National Aeronautics and Space Administration

Life in the Universe

Outreach ToolKit Manual

Test Version

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Virtual Planetary Laboratory

Distributed for testing by members of the *NASA NIGHT SKY NETWORK*

Night Sky Network

Astronomy Clubs bringing the wonders of the universe to the public

The Night Sky Network is sponsored and supported by:

- **JPL's** Exoplanet Exploration Program
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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 exciting new discoveries 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 planets 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. We hope these tools will give you the background and confidence to address the idea of life beyond Earth with your audiences.

Summary of Activities and Resources:

The Space Rocks ToolKit concentrates on asteroids and phenomena stemming from the dynamic nature of the Asteroid Belt, such as impacts and meteorites. Comets are included in some activities but the emphasis here is on asteroids.

1. **Media and Resources**
    - Manual & Resources CD contains the ToolKit Manual and a variety of other resources, including a folder called Masters with master copies of all materials.
    - Training DVD is for training your club members on the ToolKit
    - PowerPoint: Anyone Out There? along with a script (on the Manual & Resources CD)
    - "Where Are the Distant Worlds?" Star Map examples. Links to these masters can be found on the Manual and Resources CD in a document called AdditionalResources.pdf
    - Planetary Postcards can be used at the telescopes to allow operators to show the public naked-eye stars that have confirmed planets.
    - Background Materials on NASA Missions for sharing with club members

2. **What Are We Looking For?**
    - 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.
    - Habitability Dice is an interactive way to discuss what types of planets we are searching for in our search for life in the galaxy.
    - Earth Timeline Banner shows the progression of life on Earth from single-celled organisms to current human civilization. The backside shows off the Watery Worlds of our Solar System.

3. **How Are We Searching?**
    - Anyone Out There? is an interactive version of the Drake Equation that can be used with or without the PowerPoint found in the Manual.
    - 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.

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 life on other worlds?

Big Activities:

Participants are each given one of 16 examples of Extremophiles -- organisms found in some of the toughest conditions on Earth. They sort themselves into groups according to the preferences of their organisms. Finally, they discover that all known life on Earth requires liquid water to survive.

Participants:

From the club: A minimum of one person

Visitors: This activity works best with a group of at least 12 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. Ages 7 to adult will enjoy this activity at different levels.

Duration:

10 to 15 minutes

Topics Covered:

- Life is found in extreme environments on Earth.
- Science is studying 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 16 Extremophile Cards (Optional) Presenter's Cue sheet	Nothing	The first time you do this activity, you will need to fold each card in half and glue them together using the included glue stick or staples.

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 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 us?

Types of Extremophiles (from Wikipedia)
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
Alkaliphile: An organism with optimal growth at pH levels of 9 or above
Cryptoendolith: An organism that lives in microscopic spaces within rocks, such as pores between aggregate grains; these may also be called Endolith, a term that also includes organisms populating fissures, aquifers, and faults filled with groundwater in the deep subsurface
Hyperthermophile: An organism that can thrive at temperatures between 80–122 °C (176 – 250 °F), such as those found in hydrothermal systems
Metallotolerant: Capable of tolerating high levels of dissolved heavy metals in solution, such as copper, cadmium, arsenic, and zinc
Oligotroph: An organism capable of growth in nutritionally limited environments
Piezophile: An organism that lives optimally at high pressure; common in the deep terrestrial subsurface, as well as in oceanic trenches
Polyextremophile: An organism that qualifies as an extremophile under more than one category
Psychrophile/Cryophile: An organism capable of survival, growth or reproduction at temperatures of -15 °C (5°F) or lower for extended periods; common in cold soils, permafrost, polar ice, cold ocean water, and in or under alpine snowpack
Radioresistant: Organisms resistant to high levels of ionizing radiation, most commonly ultraviolet radiation, but also including organisms capable of resisting nuclear radiation
Thermophile: An organism that can thrive at temperatures between 60–80 °C (140 – 176 °F)
Xerophile: An organism that can grow in extremely dry, desiccating conditions; such as the soil microbes of the Atacama Desert

Detailed Activity Description

Life in the Extreme

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td><u>To Say:</u>
Did you know that scientists are looking for possible life in our galaxy? How many places besides Earth have you heard that we've found evidence of life?

