Shadows & Silhouettes Outreach Toolkit Manual

Updated July 2009, October 2015, Astronomical Society of the Pacific

Distributed for members of the NASA Night Sky Network

The Night Sky Network is sponsored and supported by:

- NASA'S Kepler Mission, GRANT NAG 2-6066, SETI Institute
- JPL'S PlanetQuest Public Engagement Program
- NASA'S Origins Forum
- NASA'S Structure and Evolution of the Universe Forum
- NASA'S Solar System Education Forum

The Night Sky Network was founded by:

JPL'S Navigator (**PLANETQUEST**) Public Engagement Program

NASA Night Sky Network:
http://nightsky.jpl.nasa.gov/

Contacts

The non-profit 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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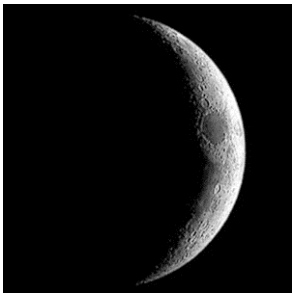
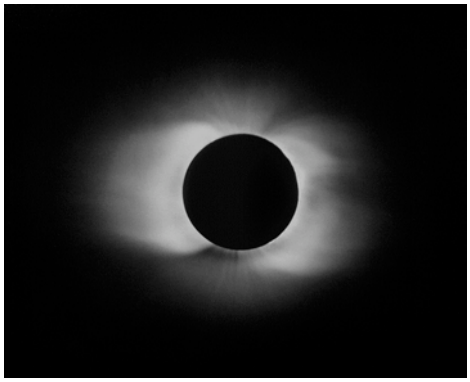
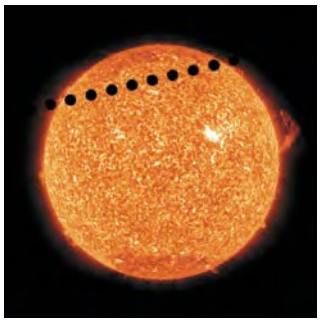
Introduction: Shadows & Silhouettes



Amateur astronomers offer the unique service of providing the public with real sky experiences – experiences that cannot be obtained in classrooms, lecture halls, or inside museums.



This ToolKit covers topics you can address during that shadowy time just before and just after sunset. It also covers those special events enhanced by views through telescopes and binoculars: eclipses and transits.



The significance of transits in NASA's search for habitable planets begins with the *Kepler and K2 Missions*. *Kepler* monitored an area in the Summer Triangle, a part of the sky amateur astronomers find filled with telescopic targets of beauty and interest. *K2*, a follow up mission using the same spacecraft, is currently monitoring designated areas along the galactic ecliptic to continue its hunt for extrasolar worlds as well as other targets of interest to its incredibly sensitive photometry instrument.

The ToolKit covers topics on Shadows:

- The shadow of Earth
- Phases of the Moon and Venus
- Solar & Lunar Eclipses

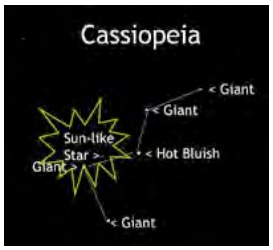
It also covers topics on Silhouettes:

- Transits of Mercury and Venus
- Detecting transiting planets around distant stars
- NASA's *Kepler Mission* – NASA's first mission to
    - Detect transits of Earth-size planets
    - In the Habitable Zone of Sun- like stars
- K2, the followup to the Kepler Mission
    - A sky survey using photometry to study the light of various objects in the galactic plane.

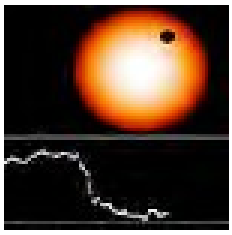
Have fun introducing your visitors to the shadows and silhouettes found in space!

Summary of activities and resources:

1. **PowerPoint "*Kepler Mission*"** introduces NASA's mission to detect transits of planets orbiting in the habitable zone of Sun-like stars. This is found on the Manual & Resources CD in the folder, "PowerPoints". An updated version can be found on the Night Sky Network website with info on the Kepler and K2 missions.

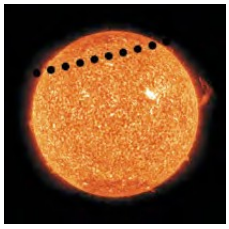


2. **PowerPoint "Sun-like Stars"** discusses what kind of stars we can see naked eye and where are stars like our Sun. This is found on the Manual & Resources CD in the folder, "PowerPoints".

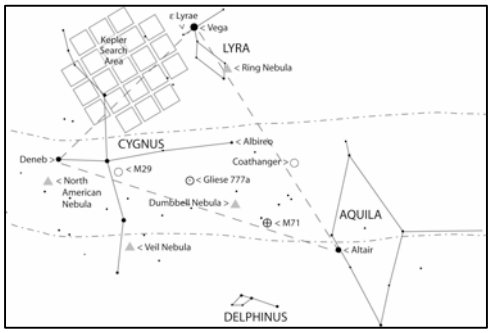


3. **Animations:** *Kepler* Mission animations, eclipses from different perspectives in space, transits, and light curves of transiting planets. This is found on the Manual & Resources CD in the folder, "Animations". Click on "SSAnimations.html".

4. **Activity: "Shadows in Space, Phases and Eclipses"** This set of activities provides a variety of methods to explain Moon phases, solar and lunar eclipses, and phases of Venus, including addressing a common question: Why don't eclipses happen every month?



5. **Activity: "Be the Local Transit Authority"** This set of activities addresses transits and various aspects of the *Kepler Mission*'s objective: To detect transits of Earth-size planets in the habitable zone of Sun-like stars.



6. **Activity: "Trip Around the Triangle"**: Visitors to a star party use a printed handout to take a walk through the telescopes to view the area of the sky where the *Kepler Mission* will be monitoring stars, and to view the variety of naked-eye and telescopic treats that occupy this very popular area of the night sky: the Summer Triangle.

In general, there are activities in this ToolKit appropriate for ages 6 to adult.

Thanks to the ToolKit Testers

NASA and the ASP wish to thank the members of the astronomy clubs around the country who took the time and made the commitment to test these activities in a variety of settings and with a wide range of audiences. Their dedication and feedback helped to make this ToolKit appropriate and fun for the members of the Night Sky Network.

Astronomy Club	State
Amateur Astronomers, Inc.	NJ
Astronomical Society of Kansas City	MO
Astronomical Society of Northern New England	ME
Central Appalachian Astronomy Club	WV
Darien O'Brien Astronomy Club	CO
Eastbay Astronomical Society	CA
North Eugene High School Astronomy Club	OR
Phoenix Astronomical Society	AZ
Seven Ponds Astronomy Club	MI
Space Science for Schools	NV
Von Braun Astronomical Society	AL
Westminster Astronomical Society	MD

Suggestions from the ToolKit Testers

Here are some comments from a few of the astronomy clubs who tested the Shadows and Silhouettes ToolKit in answer to the following questions.

"If you had just 2 minutes to tell someone in your club about this ToolKit, what would you say?"

Astronomical Society of Kansas City
Best of all, the kit contains a variety of materials suitable for a variety of age groups and types of situations. The materials covering moon phases and solar and lunar eclipses are some of the best and easiest ways to demonstrate these events that I have ever encountered. I used some of these materials with experienced astronomers who said that the materials helped them to finally really grasp why there were not eclipses each month.

Seven Ponds Astronomy Club
This new kit is another tool to instruct people on the wonderful world of astronomy. The Trip around the triangle is a good way to acquaint some newcomers to astronomy - shows them several prominent stars, where several nice deep-sky objects are located and the general area of the sky where the Kepler Mission will be focusing their efforts.

North Eugene High School Astronomy Club
It's easy to involve more club members in outreach with the tools in this kit. A wonderful and easy to use collection of tools to help explain phases of the moon (and Venus), eclipses and transits.

Darien O'Brien Astronomy Club
The Shadows & Silhouettes ToolKit provides excellent demonstrations and explanations (especially inspiring to elementary school age members) including phases of the Moon, eclipses, transits as well as providing an opportunity to discuss NASA's Kepler mission to find Earth-size planets in the habitable zones of stars. The ToolKit's focus is on many of the concepts and recent/forthcoming astronomical events that are at the forefront of astronomical research.

Amateur Astronomers, Inc.
The materials in the ToolKit really drive home some of the concepts we are all aware of but have some difficulty explaining: in particular, the demo showing why we don't get a total solar eclipse every month. Also quite dramatic is the value of oblique lighting near the Moon's terminator. I was skeptical about the flour pan activity until I actually ran it. Now I'm an enthusiastic convert.

"If you were to give advice to other clubs regarding this ToolKit, what would it be?"

Phoenix Astronomical Society
Have fun with the items and let the kids rule, they are smarter than you expect.

Astronomical Society of Northern New England
The Powerpoint about Sun-like Stars will amaze even the astronomy experts in your club! This toolkit may be your most used toolkit.

Darien O'Brien Astronomy Club
Be sure to include kids of all ages--young and old alike--for a fun evening together with one of the more interesting and informative ToolKits that has ever been produced.

Astronomical Society of Kansas City
Don't hesitate to blend materials from this kit with materials from other kits. They often can be used together very easily with very good results. Be creative!

Westminster Astronomical Society
Don't try and do everything at one program. Pick a couple of activities and really spend some time with them. Do the lunar shadows activity with the flour and cocoa...it is a lot of fun!

Media and Resources

The "Media and Resources" bag includes:

- The ToolKit Manual on a CD labeled "Manual & Resources CD"
- The Training Video as a DVD
- *Kepler* Mission Lithographs
- Solar System Lithographs

The "Training Video DVD" should be viewed as soon as you receive the ToolKit. This will provide an introduction to the activities and materials.

Explore the "**Manual & Resources CD**":

- For the ToolKit Manual, open the PDF file, "**ShadowsManual.pdf**"
- For PowerPoints, go to the folder labeled "**PowerPoints**". See below for more information.
- For Animations, go to the folder labeled "**Animations**". See below for more information.
- The folder labeled "**LogosLabels**" includes the following:
  - The logo for the ToolKit as a jpeg file, "ShadowsLogo.jpg".
  - A PDF file "**CDDVDlabel.pdf**" to make labels for any additional DVDs and CDs that you choose to copy. Formatted for printing on Avery labels 5931 and 8692.
  - A PDF file for the ToolKit Box labels, "**ShadowsBoxlabel.pdf**". These are 3-1/3" x 4" labels. Formatted for Avery label 5524.

The handouts for the activities can be found in ShadowsManual.pdf so you can personalize them with your club information and print out copies to make for your guests and other club members. The manual also includes sources where you can get more materials.

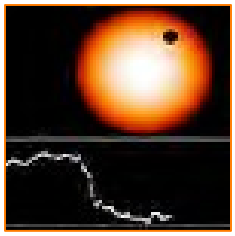
Feel free to make copies of the **Training DVD and Manual & Resources CD** for distribution to other club members or educators. All materials must be provided free or at your cost.

PowerPoints

KeplerMission.ppt, along with the script, KeplerMissionScript.doc, is designed for use with your audiences. This PowerPoint introduces the *Kepler Mission*, NASA's first mission to search for transits of Earth-size planets in the habitable zone of Sun-like stars.

Sun-LikeStars.ppt, and its accompanying script, Sun-LikeStarsScript.doc, allows you to introduce what kinds of stars we see in the night sky and which ones are like our Sun. This is referenced under the "**Be Your Local Transit Authority**" activity.

Animations



Review the animations provided on the Manual & Resources CD in the folder, "**Animations**". Click on "**SSAnimations.html**" for the full listing. Animations include the *Kepler* Mission, eclipses, transits, and light curves of transiting planets.

Kepler Lithographs and Fact Sheets

For additional information on NASA's *Kepler* Discovery Mission, go to http://Kepler.NASA.gov Additional information on both the Kepler and K2 Missions can be found at: http://keplerscience.arc.nasa.gov
You can view and download a series of print-ready posters abut exoplanets, Kepler, and K2 and their discoveries as PDF files from: http://kepler.nasa.gov/education/resources/info/

Solar System Lithographs and Fact Sheets

These lithographs were provided by the Cassini Saturn Observation Campaign:
http://saturn.jpl.nasa.gov/education/saturnobservation/

To download these as PDF files:
http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=262

Materials for Media & Resources

Copies of the **Training DVD and Manual & Resources CD** can be made at your local photo center or other media duplication service.

You are free to make copies of the **Training DVD and Manual & Resources CD** for distribution to other club members or educators. All materials must be provided free or at your cost.

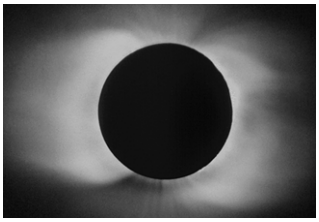
Kepler Mission Lithographs:

To download these as PDF files:
http://kepler.nasa.gov/education/resources/info/

Solar System Lithographs:

To download these as PDF files:
http://solarsystem.nasa.gov/multimedia/download-detail.cfm?DL_ID=262

Shadows in Space: Phases and Eclipses



What's this activity about?

Big Question:

Where are the shadows in space and how do shadows make phases and eclipses?

Big Activities:

Using the Sun, Moon, and simple props, address questions regarding Moon phases, eclipses, and shadows in space.

Participants:

From the club: A minimum of one person (it is helpful to have one presenter for every 10 visitors for the Moon phases and eclipses activities).

Visitors: Most activities are appropriate for families, the general public, and school groups in grades 2 and up.

Duration:

A few minutes, up to a half hour, depending on the number of topics covered.

Topics Covered:

Standing in the shadow of Earth: Night doesn't fall – night rises
Why does the Moon have phases?
Why do eclipses happen?
Why don't eclipses happen every month?
If I lived on the Moon would the Earth have phases?
Does the Moon rotate?
Spotting Craters: Why is full Moon a poor time to observe the Moon?
Observing the Moon: What can you see on the Moon?
Venus phases – Why does Venus look like the Moon?

Where can I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. Standing in shadow of Earth	√	√		√		√	√	√		
2. Why does Moon have phases?		√		√	√	√	√	√		√
3. Why do eclipses happen?		√		√	√	√	√	√		√
4. Why don't eclipses happen every month?	√	√	√	√		√	√	√		√
5. If I lived on the Moon would Earth have phases?		√		√		√	√	√		√
6. Does the Moon rotate?		√		√		√	√	√		√
7. Spotting Craters: Why is Full Moon a poor time to observe the Moon?	√	√	√	√	√	√	√	√		√
8. Observing the Moon	√									
9. Why does Venus look like the Moon?	√	√	√	√	√	√	√	√		√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Activity 7: Five-pound bag of white flour	*Optional for Activity 7:* Newspapers, Broom, dustpan	*Activity 7:* Fill aluminum pan with flour & sprinkle with hot cocoa mix

Helpful Hints

Activities to do in the hour or two before sunset:

- "Why does the Moon have phases?" is best done when the Moon and Sun are both in the sky and the Sun is within 30 degrees of the horizon – normally within about 3 hours of sunset. Duration: 3 – 10 minutes.
- "Why do eclipses happen?" Duration: 3 – 5 minutes.
- "If I lived on the Moon, would the Earth have phases?" Duration: 3 – 5 minutes.
- "Does the Moon rotate?" Duration: 3 – 5 minutes.

Activity to do right at sunset:

- "Standing in the shadow of Earth" – you need a clear view of the eastern horizon. Duration: 1 – 5 minutes.

Activities best done at night or in a darkened room:

- "Why don't eclipses happen every month?" Duration: 5 – 10 minutes.
- "Spotting Craters: Why is Full Moon a poor time to observe the Moon?" Duration: 3 – 10 minutes.
- "Why does Venus look like the Moon?" Duration: 1 – 3 minutes.

Common Misconceptions:

- Moon phases are caused by Earth's shadow
- Moon phases are caused by clouds
- The full Moon is the best time to observe detail on the Moon's surface

Background Information

Earth's Shadow

For another way to model day and night on the Earth and talk about the shadow of Earth:
http://astrosociety.org/pubs/mercury/9803/dahlman.html

Moon Phases

For a photo mosaic of the phases of the Moon:
http://astropixels.com/moon/phases2/phasesmosaics.html

Moon's Rotation

Does the Moon rotate? Why does the Moon always keep the same face to Earth? What does the other side of the Moon look like?
A discussion of these topics can be found here:
http://www-spof.gsfc.nasa.gov/stargaze/SMoon.htm

Eclipses

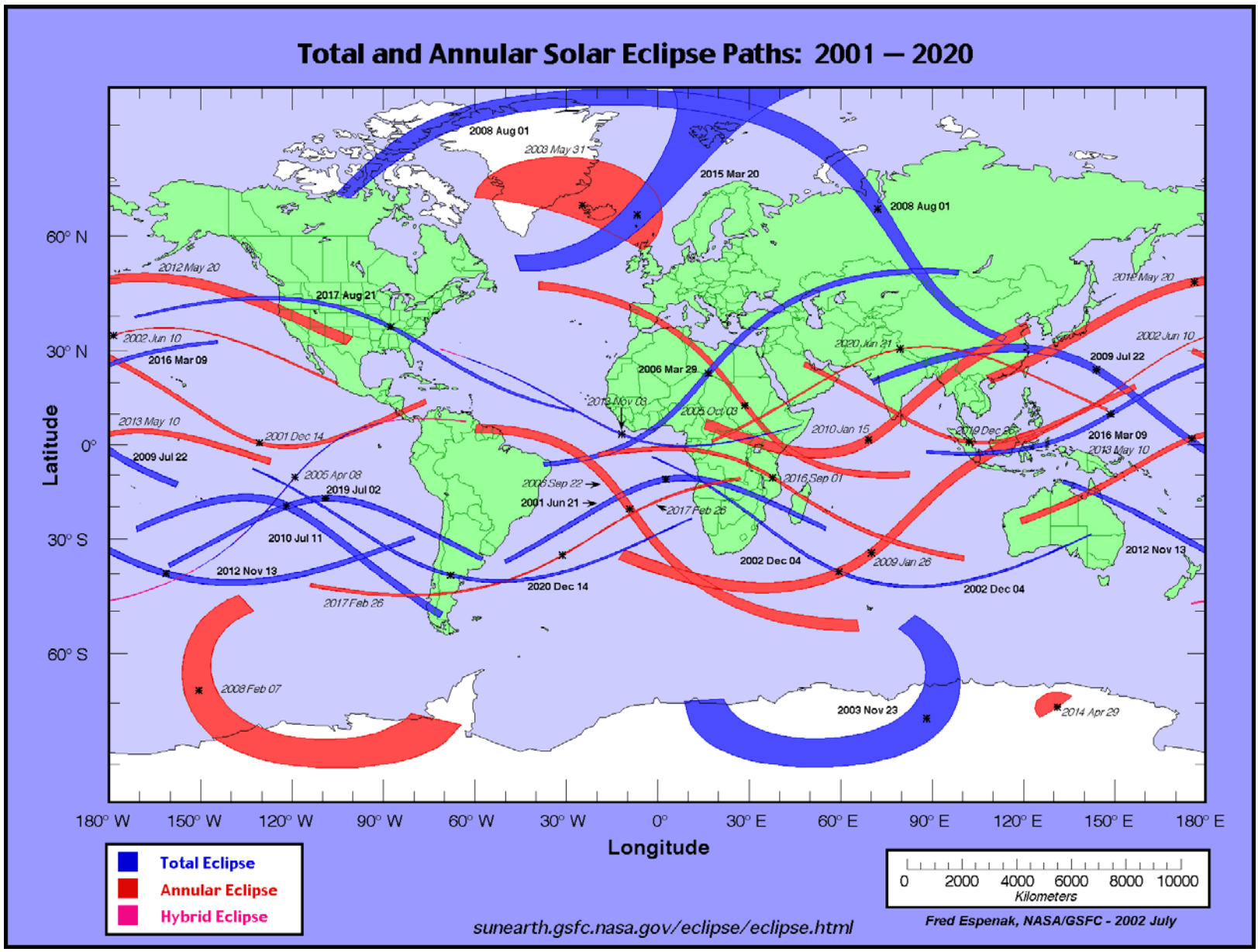
Everything you ever wanted to know about Solar and Lunar Eclipses:
http://eclipse.gsfc.nasa.gov/eclipse.html

Schedule of Lunar Eclipses

Date	Eclipse Type	Umbral Magnitude	Total Duration	Geographic Region of Eclipse Visibility
2016 Mar 23	Penumbral	-0.312	-	Asia, Aus., Pacific, w Americas
2016 Sep 16	Penumbral	-0.064	-	Europe, Africa, Asia, Aus., w Pacific
2017 Feb 11	Penumbral	-0.035	-	Americas, Europe, Africa, Asia
2017 Aug 07	Partial	0.246	01h55m	Europe, Africa, Asia, Aus.
2018 Jan 31	Total	1.315	01h16m	Asia, Aus., Pacific, w N.America
2018 Jul 27	Total	1.609	01h43m	S.America, Europe, Africa, Asia, Aus.

Umbral magnitude is the fraction of the Moon's diameter obscured by Earth's Umbra (the darkest part of Earth's shadow). For penumbral eclipses, the umbral magnitude is always less than 0. For partial eclipses, the umbral magnitude is always greater than 0 and less than 1. For total eclipses, the umbral magnitude is always greater than or equal to 1.

A **penumbral eclipse** occurs when the Moon only passes through the Earth's penumbra (the outer portion of the Earth's shadow).

