palm through the middle knuckle of a finger. • And filing the end of your fingernail could erase all of human history. 	 
Leader's Role	Participants' Role (Anticipated)
<p><u>To Do:</u> Hang the banner using the Velcro straps attached to the grommets or place it on a long table. Fold the bottom of the banner to cover the life forms, using the Velcro dots.</p> <p><u>To Say:</u> What do you think aliens might look like?</p> <p><u>To Do:</u> Hold up the alien card and the single-celled organism drop. Ask the audience what they think we are more likely to encounter as we search for extraterrestrials.</p>	 <p>Little green men</p> <p>Most think the "alien" is more likely</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> We only have one example of life in the Universe, and that's right here on Earth. Let's take a look at how life has developed on Earth and see if it gives us any clues about the types of life we might find elsewhere.</p>	
<p><u>Presentation Tip:</u> If you're worried about the response that words like "evolution" might elicit from an audience, try using words such as "develop" or "progression" instead. You can often get across the concept without hitting any hot-button issues.</p>	
<p><u>To Say:</u> Earth is known to be about 4 and a half billion years old, shown on the left side. We represent that 4 ½ billion years by this 4 ½ feet, with the formation of the Solar System and Earth on the left, and today located all the way here on the right.</p> <p>A lot has happened in that 4 ½ billion years. The early Earth survived bombardment to form a Moon and oceans. It had several ice ages, many extinction events, and eventually become home to us, here on the far right.</p> <p><u>To Do:</u> Place Modern Civilization on the far right of the timeline, above the word "present." Hand out the remaining life form drops to 6 visitors.</p> <p><u>To Say:</u> You each have a type of life that has developed on Earth. Who thinks they have one of the earliest life forms?</p> <p>That's right. That's the very first kind of life that developed on Earth. When do you think that happened in Earth's history? Go ahead and put the single-celled organism on the timeline where you think it developed. The pictures on top of the Timeline might help you decide.</p>	<p>Single-celled organisms</p>

Leader's Role	Participants' Role (Anticipated)
<p><u><i>To Say:</i></u> Now, which life form do you think comes next? Great! The rest of the life forms, go ahead and guess where you think this type of life first developed. If you don't have a life form, help cheer us on.</p> <p><u><i>To Do:</i></u> After everyone has placed their life forms on the banner, encourage the other visitors to chime in with changes they would make. Move the life forms as the group directs. Encourage discussion so the group owns the exercise and there is less pressure to get it right on the people who initially guessed.</p>	<p>Placement varies for all life forms</p>
<p><u>Presentation Tip:</u> For younger audiences, ask them to put themselves in the order that these life forms developed first. Then have them place their life forms on the Velcro. At any age, it's fine that your visitors get this guess completely wrong. Most people don't have a good concept of the timeline of life on Earth. This is an opportunity to dispel some misconceptions.</p>	

Leader's Role	Participants' Role (Anticipated)
<p><u>To Do:</u> Once everyone has finished, unfold the bottom of the banner to show the actual timeline. Leave the guesses where they are for comparison.</p> <p><u>To Say:</u> How did we do? What do you notice?</p> <p>Wow, simple life developed very early in the history of the Earth. The first fossils have been dated back to 3.5 billion years ago, but there is other evidence that life may have developed even earlier. Basically, as soon as there were stable oceans, there was life.</p> <p>What else?</p> <p>That's right. It took almost 3 billion years for anything other than simple life to develop!</p> <p>And Humans are one of the very most recent animals to develop.</p> <p><u>To Do:</u> Hold out your arms like the illustration on the timeline.</p> <p><u>To Say:</u> In fact, if this timeline were as long as my arms, a simple file of my fingernail would remove all trace of humans on Earth.</p> <p>Okay, so when we go looking for aliens on other worlds, do you think those other worlds might also take a while to develop complex life?</p> <p>It's true, we don't know what kind of life forms we might find on other planets. But our experience on Earth gives us some clues. They may not be as advanced as the aliens in science fiction stories. What do you think some alien looking at our planet would have thought about Earth's inhabitants a billion years ago?</p>	<p>Most people put the beginning of life much later.</p> <p>Animals are pretty recent</p> <p>Maybe?</p>

Common Follow-up Questions

You can inspire these questions by asking, "What else might we take into consideration when thinking about life on Earth?" or, "How long do you think Earth will have intelligent civilizations on it?"

How much longer will Earth be around?

Certainly no longer than another 5 billion years. That's another timeline added after the present point. What do you think might happen in the next half of Earth's lifetime?

How long humans will be around?

If we are as lucky as dinosaurs, maybe many millions of years. Mammal species have an average lifespan from origination to extinction of perhaps a few million years. But that is just an average.

Other Questions to Answer with the Earth Timeline

How often do asteroids hit Earth?

In the beginning of Earth's history, asteroids were constantly hitting the Earth. This was called the Heavy Bombardment Phase and ended 3.8 billion years ago, allowing a more stable environment for life to form. In Earth's recent history, there are fewer impacts, but they do still happen. The last large impact happened 65 million years ago and that spelled doom for the dinosaurs but made space for mammals.

Will the Sun die and freeze the Earth?

The Sun will eventually run out of fuel and puff out into a big, old, bloated star. This will make the Earth too hot for liquid water before the Sun finally throws off its outer shell and becomes a white dwarf. This will all happen in another 5 billion years. So, imagine another timeline of the same length next to this one. Who knows what will happen in Earth's future before then?

How long do stars live?

Stars like our Sun live 2 people-widths, or about 10 billion years. Big, bright stars live only a few million years. On this scale a few million years is less than 1 cm (less than a quarter inch even). Very small stars can live for trillions of years. That would be more than 20 banners (or people with their arms out) in a row.