Actually, there's no clear evidence of life anywhere besides Earth. But we have a lot of strange and wonderful types that live in environments you and I might think are inhospitable. Scientists are looking 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.

<u>To Do:</u>
Hand out the Extremophile Cards to your visitors.</td><td>

Mars?</td></tr>
<tr><td colspan="2"><u>Presentation Tip:</u>
If there are more than 16 visitors, have them form "colonies" of organisms around each card. If there are fewer than 16, 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.</td></tr>
</table>

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td colspan="2"><u>Presentation Tip:</u>
For the first few times you use this activity, it might be useful to have the Presenter's Cue sheet to refer to.</td></tr>
<tr><td><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.

<u>To Say:</u>
Which of your organisms can live without water? Come over here.

Ahh! Interesting. Did you know that every single living organism we've discovered on Earth needs liquid water to survive, grow, and reproduce?

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?

<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.</td><td>No one goes to that side</td></tr>
</table>

Materials

What do I need to prepare?

- The first time you do this activity, 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 sheet 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.

Habitability Dice

What's this activity about?

Big Questions:

- What characteristics are we searching for when we look for potentially habitable planets?
- Where are we looking for possible alien life right in our own Solar System?

Big Activities:

Roll three dice, each defining one attribute of a planet (size, energy source, and atmosphere) and see if you can roll a habitable planet.

Participants:

From the club: A minimum of one person

Visitors: The Habitability Dice are best used with small groups of 2-5 people. Ages 10 to adult will get the most out of this activity.

Duration:

5 to 15 minutes

Topics Covered:

- We are looking for potential life on small, rocky planets and moons.
- We are looking for potential life on distant worlds in a star's habitable zone.
- We are looking for potential life here in our Solar System in the habitable zone and on moons that are tidally heated by the gravity of their parent planets.
- If we hope to detect life on worlds around other stars, those worlds will need an atmosphere.

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			
Habitability Dice		√	√	√		√	√	√		√

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
Three Habitability Dice	A flat surface -- a table or the ground are fine.	Before using the dice for the first time, place the stickers on all sides.

Background Information

Worlds of our Solar System

Scientists are looking for possible life around other stars in the "Habitable Zone" or "Goldilocks Zone." This is the area around a star where liquid water could exist. In our Solar System, both Earth and Mars are located in the habitable zone. But Mars lacks the atmosphere to hold in enough heat, so the water on Mars is locked up in ice on its surface.

Once you've established how we search for liquid water, participants roll the dice to attempt to combine the elements and create a potentially habitable world. This is an excellent opportunity to point out worlds in our Solar System that have similar properties to the planets they are rolling.

Small Rocky Planets: The Earth is one of four small rocky planets in our Solar System including Mercury, Venus, and Mars. Mercury orbits our Sun too closely and is too hot to have any liquid water. Venus is probably too close to the Sun to have water, plus its thick atmosphere of greenhouse gases makes it even hotter -- far too hot for liquid water. Mars, like Earth, is firmly in the Sun's habitable zone but lacks much atmosphere and so only has water ice on its surface.

Gas Giants: In our Solar System, Jupiter, Saturn, Uranus, and Neptune all orbit beyond the habitable zone, at a great distance from the Sun. However, many of the other star systems we are discovering have large gas giant planets orbiting close to their parent star. These are the easiest types of planets to find. (You can find more information on this in the *How Do We Find Planets?* activity.)

Moons around Gas Giants:
Both Jupiter and Saturn are so large that their gravity exerts pressure on moons that orbit in eccentric (or oval-shaped) orbits. As the moons get closer to the massive planets, the surface of a moon is pulled, just like our Moon pulls on the water on Earth, making tides. Then as its orbit takes it far away, the pull lessens and the moon relaxes. These stresses cause friction, and that heats the planet, melting ice beneath the surface. Some moons, such as Jupiter's Europa and Ganymede and Saturn's Enceladus, may have vast oceans beneath icy crusts.

Detailed Activity Description

Habitability Dice

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td colspan="2"><u>Presentation Tip:</u>
Red sides are not good places to look for life. Green sides are! And yellow sides are questionable. These require further exploration.</td></tr>
<tr><td><u>To Say:</u>
Did you know that NASA is looking for aliens? Well, what they're actually looking for is a planet that might have aliens on it. Do you know what they’re looking for in a good planet?