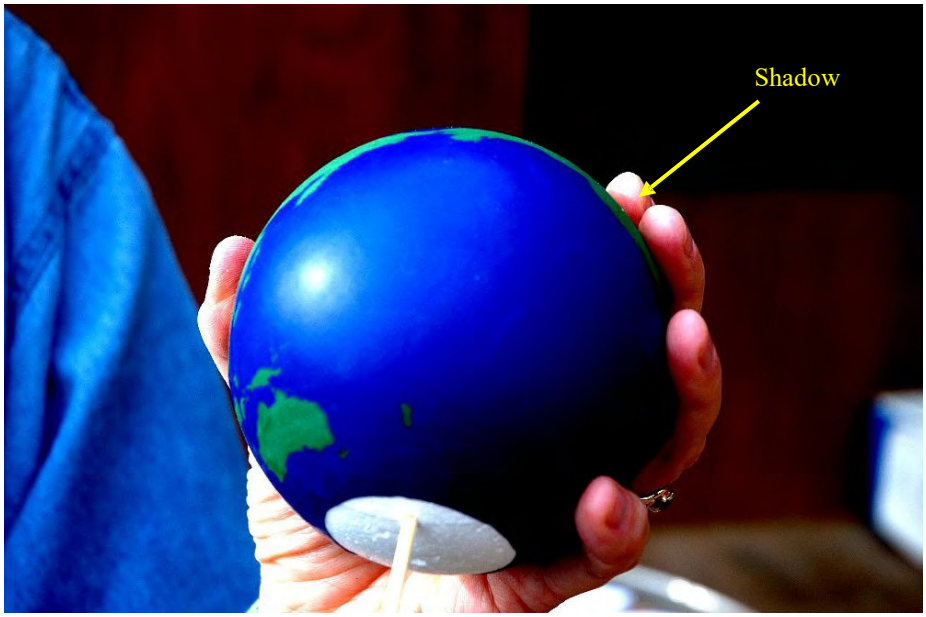


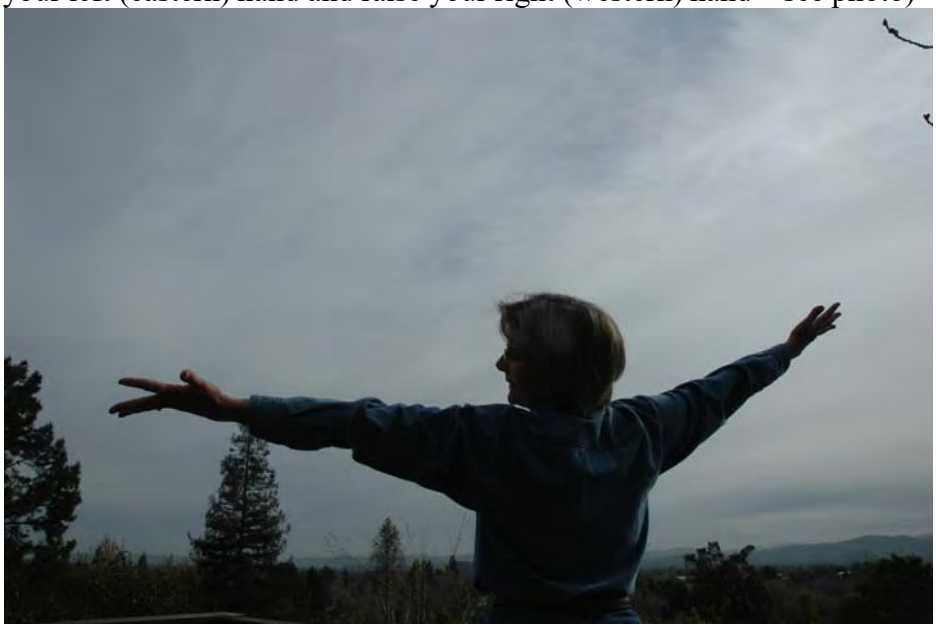
Detailed Activity Descriptions

Standing in the shadow of Earth: Night doesn't fall – night rises

Leader's Role	**Participants' Role (Anticipated)**
Materials: 4" Earth Globe on a stick or supply your own globe.	
To say: Do you have a shadow? Where is it? (If it is dark, ask: how can we make you have a shadow?) Does that (tree, house, my telescope) cast a shadow? Why do we have a shadow? Is there a light shining on us? And we are blocking some of that light, so anything that is on the opposite side of us from the light is going to be dark. What is the brightest light we see almost every day? *To do:* Hold up an Earth globe so the Sun or a single light bulb is shining on it. *To say:* Does the Sun shine on the Earth? Does the Earth have a shadow? Can you show me Earth's shadow?	 Yes There. Yes. Yes. The Sun! Sure It must. Points to dark side or shadow of Earth on the ground.
Misconception Tip: Many children (and some adults) think a shadow is just the visible shadow cast on the ground. They do not think of all the area between the ground and the object as a part of the shadow – They do not conceive of a shadow as being three-dimensional. This is why some people do not think of the night side of the Earth as being in the Earth's shadow. This next exercise demonstrates that the shadow runs all the way from the ground to the object.	

Leader's Role	**Participants' Role (Anticipated)**
To do: Hold your hand in the Earth globe's shadow, a foot or two away from the globe. *To say:* Is my hand in the shadow of Earth? *To do:* Move your hand a little closer to the globe, still in the globe's shadow. *To say:* Is my hand still in the shadow of Earth? *To do:* Lay your hand on the globe, still in the globe's shadow. *To say:* Is my hand still in the shadow of Earth? When are we standing in Earth's shadow? Sure, at night!	 Yes. Yes. Yes. When we're over here (indicating dark side)

Leader's Role	Participants' Role (Anticipated)
To say: When can we see the Earth's shadow? Almost every evening, you can watch the Earth turn into its shadow. *To do:* (this must be done within an hour before sunset) Place your hand on the globe with your fingers pointed west – toward the sun, over your approximate location on the globe (see photo). Tip the north pole of the globe so it is roughly pointed to where the North Star would be.  Turn the globe so the shadow of the globe starts rising onto your fingers. *To say:* My hand represents Earth's atmosphere. Just as the Sun sets, we'll start to see the shadow of Earth appear up against the atmosphere. Just like you see the shadow of this globe up against the ends of my fingers. You'll see a hazy dark blue band appear on the eastern horizon. That's the shadow of Earth. Let's watch for it.	Not sure. Looks to the east.

Leader's Role	**Participants' Role (Anticipated)**
To do: (this must be done immediately after sunset – you need a reasonably clear view of the eastern horizon) Face south with your arms extended east and west. *To say:* Now that you've watched the sunset, turn around and watch the shadow rise. The Earth is turning this way, away from the Sun. (facing south, drop your left (eastern) hand and raise your right (western) hand – see photo)  Everyone face this way and extend your arms. Like you are lying down on the surface of Earth. Now turn – We are moving into the Earth's shadow.	All extend arms.

Leader's Role	Participants' Role (Anticipated)
 See that dark band just above the eastern horizon? That's Earth's shadow. Hold you hand out at arm's length. Close one eye and measure how many fingers thick the band is. Is it one finger, two, or three fingers thick? As we turn farther, the shadow will appear to get higher.	Wow. Holds fingers parallel to horizon. About 2 fingers.
(check the shadow again about 5 - 7 minutes later)  *To say:* Hey! Look at the shadow now! Is it higher? How many fingers thick is it now? Night doesn't fall – night rises! And you'll see our Earth's shadow every clear evening. And in an hour or so, we will have turned completely away from the Sun and we'll be standing in the shadow of Earth. And that's called what?	Yeah! Four fingers! Nighttime!

Why does the Moon have phases?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: 1" polystyrene balls on sandwich picks or toothpicks (representing Moon)	
To Do: This must be done outside in the daytime when both the Moon and the Sun are in the sky. This will be the case in the morning a few days after full to a few days after last quarter and in the afternoon a few days before first quarter to a couple days before full. Point to the Moon or ask, "Who can find the Moon?" Once the visitors are looking at the Moon: *To say:* Why does the Moon look like it does right now? Why does the Moon appear to change shape? Why does the Moon have phases? OR: Would you like to find out a way to show why the Moon has phases? *To do:* Hand out Moon balls.	 Visitors point. Guesses.
Optional: Have participants take a couple minutes and use the Moon ball to try to show why the Moon looks like it does. **Misconception Alert:** Many people believe the Moon's phases are caused by the Earth's shadow. Others think it is clouds passing in front of the Moon.	
To say: This ball will represent the Moon. Your head is the Earth. And the Sun, well, where is the Sun? Where is the real Moon? And the real Earth?	 Over there. Points. Below our feet.
To Say (if you've already talked about the Earth's shadow): Just like the Earth, the Moon has a shadow too. Where is your Moon ball's shadow? Where is it nighttime on your Moon?	 Points to dark side of their Moon ball.
Short Version: *To say:* Face South. Look for the real Moon. Hold your moon just below the real Moon. How much of your moon is lit up compared to the real Moon? 	 Whoa. It's the same amount.

Leader's Role	Participants' Role (Anticipated)
To say: Now put the Moon in orbit (*demonstrate by turning to your left, making sure the move the Moon counterclockwise around your head)* and watch how the phase of the Moon changes.  Make a full Moon. Make a last quarter Moon. Bring it all the way back around and line it up again with the real Moon. So why does the Moon have phases? Sure – the dark area is the shadow side of the Moon – where the Sun is not shining. The lit side of the Moon will always be pointing in the direction of the Sun!	The Sun is shining on the Moon and the Moon is orbiting us.

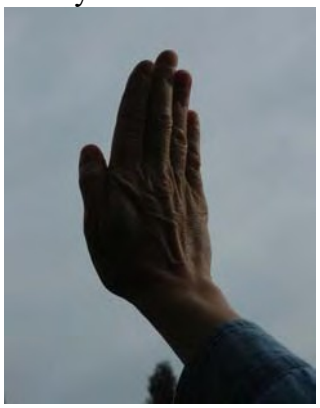
Leader's Role	Participants' Role (Anticipated)

Presentation Tip:

If the Sun is within about 20 degrees of the horizon, you and your visitors can orbit the Moon in a level plane even with the horizon and make the phases look right.

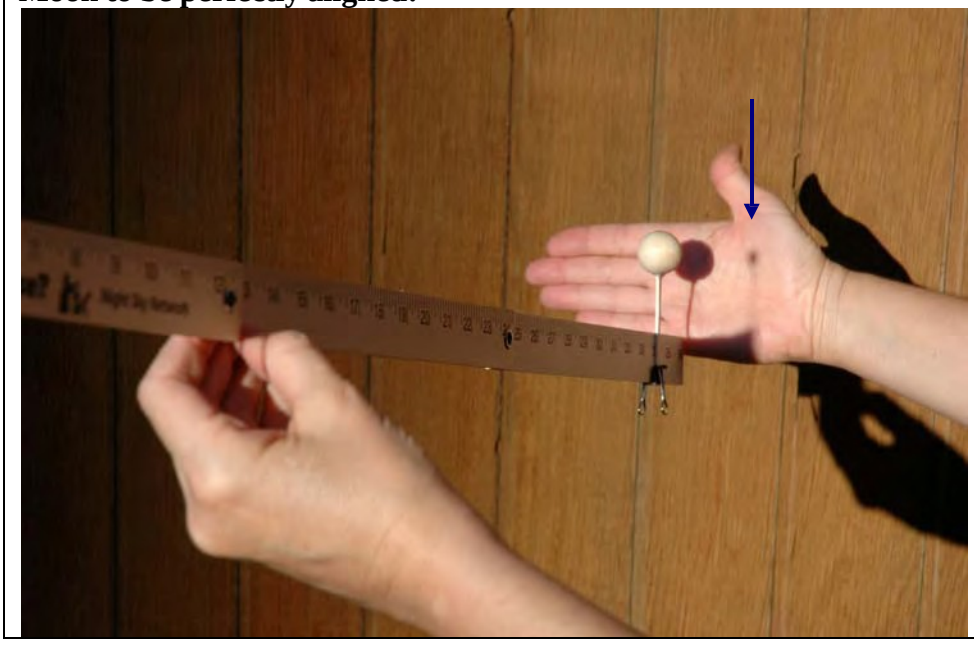
If the Sun is much higher in the sky, or if you want to make the Moon ball's orbital path around your head to be more like the real Moon's orbit around Earth, you'll need to adjust the way you orbit the Moon ball around your head. For example, if you orbit the Moon ball level with the horizon when the Sun is high in the sky, you'll never get a full Moon, since the Moon ball needs to be on an almost straight line on the opposite side of your head from where the Sun is.

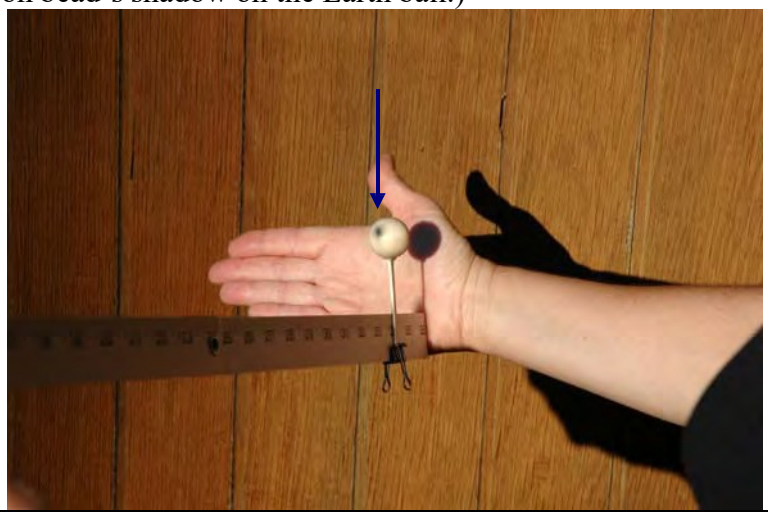
You might want to say:
"We want to make our Moon ball go around our head in the same way the real Moon orbits the real Earth."
Then demonstrate this for your visitors: Face south and imagine a hula hoop encircling your head. Mentally line up the imaginary hoop such that the real Moon and Sun are aligned at points along the hoop. Note that the imaginary hoop is at a considerable angle compared to the horizon. Then imagine tracing the hoop with your Moon ball. The phases on your Moon ball will look more convincing.

Leader's Role	Participants' Role (Anticipated)
Long Version (you can continue with this if your audience has an interest): *To say:* How long does it take the Moon to make one full orbit around the Earth?	Various answers are likely: A day – a month – a few weeks – 29 days.
Why do you suppose we call it a "Moon-th?"	Oh. A month.
So every day the Moon moves a little farther over. How many degrees in a circle?	360 degrees
How many days in a month?	about 30
So about how many degrees does the Moon move every day?	12 degrees?
Roughly 12 degrees. (360 / 30) Hold your hand out at arm's length (*demonstrate*). 	
That's covers about 10 degrees of sky. Stick your thumb out just a little (demonstrate). 	
That's about 12 degrees. Hold this side of your hand against the Moon and look at where the tip of your thumb is. At this time tomorrow night, the Moon will be approximately where the end of your thumb is.	Really?
So in three/seven/xxx days, about where will the Moon be?	Use hand to measure over.
And what will it look like – use your Moon balls to see.	Use Moon balls.
Now let's take a look at the Moon through the telescope.	Yeah!

Why do eclipses happen?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: 1" polystyrene balls on sandwich picks or toothpicks (representing Moon) 4" Globe Eclipse glasses Earth and Moon beads & binder clips attached to the yardstick at 4" and 34". *Optional:* A 10-foot length of string that you supply	
Presentation Tip: The Moon is roughly 2,000 miles in diameter and the Earth is about 8,000 miles in diameter. The Moon's average distance from Earth is about 240,000 miles. In a scale model, this makes **the Moon's distance from Earth thirty times the diameter of Earth**. So, if you have a 4-inch Earth, a 1-inch Moon would be 120 inches or ten feet away from Earth.	
To Say: So now, what's an eclipse? Let's make a lunar eclipse. That's when the Moon passes through the Earth's shadow. Where does the Moon have to be to go through the shadow of Earth? What phase is the Moon at that time? *To Do:* Choose one (or more) of the following three methods to demonstrate a **Lunar Eclipse**:	Where the shadow is. Opposite the Sun. Full Moon!
Lunar Eclipse Method 1: *To Say:* Make your Moon ball pass through your Earth-head's shadow. *To Do:* Move Moon ball into the shadow of your head	
Lunar Eclipse Method 2: Hold up 4" globe and have someone move Moon ball into globe's shadow *(to make this to scale, move the Moon ball **ten feet** from the 4" Earth. This will only work if the Sun is within about 20 degrees of the horizon – otherwise, the 4" Earth's shadow is likely to hit the ground before it hits the Moon ball. Alternatively, you can have the person holding the 4" Earth stand on a chair. Supply a 10-foot length of string to measure the distance.)*	

Leader's Role	Participants' Role (Anticipated)
Lunar Eclipse Method 3 (scale model): *To Do:* Clip Earth at the 4-inch mark on the yardstick. *To Say (Optional):* But how far apart do you suppose the Earth and Moon are? Here are smaller versions of the Earth and Moon (hold up 1" ball for Earth and 1/4" bead for Moon). And here is a yardstick. I'll clip the Earth here at the 4" mark.  Let's take some ideas of where we need to place the Moon to make this to scale. Here's a hint: Earth is about 8000 miles in diameter and this ball, representing Earth, is 1 inch in diameter. The Moon averages about 240,000 miles from Earth. We'd need to place this Moon-bead 30 inches from our Earth ball. *To Do:* Clip Moon at 34-inch mark. Hand Yardstick Earth-Moon model (this one is to scale) to a visitor. *To Say:* Try to move Moon-bead into Earth-bead's shadow and make a lunar eclipse. *To Do:* If the person is having difficulty, have them project the Earth's shadow onto a card or their hand. Then line up the shadows on the card. (See photo – the arrow is pointing to the Moon bead's shadow). **The point you might want to make is that it is not easy for the Sun, Earth, and Moon to be perfectly aligned!** 	Guesses, tries. More tries.

Leader's Role	Participants' Role (Anticipated)
To say: Would everyone on the night side of Earth be able to see the lunar eclipse?	Yes!
To Say: Great! Let's make a solar eclipse. That's when the Moon casts a shadow on the Earth. Where does the Moon have to be to do that? *To Do:* Choose one (or more) of the following three method to demonstrate a **Solar Eclipse:** ***Solar Eclipse Method 1:*** Choose a person to put on the eclipse glasses and have that person face the Sun. Move Moon ball so that it casts a shadow on the person's face. Have other participants watch the Moon's shadow move across the person's face. ***Solar Eclipse Method 2:*** Hold up the Earth globe and have someone move Moon ball between the Sun and the Earth globe. Have other participants watch the Moon's shadow move across the Earth globe. ***Solar Eclipse Method 3:*** Use Yardstick model: Align the Moon-bead toward the Sun and cast a shadow on the Earth-bead. Have the participants try. (The arrow in the photo is pointing to the Moon bead's shadow on the Earth ball.) 	On the side of Earth nearest the Sun.
To say: From where on Earth would the solar eclipse be visible?	Just the part where the Moon's shadow crosses.

Leader's Role	Participants' Role (Anticipated)
Presentation Tip: After demonstrating Moon phases, and solar and lunar eclipses, someone will almost always ask "So why don't we have eclipses EVERY month?" The activity on page 33 explains why.	

Modeling a *Meaningful* Eclipse

Materials, per group of 2-3
- 1" Earth ball on stick
- 1/4" Moon bead on a stick
- 1 yardstick
- 2 binder clips

For the whole group
- 1 bright light if doing the activity indoors
- *or* a sunny day if outdoors

You've seen the Modeling An Eclipse activity. With just a few adjustments, take your outreach up a notch by turning a demonstration into a deep learning experience using 3 simple steps.

Educational research has shown that active engagement and questioning lead to deeper understanding. Here, we've taken a favorite Night Sky Network activity and modified it to encourage deeper understanding as learners explore the phenomena.

Think of the difference between using a go-to telescope and star hopping. When you're in a hurry the go-to is convenient and fast. But do you remember the satisfaction when you first started finding things by star hopping? Give learners the same feeling of discovery with this activity and ensure that they really understand the material.

The Big Idea Behind this Method

Do not immediately address all misconceptions!
Allow learners to work their way through misconceptions using guiding questions and these simple steps:

1) **Engage** – pique learner interest and get them personally involved
2) **Explore** – give them a chance to build understanding
3) **Making Meaning –** see how a model relates to what they observe

The learners do most of the work and walk away with a deeper understanding – it's a win-win! You can apply this to any activity by asking open-ended questions and providing the space for learning to take place. See how easy it is to put them into practice below.

Note: Prior understanding of Moon phases recommended.
If your visitors are unfamiliar with the phases of the Moon, you may want to start with
- Earth-Moon scale:
  Sizing up the Moon
- And modeling lunar phases:
  Daytime Moon

If visiting a classroom, be sure to ask the teacher if the students have already covered this. You may suggest that they do these 2 activities before your visit.

How to Model a Meaningful Eclipse:

1) Engage – pique their interest

To Do: Show an image of a lunar or solar eclipse.

Now Listen!
Allow them to elaborate on their experience and the impression it made on them.

Engaging Questions:
"Have any of you ever seen an eclipse?"
"What did you notice?" or
"What did the Moon/Sun look like?" or
"What do you think was happening?"

It is important at this stage to probe for their understanding of eclipses without judgment as to the correctness of their ideas. The goal is to allow learners to construct their own mental model of eclipses without providing the "answer" prematurely. It is possible many learners will convey some significant misconceptions about eclipses at this point. *It is important for you to NOT address each individual misconception.*

2) Explore – build understanding

To Do:
Hand out materials to groups of 2-3. If possible, use the actual Sun in the model. If not, have a single bright light source and no other lights in the room.

Tell them that we are going to make a model and let them know that the sizes of the 2 balls are to scale with the sizes of the Earth and Moon. Either show them where to clip the balls on the yardstick so that the actual distance is modeled (30" apart) or have them figure it out based on their previous knowledge.

The Challenge Question:
"How would you arrange the materials to recreate the earlier image of an eclipse that we saw?"

Now Listen!
Now it is the learner's turn to work with the materials. Guide them and try to give as few direct answers as possible. Instead answer their questions with leading questions that give them the joy of discovery.

Questions that encourage exploration:
"Show me where the Moon is when it is full."
"Show me where the Moon is during a lunar eclipse."
"What is the relationship between the two?"
"Where was the shadow of the Earth/Moon?"

Questions that guide learners through misconceptions:
"When you arranged it like this, what did you observe?"
"What happened when you…"
"How were you able to…"

To Do:
After all learners have had the opportunity to explore making eclipses with their models, engage them in a group discussion about the results of their modeling investigation. Give them a chance to show off what they learned.