You can connect this distribution of stars visible in the night sky with the *Are All Stars Like Our Sun? PowerPoint* found here:

http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=182

When did major extinctions happen?

Extinctions have occurred many times over the history of Earth. In the past 540 million years there have been five major events when over 50% of animal species died. For example, around 200 billion years ago, the Great Oxygenation Event (also called the Oxygenation Catastrophe) was when the iron in the oceans was mostly rusted and all of the oxygen being produced went into the atmosphere. This sounds great to us, but it was poisonous to organisms on Earth at the time.

Weren't all of the continents once a big land mass?

Around 3.8 billion years ago, the Earth's crust cooled enough to form continents. At that time, continental plates were probably moving around quite quickly, forming many different super-continent and breaking apart many times. Are you familiar with the most recent super-continent, Pangaea? In this configuration, the Americas were connected to Europe, Asia, and Africa. It occurred just before the time of the dinosaurs, not very long ago on the Earth Timeline.

Materials

What do I need to prepare?

Before using for the first time:

- Place Velcro dots on the two rows of "x"s, with the soft loop side on top by the timeline and the harder hook side on the "x"s along the bottom of the banner.



- Cut out the life form drops and one alien of your choice. Place a removable glue dot on the back of each life form drop, at the top.



To begin the activity:

- Hang the Earth Timeline banner or place it on a table
- Fold the bottom of the banner up so the Velcro dots meet.

Where do I get additional materials?

1. There are masters of the life form cards on the Manual & Resources CD.
2. A large pdf of the banner is included on the Manual & Resources CD in the file named Masters. It can also be found on the Night Sky Network website by searching under Astronomy Activities for "timeline." You can get prints made for around \$100 at many banner and copy centers:
<http://nightsky.jpl.nasa.gov/>

Anyone Out There?

What's this activity about?

Big Questions:

- What are the chances that there are other intelligent civilizations in our Milky Way Galaxy?
- What are the factors to consider when we think about finding other intelligent civilizations?



Big Activities:

Participants form groups around 6 questions about the likelihood of life in the Universe. Starting with all of the stars in the Milky Way, the presenter uses the participants' answers to come up with an estimate of the potential number of intelligent civilizations in the galaxy.

Participants:

From the club: A minimum of one person. With large groups, it is good to have at least two presenters.

Visitors: 25 or more visitors at a time may actively participate. It is best to have at least a dozen participants so that discussions emerge. "Anyone Out There?" is best used with ages 12 through adult, as the discussions can be elaborate.

Duration:

20 minutes to an hour, depending on the discussions and extensions.

Topics Covered:

- How scientists are searching for intelligent life on our galaxy
- Planets being discovered around other stars
- Why water is important for life
- When life developed on Earth
- How life evolved on Earth
- The fraction of Earth's life that humans have been here
- Humans' ability to communicate across interstellar distances

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Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Anyone Out There?		√	√			√	√	√	√	√

What do I need to do before I use this activity?

What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set-Up
Six Question cards Presenter's Cue Card/Tally Sheet Dry-erase marker	(Optional) This activity can be used with the <i>Anyone Out There PowerPoint</i> . If so, you would need a computer and projector.	None

Background Information

The Drake Equation

This activity is a simplified version of the Drake Equation, a very useful tool for examining the factors that determine the likelihood of other intelligent civilizations existing right now in our galaxy. It should be emphasized that **this is not an equation with an answer** that we know.

Frank Drake proposed these factors in 1961, when there were few scientists thinking seriously about life on other worlds. Since that time, astrobiology (sometimes referred to as exobiology) has become a mainstream science studying of the origin, evolution, distribution, and future of life in the universe. You can learn more about the Drake Equation from the SETI institute:
<http://www.seti.org/drakeequation>

If you would like to see what other values of the variables could mean, PBS hosts this clever interactive site:
<http://www.pbs.org/wgbh/nova/origins/drake.html>

To watch Carl Sagan's eloquent description of the Drake Equation, see this video on YouTube:
<http://www.youtube.com/watch?v=0Ztl8CG3Sys>

The Universe in the Classroom issue #77 provides an excellent background to the Drake equation:
<http://www.astrosociety.org/education/publications/tnl/77/77.html>

The Factors

Adapted from an article by Anna Lee Strachan, NASA Astrobiology Institute

Many people falsely believe that The Drake Equation "proves" the existence of intelligent life elsewhere in the universe. On the contrary, the Drake Equation simply expresses how many civilized worlds there would be in our galaxy given certain assumptions and known mathematical relationships. The equation is expressed as follows:

$$N = R * F_p * N_e * F_l * F_i * F_c * L$$

Where N = The number of communicating civilizations in the Milky Way, and where:

R = The rate of formation of suitable stars in the galaxy

F_p = The fraction of those stars with planets

N_e = The number of habitable planets (planets with liquid water) per planetary system

F_l = The fraction of those planets where life develops

F_i = The fraction of planets that ever develop life where intelligence develops

F_c = The fraction of planets with intelligent civilizations where technology develops

L = The "lifetime" of such technological civilizations releasing detectable signals into space

While the first three factors (R*, F_p, and N_e) can be estimated by scientists to some degree of certainty, the latter factors can only be reasonably guessed. For example, many scientists believe that where life can evolve it will (F_l = 100%), while others believe that the development of life is far more rare (F_l < 10% or even < .01%). Changes in each of the latter four factors of the Drake Equation can cause the solution, N, to equal anything from zero to the hundreds of thousands! Clearly, the Drake Equation is only a theoretical tool at this point; it has no unique solution. Estimates change as new discoveries bring us more information. For current estimations of the parameters, see this site:

http://en.wikipedia.org/wiki/Drake_equation#Current_estimates_of_the_parameters

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Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>

Note: For this activity, we have made some assumptions and changed the equation slightly for simplification.