We think that a planet where liquid water exists is a good place to look for life in our galaxy. But it turns out that it's not so easy to find. Let me show you what we're looking for.

<u>To Do:</u>
Pick up the die with planet sizes to show visitors.

<u>To Say:</u>
First, a planet needs to have a surface, like Earth or Mars. Big gas giants like Jupiter are mostly made of gas with no surface to speak of. We think it's probably too wild and windy on gas giants for life to have formed. Here, see if you can roll a small rocky planet.

<u>To Do:</u>
Hand the die to a visitor and ask them to roll until they get a green "small rocky world" on the topside. Leave it there when they do. Pick up the heat source die.

<u>To Say:</u>
Great. Okay, so we've found a planet small enough to have a surface. Astronomers are finding planets like these all the time. But they're not all good places to look for life. Space is cold, and life needs some kind of heat source. There's a certain area around each star that we call the "Goldilocks Zone" -- not too hot, not too cold. Let's see if we can roll a warm planet.</td><td>Signals?

Visitor rolls first die</td></tr>
</table>

Leader's Role	**Participants' Role (Anticipated)**
To Do: Hand the die with heat sources to another visitor and ask him/her to roll until it lands on a green "Goldilocks Zone".	Rolls 2nd die
Presentation Tip: If the participant gets a yellow "Tidal Heating" roll, it is your opportunity to talk about some of the moons of large planets in our Solar System. *To Say:* Oh, what if we roll the yellow "Tidally Heated" side. Well, some of the moons around gas giant planets right here in our Solar System are tidally heated. These moons are too far from the Sun to receive enough heat to stay warm, but the friction from constant squeezing by the gravity of Jupiter or Saturn heats them. This creates enough heat for water to exist under the cold outer layer of ice. You can see some of the moons of Jupiter and Saturn that likely have liquid water here on the banner. We think it's *possible* that life might be able to form under thick ice sheets on these moons, but we're not sure. Hopefully, someday we can look in depth at these moons in our Solar System. But unfortunately, if we're looking for planets around other stars, we can't send space probes to look under the ice. They're too far away. So let's try for a planet in the "Goldilocks Zone," since we could detect water there.	
To Say: Wonderful. Now we've got a small rocky planet in the "Goldilocks Zone," or what scientists call the "Habitable Zone." Did you know we've even found planets around other stars like that? In our Solar System, there are two planets that could fit that description. *To Do:* Point to Earth and Mars on the Watery Worlds banner. *To Say:* You can see them here on the banner -- Earth and Mars. But only one of those planets has liquid water on it. That's because we have an atmosphere that keeps us warm but not too hot. Mars has a very thin atmosphere that doesn't hold the heat in. So last but not least, let's see if we can roll an atmosphere that will keep our planet warm enough but not *too* warm.	

<table>
<tr><th>Leader’s Role</th><th>Participants’ Role (Anticipated)</th></tr>
<tr><td><u>To Do:</u>
Hand the third die to a third visitor and encourage them to roll a world with an atmosphere.

Once they've established what makes a habitable planet, they can begin to take turns rolling all 3 dice to see who can roll a habitable planet. As they roll planets, you can point out similar places in our Solar System. For older audiences, see if they know the worlds in our Solar System with those properties, even if they aren't candidates for water. (see Background Information for more on the worlds in our Solar System).

<u>To say:</u>
It's not so easy to find a planet with the "right" ingredients for life, is it? In our Solar System, Earth is still the only place where we've found evidence for life, even with many potential worlds and two planets in the Goldilocks Zone.

The only planets we can even begin to explore in depth are those in our own Solar System. With our fastest rockets, it would still take many thousands of years to reach a planet around the closest star. Planets around other stars are so far away that we have to look for life in other ways, like detecting water in their atmospheres.</td><td>Rolls 3rd die</td></tr>
<tr><td colspan="2"><u>Extensions:</u>
You can extend this activity with the Keys to the Rainbow activity to explain how we search for water on distant worlds.

Or hand out the Where Are the Distant Worlds Star Maps and show visitors where they can find stars with orbiting planets we've discovered.