Questions that encourage conversation:
"How were you able to make a solar eclipse with the materials?"
"How were you able to make a lunar eclipse with the materials?"
"What did you observe in your model when you made a (solar/lunar) eclipse?"

Now Listen!
Allow the learners to defend their ideas about what causes eclipses with evidence collected through their modeling investigation. Make sure you allow enough wait time after questions posed to learners to allow them the chance to respond.

3) Making Meaning – apply that new understanding

To Ask:
"What time of day would you expect to see a solar/lunar eclipse?" or
"Who on Earth is able to see a solar/lunar eclipse?"
Remember to allow adequate exploration and wait time before asking specific learners to share their response(s) to the questions. Ideally, they will understand that lunar eclipses can be seen from the whole night side and solar eclipses can only be seen from parts of the dayside.

Extensions:

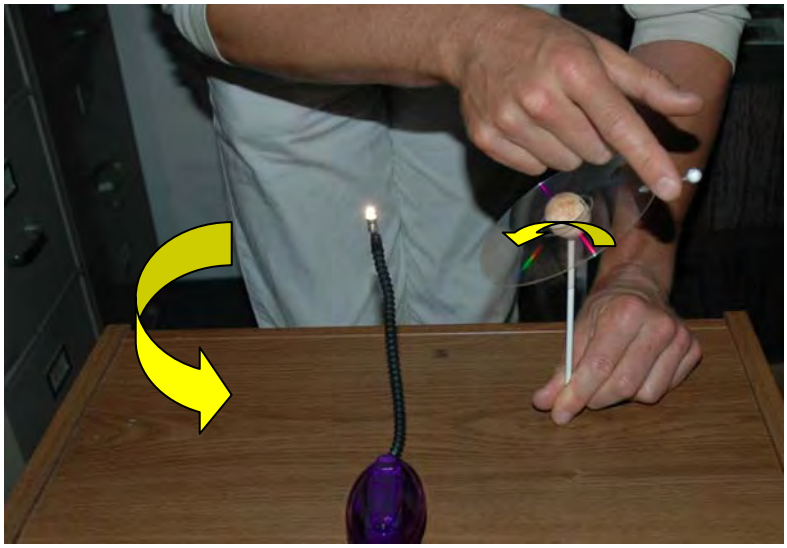
A. Show image of annular eclipse, ask how this is different from a total eclipse. See if they can manipulate their model to explain the phenomena.
B. Extend the modeling of solar and lunar eclipses. Questions for exploration include:
    - "How often does a full moon occur?" and "How often do we have lunar eclipses?" or
    - "How often does a new moon occur?" and "How often do we have solar eclipses?"
    - The materials for the *Why Don't Eclipses Happen Every Month?* activity may prove useful. Remember, at no point in this sequence should you offer up the "correct" answer to the investigation, it is more powerful for the learner to discover it for themselves through their modeling activity.
C. Provide learners with several years of data on lunar phases and eclipses, and ask them to explore the data, searching for patterns and correlations between the two sets. They then could use their models to demonstrate the patterns they discover in the data.

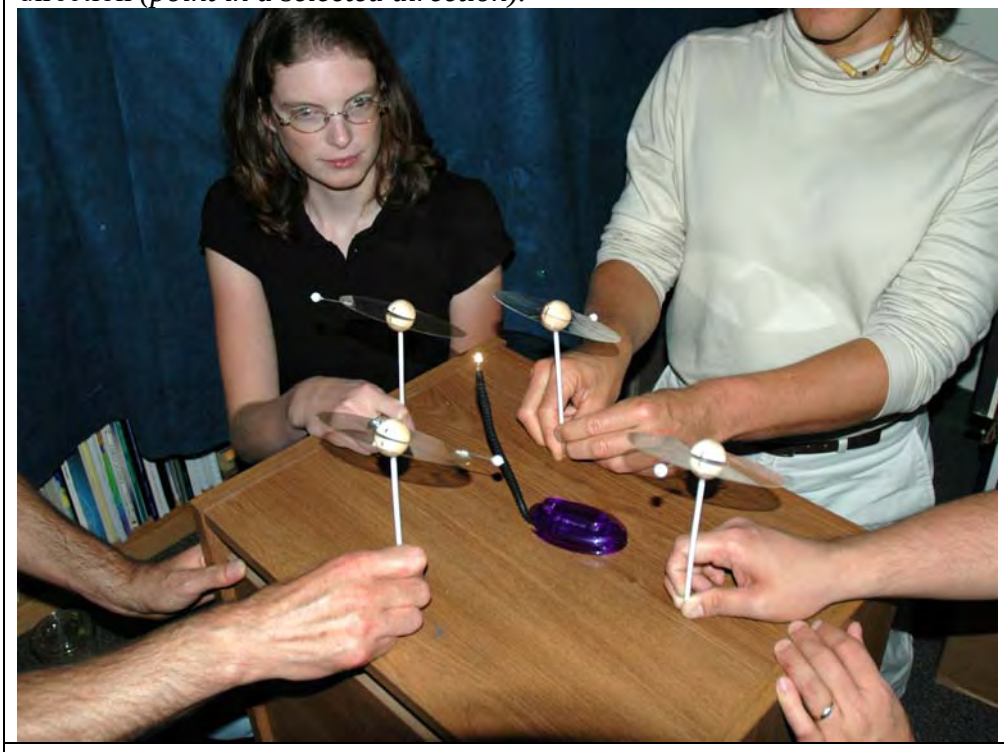
End Notes

Many teachers use a similar model called the 5E's method that can be especially useful when working in classrooms. The adoption of new science standards across the country, including the Next Generation Science Standards is a fantastic opportunity for amateur astronomers to help educators in a new way. In particular for middle school teachers (grades 6-8), where the Next Generation Science Standards identifies a Performance Expectation that states:
Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

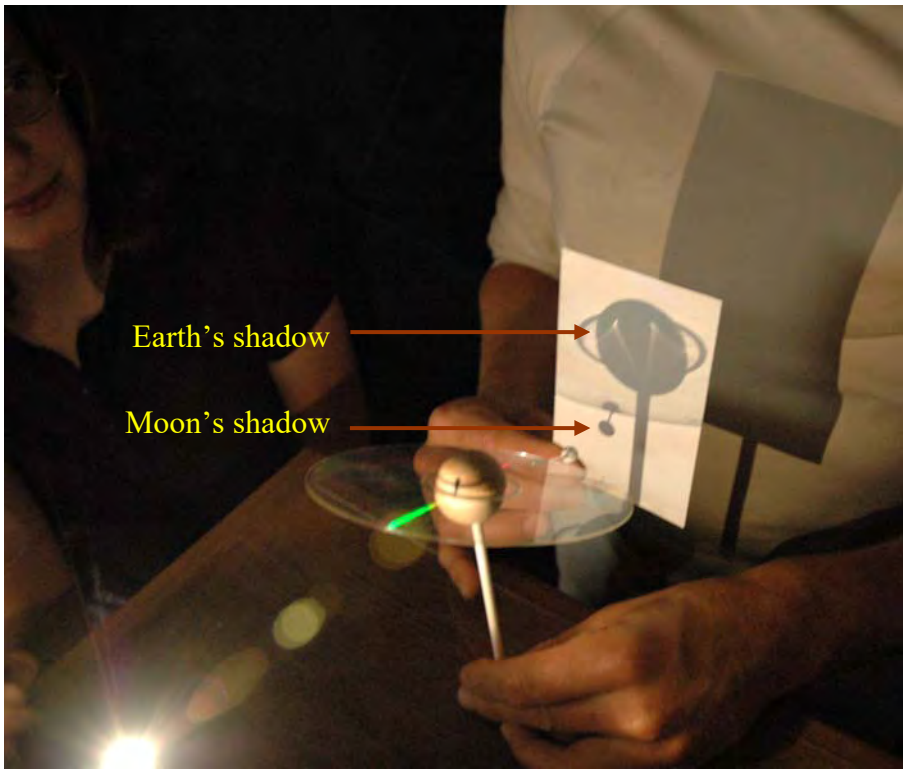
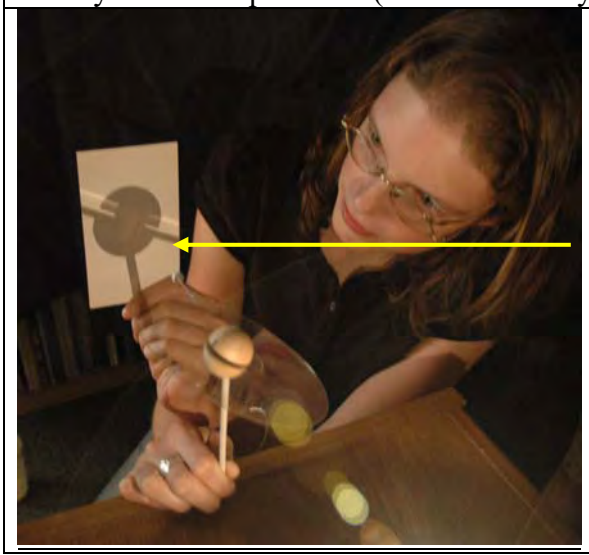
For more information on the 5E's see NASA for Educators' EClips:
http://www.nasa.gov/audience/foreducators/nasaeclips/5eteachingmodels/

Why don't eclipses happen every month?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: 4 assembled Plastic disks with Earth-ball in center and Moon bead on the edge. See "Make Earth-Moon Plastic Disks" instructions under "**What do I need to prepare?**" Snake light with ping-pong ball removed or use a frosted incandescent light bulb. White cards	
Presentation Tip: This MUST be done in a dark location with no other light sources.	
To Do: **(NOTE: for the best shadows, remove the ping pong ball from the snakelight for this activity)** *To Say:* The Moon's orbit is tilted, compared to Earth's orbit around the Sun. Here's what that means. The Earth and Moon orbit the Sun together like this. One full orbit is one year. *To Do:* Demonstrate Earth's orbit around the snakelight Sun and move the Moon in orbit around the Earth at the same time.  (**NOTE:** The Moon's tilt is actually only about 5 degrees, but for this model, the tilt is being exaggerated to about 30 degrees for clarity). *To Say:* The size of the Earth and Moon are to scale, but they are too close to each other. So this model is not completely to scale. We're also exaggerating the tilt of the Moon's orbit so it is easier to see. The Moon's orbit around Earth is actually tilted only about 5 degrees from Earth's orbit around the Sun. Also, the Moon and Earth would be much farther apart in a scale model. Here's a disk for each of you to have your own Earth-Moon system.	Take Earth-Moon disks

Leader's Role	Participants' Role (Anticipated)
To Say: Let's have each of you stand at different points in Earth's orbit around the Sun, representing different times of the year. Hold your Earth and Moon so the Moon's orbit is oriented the same direction and tilt for all the positions. Hold your sticks perpendicular – straight up and down. See the little mark on the side of the Earth ball? Everyone should have that mark facing THAT direction *(point in a selected direction).* 	Participants arrange themselves Participants orient their Earth-Moon disks.
To Do: If using the snakelight Sun, have the participants hold their disks within a couple feet of the light. This allows you to have four people comfortably around the light. If you are using a light bulb, they can be up to 5 feet away from the light. This allows you to have a few more people holding Earth-Moon disks (if you have made additional disks) Make sure no one is standing or holding their disk such that their own shadow is falling on their own disk or anyone else's disk.	

Leader's Role	Participants' Role (Anticipated)
LUNAR ECLIPSE: *To Say:* Now let's see if anyone has a lunar eclipse. What phase is the Moon when you have an eclipse of the Moon? Right. Move your Moon so it is full – on the opposite side of the Earth from the Sun. *To Do:* Check that each person moves their Moon bead around to full Moon position. (you may need to help people figure this out – move it to the side of the disk opposite the Sun from the Earth)  Note that all Moons are positioned on the opposite side of the Earth from the Sun. **Make sure everyone still is holding their stick perpendicular and the mark is pointed in the right direction.**	Full Moon Moves Moon to correct position on the disk.

Leader's Role	Participants' Role (Anticipated)
To Say: We'll use this card to check the alignment of the shadows. *To Do:* Hold white card opposite the "Sun" and within an inch of the edge of the disk such that the shadow of the "Moon" and the shadow of "Earth" fall on the white card.  *To Say:* You can also hold your hand in this same position to check the shadows of your own disk.	
To Do: At each location, ask if the shadow of Earth is falling on the Moon. In all but two positions, they will discover that the Earth's shadow falls above or below the Moon's shadow. In only those two positions (or times of the year) can eclipses occur.	
 Earth and Moon shadows are lined up!	

Leader's Role	Participants' Role (Anticipated)
SOLAR ECLIPSE: *To Do:* Next, have your visitors move their Moon so it is at new Moon – on the same side of the Earth as the Sun. Ask who has a solar eclipse – where the Moon is casting a shadow directly on the Earth. Use the card or their hand to check the alignment of the shadows. They will discover that the same two people have a solar eclipse. Almost every time there is a lunar eclipse, a solar eclipse would have occurred either two weeks before or two weeks after the lunar eclipse. *To ask:* So why don't we have eclipses every month?	The tilt of the Moon's orbit!
Presentation Tip: The most common mistake your visitors will make is not having their Moon orbits pointed in the same direction. Another common mistake is rotating the white stick instead of moving the Moon bead around the Earth bead to change the position of the Moon. A few may have a problem figuring out where to place their Moon to make it a full or a new Moon.	

If I lived on the Moon would the Earth have phases?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: 1" Moon balls on toothpicks 4" Globe *Optional:* You supply a sticky-note to place on Earth	
Presentation tip: This must be done outside in the daytime when the Sun is in the sky – preferably when the Sun is within 20 degrees of the horizon or roughly within an hour and a half before sunset.	
To Do: Put a person holding the Earth above their head in the center of a circle of participants. Each person in the circle is holding a Moon ball. People in circle move around Earth, always facing Earth. *To Ask:* You live on the Moon: does the Earth have phases?	Yes!

Leader's Role	Participants' Role (Anticipated)
EXTENDED ACTIVITY: Showing that Moon rises a little later each day. Have one person standing holding the Earth. Have another person holding the Moon a few feet away, ready to orbit the Earth. Start Moon-person at first quarter. Please a sticker on Earth where you live. Position Earth so sticker is facing Moon. Have Earth rotate once as Moon-person takes one step counter-clockwise. Continue for at least half a Moon orbit (~14 days).   At each step, ask what time it is (or at least if it is day or night) on Earth when the Moon rises (comes into view for your position on the Earth).	

Does the Moon rotate?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: 1" Moon balls on picks 4" Globe on a skewer stick Toothpick *Optional:* Supply a sticky-note.	
Presentation tip: This must be done outside in the daytime when the Sun is in the sky – the best time is within two hours of sunset or within two hours after sunrise**.**	
To Say: People sometimes wonder if the Moon rotates. To us on Earth, the Moon always has the same face pointed toward us. So the Moon might not seem to rotate. But to someone on the Moon, it certainly does – the Moon experiences day and night, but each day lasts about 14 Earth days, as does each night on the Moon. *To Do:* Put a person holding the Earth above their head in the center of a circle. Place a sticker on the Earth where you live. Another person is holding a Moon ball. Stick a toothpick in the side of the Moon ball facing the Earth. Everyone else stands outside the Moon's orbit.	
To Ask: Does Earth rotate? *To Do:* Have person in center slowly rotate the Earth. *To Say:* Watch the sticker – does it go into shadow, then into light as the Earth rotates? Does that place on Earth have day and night? Earth's rotation is why we have day and night. *To Do:* Put Moon person in orbit around Earth, always facing the toothpick toward Earth. *To Say:* Everyone else watch the toothpick sticking out of the Moon. Imagine you are standing where the toothpick is. Do you go into shadow, then into light as the Moon orbits the Earth? Does that place on the Moon have day and night? Is the Moon rotating?	 Yes. Yes. Yes. Yes!

Leader's Role	**Participants' Role (Anticipated)**
To Do: Move the toothpick to the side of the ball opposite the Earth and have the Moon continue orbiting the Earth. *To Say:* Now imagine you lived over here. If you lived on the other side of the Moon – would you know that Earth existed?	Wow. No – I'd never see it. I'd always be faced away from Earth.

Spotting Craters: Why is full Moon a poor time to observe the Moon?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: ***"Pan with Flour" Method:*** **From the ToolKit:** ▪ 1-3/4" polystyrene ball (draw a small square on the ball with a pen or magic marker) ▪ Skewer stick ▪ Snakelight with ping-pong ball (or flashlight covered with a paper towel – see below) ▪ Aluminum pan ▪ Several "meteorites": rocks (you can also supply small balls of clay or even wrapped candy such as bite-size Reese's, Rolos, or Hershey's Kisses. Wrapped bite-size Milky Way or Mounds also work). ▪ 1/2 packet powdered hot cocoa mix **You Supply:** 5 pound bag of flour. Newspaper Broom, dustpan *Optional:* Flashlight covered with a paper towel and secured with a rubber band. This can be used instead of the snakelight to represent the Sun. The paper towel is used to diffuse the light. ***"Play Dough Moonscape" Method:*** **From the ToolKit:** ▪ 1-3/4" polystyrene ball (draw a small square on the ball with a pen or magic marker) ▪ Skewer stick ▪ Snakelight with ping-pong ball (or flashlight covered with a paper towel) ▪ Aluminum pan **You Supply:** See instructions and ingredients for "Play Dough Moonscape" as described under "What do I need to prepare?" at the end of this section. SETTING: Do this at night or in a room where you can turn off all the lights. If using the "Pan with Flour" method, and this is done outside at night, do it downwind from telescopes, especially if there is a breeze. If very windy, do this inside. Otherwise, the flour will blow around when participants brush flour off their hands and clothes.	

Leader's Role	Participants' Role (Anticipated)
To prepare: Prepare EITHER the "***Pan with flour***" or the "***Play Dough Moonscape***". ***Pan with flour:*** Fill aluminum pan almost to the rim with flour. **Make sure the flour is loose and not packed down.** Run a slotted spoon, or a wire whisk through the flour to loosen it as necessary. Sprinkle the flour with hot cocoa mix. Place the 1-3/4" ball on a skewer stick and place it next to or in the pan of flour. Make a Moonscape by using a spoon or your hand to make a mountain range on one side of the pan.  Either poke holes in it with your fingers, or for more fun (and more mess!), have participants drop small rocks or wrapped bite-size candies ("meteorites") into the flour, simulating the early bombardment of the Moon by meteorites. ***Play Dough Moonscape:*** Use the recipe found at item #25 under "Where do I get additional materials?" to make your own play dough. Refer to the instructions "Play Dough Moonscape" as described under "What do I need to prepare?" at the end of this section.	
Presentation Tips: Many people think the full Moon is the best time to see a lot of detail on the Moon. This presentation addresses that idea.	

Leader's Role	**Participants' Role (Anticipated)**
To Say: Shadows allow us to see features on the Moon! When you look at the full Moon through the telescope, it is difficult to clearly see the mountains and the craters. From a crescent phase to a few days on either side of full and there is a part of the Moon where craters and mountains can be clearly seen in strong relief. This activity illustrates why. The Moon's surface has mountains and a lot of what?	Craters
To Do: Point to the pan full of flour (or the play dough Moonscape). *To Say:* This represents a small area of the surface of the Moon. (Pointing to ball) Here's the whole Moon and this pan represents the middle area right here magnified (pointing to middle of ball where the small square is).	

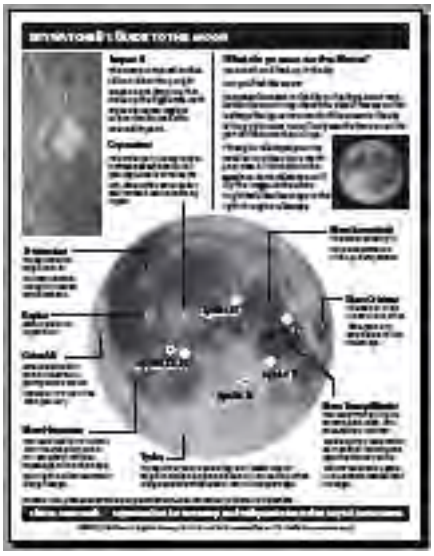
Leader's Role	Participants' Role (Anticipated)
(If using the "Pan with Flour") <u>To Say</u>: We have some mountains here, but what's missing from our Moonscape? Right – let's make some! *<u>To Do:</u>* Show rocks (or wrapped bite-size candies). *<u>To Say:</u>* We'll take these rocks, representing meteorites that bombarded the Moon early on, and drop them to create craters, like this. *<u>To Do:</u>* Hold hand up high above the pan and drop one rock. Pass out rocks to participants. *<u>To Say:</u>* Don't throw them. Just drop them. 	Craters! Drop rocks into flour.
<u>Presentation Tip:</u> Encourage people to just drop their object into the flour. Your participants may want to THROW their objects into the flour. Discourage this. If they miss the pan, they might hit and hurt someone. To reduce the likelihood of injury have all the participants group themselves on one side of the pan. That way, if someone does throw their object at the pan, it will not hit anyone.	

Leader's Role	Participants' Role (Anticipated)
(If using the "Play Dough Moonscape") ***<u>To Say</u>:*** We have a Moonscape here. What do you see? 	Mountains. Craters
<u>To Do:</u> Using the snakelight with ping-pong ball (or a flashlight covered with a paper towel – as shown in photo below) to represent the Sun, have visitors move the Sun over the Moonscape, starting with the Sun high above the Moonscape (as in photo at left).  *<u>To Say:</u>* How much of the Moon ball is lit up? Right now, we have a full Moon.	This whole side.