The first factor, the rate of star formation (R), has been changed to the number of stars in our galaxy. That is generously estimated as 400 billion, as shown on the Presenter's Cue Card. We make up for that by changing the last factor, the lifetime of intelligent communicating civilizations (L). We make this instead, the fraction of a planet's lifetime that an intelligent, communicating civilization will survive. This is a common change for clarity's sake.

The number of stars in our galaxy is probably between 200-400 billion. However, this number is not very much fun for the layperson to debate. In this activity, we have made an estimate of 400 billion stars that begins the presentation. This is where the number on the Presenter's Cue Card originates.

Detailed Activity Description

Anyone Out There?

<p><u>Presentation Tip:</u> You can use this activity alone, or in conjunction with the included PowerPoint of the same name. To use this activity with the PowerPoint, follow the PowerPoint script that accompanies the presentation. It includes prompts for passing out the cards and soliciting answers from an audience. The following description is for use with the cards alone.</p>	
Leader's Role	Participants' Role (Anticipated)
<p><u>To Do:</u> Have the Presenter's Cue Card with the image of the Milky Way galaxy facing the audience.</p> <p><u>To Say:</u> Does anyone here think there are aliens somewhere out there, looking to make contact with us?</p> <p>Well, we don't have any evidence of creatures from other worlds, but we are looking. Some of you may have heard of Area 51 and claims of UFO invasions. These are extra-ordinary claims. Science investigates these claims, and so far hasn't found any of them to hold up.</p> <p>Until we have evidence, let's take a look at what we think the chances are that there are other intelligent civilizations in our galaxy. A famous astronomer named Frank Drake broke down some of the factors we should consider. Let's look at them together and see what value we come up with.</p> <p><u>To Do:</u> Pass out the 6 factor cards to 6 people in the audience. Ask your visitors to get in groups around the cards and discuss their factor.</p> <p><u>To Say:</u> I want to emphasize that there are no right or wrong answers to these questions. At least not that we know. We are going to examine what factors might make a difference in whether or not there are other intelligent civilizations out there.</p>	<p>Usually "yes!"</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> Let's start with the number of stars in the Milky Way galaxy. There may be as many as 400 billion stars in our galaxy. That's a huge potential for aliens! But not all of those stars have planets. First, we have to see which of those stars have planets.</p> <p>Question #1 -- Will you read us your question and give us your best guess?</p> <p><u>To Do:</u> (These instructions are also written on the Cue Card) If the group guesses:</p> <ul style="list-style-type: none"> • <i>All of them</i> (make no changes) • Half of them (cross off the 4 and write "2") • <i>¼ of the stars</i> (cross out the 4 and write "1") • <i>1 out of every 10 stars</i> (keep the 4 and cross off the last zero on the right) <p><u>To Say:</u> Okay, so, half of 400 billion is still 200 billion. Let's start to narrow that down a bit. Who has Question #2? Could one of you please read us the question and give us your guess?</p>  <p>Okay, that gets rid of two of our zeros. Now we're down to 2 billion places that might have aliens. Now for Question #3...</p> <p><u>To Do:</u> Continue with each question in order, crossing off the appropriate number of zeros at each step. The chart on the back of the Presenter's Cue card tells you how many to cross off, depending on your audience's answer.</p>	<p>"What fraction of all stars in the Milky Way have at least one planet orbiting them?" ...We think half of them do</p> <p>"How many worlds have the right environment to support life?" ...we think 1 in 100</p>

Presentation Tip:

You can easily connect questions #4 and #6 to the Earth Timeline activity. Show how long it took for intelligent life to develop on Earth. For #6, mention that the Earth will likely be around another 5 billion years, about the same amount of time as it has existed so far. How much of that time does your audience think intelligent life will survive?

It's okay to say, "I don't know." Most importantly, never make up an answer. Many presenters find that they learn the most by talking with the public. You can always send visitors to the NASA website Ask an Astrobiologist:
<http://astrobiology.nasa.gov/ask-an-astrobiologist/>

Misconception Tip:

Remember to let your audience know that these are all just guesses. Scientists don't know the answers to these questions.

Leader's Role	Participants' Role (Anticipated)
<p><u>To Do:</u> When you finish all 6 of the cards, you'll have a number left. This is the number of intelligent, communicating civilizations that this group predicts are currently active in the Milky Way.</p> <p>If you cross off all of the zeros and still have more to cross off, then that tells you that their prediction is that we are likely alone in the galaxy. Cross off all of the numbers, including the one you wrote for Question #1 and instead write a big "1" underneath, indicating that they predict we are all alone.</p> <p><u>To Say:</u> So, what does this number tell us? Well, it's our guess of how many intelligent, communicating civilizations might exist in our galaxy right now.</p>	

Wrap-Up

(If this number is 1 or less) You predict that we are alone in our galaxy! Unfortunately, the closest big galaxy is Andromeda and any signals we might receive from them would be 2 million years old. Plus, we would have no way to send back such a strong signal.

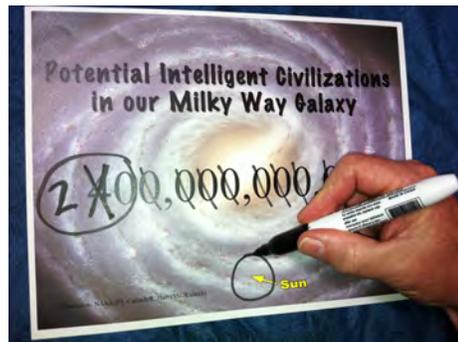
(If the number is less than 10) With this few civilizations in our Milky Way, we will be very lucky indeed to find them. Right now, most of the planets we are monitoring are in our corner of the Milky Way.

To Do:

Draw a circle of about 1" diameter around the Sun in the picture.