For younger audiences doing this activity indoors, once they roll a potentially habitable planet, ask them to create an alien that might live there. They can draw this, tell about it in a story, or build it with odds & ends or modeling clay if you have those materials available.</td></tr>
</table>

Materials

What do I need to prepare?

- Before using this activity for the first time, place the included stickers on the dice.

Where do I get additional materials?

1. In this ToolKit, we used Everrich EVC-0174 Foam Dice Set -- set of 6 colors, 3" cube. Look this product up in a search engine; there are many providers. Any 3" cubes should work for this activity.
2. Stickers may be printed on Avery 5196 or compatible labels. Master copies are located on the Manual & Resources CD in a folder named Masters.

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 organisms and animals developed in the history of Earth. Then the actual timeline of life is revealed, surprising many. The early development of simple life and the relatively late development of complex life change many people's ideas of what alien life may look like.

Participants:

From the club: A minimum of one person.

Visitors: Cratering is appropriate for families, the general public, and school groups ages 10 and up. Up to 15 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 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	√	√	√	√		√	√	√		√

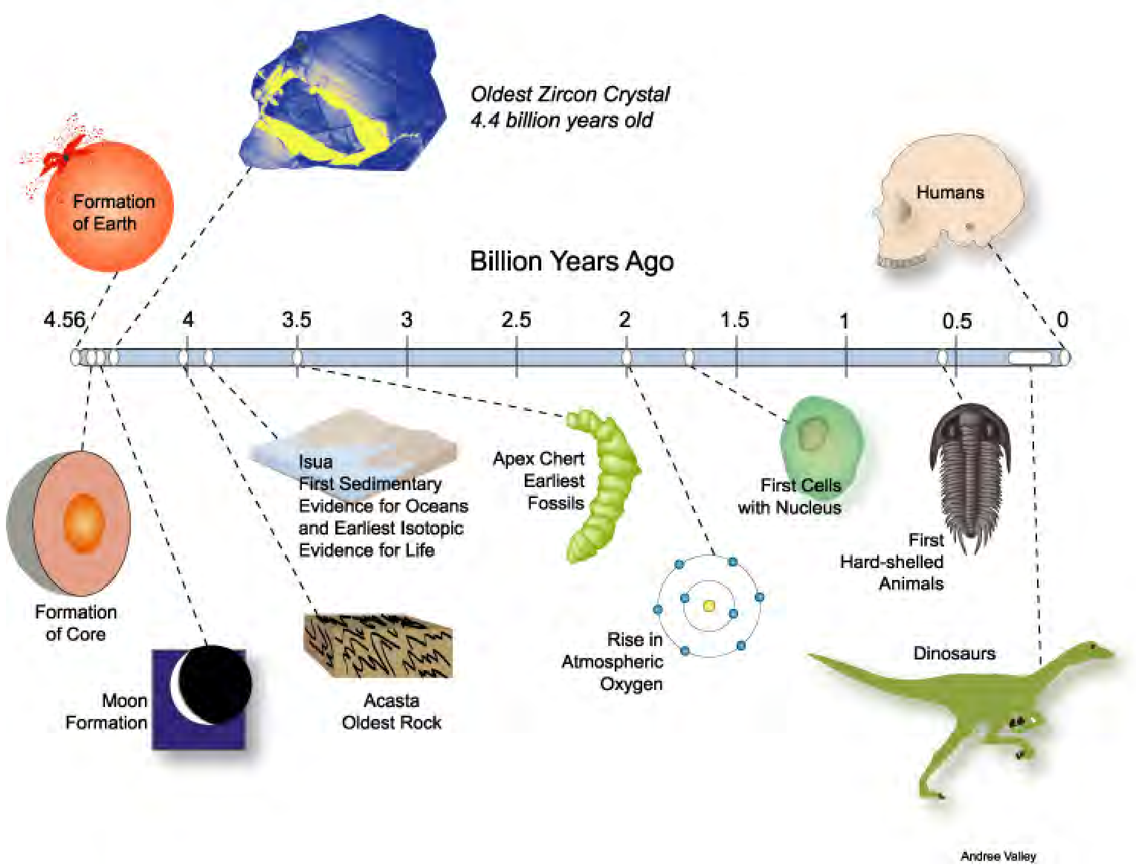
What do I need to do before I use this activity?