Leader's Role	Participants' Role (Anticipated)
To Say: Now move the Sun down toward the edge of the pan (as in photo below). How much of the Moon-ball is lit up? This is called a quarter Moon. How much more detail can we see? 	 Just half of it. A lot!
To say: Where must the Sun be for you see the craters and mountains best? When we look at a full Moon, the Sun is shining overhead from the viewpoint of someone standing in the middle of the Moon. *(Optional: you can stick a toothpick into the ball or into the Moonscape to represent a person)* Would that person have much of a shadow? When we look at a quarter Moon, now does the person have a shadow? So shadows bring out detail on the Moon. Ready to go look at the Moon through the telescopes?	 Near the edge. No. Yes, a long one. Yeah!
Presentation Tip: At the end of the presentation, if you used the Pan with Flour and used wrapped candies instead of rocks, you can either: • (least messy option) pass out a candy from the original bag to each participant or • retrieve the candy from the flour using a potato masher or slotted spoon, Allowing participants to reach into the flour to retrieve their candy will result in flour-covered hands – not a good combination with telescope viewing.	

Leader's Role	Participants' Role (Anticipated)
Optional Quote: "Mountain walls that tower tonight may appear insignificant tomorrow. Small craters that dot floors of larger rings under one illumination may be absent under others. Long clefts, clearly marked at times, vanish with the shifting of light and shadow." Leland S. Copeland in the April 1956 issue of Sky & Telescope.	

Observing the Moon: What can you see on the Moon?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: Copies of the Skywatcher's Guide to the Moon. You may want to copy your club information on the back of the handouts. The master for the handout can be found at the end of this section under "Skywatcher's Guide to the Moon". You may print out and copy as many as you need.	
To Do: Hand out the Moon map guides. *To Say:* (Pointing South) Face south and look up – can you find the Moon? Compare the Moon in the sky to the large Moon map on the handout. The Moon map shows the side of the Moon that is always facing us. How much of the Moon in the sky is lit up right now? Now look at the map. You will only see the features on the part of the Moon that is lit up. When you look at the Moon through the telescopes tonight, you may need to turn the map to match your view of the Moon in the eyepiece. Some telescopes will flip your view as if you were looking at the Moon in a mirror. The small photo of the Moon on your handout shows a mirror image of the Moon.	 There it is! Participants study Moon and Moon map handout. Answers.

Venus phases – Why does Venus look like the Moon?

Leader's Role	**Participants' Role (Anticipated)**
MATERIALS: Snakelight with ping-pong ball 1" dylite ball representing Venus.	
Presentation Tip: Sometimes a person will look into your telescope at Venus and say "It looks like the Moon!" This explains why. This should be done under dark conditions.	
To Do: Use snake light with ping-pong ball, representing the Sun. Have visitors stand in a semi-circle. *To Say:* You are viewing Venus from Earth. Venus is closer to the Sun than Earth is. As I orbit this ball, representing Venus, around this light, representing the Sun, notice how much of Venus is lit up. *To Do:* Orbit the ball, representing Venus, around ping pong ball.	Venus has phases like the Moon!
 If Venus is in the sky, align ball-Venus and the ping-pong-Sun in the same positions as they appear in the sky. *To Say:* Here is where Venus and Sun are in the sky right now. Look at the ball. Is that what Venus looked like in the telescope? *To Do (Optional):* Do the same thing but identify the ball as Mercury. (Can segue from here to Transits)	Yes!

Leader's Role	Participants' Role (Anticipated)
Presentation Tip: When showing the demonstration, if you have more than 3 or 4 people watching, those people standing at the edge of the crowd might not see the same Venus phase as those in the middle who are directly facing you. Be sure to turn and hold the props so that everyone will be able to see the correct Venus phase.	

Materials

What materials from the ToolKit do I need?

In the "Shadows In Space" Activity bag:

1. 2 – snakelights
2. 2 – Ping-pong balls with hole
3. 1 – StikkiWax® stick wrapped in wax paper with label
4. 1 – pack of AAA batteries (4-pack)
5. Copies of Moon map handout "Skywatcher's Guide to the Moon"
6. **Bag labeled "Moon Phases and Earth's Shadow" (Requires assembly)**
   a) 1" dylite balls
   b) Sandwich picks
   c) 2 – Earth balloons
   d) 2 – Eclipse shades
   e) 1 – Skewer stick

7. **Bag labeled "Why don't eclipses happen every month?" (Requires assembly)**
   a) 4 – Clear plastic disks
   b) 4 wooden 1" split ball halves – undrilled
   c) 4 wooden 1" split balls with hole drilled & felt pad attached
   d) 4 – 8 mm white beads for the Moon
   e) 4 short pins
   f) 4 small washers
   g) 4 – white cards
   h) 4 – white sticks

In the ToolKit Box:

8. 1 – folding yardstick with bag labeled **"Can you make an eclipse?"** attached **(Requires assembly)**
   a) 1 – Moon bead (8 mm)
   b) 1 – long pin
   c) 1 – sandwich pick
   d) 1 – 1" wood bead
   e) 2 – Binder clips
9. 1 – 4" dylite ball
10. 1 – Aluminum pan
11. 1 – Alum pan lid (underneath the pan)

Inside Aluminum pan:

12. **Bag labeled "Spotting Craters" (Requires some assembly)**
    a) 1 – dylite ball
    b) rocks to represent meteorites
    c) 1 – short skewer stick
    d) 1 – Packet powdered hot choc mix
    e) 1 – cream of tartar

What must I Supply:

- 5-pound bag of white flour
- Instead of using rocks for "meteorites" you might prefer to use wrapped candy such as bite-size Reese's, Rolos, Hershey's Kisses, bite-size Milky Way or Mounds.

Optional:

- Broom, dustpan
- Newspaper
- Flashlight covered with a paper towel
- You can replace the folding yardstick with a yardstick or meter stick from a variety store or lumber/hardware store
- Additional ingredients to make a permanent Moonscape: salad oil, salt, boiling water (See recipe under #25 in the section below: "Where do I get additional materials?")
- Alternate plastic or foam tray to use for the permanent Moonscape. The type of foam tray used in grocery stores to package meat works well. Be sure to wash it thoroughly before use.
- 10-foot length of string
- sticky notes

What do I need to prepare?

Make Moon Balls:

- Insert sandwich picks into 1” dylite balls to make Moon balls

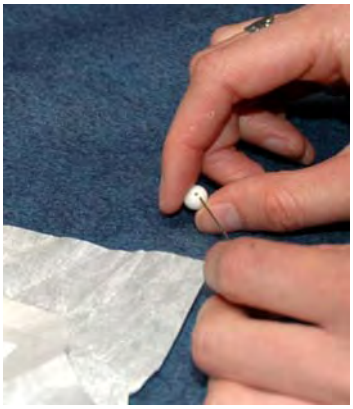
Make a 4” globe:

- Cut the bottom (tail end) off one of the Earth balloons

- Stretch the balloon over the white 4” ball, like you would put on a swim cap.
- Insert the skewer stick into the bottom of the Earth (you can say the exposed white area is Antarctica)
- This Earth and one of the 1” balls provide you with the properly scaled sizes of the Earth and the Moon.

Make Yardstick Moon-Earth scale model:

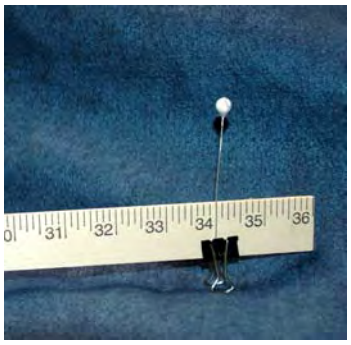
- The wooden bead representing Earth is 1 inch in diameter and the Moon bead is about 1/4 inch (8 mm).
- Use the StikkiWax® to put this together. Alternatively you may use craft glue from an arts & crafts store.



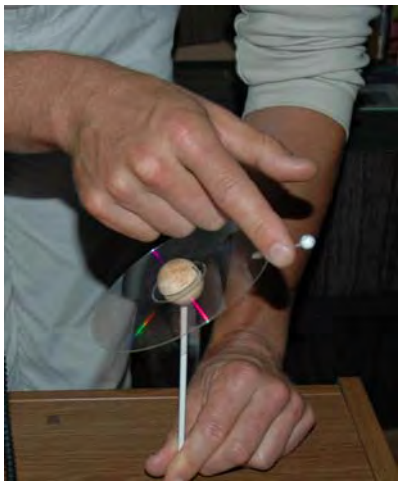
- Insert the pin into the Moon bead (see photo at left).
- Take a tiny pinch of the StikkiWax® and press it under the bead to secure it in place on the pin (see photo at right)

- Put another tiny pinch of the StikkiWax® in the hole at the top of the 1" wood bead and insert the sandwich pick. Press more StikkiWax® in the hole under the wood bead.
- Since the real Moon averages 240,000 miles away from the 8,000-mile diameter Earth, to be scaled correctly the Moon bead must be 30 inches (about 76 cm) from the Earth ball.

- With the binder clip, attach the stick attached to the 1" Earth ball at the 4" mark on the yardstick (or 10 cm mark on a meter stick) as shown in the photo on the left. If you wish, you may paint or draw continents on the 1-inch Earth ball.

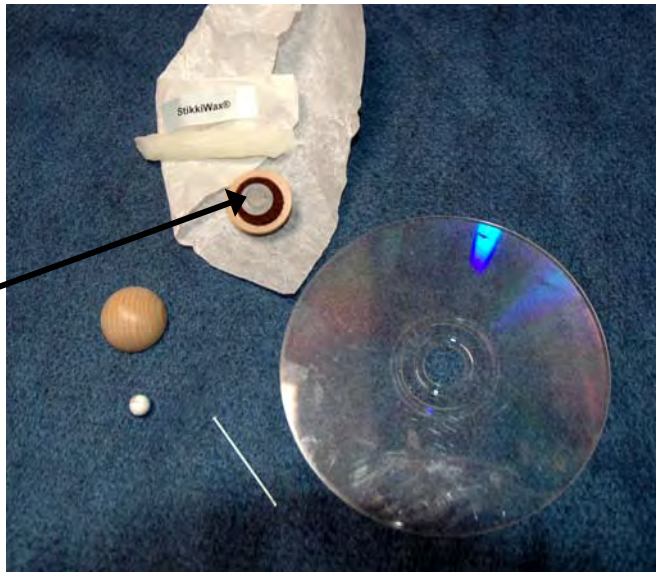


- With the binder clip, attach the pin on the Moon bead at the 34" mark on your yardstick (or 86 cm mark on your meter stick).
- *Special thanks to the Night Sky Network members Linda Prince and John Land for suggesting the idea and the design of this model.*

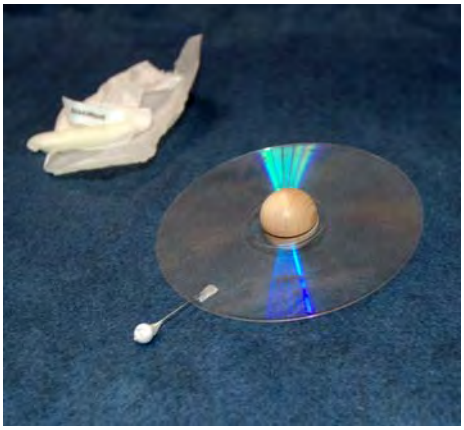


Make Earth-Moon Plastic Disks (used to show why eclipses don't happen every month):

- Get one of the half balls with the felt pad on it and place one of the washers in the middle. It's got to be <u>in the middle</u>.
- Take a pinch of the StikkiWax® and completely fill the center of the washer.

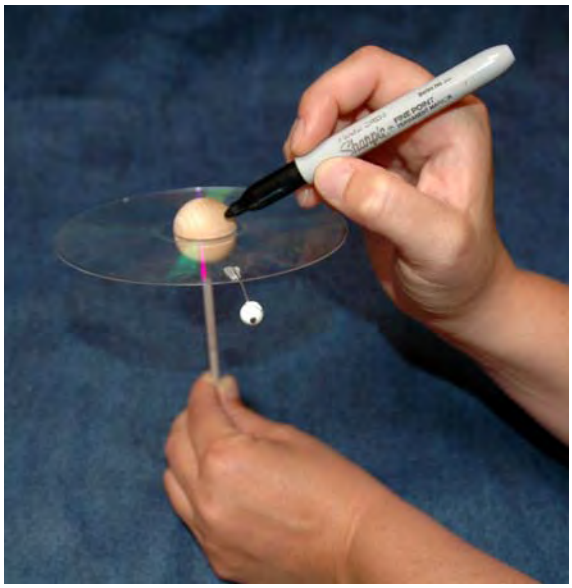


- Place one of the clear disks over the washer and squeeze a ball half without the felt pad down over it. This is the Earth.



- Take another small pinch of StikkiWax® and place it on the edge of the clear disk. You can either attach the 8 mm bead (representing the Moon) directly to the patch of StikkiWax® or attach the pin to the Moon bead using StikkiWax® like you did for the yardstick model.

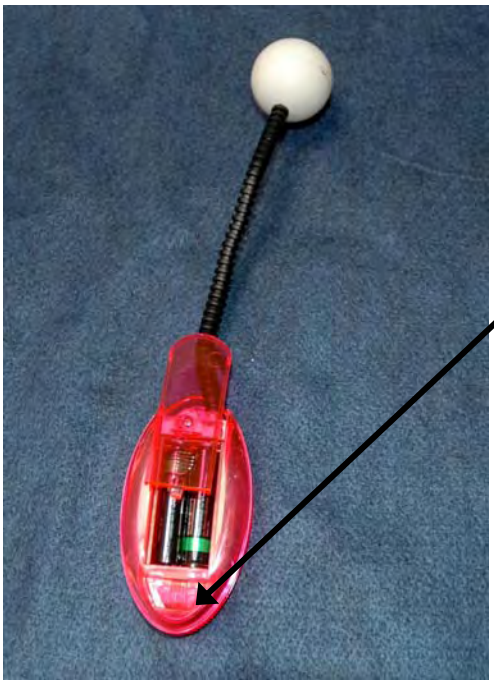
- Push the Moon pin into the StikkiWax®. Now you have a Moon that orbits the Earth.
- Push the white stick into the hole in the bottom of the bottom half ball.
- Make a vertical mark on the Earth at the **highest** point of the Moon's orbit with a marking pen.



- Make the other three the same way.
- **If you prefer, you can supply craft glue to assemble the items.**

Make the Sun (snakelights):

- Pull the hoods off each snakelight.
- Line up the hole in the ping-pong ball and press it over the bulb.



- Insert the batteries and turn on the light at the switch.

- **TROUBLESHOOTING:** Sometimes the process of pulling the hood off the snakelight can loosen the bulb. If the light fails to turn on, try gently pressing and twisting the bulb into its receptacle.

These are also used with the "Transits" activity bag.

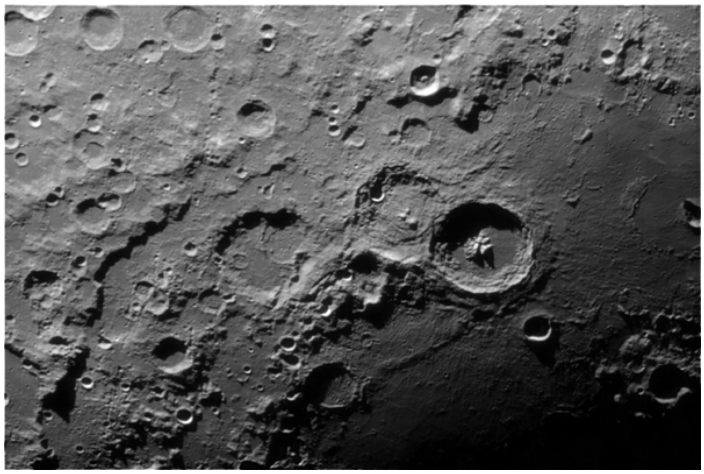
Prepare a Moonscape:

- Draw a small square on the 1-3/4" dylite/polystyrene ball to mark the area of the Moon represented by the pan of flour.
- Fill the large aluminum pan with your 5-pound bag of flour. Make sure the flour is loose and not packed down too tightly. Run a potato masher, slotted spoon, or a wire whisk through the flour to loosen it as necessary.
- Smooth the top with your hand.
- Sprinkle about half the packet of hot cocoa mix over the top.

This is used to illustrate why full Moon is a poor time to observe detail on the Moon.
STORAGE: If you want to save the flour for a later demonstration, you may want to store the flour in a sealed container to prevent insect infestation.

Alternate method –
Play Dough Moonscape (see photo at right): so you have a Moonscape already made:

1. Use the recipe under #25 in the section "Where do I get additional materials?" to make your own dough.
2. Line the aluminum pan with wax paper or heavy-duty plastic wrap. Direct contact of the dough with the aluminum pan will cause the pan to corrode. You might prefer to use a plastic pan or tray. The type of foam tray used in grocery stores to package meat works well. Be sure to wash the tray thoroughly before use.
3. Spread the dough in the pan.



4. Fashion a Moonscape in the dough with your hands to make mountains and craters. You might want to refer to a photograph of an area of the Moon, such as the one to the left.
5. Cover to store.

Moon image by Conrad Jung, Chabot Space & Science Center

Where do I get additional materials?

1. Snakelights: www.orientaltrading.com – item #IN-50/80
2. Ping-pong balls with hole: sporting goods – you need to drill your own 1/4" hole.
3. StikkiWax®: office supply store
4. AAA batteries: grocery, hardware, or office supply
5. Moon map handout "*Skywatcher's Guide to the Moon*" follows this section. Print or copy as many as you need. You may want to copy your club information on the back.
6. 1" dylite/polystyrene balls: http://plasteelcorp.com/. You might also find polystyrene balls at arts and craft stores, but be sure you are using polystyrene, NOT styrofoam. The material is also called "dylite".
7. 1-3/4" dylite/polystyrene balls: http://plasteelcorp.com/
8. 4" dylite/polystyrene ball: http://plasteelcorp.com/
9. Sandwich picks: Restaurant supply or you can use toothpicks
10. Earth balloons (14" Qualatex Globe Balloons from balloonparadise.com)
11. Eclipse glasses: ASP: www.astrosociety.org: click on "AstroShop", search for "eclipse glasses" or from www.rainbowsymphony.com
12. Skewer sticks: grocery store or restaurant supply
13. 1/4" (or 8 mm) bead for the Moon: arts & crafts store
14. Clear plastic disks: save the top and bottom protective disks that come with stacks of CDs or DVDs. Use modeling clay or Play Dough (see recipe under #25 below) to make the Earth-centers. You can use balls of Stikkiwax® to make the Moon (just make a small ball and place it on the edge of the disk. To change its position, just pick it up and put it at another place on the edge of the disk). The Moon will not "orbit". Insert a skewer stick in the center Earth ball at about a 30-degree angle. See photo at right.

15. White cards: office supply
16. Yardstick: hardware store.
17. Beads for the Moon (8 mm or 1/4"): arts & crafts store
18. 1" wooden bead: arts & crafts store
19. Pins for beads: jewelry-making or arts & crafts store.
20. Binder clips: office supply store.
21. Aluminum pan: grocery store
22. "Meteorites": rocks: your yard or a garden supply store (alternatively you can purchase bite-size wrapped candy such as bite-size Reese's, Rolos, or Hershey's Kisses, or wrapped bite-size Milky Way or Mounds.)
23. Powdered hot cocoa mix: grocery store
24. Cream of tartar: grocery store

25. Play Dough: purchase commercial children's clay or make your own (adapted from http://www.cooks.com/rec/doc/0,1611,147171-236192,00.html):

Play Dough

4 c. flour
4 c. boiling water
1/4 cup cream of tartar (or the contents of the 1.6 oz jar of cream of tartar included in the ToolKit)
2 cups salt
1/4 cup salad oil
Food coloring (optional)

Place all ingredients except hot water in a large bowl and stir. Pour in hot water and mix together with a spoon until well combined. When the dough has cooled, place the dough on a lightly floured surface and knead it to a smooth consistency. This dough is not sticky and does not dry out unless left open to the air for several days. Store in a sealed container (plastic tubs are good).

SKYWATCHER'S GUIDE TO THE MOON

Impact!

The Moon's cratered surface tells a violent story. Bright areas are ancient crust that make up the highlands. Dark areas are newer regions of lava that formed after asteroid impacts.

Copernicus

This crater (left) is easy to spot. It formed about 800 million years ago, and is 57 miles (92 km) wide. Note central peaks and terraced walls, caused by impact.

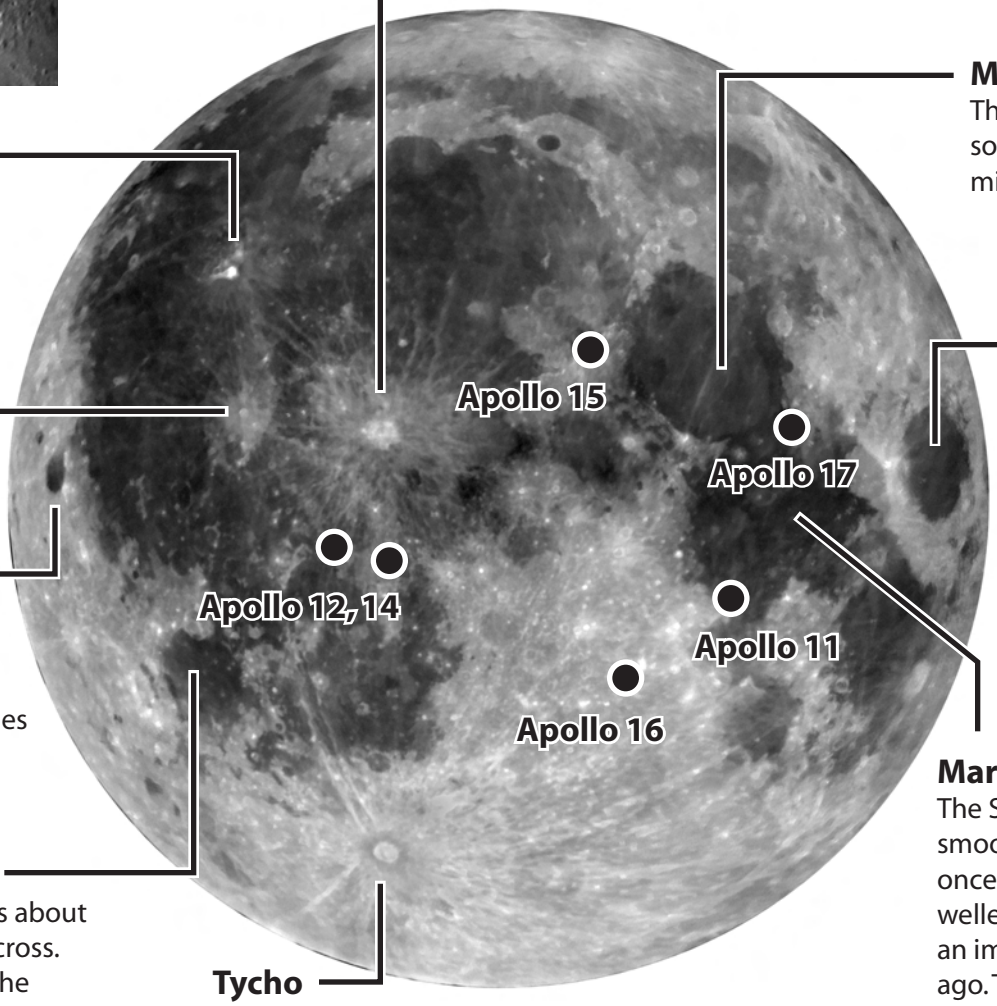
What do you see on the Moon?