To Say:

It's unlikely that any of these few civilizations will be in there. Here's hoping they contact us first.



(If the number is 10 or greater) Wow, IF it turns out there really are that many intelligent civilizations in our galaxy, we can hope to hear from at least one of them. We may even detect their presence in sky surveys that are looking for planets around nearby stars.

Common Questions and Answers

Can we search other galaxies?

Not presently. Even our own galaxy is hard to see in its entirety. Even the closest galaxies are much too far away to imagine communicating with another civilization. The energy required to send a signal to another galaxy is more than our Sun produces, for starters. And we can't even see individual stars very well in other galaxies; much less detect planets or life. We are confined to the Milky Way for now.

Why haven't we heard from anyone?

This is called the Fermi Paradox. The short answer is that we don't know. But there are many possible reasons.

You can find more information and a debate on that question here:

<http://www.astrobio.net/debate/242/fermi%E2%80%99s-paradox-where-are-they>

There is also an overview in this podcast:

<http://www.astronomycast.com/astronomy/episode-24the-fermi-paradox-where-are-all-the-aliens/>

Isn't it possible that...

Yes, it is entirely possible that we are being observed by aliens (the Zoo Hypothesis), or that Earth has very special features that make it the only hospitable place in the galaxy (the Rare Earth hypothesis), or that many other wild things are possible. We simply don't know. And science requires extraordinary evidence to back up extraordinary claims. So until then, they are fun to think about, but we cannot debate them scientifically.

Materials

What do I need to prepare?

- Just wipe off the Presenter's Cue Card with a tissue if you have used it before.

Where do I get additional materials?

1. Print additional copies of the presenter sheet and audience cards. You can find these on the Manual and resources CD in the folder labeled "Masters."
2. These can be laminated at a copy center.
3. If you are using laminated version, dry erase pens can be purchased at any office supply store.

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Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>

How Do We Find Planets Around Distant Stars?

What's this activity about?

Big Question:

How do we find planets around other stars?

Big Activities:

Spin "stars" to simulate star wobble (astrometry and radial velocity). Briefly explain transit method and direct imaging of planets



Participants:

From the club: A minimum of one person.

Visitors: One to six participants (per set of materials)

Duration:

5 to 10 minutes

Topics Covered:

- Two ways we are detecting planets around a star: the transit method and the wobble method

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
How Do We Find Planets?	√	√	√	√	√	√	√	√	√	

What do I need to do before I use this activity?

What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set-Up
<ul style="list-style-type: none"> • 3 Foam balls (“stars”) • 1 Large “planet” (small ball) attached to a golf tee • 1 Toothpick • Tiny ball of clay (1 mm) – pinch this off the block of clay. 	A flat surface	<ul style="list-style-type: none"> • Insert the Golf tee with the small ball (“gravi-tee” and “planet”) into one of the foam balls. • Make a very small ball of clay (about 1 mm in diameter). Place it on the end of the toothpick and insert the other end of the toothpick into one of the other foam balls.

Background Information

Find a New World Atlas listing the **current tally all of the planets** discovered around other stars here:

http://planetquest.jpl.nasa.gov/atlas/atlas_index.cfm

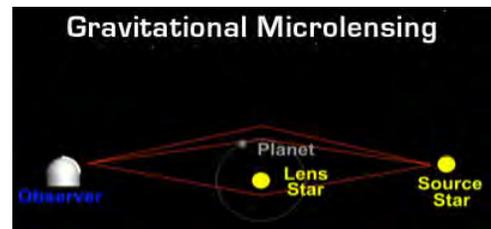
The **Wobble Method** actually uses *Radial Velocity* (or Doppler Shift). This involves measuring the redshift or blueshift of a star's spectral lines as it moves away from (redshift) and toward (blueshift) us along our line-of-sight ("radial" movement). The light is stretched out (longer wavelengths toward the red) when the star is moving away and gets bunched up (shorter wavelengths toward the blue) when the star is coming toward us.

See the Keys to the Rainbow activity for more information about spectra and how we see elements in a star's spectra.

The **Transit Method** relies on the extrasolar planet's orbit lining up directly between the star and Earth. The Kepler Mission uses this method to study one small area of the sky. You can find more information about the mission here:

Other methods for detecting planets are also quite useful, such as:

- **Microlensing:** Uses the gravity's effect on the light coming from as distant star when another star with planets passes in front. (see image on right)
- **Direct Imaging:** By blocking out the light from the parent star, it is sometimes possible to view the orbiting planets. This works best for large planets orbiting very distantly from their star.



A Note About Scale: On the scale where our Sun is the size of the foam ball (approx. 3"), one light year is about 330 miles. Jupiter would be about 150 feet away (halfway down a football field) and Earth would be 30 feet away. The nearest star (Alpha Centauri – at roughly 4 light years) is about 1300 miles away (about halfway across the USA). The distance of a star 10 light years away would be similar to the distance from Los Angeles to New York. A star 35 light years away would be halfway to the Moon. This demonstration uses shorter distances in the examples.

Detailed Activity Description

How Do We Find Planets Around Distant Stars?