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
Earth Timeline banner 7 Life Form cards with Velcro dots One Alien card	A table, fence, or car to present the banner	• Use the Velcro strips to attach the banner to a fence or car. • Fold the bottom of the timeline to hide the life forms, leaving half of the Velcro strip exposed for the guesses.

Background Information

Origins of Life

The earliest life formed on Earth at least 3.5 billion years ago. 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

Detailed Activity Description

Earth Timeline

Leader's Role	**Participants' Role (Anticipated)**
Presentation Tip: This activity can be done without the banner as well. There is silhouette of a person on the bottom of the banner, indicating where the events occurred. • The first life developed at some point on the earliest 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.	
To Do: 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, leaving half of the Velcro exposed for your visitors' guesses. See image, right.	
To Say: What do you think aliens might look like?	Little green men
To Do: Hold up the alien life form and the single-celled organism life form. Ask the audience what they think we are more likely to encounter as we search for extraterrestrials.	Most think the "alien" is more likely
To Say: 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.	
Presentation Tip: 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.	

To Say: 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. 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. *To Do:* Hand out the life form cards to 7 visitors. *To Say:* You each have a type of life that has existed on Earth. Who thinks they have one of the earliest life forms? 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. You can use any of the pictures on the top for reference. Now, the rest of the life forms, go ahead and place yours where you think this type of life first developed.	Single-celled organisms Placement varies for all life forms
Presentation Tip: 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.	

Leader's Role	Participants' Role (Anticipated)
To Do: Once everyone has finished, unfold the bottom of the banner to show the actual timeline. Leave the guesses where they are for comparison.	
To Say: Do you want to see how we've done? What do you notice?	Most people put the beginning of life much later.
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 developed even earlier. Basically, as soon as there were stable oceans, there was life.	
What else?	Animals are pretty recent
That's right. It took almost 3 billion years for anything other than simple life to develop!	
To Say: And Humans are one of the very most recent animals to develop.	
To Do: Hold out your arms like the illustration on the timeline.	
To Say: 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.	
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?	Maybe?
It's true, we don't know. What else might we take into consideration when we ask that question?	How much longer will Earth be around?
Good question! We have about another 5 billion years before our Sun begins dying, likely making conditions on Earth unbearable for life. What else?	How long humans will be around?

Leader's Role	**Participants' Role (Anticipated)**
To Say: Yes, we don't know that either. How long will intelligent life survive on Earth? We don't know the answer to that question. We also don't know what kind of life forms we might encounter 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 visiting our planet would have thought about us for most of Earth's lifetime? There are a few places in our Solar System where we would like to explore the possibility of life. We are looking for worlds with water on them. In our Solar System, we're fairly sure that IF there's any life on other worlds, it will be simple life forms. Why do you think we are looking for simple life forms? *To Do:* Flip the banner over to show the Watery Worlds where we hope to look for life.	Boring planet! Discuss

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. 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?

The extinctions we mostly hear about all happened here, in the palm of your hand! But there were many more before these big 5, and they had many causes. For example, here 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?

Land initially erupted from the oceans early in Earth's history. Continental plates were moving around probably quite quickly and formed many different super-continents and broke apart many times before now. Many people are familiar with the most recent super-continent, Pangaea. This was when the Americas were connected to Europe, Asia, and Africa. It occurred just before the time of the dinosaurs, not too long ago on this scale.

Materials

What do I need to prepare?

- Hang the Earth Timeline banner or place it on a table
- Fold the bottom of the banner up to meet the Velcro strip. Leave the top half of the strip exposed for your visitors to make guesses.
- The first time you do this activity, tear the cards apart and place the included Velcro on the back near the top, as shown right.

Where do I get additional materials?

1. There are masters of the life form cards on the following pages.
2. A large pdf of the banner is included on the Manual & Resources CD in the folder named Masters. You can get prints made for around $100 at many banner and copy centers.

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: Up to 24 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 10 through adult.

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

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 Dry-erase marker	(Optional) This activity can be used with the *Anyone Out There PowerPoint*. If so, you would need a computer and projector.	None

Background Information

<u>The Drake Equation</u>

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. 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, besides Earth. 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 communicative 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

Note: For this activity, we have made some assumptions and changed the equation some to make it simpler.