Face south and look up in the sky.

Can you find the Moon?

Compare the Moon in the sky to the large Moon map below. The Moon map shows the side of the Moon that is always facing us. How much of the Moon in the sky is lit up right now? You will only see the features on the part of the Moon that is lit up.

Through a telescope, you may need to turn the map to match your view of the Moon in the eyepiece. Some telescopes will flip the image, so the Moon might look like the image to the right through a telescope.



Aristarchus
Young crater. So bright that Sir William Herschel thought it was an active volcano.

Kepler
Small version of Copernicus

Grimaldi
Lava-filled crater is one of the darkest spots you can see on the Moon. It's 145 miles wide (233 km).

Mare Humorum
The Sea of Moisture is about 220 miles (350 km) across. You can spot it with the naked eye. With a telescope, you might notice two craters along its edge.

Tycho
Young crater best seen during a full Moon. Rays of bright material are ejecta blasted out of the crust when a large asteroid struck about 109 million years ago.

Mare Serenitatis
The Sea of Serenity is solid lava, some 380 miles (610 km) across.

Mare Crisium
The Sea of Crisis is about 340 miles wide (550 km) and visible to the naked eye.

Mare Tranquillitatis
The Sea of Tranquility is a smooth plain filled with once-molten lava that welled up from below after an impact billions of years ago. The first humans to walk on the Moon, Apollo 11 astronauts, landed near the edge.

SOURCES: NASA; ADVANCED SKYWATCHING; CAMBRIDGE ATLAS OF ASTRONOMY; DK VISUAL ENCYCLOPEDIA

Photos: James Scala. Layout and text for Moon map used with permission: Robert Roy Britt/SPACE.com.

Be the Local Transit Authority!

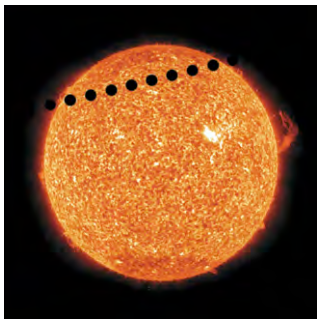
Transits & the *Kepler Mission*

What's this activity about?

Big Questions:

The *Kepler Mission*'s objective is to:

- Detect transits …
- of Earth-size planets …
- in the habitable zone …
- of Sun-like stars.



This set of activities addresses each of these points:

Detect transits …

- What are transits? Can I see one?

of Earth-size plants …

- Why are Earth-size planets important?
- How can we detect transits of planets orbiting distant stars? How will *Kepler* detect transits?

in the Habitable Zone …

- Why is there abundant life on Earth and not on Venus or Mars?
- What's the "Habitable Zone"?

of Sun-like stars.

- Are all the stars we see like our Sun?
- What's a Sun-like star?

Big Activities:

Learn about the *Kepler Mission*: NASA's first mission dedicated to finding Earth-size planets
Watch Mercury transit the Sun!
Try to detect an Earth-size planet transiting a distant star.
Find the habitable zone around the Sun and around other stars.
Discover what kinds of stars we see in the constellations.

Participants: Appropriate for families, the general public, and school groups in grades 3 and up. See "Helpful Hints" for more details.

Duration: 5 minutes to 1 hour, depending on the number of topics covered.

Topics Covered:

What is the Kepler Mission about?
Transits Part 1: What is a transit? Mercury & Venus transits
Transits Part 2: Other stars with transiting planets
Transits Part 3: How will Kepler detect transiting planets?
What's the "Habitable Zone"? Why is there abundant life on Earth and not on Venus or Mars?
Are all the stars we see like our Sun? (What's a Sun-like star?)

Where can I use this activity?

ACTIVITY	Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
***Kepler Mission* PowerPoint**			√	√		√	√	√	√	
Transits: What is a transit ? Mercury & Venus transits	√	√	√	√	√	√	√	√		√
Detecting transits around other stars	√	√	√	√		√	√	√		√
Habitable Zones: Why does Earth have abundant life and not Venus or Mars?		√	√	√	√	√	√	√		√
Are all the stars like our Sun? (PowerPoint and/or observing activity)	√	√	√	√		√	√	√	√	√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Book or shoebox	Nothing else.	*Optional:* Make copies of the constellation diagram for "**Are all the stars like our Sun?"**

Helpful Hints

This set of activities allows you and your audiences to explore as much or as little as you want about transits and the *Kepler Mission*. You have the flexibility to use as many or as few of these activities as your interest, audience, and venue allow.

You can incorporate one or more of the activities in this set of activities into a larger presentation that in includes the *Kepler Mission* PowerPoint.

Each activity in this set can also be used independently. They can be used in any order.

Summary of activities:

- *Kepler PowerPoint:* Found on the ToolKit Manual & Resources CD in the "PowerPoints" folder, this presentation provides an overview of NASA's *Kepler Mission*. A suggested script can also be found in the same folder. *Recommended audience:* 5th grade and above. Duration: 30 – 45 minutes.
- *Transits Parts 1 – 3*: Provides two methods involving audience members to model a transit. Shows why we see Mercury and Venus periodically transit the Sun. Illustrates the difficulty of detecting transits of planets orbiting distant stars. *Recommended audience:* 3rd grade and above. Duration: 5 – 10 minutes.
- *Why is there abundant life on Earth and not Venus or Mars*: Uses several audience members to model the habitable zone around stars and how an atmosphere influences the habitability of a planet. *Recommended audience:* 3rd grade and above. Duration: 5 – 15 minutes.
- *Are all the stars like our Sun*: PowerPoint and observing activity to understand that almost none of the naked-eye stars (stars we can see without a telescope) are like our Sun. They are almost all bigger or hotter or both. Only if a star like our Sun is very close to us can we see it with the unaided eye. Discusses three main categories of main sequence stars. *Recommended audience:* 5th grade and above. Duration: 10 –20 minutes.

Background Information

For complete information on the *Kepler Mission*:
http://Kepler.NASA.gov/

For FAQ's on the *Kepler Mission* (these are common questions your audiences may have):
http://Kepler.NASA.gov/Mission/QuickGuide/

Transits:

Schedule of Venus Transits (all times are UT – Universal Time):

TRANSIT starts at 10 Dec 2117 23:54
TRANSIT ends at 11 Dec 2117 5:50

TRANSIT starts at 8 Dec 2125 13:10
TRANSIT ends at 8 Dec 2125 19:01

Schedule of Mercury Transits:

TRANSIT starts at 9 May 2016 11:11
TRANSIT ends at 9 May 2016 18:45

TRANSIT starts at 11 Nov 2019 12:35
TRANSIT ends at 11 Nov 2019 18:06

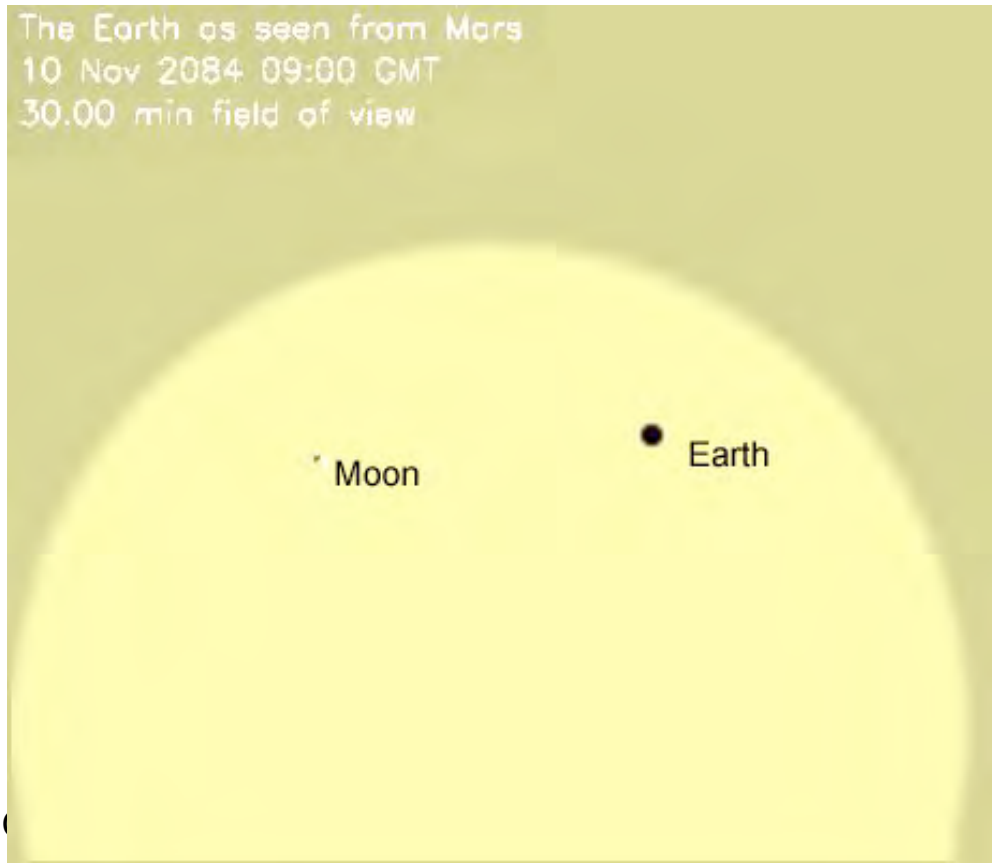
TRANSIT starts at 13 Nov 2032 6:41
TRANSIT ends at 13 Nov 2032 11:09

TRANSIT starts at 7 Nov 2039 7:17
TRANSIT ends at 7 Nov 2039 10:18

TRANSIT starts at 7 May 2049 11:03
TRANSIT ends at 7 May 2049 17:48

Schedule of Earth Transits from Mars!

Simulated view of Earth (and Moon!) transiting the Sun as seen from Mars on November 10, 2084.



Transits of Earth from Mars

- **May 11 1984**
- **November 10 2084**
- **November 15 2163**
- **May 10 2189**

http://www.answers.com/topic/transit-of-earth-from-mars

Other transit resources:

Animations on the Manual & Resources CD:

Kepler Mission animations, eclipses from different perspectives in space, transits, and light curves of transiting planets. This is found on the Manual & Resources CD in the folder, "Animations". Click on "**SSAnimations.html**".

MPEG of Mercury Transit:
http://soho.nascom.nasa.gov/hotshots/2003_05_07/
(also included on Manual & Resources CD under "Animations")

Listen to an excerpt from "The Transit of Venus" March by John Philip Sousa:

http://lcweb2.loc.gov/cocoon/ihas/loc.natlib.ihas.200002625/default.html

Amateur Search & Monitoring of Transits of Extrasolar Planets:

http://www.transitsearch.org/
Dr. Gregory Laughlin of UC Santa Cruz

Sun-like Stars & Spectral Types:

When we refer to "naked-eye" stars in this presentation, we are referring to stars brighter than 4th magnitude since most observing with the public does not occur under darker skies.

Once people understand that the Sun is a star, it is commonly believed that most of the stars we can see naked eye **(brighter than 4th magnitude)** are stars like our Sun: yellow/white main sequence stars of spectral type G. This is not the case at all. Most of the stars we see are giants: stars in the last stages of their lives, no longer on the main sequence. Super-giants, giants, and sub-giants. These are large, bright stars. Some naked-eye stars are the hot, massive, bluish main sequence stars of spectral types O, B, and A.

There are only three main sequence stars of spectral type G anywhere in the night sky (Northern or Southern Hemisphere) brighter than 4th magnitude:

- Eta Cassiopeiae: visible most of the year, but low in the northern sky March – June
- Tau Ceti is visible November through January
- One more star in the night sky that is almost exactly like our Sun: Alpha Centauri. It is very bright, but only visible from extreme southern continental USA and Hawaii. So it is not included in the "Sun-Like Stars" presentation.

In the "Habitable Zone" activity, here is how we have classified the stars to take a more simplified approach to main sequence stars of various spectral types:
"Cool, red stars": Main Sequence stars of spectral type K, M, and cooler (lowest mass)
"Yellow/white stars": Main Sequence stars of spectral type G and F (mid-mass)
"Hot, bluish stars": Main Sequence stars of spectral type O, B, and A (higher mass)

All main sequence stars are classified as "dwarf" stars.
"White dwarf" is the hot dense core of a star that has lost its outer layers – a star that has "died".
"Red dwarf" is a cool, red main sequence star.

Giant stars (of various sizes) are stars that are "in retirement", no longer fusing primarily hydrogen at their cores. These are stars no longer on the main sequence. They still are given one of the above spectral types, but they are in a different "luminosity class". Main sequence stars have a luminosity class of "V". Here are the others:

Ia	Most luminous supergiants
Ib	Less luminous supergiants
II	Luminous giants
III	Normal giants
IV	Subgiants
V	Main sequence stars (dwarfs)

For more information on spectral types of stars:
http://antwrp.gsfc.nasa.gov/apod/ap040418.html (basic discussion - follow the links)
http://cas.sdss.org/dr4/en/proj/advanced/spectraltypes/

"Habitable Zone"

For a discussion of why scientists are looking for planets that could have LIQUID water on their surface: http://www.pbs.org/wgbh/nova/evolution/liquid-of-life.html (NOTE: The explanation of why the sky is blue is generally attributed to Lord Rayleigh who described "Rayleigh scattering", rather than to Einstein as the above referenced article may imply.)

Detailed Activity Descriptions

What is the Kepler Mission about?

Leader's Role	**Participants' Role (Anticipated)**
Materials: **Manual and Resources CD, in the "PowerPoints" folder:** • *Kepler* PowerPoint: KeplerMission.ppt • **Script:** KeplerMissionScript.doc or KeplerMissionScript.pdf	
 This PowerPoint presentation provides an overview of NASA's *Kepler Mission*. The PowerPoint includes how *Kepler* detected transits, the area of the Summer Triangle *Kepler* monitored, the number and type of planets it has found so far, the followup K2 Mission, and it explains some of the concepts, like "habitable zone" and "Sun-like stars". If you'd like to make the PowerPoint presentation more interactive, you can incorporate one or more of the activities in this set of activities into your presentation.	
Presentation Tip: If you have the **PlanetQuest ToolKit**, you may want to use the "wobble balls" to demonstrate the method by which most planets around other stars have been discovered and why that method is inadequate to find the smaller planets like Earth. See the activity "How do we find planets around other stars?" in the PlanetQuest ToolKit Manual.	

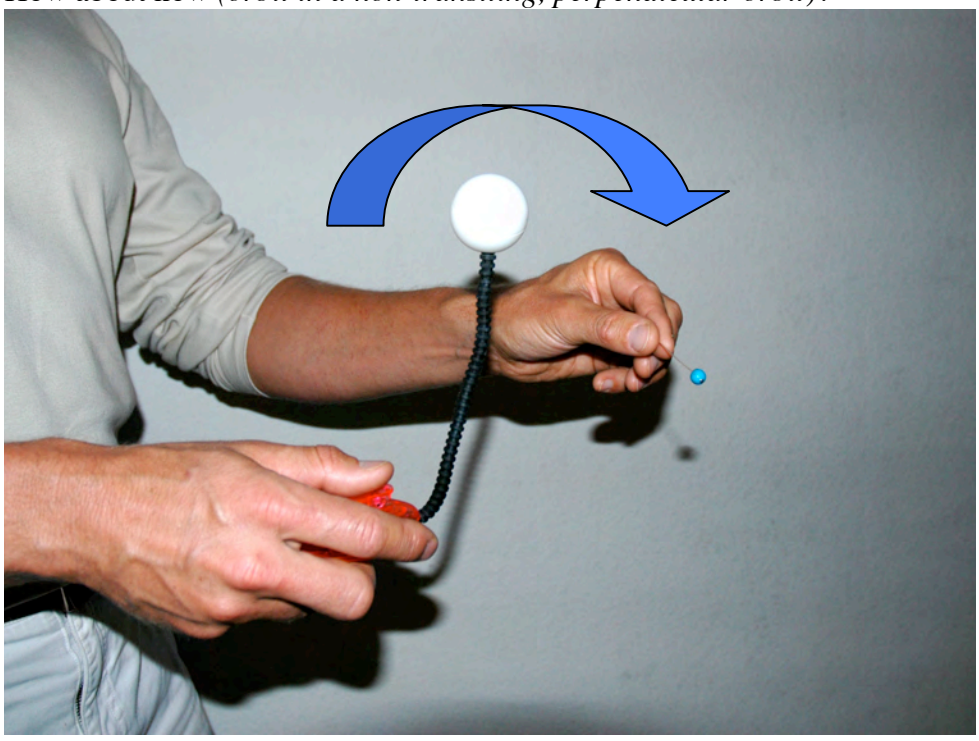
Transits Part 1: What is a transit? Mercury & Venus transits

Leader's Role	**Participants' Role (Anticipated)**
Materials: 2 - Snake lights with ping pong balls attached 4 – beads on pins– represents Mercury, Venus, Mars, and an extrasolar planet *Optional:* Solar System Litho showing all the planets. NOTE: **This can be done either during the day or in a dark location.**	
<u>*To Say:*</u> Sometimes, Venus or Mercury transits the Sun. What does that mean? How are the planets positioned around the Sun, from closest to farthest? (*Optional:* Show Solar System Litho to help visitors remember the order) Which planets are closer to the Sun than Earth?	 Not sure. Mercury, Venus, Earth, Mars, … Mercury & Venus
<u>*Presentation Tip:*</u> You may use either of the following two methods to demonstrate a transit. Recommended: • If you have a large group, you might prefer to use Method #1. • For a small group (5 or less) or for a simpler demonstration, use method #2.	
<u>Demonstrating Transits (Method #1):</u> <u>*To Say:*</u> Who wants to be the Sun? (*Pick a child or shorter person and give that person the snakelight with the ping-pong ball. Ask the person to hold the light on his/her head.* *Optional:* secure it to their head with stretchy band or scarf) Which is the planet closest to the Sun? Who wants to hold Mercury? *(Give each person a bead on a pin to represent their planet)* Who wants to hold Venus? <u>*To Do:*</u> Position the people holding the planets within a few feet of the snake light, with Mercury inside of Venus's orbit. <u>*To Say:*</u> Now hold your planet in front of you so it is at about the same height as the Sun and start slowly orbiting around the Sun counterclockwise. That's THIS way. *(Show planet people the direction to walk around the Sun).* Each of the rest of you is Earth. Spread yourselves in a circle outside Venus's orbit – you are each representing different points in Earth's orbit around the Sun. (GO TO: "***<u>Continues from either Method</u>***")	 I do! I do! Mercury I do! I do! Participants follow instructions.
<u>Presentation Tip:</u> To allow the people holding the Sun and planets to see the effect, you may want to ask other people to trade places with them after an orbit or two.	

Leader's Role	Participants' Role (Anticipated)
Demonstrating Transits (Method #2): *To Do:* Set out the snakelight with ping-pong ball on a small table or have a participant kneel on the ground and hold the light on his/her head.  *To Say:* This light represents the Sun. This model is not to scale. Which is the planet closest to the Sun? *To Do:* Hold a pin with a small bead on it (or give the bead to one of the visitors). *To Say:* This represents Mercury. It orbits the Sun like this. *To Do:* Slowly move the bead around the snakelight (orbiting Mercury around the Sun) counterclockwise at least 4 – 12 inches away from the light. This must be done slowly. A good technique is to silently count to eight seconds for each orbit. *To Say:* Each of the rest of you are standing on Earth and watching Mercury orbit the Sun.	Mercury

Leader's Role	Participants' Role (Anticipated)
(Continues from either Method): *To Say:* When a planet passes between an observer (that's all of you) and a star (in this case, the Sun), we call that a transit. From Earth, sometimes everything is lined up so we see Mercury transit the Sun. We see a black dot appear to cross the face of the Sun. The planet is silhouetted against the Sun. Close one eye and position yourself so you can watch Mercury transit the Sun. You might have to bend over and move your head up or down to get in the right position. Who saw Mercury transit? 	I did! Me too!
(OPTIONAL) *To Say:* Where does Mars orbit? Who wants to be Mars? OK. You walk around outside of Earth's orbit. Would we ever see Mars transit the Sun? Might Earth transit the Sun from perspective of Mars? The next time that happens will be in 2084. Maybe by then people will be living on Mars and get to see something no one has ever seen before!	 Out there, beyond Earth. I do! No! It could!
Presentation Tip to extend the activity: **You can continue to the next section "Part 2: Other Stars with Transiting Planets" to extend the activity.**	

Transits Part 2: Other stars with transiting planets

Leader's Role	**Participants' Role (Anticipated)**
Additional Materials: 1 – Snake light with ping pong ball attached 1 – bead on a pin – represents an extrasolar planet NOTE: **This can be done either during the day or in a dark location.**	
To Do: Walk a few feet away and hold the second snakelight in the plane of the "planets" orbiting the "Sun". *To Say:* We see lots of stars in the night sky. Some of them may have planets orbiting at the right angle for us to detect planets transiting their star. Let's pretend I live on a planet orbiting a star over in this direction. Let's say my planet orbits my star like this *(orbit the bead so it transits the "star" from Earth's perspective).* Might you there on Earth be able to detect my planet transiting my star? How about now *(orbit in a non-transiting, perpendicular orbit*)?  For us to detect a planet transiting its star, it has to be oriented the right way. That's what the upcoming *Kepler Mission* will be doing – trying to find stars with Earth-size planets orbiting them in such a way that they transit the star from our perspective.	Maybe No.