Leader's Role	Participants' Role (Anticipated)
<p>1) The Wobble Method</p> <p><u>To Say:</u> How many people have heard that scientists have found planets around other stars? How do you think we can tell the difference between stars that have planets and stars that don't?</p> <p><u>To Do:</u> Put the Star balls on a flat surface like a tabletop or blacktop with at least an area 2 feet by 2 feet clear of obstacles. Direct the participants to spin and observe the motion of the Star without a planet.</p> <p><u>To Say:</u> What motion does it take? This is the motion a star without a planet has against the sky.</p> <p><u>To Do:</u> Direct participants to spin the Star with a planet connected by the golf tee ("gravi-tee") and observe its motion.</p> <p><u>To Ask:</u> What's different about the motion of this star? How do we know a star might have planets?</p> <p><u>To Say:</u> Most methods for finding stars that have planets are dependent on detecting in some manner this movement (wobble) of a star caused by an orbiting planet. These methods cannot detect the planet itself, just the movement of the star as a result of its having one (or more!) planets in orbit around it.</p>	<p>Listen and respond.</p> <p>Participants spin the Star without a planet and observe its motion.</p> <p>Spin the Star with a planet connected by the golf tee and observe its motion.</p> <p>Answer: Its wobble; How it moves ... etc.</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> Do you suppose our star, the Sun, wobbles?</p> <p>Which planet do you think makes the Sun wobble the most? Which is our biggest planet?</p> <p>So do you think we've found any Earth-sized planets around other stars yet? We have. Do you think those small planets make the star wobble too? Let's see.</p> <p><u>To Do:</u> Direct participants to spin the star with the small planet connected by the toothpick and observe its motion.</p> <p><u>To Say:</u> What do you notice? Does it wobble?</p> <p>Yes it does, but that motion is harder to detect. Smaller planets like Earth are harder to detect, but we have found those too. Let's see another method we have used to detect planets around other stars.</p> <p>2. The Transit Method or Photometry</p> <p><u>To Say:</u> "Photometry" is measuring the brightness of a star. The brightness of the star changes when a planet passes in front of the star from our perspective. This is also known as the Transit Method – because the planet transits the star from our perspective.</p> <p><u>To Do:</u> Put the star with a large planet (foam ball with tee and ball) onto a skewer. Hold the star with a planet at eye level and orbit the planet in front of the star from the participant's perspective.</p> <p><u>To Say:</u> Imagine this star being bright like the Sun. As the planet orbits in front of the star, the planet blocks a little of the star's light. Now, imagine this star as being a few hundred miles away in ___(pick a city at least 300 miles away)____. We can't see the planet, just the change in the amount of light coming from the star.</p>	<p>Discuss the possibility that our Sun wobbles. Jupiter Discuss.</p> <p>Spin the star with the small planet</p> <p>Just a little</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> The Kepler Mission uses this method to detect many planets in a small area of the sky, in the Summer Triangle. They are even finding small, Earth-sized planets, smaller than the planet we are using on this scale.</p> <p><u>To Do:</u> Put the star with a small planet (foam ball with toothpick and small clay) onto a skewer. Show how it orbits in front of the star.</p>  <p><u>To Say:</u> They are using very precise instruments to measure this small change in light. This is like detecting a flea crossing a big streetlight -- from all the way across the country!</p>	

Materials

Where do I get additional materials?

1. Foam Balls: The ones you received in the kit are "stress balls." You may be able to find them at a local craft store, but generally, these can only be ordered in large quantities. Quantum Promotions will sell as few as 10 stress balls at once. They refer to these as "sample" shipments. You can order them by any of these methods:
 - EMAIL: sales@quantumpromotions.com or contact the sales rep, Steve Tallman, at: stallman@quantumpromotions.com.
 - CALL toll free at: 1-877-776-6674.
 - For 10 stress balls, the quoted price as of February 2011 is \$2.23/ea, plus shipping.
2. Golf Tees: golfing supply store
3. Attached planet: Glue a small rubber ball or marble with super glue to a golf tee. Using super glue is the most effective and secure method. You don't want the ball flying off the tee and hitting someone. Alternatively, you can wrap a small ball of clay around the end of the golf tee
4. Clay: craft store non-drying clay

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Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>

Keys to the Rainbow (How will we detect life around other stars?)

What's this activity about?

Big Questions:

- How do we get information out of light?
- How are we looking for life around distant stars?
- How do we detect the composition of the atmospheres of planets around different stars?



Big Activities:

Match up the spectra of stars and planets with their atmospheric ingredients.

Participants:

From the club: A minimum of one person.

Visitors: Up to 6 visitors at a time may comfortably participate.

Duration:

5 to 15 minutes

Topics Covered:

- How we spread light out to glean more information about its source
- What's in stellar atmospheres
- What kinds of ingredients we are looking for in the atmospheres of potentially habitable planets

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Keys to the Rainbow		√	√	√	√	√	√	√		

What do I need to do before I use this activity?

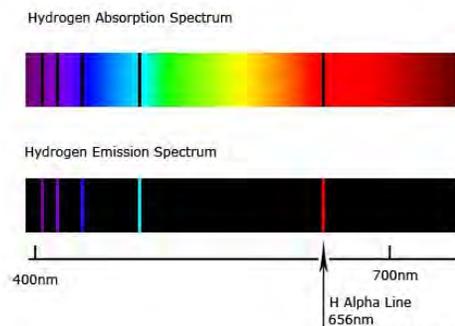
What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set-Up
<ul style="list-style-type: none"> • 1 Rainbow Sheet in its box • 1 Star Transparency • 2 Planet Transparencies • 6 Ingredient transparencies • Wobble ball with Gravi-tee 	Nothing	<ul style="list-style-type: none"> • Start with the opaque Rainbow sheet in the box • Keep the Star and both Planet transparencies to the side • Be ready to hand out the 6 ingredients cards

Background Information

Adapted from NASA's Imagine the Universe website:
http://imagine.gsfc.nasa.gov/docs/science/how_l1/spectra.html

The word 'spectrum' (the plural of which is 'spectra') comes from a Latin word, spectare, which means 'to make a display out of something.' In astronomy, we make a display of electromagnetic radiation, or light. In particular, we spread out radiation into tiny increments of energy in order to examine all of its pieces. On a big scale, we can think of the electromagnetic spectrum, which refers to all the different energies of radiation from the very lowest energy radio waves to the very highest energy gamma-rays. It is hard to examine the whole electromagnetic spectrum at once, so scientists often break it down into smaller regions for their studies. In this activity we are looking at the visible light spectrum.