The first factor, the rate of star formation (R), has been changed to the number of stars in our galaxy. 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. Also, the Number of watery worlds (N_e) is split into two questions: How many planets around a star and how many of those are watery.

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 100 billion stars that may have planets around them to begin the presentation. This is a fair estimate of the percentage of stars that have planets around them from current data. This is where the 11 zeros on the Presenter's Sheet originate.

Detailed Activity Description

Anyone Out There?

Leader's Role	**Participants' Role (Anticipated)**
Presentation Tip: 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.	
<u>To Do:</u> Have the Presenter's Sheet facing the audience or face-up on the table. <u>To Say:</u> Does anyone here think there are aliens somewhere out there, looking to make contact with us? Well, we don't have any evidence of creatures from other worlds, but we are looking. Some of you may have heard of Area 54 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. 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. <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. <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.	Usually "yes!"

Leader's Role	**Participants' Role (Anticipated)**
To Say: Let's start with the number of stars in the Milky Way galaxy that might have planets. Already we make some assumptions. There may be about 400 billion stars in our galaxy, and we estimate that about a quarter to half of those have planets. A fair guess is about 100 billion stars with planets around them. That's a huge potential for aliens! But not all of those stars with planets will be good places to look for life. Question #1 -- Will you read us your question and give us your best guess? Great, so I'll put a 5 in this place, giving us 500 billion potential planets that might host aliens. *To Do:* Place whatever number group #1 guesses in the blank space in front of the zeros. *To Say:* 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? Okay, that gets rid of two of our zeros. Now we're down to 5 billion places that might have aliens. Now for Question #3… *To Do:* 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.	(reads question) …we think 5 (reads question) …we think 1 in 100
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/	

Leader's Role	**Participants' Role (Anticipated)**
Misconception Tip: Remember to let your audience know that these are all just guesses. Scientists don't know the answers to these questions.	

<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.
 	
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.
 	
<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.
 	
(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.
    <u>*To Do:*</u>
    Draw a circle of about 1" radius around the Sun in the picture.
    <u>*To Say:*</u>
    It's unlikely that any of these few civilizations will be in there. Here's hoping they contact us first.
 	
(If the number is greater than 10) 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.
	Can we search other galaxies?

Materials

What do I need to prepare?

- Just wipe off the Presenter's Sheet 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.

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 20 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
• 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	• 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

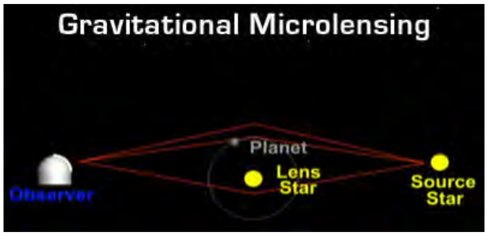
The **Wobble Method** actually uses *Radial Velocity* (or Doppler Shift). This involves measuring the redshift or blueshift of a star's spectral lines as it moves away from (redshift) and toward (blueshift) us along our line-of-sight ("radial" movement). The light is stretched out (longer wavelengths 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 planets orbiting. 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)**
1) The Wobble Method	
<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?	Listen and respond.
<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.	Participants spin the Star without a planet and observe its motion.
<u>*To Say:*</u> What motion does it take? This is the motion a star without a planet has against the sky.	
<u>*To Do:*</u> Direct participants to spin the Star with a planet connected by the golf tee ("gravi-tee") and observe its motion.	Spin the Star with a planet connected by the golf tee and observe its motion.
<u>*To Ask:*</u> What's different about the motion of this star? How do we know a star might have planets?	Answer: Its wobble; How it moves … etc.
<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.	

Leader's Role	Participants' Role (Anticipated)
To Say: Do you suppose our star, the Sun, wobbles? Which is our biggest planet? Which planet do you think makes the Sun wobble the most? 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.	Discuss the possibility that our Sun wobbles. Jupiter Discuss.
To Do: Direct participants to spin the star with the small planet connected by the toothpick and observe its motion.	Spin the star with the small planet
To Say: What do you notice? Does it wobble? 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.	Just a little
2. The Transit Method or Photometry *To Say:* "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. *To Do:* 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. *To Say:* 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.	