Leader's Role	**Participants' Role (Anticipated)**
To Say: But how far away are the other stars? On the size scale of these stars, we'd have to move this star to <pick a state or other location 1500 miles away> for a star that was only 10 LY away. We can't do that, but we can move it a little farther away.	Really far!
Calculations for the scaled distance to a star 10 light years away : The ping pong ball is about 1-1/2" – represents a star about one million miles in diameter – or about 5 light seconds. This makes 1 light min 18", one light hour 1,080" and one light day 2,160 feet. Making one light year about 150 miles. 10 light years = 1500 miles.	
To Do: Take the snakelight and bead on a pin and move at least 50 feet away (4 to 5 car lengths). (If you haven't already done so, the participants who helped make a demonstration of the Sun, Mercury, and Venus can put their items down.) Face the crowd and orbit the "planet" around the snakelight such that the crowd might see a transit if they were closer. *To Say:* Can you see the planet transiting from there? *(NOTE: It is almost impossible for our eyes to resolve the tiny bead against the light – only people with extraordinary vision can still see it transit).* Do you think you'd see it if it was 1500 miles away? The *Kepler Mission* will be detecting transiting planets around stars hundreds to thousands of light years away. So how do you suppose it will do that?	No. No!
Presentation Tip to extend the activity: **You can continue to the next section "Part 3: How will *Kepler* detect transiting planets" to extend the activity.**	

Transits Part 3: How will Kepler detect transiting planets?

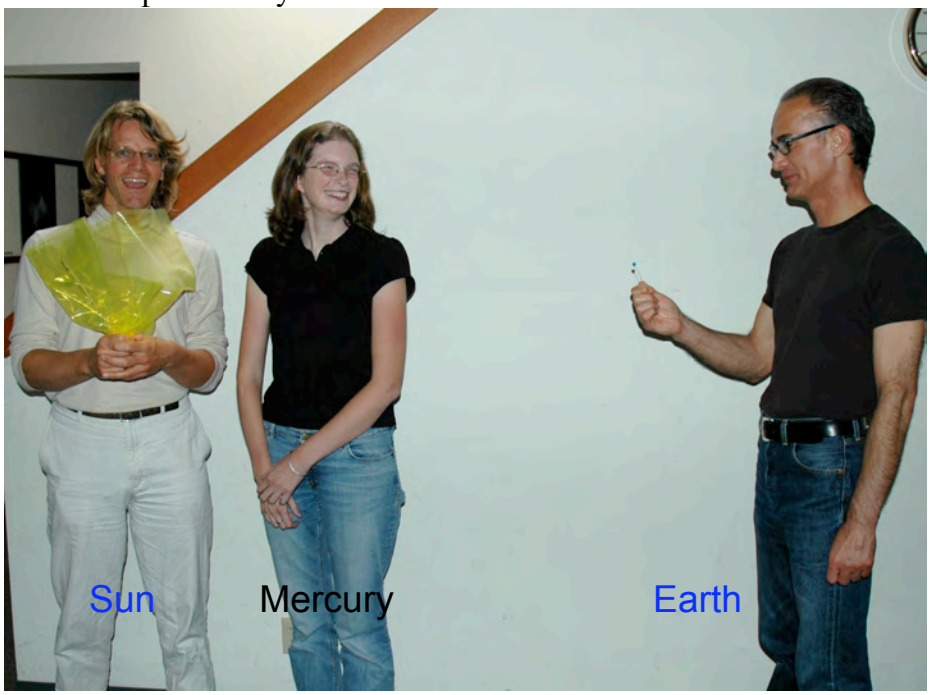
Leader's Role	**Participants' Role (Anticipated)**
Materials: 1 - Snake light with ping-pong ball over the bulb 3 – different-sized beads on sticks or pins – representing extrasolar planets 1 - White card **You supply:** Book or shoebox to hide light **NOTE: This must be done in a dark room or outdoors at night in an unlit area. This is much easier with a helper.**	
To Do: Place snakelight on table. Fold the white card in half. Hold up white card. *To Say:* This card represents one of the detectors aboard the *Kepler* spacecraft. The light from this star is being detected here. *Kepler* will be looking for stars that dim, then brighten, then dim again as a result of the planet orbiting the star. We can't see the planet, but we can detect the dimming of the star. Let's block the star's light so it will be easier for you to see just the detector.	
 *To Do:* Block the view of the light from the audience members with a book or shoebox. Choose a colleague or audience member to hold the card. *To Say:* (Pointing to a person) Will you be the detector? *To Do:* Hand the card to the person and have him/her hold the card about a foot above the light.	Sure.

Leader's Role	Participants' Role (Anticipated)
To Do: Hold up largest planet. *To Say:* Tell me when this large planet passes between the star and the *Kepler* spacecraft. *To Do:* Orbit the largest bead (representing a large planet) slowly around the light such that the light shining on the card clearly dims as the planet passes between the light and the card. *To Say:* Let's look at the dimming for a little bit smaller planet. *To Do:* Orbit the medium bead slowly around the light. *To Say:* Did you see the light dim? But we're looking for Earth-sized planet – will this be harder or easier to detect? Let's try.	I see it! There it is again. Is that it? There it is. Harder.
To Do: Orbit the small bead slowly around the light. (NOTE: This last one may be difficult to see unless you are in a very dark location.) *To Say:* Essentially, that's what *Kepler* will do – detect that very small dip in the light from the star. It's about like how much a headlight would dim if a gnat flew in front of it. We also want to see at least two or more passes to confirm that something is orbiting the star. *Kepler* will identify stars that we want to study further using other instruments and other telescopes – to make sure it's a planet, and to see if it might have an atmosphere. What might that mean?	That's hard. I think I see it. There – was that it? Maybe there could be life on it!
Presentation Tip: The beads being used as planets are still scaled way too big for this star – but it will give your audience an impression of how very little dimming of a star an Earth-sized planet will cause. In addition, the planets are being orbited much faster than real planets orbiting real stars. In the demonstration, the planets are orbiting once every few seconds. Planets normally take many days, months, or years to orbit their star. Another way to imagine the amount of dimming of the star's light: Being able to detecting the dimming of a star by an Earth-sized planet is about like being able to detect the dimming a searchlight by a ladybug walking across it.	

What's the "Habitable Zone"? Why is there abundant life on Earth and not on Venus or Mars?

Leader's Role	**Participants' Role (Anticipated)**
Materials: Candle, yellow and blue cellophane *Optional:* 4" Earth from "Shadows in Space" activity bag and/or blue bead on a pin from the "Transits" bag. NOTE: This activity was developed from an idea in NASA's "Astro-Venture" guide: http://astroventure.arc.nasa.gov/	
<u>*To Say:*</u> Look up – what do you mostly see in the sky at night?	Stars!
Can we see any stars in the daytime?	Yes, one – our Sun
Does our star have planets orbiting it?	Yes.
Do you suppose some of the stars we see at night also have planets orbiting them?	Maybe. Don't know.
Yes. Scientists have already found many that do, but only planets that are very large, close to the size of Jupiter and bigger.	
Do you suppose some of those planets might be able to support life?	Maybe.
NASA's *Kepler Mission*, within about five to eight years, will determine if small Earth-size planets exist around other Sun-like stars. It is looking for planets in the habitable zone of stars.	
But what is a "habitable zone"? Why do you suppose there is so much life on Earth and no apparent life on Venus or Mars?	Variety of answers.
Earth is in the "habitable zone" of our star, the Sun. Let's see what it means.	

Leader's Role	Participants' Role (Anticipated)
PART I: Habitable Zone of a Sun-Like Star **This section addresses the topic of "habitable zone" and how atmosphere affects the habitability of a planet.** *To Do:*   Grab the sheet of yellow cellophane in the center and flare it into a bouquet shape. *To Say:* Pretend we are outside on a cold night and all we have is this campfire. *To do:* Give the campfire prop (one sheet of yellow cellophane) to one person. *To say:* Imagine this fire is as big as [his/her] upper body. *(Point to someone in the crowd)* Where would you have to stand to be comfortable? The campfire represents the Sun and you represent the position of Earth. *(You can give the 4" Earth or the blue bead to this person)* Does Earth have liquid water? What about the people in the back – would you be comfortable? Would you be too warm?	Person adjusts their position. Yes. Lots. No. No! Too cold.

Leader's Role	Participants' Role (Anticipated)
To do: Move one person very close to the fire.  *To say:* I need you to take off your jacket. Would you be comfortable here?	No, I'd be too hot.
To say: *(Indicating person next to fire)* This person is like Mercury – too close to the Sun. Mercury has a daytime high temperature of 800° F (430° C). Can liquid water exist on its surface? *To do:* Pick another person and place him/her far from the campfire *To say:* I'm going to ask you to take off your jacket too. This person is like Mars – too far from the Sun and too cold. The temperature at the planet's surface varies widely during the course of a Martian day, from about -125° F (-87° C) just before dawn and warms up to about -4° F (-20° C) in the afternoon. Can it have liquid water? *(Indicating the person in the middle)* This person is like Earth – just right. Earth is in the habitable zone around our star, the Sun.	No – that's way too hot. Removes jacket. No– it would all be frozen.

Leader's Role	Participants' Role (Anticipated)
To say: The "habitable zone" around a star is where liquid water could exist on the planet's surface year-round. What's the most common substance in most living things? Yes, Water! And not just any water, but liquid water. Most living things we know of require liquid water to live. So one thing that determines habitability is a planet being at the right distance from its star so the planet might have liquid water.	Water?

More info about Mercury:

Virtually no atmosphere and very close to the Sun. Like being in the desert in a swimsuit. Daytime high temperature on Mercury is 800° F (430° C) and nighttime is about –300° F (–180° C).

Mercury's "day", from one sunrise to the next, is 176 Earth days long and its "year" is about 88 Earth days – its day is longer than its year!
(NOTE: You may have seen Mercury's day quoted at 58 Earth days. 58 days is its sidereal day, not its solar day.)

More info about Venus:

A very dense atmosphere. Like wearing a parka in the desert. The temperature of Venus is always about 880° F (470° C).

Venus's "day", from one sunrise to the next, is about 117 Earth days long (it rotates very slowly) and its "year" is about 225 Earth days.
(NOTE: You may have seen Venus's day quoted at 243 Earth days. Once again, 243 days is its sidereal day, not its solar day.)

Venus has a pressure at the surface about 90 times that of Earth - a pressure equivalent to a depth of 1 kilometer under the ocean – lie down and imagine the weight of one dictionary sitting on your chest. Now imagine 90 dictionaries. That represents the pressure difference between Earth's atmosphere and the atmosphere of Venus. What do you think would happen to you if you were on the surface of Venus? (I'd be crushed!)

More info about Mars:

Very little atmosphere – like wearing a t-shirt in the Arctic.
The temperature at the surface of Mars varies widely during the course of a Martian day, from about -125° F (-87° C) just before dawn and warms up to about -4° F (-20° C) in the afternoon.
A day on Mars is about 24 hours 40 minutes – just a bit longer than an Earth day.

Atmospheric pressure at the surface of Mars is like Earth at 20 miles up – 0.7% of the surface pressure on Earth.

Leader's Role	**Participants' Role (Anticipated)**
To Say: Now let's look at something else that determines habitability: an atmosphere! Let's use a jacket to represent a planet's atmosphere.	
Why do you suppose I had Mars and Mercury take their jackets off? Mars and Mercury have little or no atmosphere. Wearing a jacket is like a planet having an atmosphere. Earth has just the right amount of atmosphere to insulate it and maintain a comfortable temperature.	No atmosphere?
The Moon is essentially the same distance form the Sun as Earth – but has no life and no liquid water - what's different? Right – no atmosphere – daytime temp on Moon:273° F (134° C) Nighttime temp on Moon: -274° F (-170° C)	No atmosphere!
But we have a planet missing. Which planet is between Mercury and the Earth? *(Select another person from the audience)* Would you stand here and be Venus? Venus has a very dense atmosphere. I'm going to have you keep your jacket on and imagine that I'm putting another other big down jacket on you too. Imagine I'm also wrapping a blanket around you. Would you be comfortable here?	Venus! OK. No – I'd get way too hot.
Right – Venus has too dense an atmosphere too close to the Sun. The temperature of Venus is always about 880° F (470° C). Can it have liquid water?	No.
So an atmosphere can make a big difference too in whether a planet might be habitable.	
Would it be easy for us to live on any of these planets, other than Earth?	No!

Leader's Role	Participants' Role (Anticipated)
PART I: Habitable Zone of Other Kinds of Stars **This section introduces the concept of different masses of stars along with the topic of "habitable zone".** *To Say:* But not all stars are like our Sun. Stars come in many different sizes. When a cloud of gas and dust collapses to form a group of stars, the stars are not all the same size, or mass. *To do:* Pick a person from the audience and give the candle to that person. Give the campfire prop (one sheet of yellow cellophane) to a second person. Pick 2 people to hold bonfire prop (2 sheets of blue cellophane). *To say:* These represent 3 different kinds of stars. *(Pointing to person with candle)* This candle represents a small cool red star. *(Pointing to person with campfire)* This campfire represents a yellow-white star like our Sun. Remember to think of the fire as being the size of his/her upper body. *(Pointing to people with bonfire)* Imagine this bonfire is as big as both of these people together. And what kind of star does this bonfire represent? Right, a hot massive bluish star.	Holds props. A big, hot star.

Leader's Role	**Participants' Role (Anticipated)**
<u>*To Do:*</u> Line the "stars" up at least 5 feet apart from each other. You need 10 – 20 feet of clear space in front of them. <u>*To Do:*</u> Hand the blue bead to one person from the audience. <u>*To say:*</u> *(To person with blue bead)* Where would you place your planet in front of the candle so it would stay warm, but not too hot? <u>*To Do:*</u> Choose two other people. <u>*To say:*</u> Each of you stand at a distance from your fire where you can be comfortable. These represent stars with three different amounts of mass. You are each in the habitable zone of that star. Are each of the habitable zones the same distance from the star?	 Visitor holds bead close to candle. Visitors position themselves. No!
<u>*To say:*</u> *(Standing by the campfire)* As we mentioned, this campfire represents a star like our Sun. That's what we mean by "habitable zone around Sun-like stars". The stars like our Sun with planets in this vicinity *(indicating the position of the person standing in front of the star)* are what the *Kepler Mission* is hoping to detect. The mission will also collect information on other planets orbiting the stars and the variety of planetary systems in our neighborhood of the Galaxy. *OPTIONAL:* If desired, you can talk more about the *Kepler Mission* or show the *Kepler* PowerPoint.	
OPTIONAL Continuation of the activity: Have one person orbit the campfire in a highly elliptical orbit. <u>*To Say:*</u> If this fire represented another Sun-like star, and it had one planet with an orbit that brought it really close, then really far away (a highly elliptical orbit) – could you ever be comfortable on it? When it is close to the star, what would happen? How about when it is far away? Could that planet have liquid water on its surface year-round?	 You'd get too hot You'd get too cold. Not likely.

Are all the stars we see like our Sun? (What's a Sun-like star?)

Leader's Role	**Participants' Role (Anticipated)**
Materials: **Alternatives:** 1. *For indoors:* Present the "Sun-likeStars.ppt" PowerPoint found in the PowerPoints folder on the Manual and Resource CD. Use the script for the PowerPoint: Sun-likeStars.doc or Sun-likeStars.pdf. 2. *For outdoors:* Print out and copy the sheet "Are all the stars like our Sun?" with the constellation diagrams (you can find them below at the end of this activity section). Use this sheet as a reference or a handout as you point out the stars in the night sky.	
Presentation Tip: There are only three main sequence stars of spectral type G (like our Sun) anywhere in the night sky (Northern or Southern Hemisphere) brighter than 4th magnitude: • Eta Cassiopeiae (but it is low in the northern sky March – June) • Tau Ceti is visible in the evening November through January • Alpha Centauri. It is very bright, but only visible from extreme southern continental USA and Hawaii. **When we refer to "naked-eye" stars in this presentation, we are referring to stars brighter than 4th magnitude.**	
To Say: What is a Sun-like star? Can we see any stars that are like our Sun? Stars come in different colors, brightnesses, and temperatures. Most of the *naked-eye stars* we see in the sky are giants, stars either in the last stages of life or just moving into "retirement". They are all swollen up – big to huge! A few times the diameter of our Sun to hundreds of times the diameter of our Sun. (e.g. Betelgeuse is about 650x the Sun's diameter). Only some of the stars we can see are healthy, stable stars called "main sequence" stars – still using primarily hydrogen for fuel at their cores. Our Sun is one of these. These stars in the "main" part of their life – not just being born and not in "retirement" – they are still "working". These healthy, stable stars vary in mass from small, cool, red stars through the yellow/white stars similar to our Sun, to the massive, hot, bluish stars. For the most part, the healthy, stable stars we can *see* are the hot, bright, bluish stars. These stars live only a very short time (up to several million years), and nature doesn't make very many of them. Small, cool red main sequence stars are way too dim – we can't see any of these with just our eyes. We can only see a very few of the main sequence yellow/white stars like our Sun. Let's look at a few constellations and see what kind of stars they have.	Guesses.

Leader's Role	**Participants' Role (Anticipated)**
To Do: Point out bright stars by using the Orion, Big Dipper, or Summer Triangle diagrams. All are either giants or hot bluish main sequence stars.	Visitors look at stars and comment.
But the giants are actually in the minority of all stars. Only one percent or so of all the stars in our Galaxy. Stars like our Sun must be very close to us for us to be able to see them without a telescope. Why? They are small and dim compared to most of the stars we CAN see. In fact, there are only two stars (brighter than 4th magnitude) that we can easily see without a telescope from here in the Northern Hemisphere that are like our Sun. Let's look at one of them. The star called "Eta" in the constellation of Cassiopeia is one of the VERY few stars in the sky that is much like our Sun that we can see without a telescope. Only 19 LY away. The other is Tau Ceti in the constellation of Cetus – it's only visible for a couple of months during the year. 12 LY away. *Optional:* Only one more naked-eye star is almost exactly like our Sun: Alpha Centauri. It is very bright, but only visible from extreme southern continental USA and Hawaii. There are lots more stars like our Sun, but they are farther away, therefore dimmer – too dim for us to see with just our eyes. Like a candle more than a mile away. The bigger, brighter stars are more like flashlights, headlights, or searchlights!	They're dim?

More information:

All but one of the bright stars of the W in Cassiopeia are giant stars – in retirement. They are no longer part in the main part of their lives – no longer in the main sequence, except the one in the middle. That one is a hot bluish star – MUCH brighter than our Sun. It is over 600 ly away. The others are between 54 and 444 ly distant.

But this little star "Eta" is only about 19 LY away. That's the one that is like our Sun. It might even have small planets the size of Earth, like our Sun does. We don't know yet. It's dim, but it's close. Like a candle about a quarter mile away – or over by <pick a landmark 1/4 mile away>. Would it be hard to see?
If we moved the candle 30 times farther – or about 8 miles away – to the top of a building in <pick a city or landmark 8 miles away> – do you think we could still see it?
That would be like moving Eta Cass to the distance of the middle star – to 600 LY away – we wouldn't be able to see it without a telescope either!

Presentation Tip:

If you have the Night Sky Network Outreach ToolKit, "**Our Galaxy, Our Universe**", you can use the "Constellation/Asterism CDs" and include the scaled distances to the stars in these constellations.

Materials

What materials from the ToolKit do I need?

Transits:

Bag labeled "Transits":

a) 4 – 8mm beads (to represent Mercury, Venus, Mars, extrasolar planet)
b) 4 – Long bead pins
c) 5/8" wood bead (mid-size planet)
d) 1" wood bead (large planet)
e) 6" white paper sticks for wood beads
f) White card

Habitable Zone:

1 – Candle (representing a small, red star)
1 – sheet of yellow cellophane (for the campfire representing a Sun-like star)
2 – sheets of blue cellophane (for the bonfire representing a hot, blue star)

Sun-Like Stars:

Sheet with constellation/asterism diagrams with labeled stars:

- Cassiopeia
- Orion
- Summer Triangle
- Big Dipper

What must I Supply:

Book or shoebox to hide the snakelight during "How will *Kepler* detect transiting planets?"
Optional: Scarf or stretchy head band to hold snakelight on a person's head.

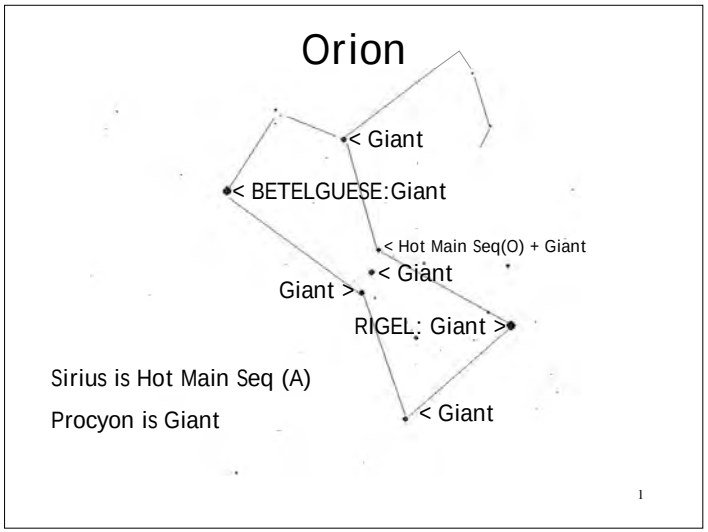
What do I need to prepare?