Each element in the periodic table can appear in gaseous form and will produce a series of bright lines in the spectrum unique to that element. (right, lower) Hydrogen will not have the same lines as helium that will produce different lines than carbon... and so on. When white light passes through a cloud of hydrogen gas, you will see dark lines imposed on the full spectrum. (right, upper) Thus, astronomers can identify what kinds of ingredients are in stars' atmospheres from the lines they find in the star's spectrum. This type of study is called spectroscopy.



The science of spectroscopy is quite sophisticated. From spectral lines astronomers can determine not only the element, but also the temperature and density of that element in the star. The spectral line also can tell us about any magnetic field of the star. The width of the line can tell us how fast the material is moving. We can learn about winds in stars from this. If the lines shift back and forth we can learn that the star may be orbiting another star. We can estimate the mass and size of the star from this. If the lines grow and fade in strength we can learn about the physical changes in the star. Spectral information can also tell us about material around stars. This material may be falling onto the star from a doughnut-shaped disk around the star called an accretion disk. These disks often form around a neutron star or black hole. The light from the stuff between the stars allows astronomers to study the interstellar medium (ISM). This tells us what type of stuff fills the space between the stars. Space is not empty! There is lots of gas and dust between the stars. Spectroscopy is one of the fundamental tools that scientists use to study the Universe.

A much more detailed explanation by Dr. James Kahler can be found here:
<http://stars.astro.illinois.edu/sow/spectra.html>

For more on what's causing the spectral lines:
<http://www.avogadro.co.uk/light/bohr/spectra.htm>

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Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>

Detailed Activity Description

Keys to the Rainbow

Leader's Role	Participants' Role (Anticipated)
<p>Presentation Tip: Notice that when this activity is presented to a general audience, we don't use words like spectrum, spectral lines, or emission. This is simply a fun matching game to give the layperson an idea of how we get information from light. If presenting to a more advanced audience, feel free to introduce more complex ideas.</p>	
<p><u>To Do:</u> Have the box ready with the Rainbow sheet showing. Keep the planet transparencies and the star transparency to the side. Have the diffraction gratings ready.</p> <p><u>To Say:</u> When we look up at night, what do you see? Do you think any of these stars have planets around them? Does our star have planets around it? How many of the Sun's planets do we know of that have life? How do you think we can find out if any planets around other stars have life too?</p> <p>Right. But even through our very biggest telescopes, all we see from a star is a point of light. The stars are so far away, we can't measure how wide one is or even see that they're round. So how do we learn about stars when all we ever see are points of light? The secret is what's hidden in that light.</p> <p>What may look like white light to our eyes is actually made up of many different colors. Does anyone know what we see when white light goes into a prism?</p> <p>Scientists spread out the light in this way to learn more about stars. Let me show you how. White light will show the full rainbow of colors. But when we take a closer look at the light of a star like our Sun, it looks like this.</p> <p><u>To Do:</u> Place the star transparency on the rainbow.</p>	<p>Stars! Yes Yes Just Earth</p> <p>Telescopes!</p> <p>A rainbow</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> What do you notice?</p> <p>That's right. What do you think is causing these lines?</p> <p>It's actually because the white light coming from the star must first pass through the star's atmosphere. That's right, stars have atmosphere too! The ingredients in a star's atmosphere block very narrow areas of color in the rainbow. Each ingredient has its own unique set of lines. This tells us what's in the atmosphere of the star. So these lines represent a combination of many ingredients together. Here, who wants to take an ingredient and see if its lines are in the in the spectrum?</p> <p><u>To Do:</u> Hand out the 6 ingredients to your visitors. Allow them to "test" whether their lines are in the stellar rainbow. That is, match the lines from the star's atmosphere.</p> <p><u>To Say:</u> Great! So hydrogen and helium are present in the star's spectrum but these others are not. We can tell a lot about what the star is made of by spreading out the light. But that's not all! Sometimes the planets orbiting a star will pass in front of the star, blocking a bit of the light and giving us valuable information. This can be especially useful if the planet has an atmosphere. Does our planet have an atmosphere?</p> <p><u>To Do:</u> Demonstrate a planet passing in front of a star to your visitors using a yellow stress ball "star" with an orbiting planet.</p> 	<p>Lines!</p> <p>Sunspots?</p> <p>Hydrogen, helium are both in the atmosphere</p> <p>Yes!</p>

Leader's Role	Participants' Role (Anticipated)
<p><u>To Say:</u> Let's say this planet has an atmosphere, like Earth does. The light from the star also passes through the atmosphere of the planet. While that planet passes in front of the star, we get information about its atmosphere, and this can tell us a lot about the planet. Let's see what's in this planet's atmosphere. We'll leave the hydrogen and helium up since those lines come from the star, not the planet.</p> <p><u>To Do:</u> Place Planet A on top of the star and invite your visitors to see if their ingredients match the planet's lines.</p> <p><u>To Say:</u> So this planet has carbon dioxide in its atmosphere. Unfortunately, that's not a promising indicator for life, and we're looking for a planet that could support alien life. What we'd like to find is water in the atmosphere!</p> <p><u>To Do:</u> Give back the ingredients and place Planet A aside. Then place Planet B on top of the star, hydrogen, and helium transparencies.</p> <p><u>To Say:</u> What if we saw THIS planet passing in front of a star? Who has an ingredient in this planet's atmosphere?</p> <p>This planet has water in its atmosphere! That's a good indication we want to look here for possible life.</p> <p>We're hoping to find a planet with water in the atmosphere someday. Oxygen, methane, and ozone would also be good indicators that we should examine a planet for life. All of those ingredients disappear out of the atmosphere fairly quickly unless something is constantly producing them. These would be excellent places to look for possible alien civilizations!</p>	<div data-bbox="846 279 1192 537" data-label="Image"> </div> <p data-bbox="1219 831 1341 898">Carbon dioxide</p> <div data-bbox="797 1213 1195 1509" data-label="Image"> </div> <p data-bbox="1219 1381 1349 1482">Water, oxygen, ozone</p>