Leader's Role	Participants' Role (Anticipated)
To Say: 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.  *To Do:* 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. *To Say:* 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!	

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

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 atmospheres of planets around different stars?

Big Activities:

Match up the spectra of stars and planets with their 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 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?

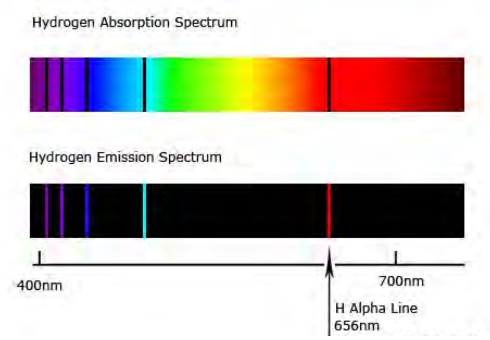
What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set-Up
• 1 Rainbow Sheet in its box • 1 Star Transparency • 2 Planet Transparencies • 6 Ingredient transparencies • Wobble ball with Gravi-tee • Diffraction gratings	Nothing	• Start with the opaque Rainbow sheet in the box • Keep the Star and both Planet transparencies • Be ready to hand out the 6 ingredients cards

Background Information

Spectra and Spectroscopy

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, the thing we often make a display of is radiation. 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 helium gas, you will see dark lines in imposed on the full spectrum. (right, upper) Thus, astronomers can identify what kinds of stuff 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

Detailed Activity Description

Keys to the Rainbow

Leader's Role	Participants' Role (Anticipated)
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.	
<u>To Do:</u> Have the box ready with the Rainbow sheet showing. Keep the planet transparencies and the star transparency (on top) to the side. Have the diffraction gratings ready.	
<u>To Say:</u>	
When we look up at night, what do you see?	Stars!
Do you think any of these stars have planets around them?	Yes
Does our star have planets around it?	Yes
How many of the Sun's planets do we know of that have life?	Just Earth
How do you think we can find out if any planets around other stars have life too?	Telescopes!
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.	
What may look like white light to our eyes is actually made up of many different colors. Rain sometimes spreads out sunlight to show what it's made of. Does anyone know what we see then?	A rainbow
Right. We can spread the colors out with a prism or special gratings, like these.	
<u>To Do:</u> Pass out the diffraction gratings and let the visitors share them to look at the rainbows from white light. **WARNING: Do Not Look Directly At The Sun!** Once they have a moment to explore, bring out the Rainbow box.	

Leader's Role	Participants' Role (Anticipated)
To Say: 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.	
To Do: Place the star transparency on the rainbow.	
To Say: What do you notice?	Lines!
To Say: That's right. What do you think is causing these lines?	Sunspots?
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?	
To Do: 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.	Hydrogen, helium
To Say: Great! So hydrogen and helium are present in the star's spectrum but these others are not. We can tell a lot about what it 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?	Yes!
To Do: Demonstrate a planet passing in front of a star to your visitors using a wobble ball.	

Leader's Role	**Participants' Role (Anticipated)**
To Say: 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. *To Do:* Place Planet A on top of the star and invite your visitors to see if their ingredients match the planet's lines. *To Say:* So this planet has sodium and nitrogen in its atmosphere. Unfortunately, those aren't indicators for life, and we're looking for a planet with alien life forms. *To Do:* Remove that planet and give back the ingredients. Then place Planet B on top of the star lines. *To Say:* What if we saw THIS planet passing in front of a star? Who has an ingredient in this planet's atmosphere? This planet has water in its atmosphere! That's a good indication we want to look here for possible life. 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!	Sodium, nitrogen Water, oxygen

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 regular star transparency on the full rainbow. Then place the star transparency with the full lines on top. 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-

This 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.

Let us know if you have other ideas for using this activity, including any other transparencies you'd like to see included.
nightskyinfo@astrosociety.org

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 and the diffraction gratings

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. You can order them by any of these methods:
3. 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.
4. Golf Tees: golfing supply store
5. 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
6. Diffraction Gratings can be found on many online educational stores. The ones included here are 1000 lines/inch linear diffraction slides from Rainbow Symphony:
   http://www.rainbowsymphonystore.com/difgratslidl.html