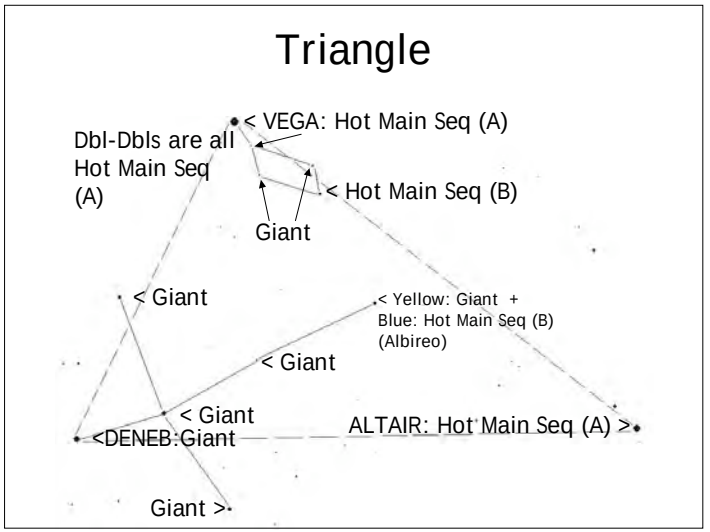
Using the StikkiWax® from the "Shadows in Space" activity bag, secure the beads to the pins: Insert the pin into the hole in the bead and place a small pinch of StikkiWax® under the bottom of the pin You can also use craft glue from and arts & crafts store to glue the beads to the pins.

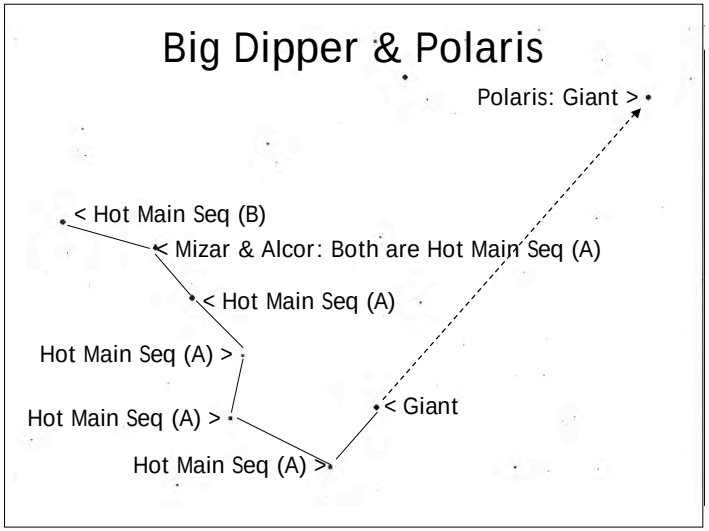
Insert the white paper sticks into the holes in the wood beads.

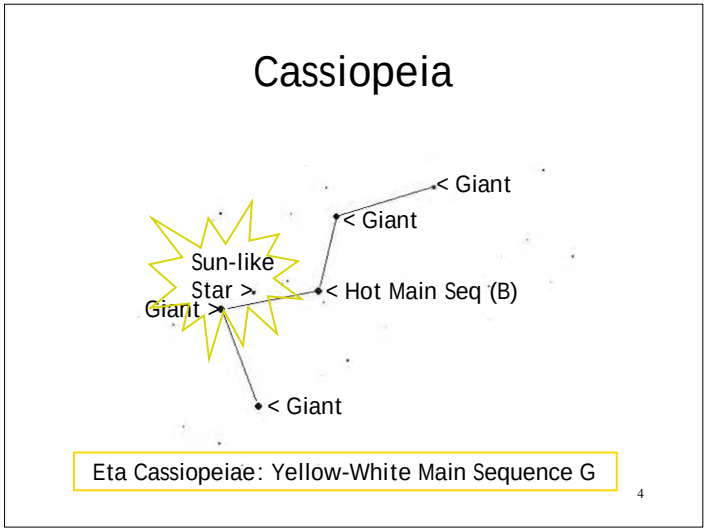
Where do I get additional materials?

- White sticks: arts & crafts store
- Beads and pins: arts & crafts or jewelry supply store
- White cards: office supply
- Candle: arts & crafts store
- Yellow & blue cellophane: arts & crafts store or gift packaging store
- Constellation diagrams: print from ToolKit manual (next page).

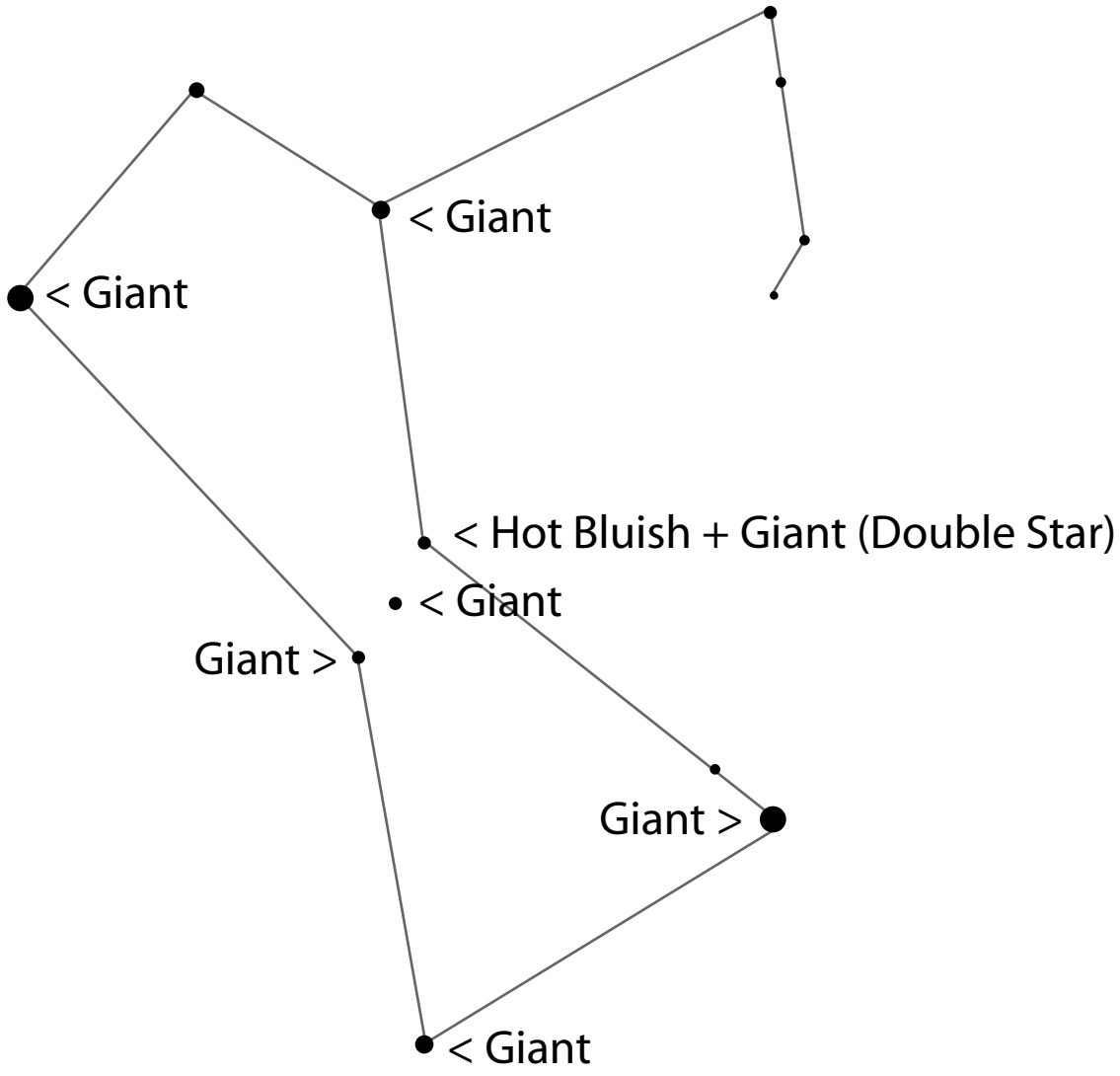




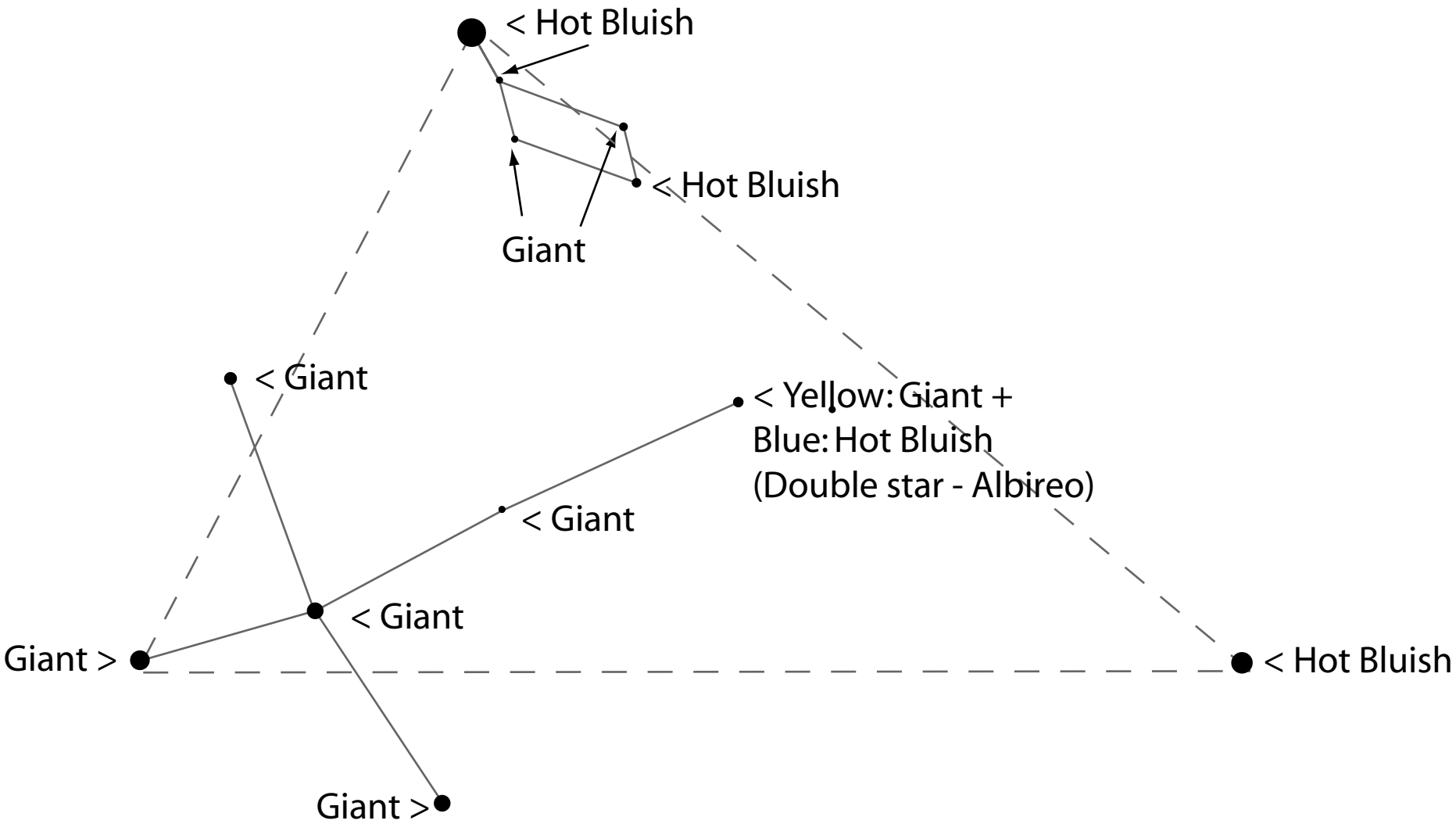




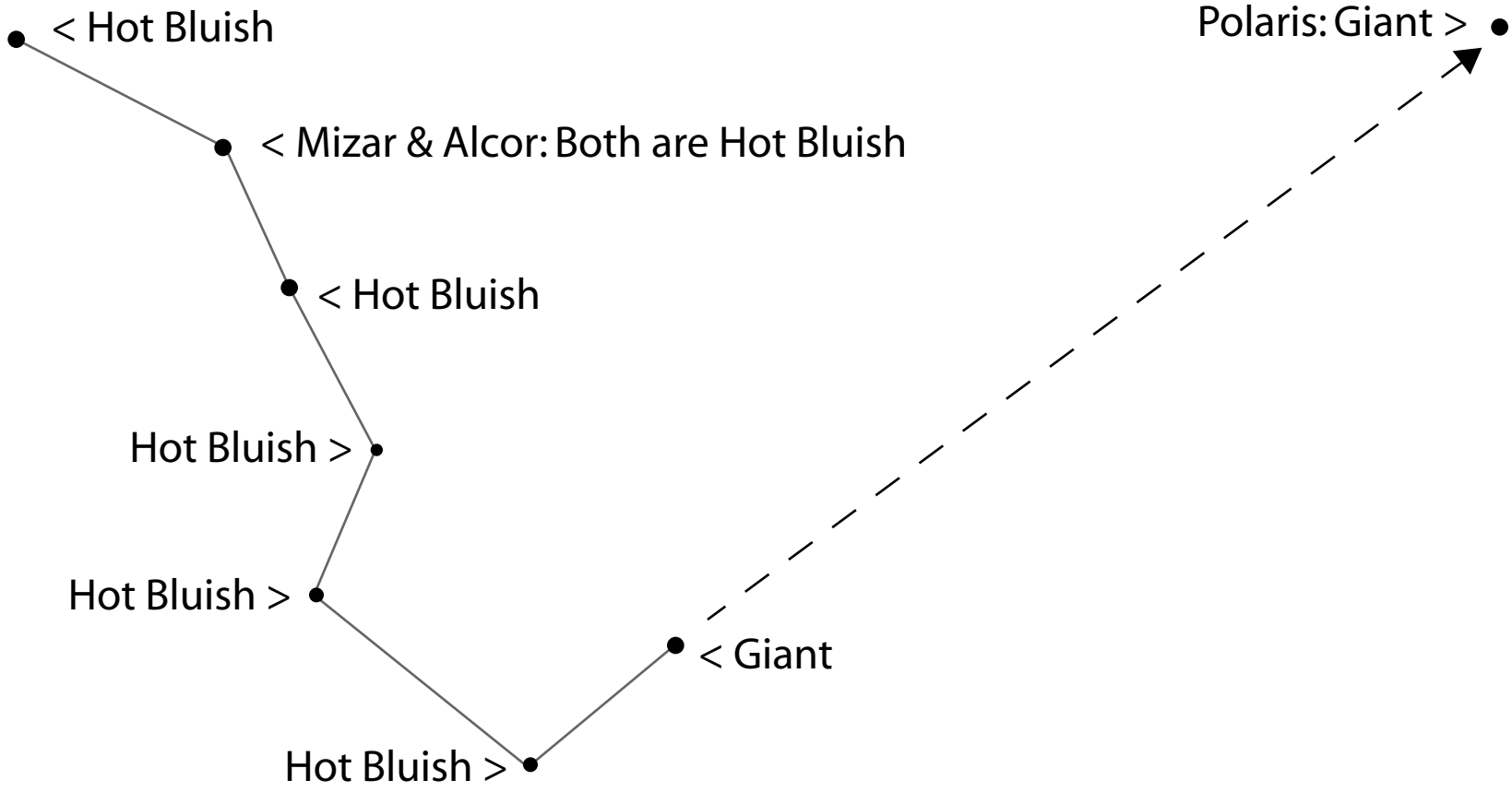
Orion



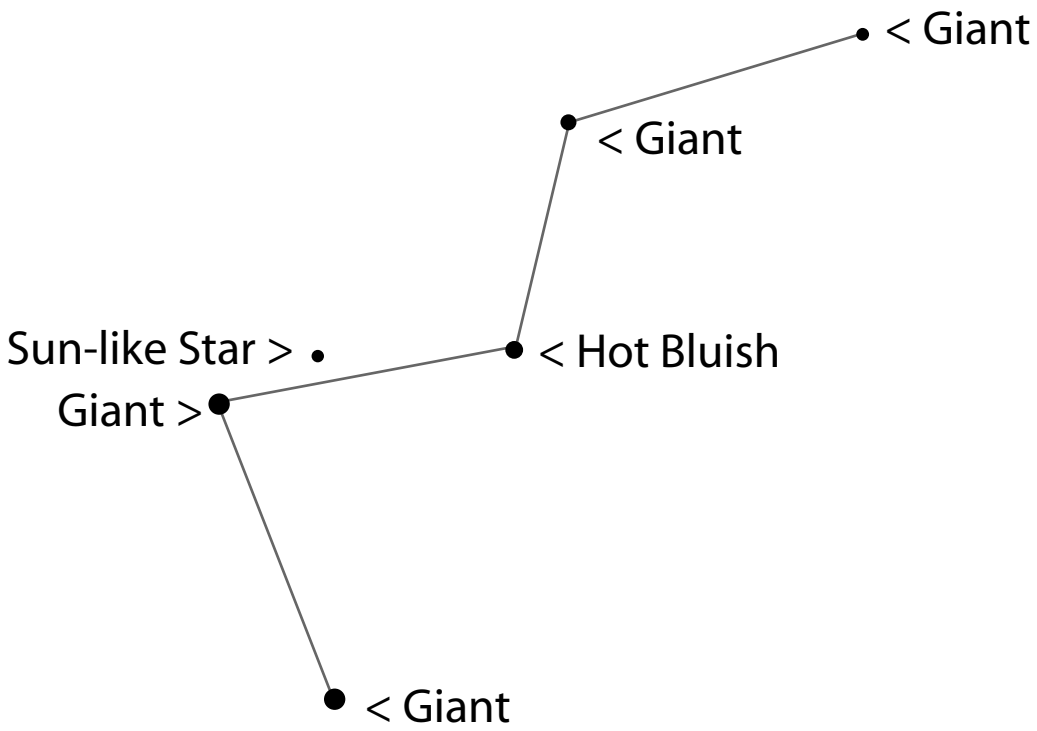
Triangle



Big Dipper & Polaris

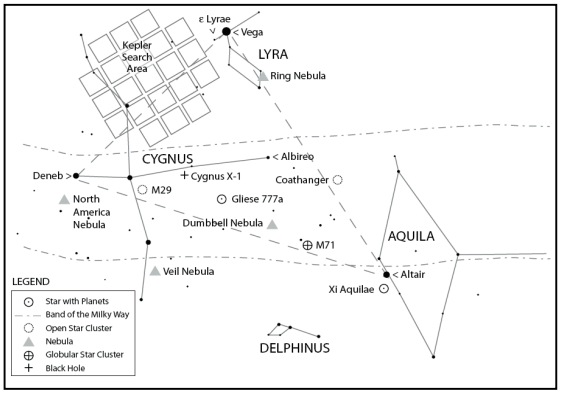


Cassiopeia



Sun-like Star is “Eta Cassiopeiae”

Trip Around the Triangle



What's this activity about?

Big Questions:

- Where in the sky did Kepler look?
- What else can be seen in the Summer Triangle?

Big Activities:

- **Trip Around the Triangle:** Visitors to a star party use a printed handout to take a trip through the telescopes to view the area of the sky where the Kepler Mission monitored stars, and to view the variety of naked-eye and telescopic treats that occupy this very popular area of the night sky: the Summer Triangle. You hand out a printed guide to your visitors for their "Trip Around the Triangle" where they can keep a record of what objects they saw.

Participants: **From the club**: A minimum of one person with a telescope up to all telescope providers at a public star party.

Visitors: Appropriate for families, the general public, and school groups in grades 2 and up.

Duration: The "Trip Around the Triangle" can be used for the duration of the star party, typically one or two hours.

Topics Covered:

- What can be seen with and without a telescope in and around the Summer Triangle asterism
- The location of the Kepler Mission's target field of view and its primary mission

Where can I use this activity?

ACTIVITY	Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Trip Around the Triangle: Telescope Tour	√									

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Nothing.	*Optional:* Completion stickers or small prizes.	Make copies of the "Trip Around the Triangle" handout

Helpful Hints

The Summer Triangle is visible in the evening sky June through January and in the early morning sky February through May.

You might want to copy your club information (public star party dates, meeting information, etc) on the back of the handout.

Background Information

Trip around the Triangle objects:

Gliese 777a: Star with planets (yellow subgiant – just starting to evolve off the main sequence – 52 light years away)
https://en.wikipedia.org/wiki/Gliese_777

Xi Aquilae (also known as ksi Aql or HD 188310): Star with planet (yellow giant star with a visual magnitude of 4.7 – about 200 light years away)
http://exoplanet.eu/star.php?st=ksi+Aql

Kepler Search Area: For more information on the Kepler Mission and its target field of view: http://kepler.nasa.gov/sci/basis/fov.html

Coathanger: There is some debate regarding whether this is a true cluster or just an asterism. For more information: http://apod.nasa.gov/apod/ap081223.html

To locate other objects on the handout, refer to star maps in any astronomy-related magazine or observing manual.

Kepler Star Wheel:

Download the latest planisphere showing the locations of stars known to have planets: http://kepler.nasa.gov/education/starwheel/ Select the link to "Kepler Star Wheels."