Extensions to the Keys to The Rainbow

Show how we use **redshift and blueshift** to tell whether a star is coming toward us or going away. Place the hydrogen and helium lines on the rainbow background. Then place the star transparency on the full rainbow. With your face on the right side, move the top transparency away from you, showing how the lines shift to the red part of the spectrum when a star is moving away. (Note that this model is not exactly accurate, since they do not shift uniformly.) This technique is used for more than stars. Find background information here:

http://www.esa.int/esaSC/SEM8AAR1VED_index_0.html

Or view this whimsical video here:

<http://www.spitzer.caltech.edu/video-audio/125-ask2006-001-What-Is-a-Redshift>

There is also further explanation behind the "wobble method" described in the *How Do We Find Planets?* activity. The tug on the star is "seen" as it wobbles toward and away from us by noticing the shifts in the spectral lines.

Materials

What do I need to prepare?

- Start with the opaque Rainbow sheet in the box
- Keep the Star and both Planet transparencies nearby, as well as the wobble ball
- Be ready to hand out the 6 ingredients cards

Where do I get additional materials?

1. Print the Light Source and Ingredients transparencies on color transparencies, available at office supply stores. It is best to print these from an electronic source, and not simply make copies. Making copies can result in mis-alignment of the rainbows.
2. Foam balls: The ones you received in the kit are “stress balls.” You may be able to find them at a local craft store, but generally, these can only be ordered in large quantities. Quantum Promotions will sell as few as 10 stress balls at once. They refer to these as "sample" shipments. For 10 stress balls, the quoted price as of February 2011 is \$2.23/ea, plus shipping. You can order them by any of these methods:
 - EMAIL: sales@quantumpromotions.com
 - Contact the sales rep, Steve Tallman, at: stallman@quantumpromotions.com
 - CALL toll free at: 1-877-776-6674
3. Golf Tees: golfing supply store
4. Attached planet: Glue a small rubber ball or marble with super glue to a golf tee. Using super glue is the most effective and secure method. You don't want the ball flying off the tee and hitting someone. Alternatively, you can wrap a small ball of clay around the end of the golf tee

Where Are the Distant Worlds? Star Maps

About the Activity

Where are the distant worlds in the night sky? Use a star map to find constellations and to identify stars with extrasolar planets. (Northern Hemisphere only, naked eye)



Materials Needed

- Current month's Star Map for the public (included)
- A small (red) flashlight
- (Optional) Print list of *Visible Stars with Planets* (included)

Find the most up to date Star Maps here:

http://nightsky.jpl.nasa.gov/download-view.cfm?Doc_ID=320

Topics Covered

- How to find Constellations
- Where we have found planets around other stars

Participants

Adults, teens, families with children 8 years and up

If a school/youth group, 10 years and older

1 to 4 participants per map

Location and Timing

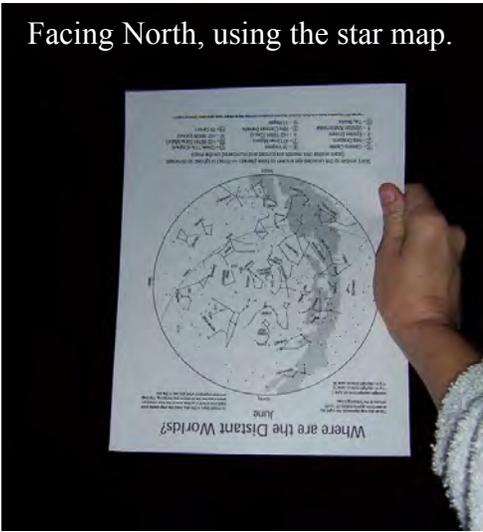
Use this activity at a star party on a dark, clear night. Timing depends only on how long you want to observe.



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Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>

Detailed Activity Description

Leader's Role	Participants' Roles (Anticipated)
<p>Introduction: <u>To Ask:</u> Who has heard that scientists have found planets around stars other than our own Sun? How many of these stars might you think have been found?</p> <p>Anyone ever see a star that has planets around it? (our own Sun, some may know of other stars) We can't see the planets around other stars, but we can see the star. We can also show you a picture of what the system might look like.</p> <p><u>To Say:</u> We're going to look at a map that will show us where to find these stars in the sky.</p> <p>NASA missions are being designed right now to find more stars with planets and to find out which planets might have life! We'll use the star map to find the constellations the stars are in and then find the stars with planets.</p>	<p>Participants begin to think about and respond to questions about extrasolar planets beyond our Solar System.</p>
<p><u>To Ask:</u> What's a constellation? (make sure the participants understand)</p>	<p>Participants share, learn, or are reminded of what constitutes a constellation.</p>
<p><u>To Do:</u> Demonstrate how to use the star map to find a constellation and one of the stars. Assist participants in finding other constellations and stars with planets.</p> <p>To demonstrate how to use a star map: If facing North, hold the map up against the sky and orient the star map so that North on the map is down - toward the northern horizon (see photo to the right). If facing East, orient the map so that East on the star map is down toward the eastern horizon.</p> <p>Participants practice using a star map to find constellations and stars with planets.</p>	<p>Facing North, using the star map.</p> 

Additional Discussion on Epsilon Eridani – the nearest star we know of with planets (besides the Sun!)

To Say:

The fastest speed recorded for a spacecraft was 150,000 miles per hour, reached by the Helios satellite that is in orbit around the Sun. That's 42 miles per *second*.