Detailed Activity Description

Trip Around the Triangle

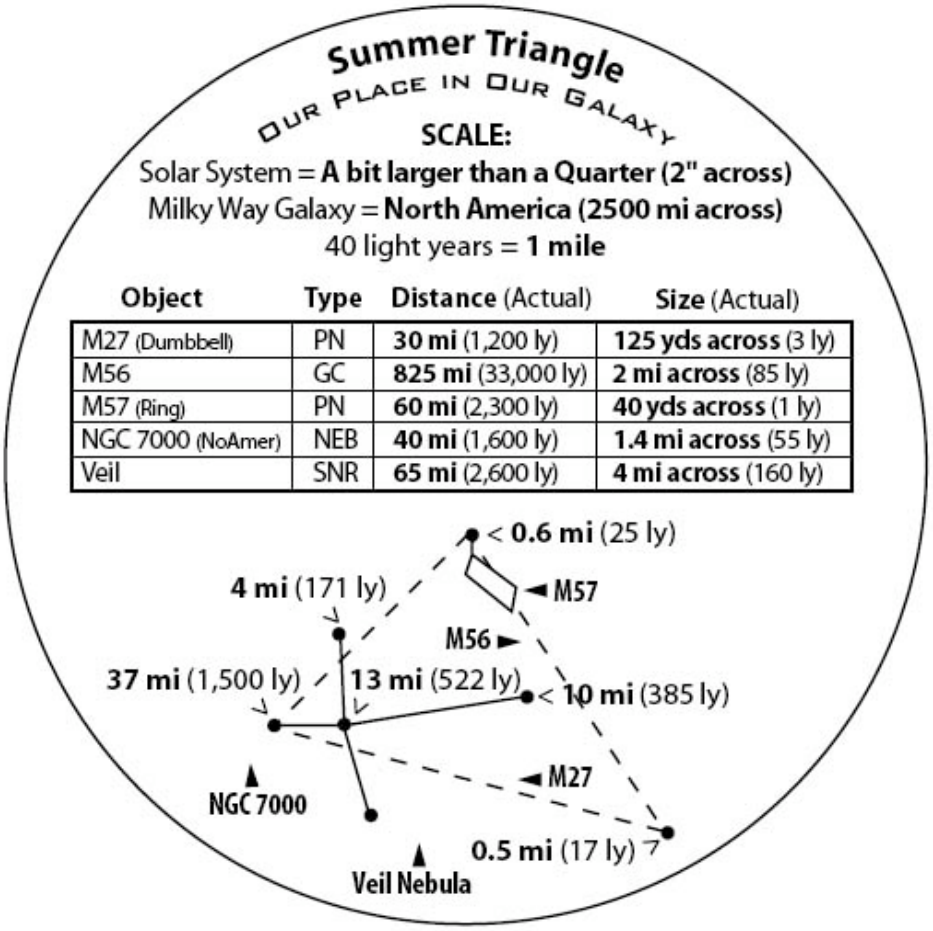
Leader's Role	**Participants' Role**
Materials: Copies of the Trip Around the Triangle handout, pencils. You may want to copy your club information on the back of the handout. *Optional:* You supply completion stickers or small prizes.	
Preparation: ***To do:*** 1. Give each participating club member a copy of the handout. Explain that your visitors will have these and be on a "Trip" to look at objects on the handout. Members operating telescopes are not limited to the objects listed or just to the area surrounding the Summer Triangle. Your visitors will just be asking the operator whether or not the object being viewed is on the handout. 2. One or two members may want to volunteer to point out constellations or other naked-eye objects on the "Trip".	
Introduction with your visitors: <u>*To Ask:*</u> Who can show me what a Triangle looks like? <u>*To Say:*</u> Well, tonight you will each take a trip around a triangle – the "Summer Triangle" – as you look through our club members' telescopes tonight. <u>*To Do:*</u> Hold up a copy of the handout. <u>*To Say:*</u> Here are all the sights you might have a chance to see. Some you can see with just your eyes, others you'll want to find a telescope operator who can show you the object. Just ask each telescope operator what they are showing and whether it is on your trip list. *(Optional):* This map might look a little complicated? Well, who can find some *little* triangles on the map? Each of those marks the location of a nebula – some are where stars might be born and some mark a dying or dead star. How about a dotted circle? Those are groups of young stars. Open star clusters. *(You can continue this, pointing out a few other details on the map. This helps your audience get oriented and familiar with the map. This reduces their sense of being overwhelmed.)*	Participants hold their hands or arms in the form of a triangle. Nods. I can! I can see a few. Yes!

Leader's Role	**Participants' Role**
To Say: Be sure not to miss the area where **NASA's *Kepler Mission*** searched for Earth-size planets around other stars. Scientists have been able to find large planets orbiting other stars. The challenge has been to find Earth-size planets. The Kepler Mission, a space-based telescope, continuously monitored 100,000 stars in one area of the Summer Triangle for a period of four years. Hold your fist out at arm's length. The area of the sky Kepler monitored for Earth-size planets is just a little larger than your fist. After it gets dark, I (or another member) can show you where that area is.	Hold out fists.
To Say: You might want to check off each item on your Trip as you find it. *(Optional):* After you have seen at least (three / six / pick a number) sights on the Trip, you will have earned a completion sticker. (Explain the procedure you have chosen to distribute completion stickers or other prize). *To Do:* Pass out handouts. *To Say:* So enjoy your Trip around the Triangle tonight! 	Take handouts.

Leader's Role	Participants' Role

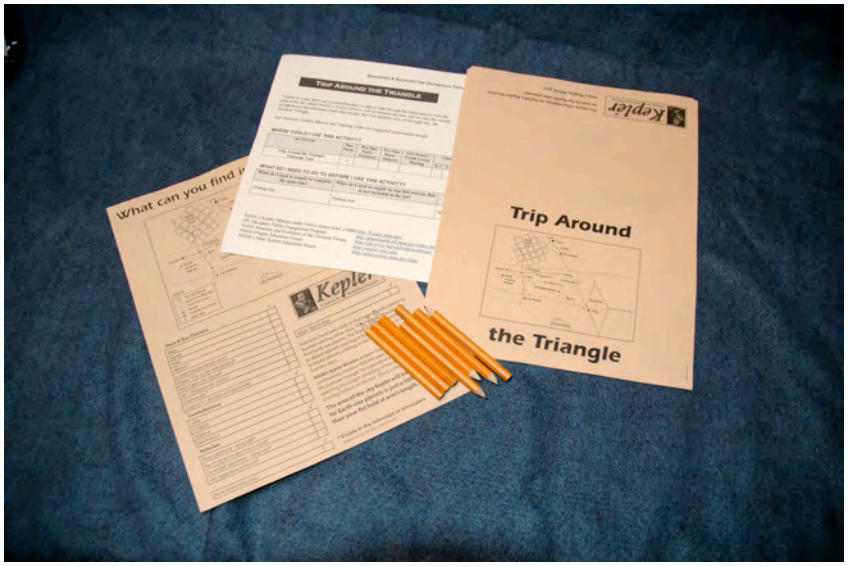
Presentation Tip:

If you have the Night Sky Network Outreach ToolKit, "**Our Galaxy, Our Universe**", you can use the "Constellation/Asterism CDs". Look for the one on the Summer Triangle and make copies for the telescope operators. They can then include the scaled distances as they talk about their object at the telescope. Here is a copy of it:



Object	Type	Distance (Actual)	Size (Actual)
M27 (Dumbbell)	PN	**30 mi** (1,200 ly)	**125 yds across** (3 ly)
M56	GC	**825 mi** (33,000 ly)	**2 mi across** (85 ly)
M57 (Ring)	PN	**60 mi** (2,300 ly)	**40 yds across** (1 ly)
NGC 7000 (NoAmer)	NEB	**40 mi** (1,600 ly)	**1.4 mi across** (55 ly)
Veil	SNR	**65 mi** (2,600 ly)	**4 mi across** (160 ly)

Materials



What materials from the ToolKit do I need?

Trip Around the Triangle:

Copies of the Trip around the Triangle handout
Golf pencils

What must I Supply:

No additional items.

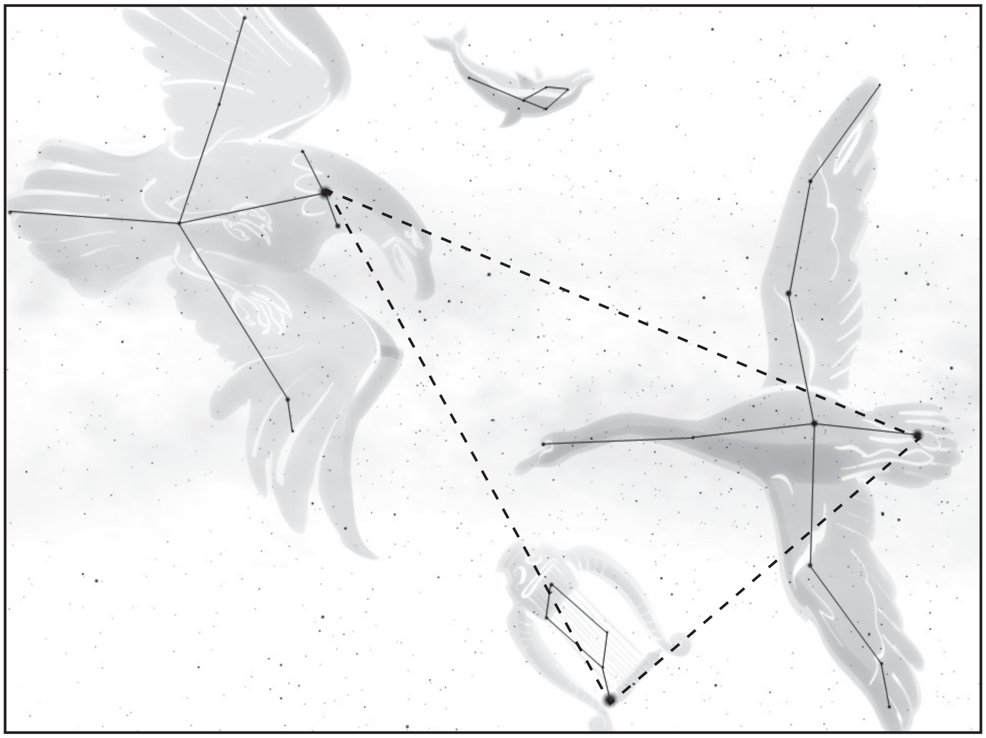
What do I need to prepare?

Additional copies as needed of the Trip around the Triangle handout. You may want to include your club information and copy it into the blank space on the back of the handout.

Where do I get additional materials?

- Copies of the Trip around the Triangle handout: The master for this handout is on the next page: "Handout: Trip Around the Triangle"
- Golf pencils: golf supply or office supply store

SEE DISTANT STARS • FIND THE CONSTELLATIONS • VIEW AMAZING NEBULAE



TAKE A TRIP AROUND THE TRIANGLE!

The Search for Exoplanets

The centuries-old quest for other worlds like our Earth has been reignited by the discovery of hundreds of planets orbiting other stars, called *exoplanets*. Scientists are just beginning to better understand the variety of planetary systems in our stellar neighborhood thanks to improved instruments and technology.

NASA's Kepler Mission, a space-based telescope, monitored more than 150,000 stars in a star field in the Summer Triangle for over four years. Scientists are searching for Earth-like exoplanets, especially those in the habitable zone of their stars where liquid water and possibly life might exist.

Kepler was designed to find exoplanets by looking for tiny dips in the brightness of a star when a planet crosses in front of it and blocks a little bit of the star's light — we say the planet *transits* the star.

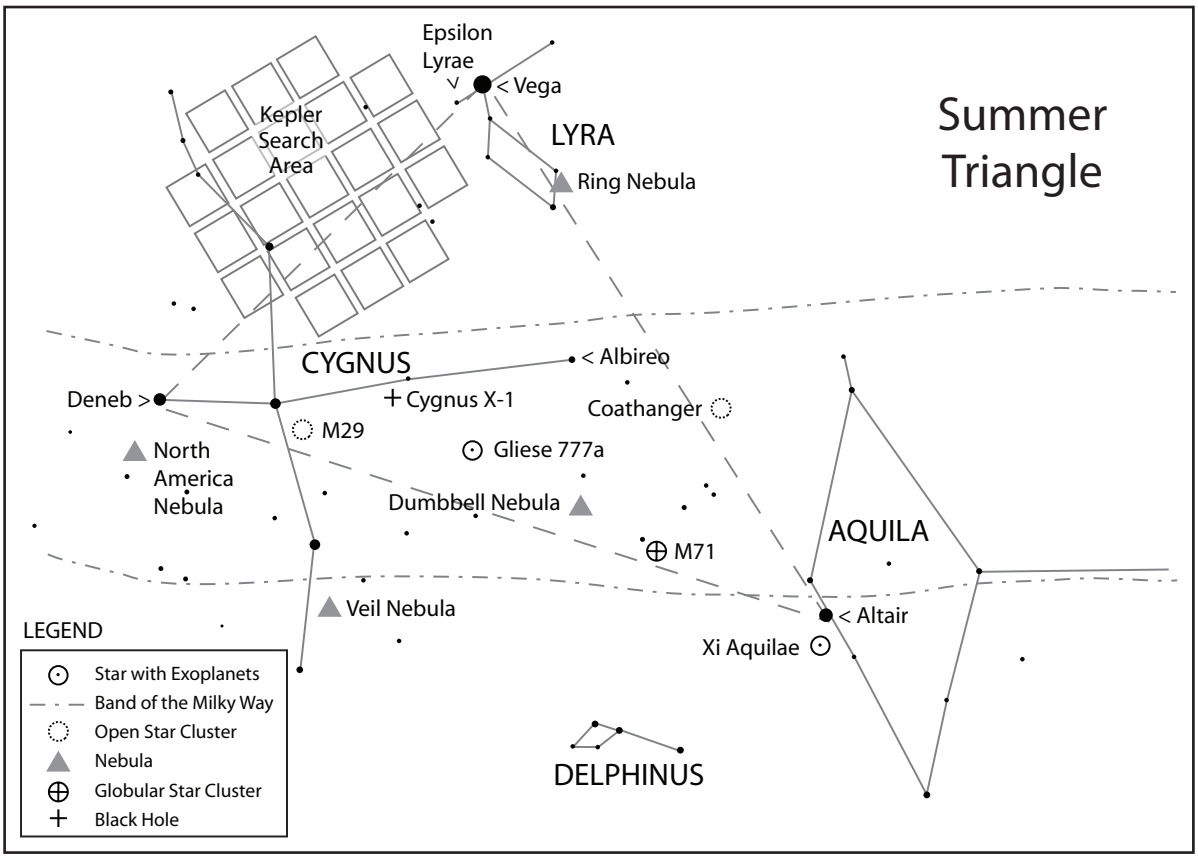
"... the ways by which men arrive at knowledge
of the celestial things are hardly less wonderful
than the nature of these things themselves"
— *Johannes Kepler*

Kepler

For more information on NASA's *Kepler Mission* to search for Earth-size planets:

http://Kepler.NASA.gov

WHAT CAN YOU FIND IN THE TRIANGLE?



Stars & Star Clusters

- Vega
- Epsilon Lyrae *(double-double stars)**
- Deneb
- Gliese 777a *(a star with exoplanets)**
- Altair
- Xi (ksi) Aquilae *(a star with exoplanets)*
- Albireo
- M29 *(Open star cluster)**
- Coathanger *
- M71 *(Globular star cluster)**
- Cygnus X-1 *(location of a black hole)*

Constellations

- CYGNUS
- LYRA
- AQUILA
- DELPHINUS

Other

- Band of the Milky Way
- Kepler Search Area

Nebulae

- Ring *(planetary - dying star)**
- North America *(gas & dust cloud)**
- Dumbbell *(planetary - dying star)**
- Veil *(supernova remnant)**

The area of the sky that Kepler monitored is just a little larger than your fist held at arm's length.

*** Visible in the telescope or binoculars**
(depending on sky conditions)

MEDIA & RESOURCES

SHADOWS & SILHOUETTES OUTREACH TOOLKIT

- GETTING STARTED -

1. **INSERT "MANUAL & RESOURCES CD" INTO YOUR COMPUTER. Click on ShadowsManual.pdf to navigate through the ToolKit Manual. You need the free Adobe Acrobat Reader to view the manual: http://www.adobe.com/products/acrobat/readstep2.html .**
2. **For best results copy the entire CD onto your computer hard drive in any folder you choose.**
3. **VIEW THE TRAINING VIDEO as you review materials in the ToolKit – this is a DVD labeled "Training Video DVD".**
4. **Review the PowerPoints and scripts in the "PowerPoints" folder on the ToolKit Manual and Resources CD.**
5. **Review the animations in the "Animations" folder on the ToolKit Manual and Resources CD. Click on SSAnimations.html.**
6. **Questions? Contact nightskyinfo@astrosociety.org**

WHERE COULD I USE THE RESOURCES INCLUDED HERE?

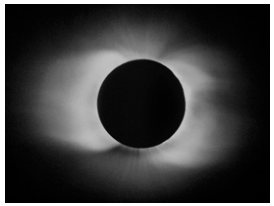
MEDIA / RESOURCE	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)
			K-4	5-8	9-12		
PowerPoint: KeplerMission.ppt	√	√		√	√	√	√
Animations	√	√		√	√	√	√
PowerPoint: Sun-likeStars.ppt	See the activity "Be the Local Transit Authority"						

NASA's Kepler Mission under NASA Grant NAG 2-6066 http://Kepler.nasa.gov/
JPL Navigator Public Engagement Program: http://planetquest.jpl.nasa.gov/index.html
NASA Structure and Evolution of the Universe Forum http://cfa-www.harvard.edu/seuforum/
NASA Origins Education Forum http://origins.stsci.edu
NASA's Solar System Education Forum http://solarsystem.nasa.gov/educ

SHADOWS IN SPACE: PHASES AND ECLIPSES

Using the real Sun and Moon, and simple props, address questions regarding Moon phases, eclipses, and shadows in space. Most of these activities can be done **outside** during the hour before sunset – waiting for darkness.

See the ToolKit Manual and Training Video for assembly and suggested presentation scripts.



WHERE COULD I USE THIS ACTIVITY?

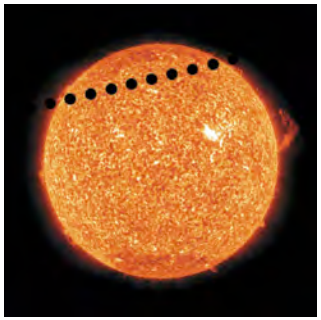
ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
1. Standing in shadow of Earth	√	√		√		√	√	√		
2. Why does Moon have phases?		√		√	√	√	√	√		√
3. Why do eclipses happen?		√		√	√	√	√	√		√
4. Why don't eclipses happen every month?	√	√	√	√		√	√	√		√
5. If I lived on the Moon would Earth have phases?		√		√		√	√	√		√
6. Does the Moon rotate?		√		√		√	√	√		√
7. Spotting Craters: make a moonscape	√	√	√	√	√	√	√	√		√
8. Observing the Moon	√									
9. Why does Venus look like the Moon?	√	√	√	√	√	√	√	√		√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Activity 7: 5-pound bag of white flour	*Optional for Activity 7:* Newspapers, broom, dustpan	*Activity 7:* Make a clay moonscape OR fill aluminum pan with flour & sprinkle with hot cocoa mix

NASA's Kepler Mission under NASA Grant NAG 2-6066 http://Kepler.nasa.gov/
JPL Navigator Public Engagement Program: http://planetquest.jpl.nasa.gov/index.html
NASA Structure and Evolution of the Universe Forum http://cfa-www.harvard.edu/seuforum/
NASA Origins Education Forum http://origins.stsci.edu
NASA's Solar System Education Forum http://solarsystem.nasa.gov/educ

BE THE LOCAL TRANSIT AUTHORITY



This set of activities addresses aspects of the *Kepler Mission's* objective:

- To detect transits …
- of Earth-size planets …
- in the habitable zone …
- of sun-like stars.

Use the PowerPoint, "KeplerMission.ppt", to introduce the mission. To make the PowerPoint presentation more interactive, you can incorporate one or more of these activities into your presentation. Each of the activities can also be used independently. See the ToolKit Manual and Training Video for assembly and suggested presentation scripts.

WHERE COULD I USE THIS ACTIVITY?

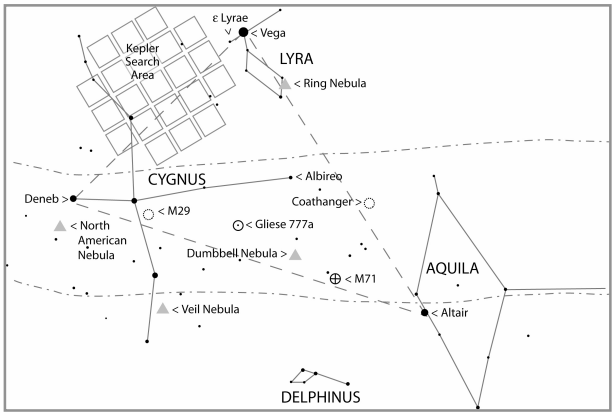
ACTIVITY	Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Transits: What is a Transit? Mercury & Venus transits	√	√	√	√	√	√	√	√		√
Detecting Transits around other stars	√	√	√	√		√	√	√		√
Habitable Zones: Why does Earth have abundant life and not Venus or Mars?		√	√	√	√	√	√	√		√
Are all the stars like our Sun?	√	√	√	√		√	√	√	√	√

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Book or shoebox.	Nothing else.	*Optional:* Make copies of the constellation diagrams for "**Are all the stars like our Sun?"**

NASA's Kepler Mission under NASA Grant NAG 2-6066 http://Kepler.nasa.gov/
JPL Navigator Public Engagement Program: http://planetquest.jpl.nasa.gov/index.html
NASA Structure and Evolution of the Universe Forum http://cfa-www.harvard.edu/seuforum/
NASA Origins Education Forum http://origins.stsci.edu
NASA's Solar System Education Forum http://solarsystem.nasa.gov/educ

TRIP AROUND THE TRIANGLE



Visitors to a star party use a printed handout to take a walk through the telescopes to view the area of the sky where NASA's *Kepler Mission* will be monitoring stars, and to view the variety of naked-eye and telescopic treats that occupy this very popular area of the night sky: the Summer Triangle.

See ToolKit Manual and Training Video for suggested presentation scripts.

WHERE COULD I USE THIS ACTIVITY?

ACTIVITY	Star Party	Pre-Star Party - Outdoors	Pre-Star Party - Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Meeting	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Trip Around the Triangle: Telescope Tour	√									

WHAT DO I NEED TO DO TO BEFORE I USE THIS ACTIVITY?

What do I need to supply to complete the materials?	What do I need to supply to run this activity that is not included in the kit?	Do This Before Your Event
Nothing else.	Nothing else.	Make copies of the "Trip Around the Triangle" handout

NASA's Kepler Mission under NASA Grant NAG 2-6066 http://Kepler.nasa.gov/
JPL Navigator Public Engagement Program: http://planetquest.jpl.nasa.gov/index.html
NASA Structure and Evolution of the Universe Forum http://cfa-www.harvard.edu/seuforum/
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