To Ask:

How long do you would it take to for someone living on Epsilon Eridani's planet about 10 light years away, to get into our Solar System if they were traveling at the speed of our fastest spacecraft (light travels at 186,000 miles per second and our fastest spacecraft travels at about 42 miles per second)? Or for us to reach them?

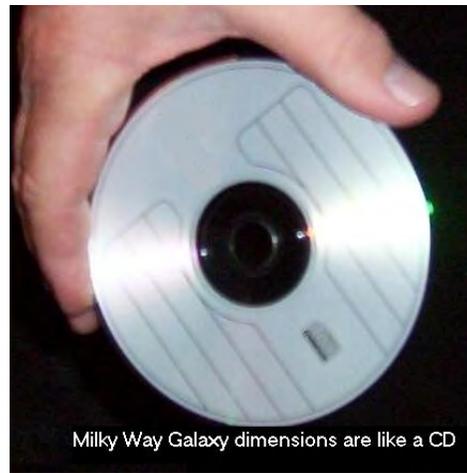
The spacecraft would travel at 2/10,000th the speed of light (42 divided by 186,000 = 0.00022). So 1 light year would take 5,000 years. Epsilon Eridani is about 10 light years from us. So . . . 10 years X 5,000 = 50,000 YEARS to get there.

To Discuss:

- What would we have to do to take such a trip?
- How would we stay in communication with the spacecraft?
- Would a manned or unmanned spacecraft be a better idea? Why?
- How long would it take for us to know the spacecraft had arrived?
- How different do you think Earth will be in 50,000 years?

Helpful Hints

- TO PROMOTE YOUR CLUB: You may want to copy your club's information and schedule on the back side of the star map which you hand out.
- Emphasize that the stars marked on the star maps have planetary systems of their own, just like our star, the Sun, does.
- When you discuss other stars that have planets, some people may think you mean that some of OUR planets (like Jupiter or Saturn) are near other stars. A common misconception is that the stars are sprinkled among the planets of our Solar System. A discussion of stellar distances is instructive. The visible part of our Milky Way Galaxy is about 100,000 light years across and where we are it is about 1000 light years thick. You can use an example where the distance across our Solar System is a bit bigger than a quarter (with the Sun as a grain of sand in the center of the quarter) and the NEAREST star (4 light years away) is 2 football-field lengths away. The Milky Way Galaxy would span the United States (about 2500 miles) and be about 25 miles thick – about the same relative dimensions as a CD (100 to 1). To imagine the 200 billion stars in our Galaxy, think of building a four-foot high wall all around a football field and then filling it with birdseed. That's roughly 200 billion bird seeds. Now imagine distributing those seeds (stars) over the entire USA, 25 miles deep. The stars are VERY far apart!
- If the participant has heard of the Voyager missions from the 1970's, these spacecraft have passed well beyond the orbit of Pluto. Many people think these spacecraft are now "among the stars". On the slightly-larger-than-quarter-sized model of our Solar System, The Voyager spacecraft are only about 2-3 inches beyond the edge of the quarter – still VERY far from even the nearest star.



Milky Way Galaxy dimensions are like a CD

Background Information

- **Planet Naming Conventions:**

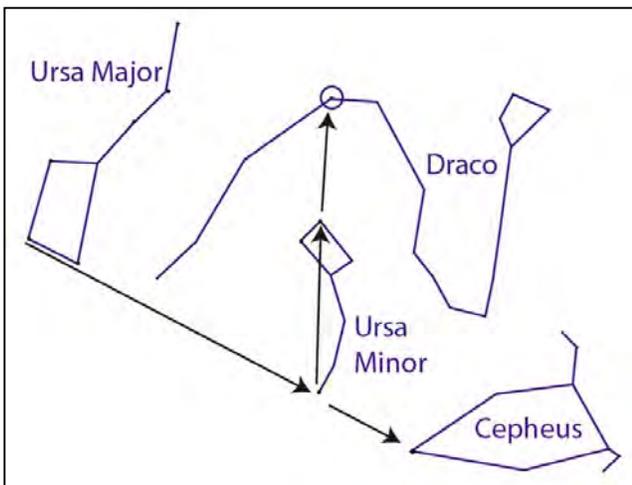
You may have noticed that the planets around a star are named b, c, d, as in gamma Cephei b, or Upsilon Andromeda b, Upsilon Andromeda c, and so on. You may have wondered why there is no “a” planet. As premier extra-solar planet hunter Debra Fisher explains it:

“The “A” component is reserved for the star. The default naming convention (since the IAU hasn’t jumped in) is that the first detected planet is “b” continuing alphabetically. Usually, the first detected planet is the inner one (Keplerian biases) but in one case, GJ 876, the outer planet was discovered first. So GJ 876 b is the outer planet, and GJ 876 c is the inner planet.”

(The IAU is the International Astronomical Union and is the organization that performs such tasks as setting naming conventions of astronomical objects.)

Note also that when there is a binary star, the two stars are called, for example, Sirius A and Sirius B. The upper case A or B refers to stars. Lower case b, c, etc. refers to the planets.

- **Finding the brightest stars with planets**



The two brightest Northern Hemisphere stars with planets are gamma Cephei and iota Draconis. Fortunately they are visible almost all year and are fairly easy to find, even though they are only about 3rd magnitude. Note in the figure that you can use the pointer stars from the Big Dipper to point to the North Star (Polaris) and then just continue on another 20 degrees or so to gamma Cephei. Iota Draconis is found by starting at the North Star, drawing a line through the star at the “bottom” of

the Little Dipper and continuing on to iota Draconis.

For more information on locations of distant worlds and for a 3-D interactive of where the distant worlds are:

http://planetquest1.jpl.nasa.gov/atlas/atlas_index.cfm