1 NASA STEM Facilitation Kit

Sun-Earth-Moon Connections

NASA @ My Library

APLS

STAR net
Science-Technology Activities & Resources For Libraries

NASA@ My Library is based upon work funded by NASA under cooperative agreement No. NNX16AE30A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the *NASA@ My Library* initiative and do not necessarily reflect the views of the National Aeronautics and Space Administration.

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Section 1:

Getting Started

NASA@ My Library

A National Earth and Space Science Initiative that Connects NASA, Public Libraries and Their Communities

SPACE SCIENCE INSTITUTE | NCIL National Center for Interactive Learning

The *National Center for Interactive Learning* (NCIL) at the Space Science Institute (SSI), in partnership with the Chief Officers of State Library Agencies (COSLA), American Library Association (ALA) Public Programs Office, the Pacific Science Center, Cornerstones of Science, and Education Development Center, has launched the *NASA@ My Library* program. This national program is supported by NASA's Science Mission Directorate. Four state libraries are project partners: Washington State Library, North Dakota State Library, the Library of Michigan, and South Carolina State Library. They are helping us increase and enhance STEM (Science, Technology, Engineering and Mathematics) learning opportunities for library patrons throughout their states, including geographic areas and populations that are currently underserved in STEM education.

Through this project, participating public libraries are engaging patrons in informal, lifelong learning opportunities with hands-on activities and high-profile events. These are often conducted in collaboration with national and local organizational partners, scientists, engineers, and other STEM experts. The *NASA@ My Library* project also includes an evaluation of STEM learning in a library setting. This NASA STEM Kit (Sun-Earth-Moon Connections) is provided by your state library. Please help us evaluate its effectiveness by filling out the evaluation form (instructions are in Section 1).

NASA@ My Library is part of the STAR Library Network (*STAR Net*), a hands-on learning network for libraries and their communities across the country (www.starnetlibraries.org). *STAR Net* focuses on helping library professionals build their STEM skills by providing "science-technology activities and resources" (STAR) and training to use those resources. I encourage you to take advantage of the many resources and opportunities available through *STAR Net*, including:

- A vibrant online community of 8,500 members, all invested in bringing STEM learning experiences to library patrons
- *STAR Net*'s *STEM Activity Clearinghouse* - an online, interactive repository that packages each of 100+ STEM hands-on activities with tips on implementation in the library setting; links to related content and online video clips and suggested books
- Online and in-person training for library staff, which introduces them to the STEM content of the exhibits, and guides them in developing complementary programming
- Webinars demonstrating hands-on activities and providing tips and resources from NASA educators, Afterschool Alliance researchers, library associations, museum educators, and more
- Blogs, a monthly newsletter, and social media updates with tips and timely information on special events, *STAR Net* conference and webinar presentations, and funding opportunities
- A collection of resources from across the STEM learning and library fields about STEM learning in libraries, collaboration, diversity, and the importance of evaluation.

I also invite you to follow us on Facebook at https://www.facebook.com/STARLibraries/.

Sincerely,

Paul B. Dusenbery

Paul B. Dusenbery
Director, National Center for Interactive Learning/Space Science Institute
Project Director, *STAR Net* and its *NASA@ My Library* Initiative

How to Use This Resource

The *Sun-Earth-Moon Connections* Kit focuses on activities and experiences that better help patrons understand their place in space, and how the Sun and Moon impact our planet. Major content areas in this kit include: modeling both lunar and solar eclipses with easy to use tools, detecting ultraviolet light in a creative way, using sorting cards to explore concepts relating to size, distance, and temperature, and an experiential activity that allows for a greater understanding of the vast scale of our Solar System.

<u>Library patrons interacting with this kit will increase their understanding of the following three key concepts:</u>

- Models help us understand scale and concepts pertaining to our vast universe
- The Sun and Moon effect Earth in different ways.
- Scientific tools enable us to make more insightful observations

The binder is divided into 4 sections:

Section 1 contains a welcome letter, an inventory of all the items in this Kit, evaluation form information, and some great NASA resources. Be sure to compare the inventory list with the contents in the Kit before returning it to your state library, and also complete an evaluation for each program given with the kit.

Section 2 contains Activity Guides that describe how to use the materials in the Kit. Our goal for providing all the necessary materials for the activities is to encourage library staff to try new activities that require unique materials (e.g. UV beads, sorting cards). Some Activity Guides were developed by external partners. These guides include a cover page that creates a consistent look and feel similar to the *STAR Net*'s "Hands-on" activities in the *STEM Activity Clearinghouse*.

Section 3 includes a Quick Facilitation Guide that will help staff be better prepared to use the STEM tools included in this kit (e.g., Sunoculars). This guide provides a quick introduction on how to use this unique tool, which should help staff facilitate the activities in Section 2 or create their own unique programs (e.g., a NASA Science Saturday event).

Section 4 includes a list of the books in this kit and provides suggestions how to tie the books and activities together. Also included is a kit materials list that guides library staff on where to locate and purchase kit items.

We hope you enjoy the *Sun-Earth-Moon Connections* Kit. Please contact your state library if you need assistance.

If you'd like to explore more hands-on activities around this and other content areas, please visit our *STEM Activity Clearinghouse* (http://clearinghouse.starnetlibraries.org).

Survey Instructions

Dear Library Staff:

As part of the *NASA@ My Library* program evaluation, we are conducting a survey to collect information about library staffs' use of and thoughts about the *NASA@ My Library* kit. Your honest feedback will help the project team improve future kits and better serve your needs and the needs of other public libraries. Below you will find information about the survey and how to complete it. Please feel free to contact Melinda Smith at your State Library at msmith@apls.state.al.us if you have any questions.

Thank you for your cooperation and support,

Alabama Public Library Service

About the Survey

- The kit survey includes questions about:
  - **The people your *NASA@ My Library* programs serve**: including number of attendees, age groups, and underrepresented groups
  - **Your *NASA@ My Library* programs**: including who led the program, resources used, and any stories you have about the patron experience
  - **Your experience with kit resources**

- A copy of the survey questions is provided in the kit for your reference

How to Complete the Survey

- We ask that library staff complete one survey for **each** program that uses *NASA@ My Library* kit resources and/or involves a local Earth or space science expert (e.g. individuals from local astronomy clubs, planetariums, universities)

- Surveys can be completed at the following link: https://go.edc.org/Kit1Survey

- It should take less than 10 minutes to complete the survey

Evaluation Survey

Instructions: Please complete online at: https://go.edc.org/Kit1Survey

Library & Program Information

Program Date:	
Name of Library (branch name, city, state):	
Community Type (check one):	☐ City ☐ City/Suburb ☐ Suburb ☐ Suburb/Rural ☐ Rural ☐ Other (e.g., tribal reservation, please describe):
How did you learn about this kit? (check all that apply):	☐ State Library Website ☐ Regional Conferences or Meetings ☐ Promotional Materials (e.g., flyers, emails) from my State Library ☐ Word of Mouth ☐ Other (please describe):
Contact Name/Title:	
Contact Email:	

People Served

Total # of people in attendance:	
Age group(s) in attendance (check all that apply):	☐ Infant ☐ Pre-K ☐ Early Elementary ☐ Upper Elementary ☐ Tweens ☐ Teens ☐ Adults ☐ Seniors
Did families attend (check one):	☐ Yes ☐ No
Which underserved audiences did you specifically reach out to for this program? (check all that apply):	☐ African-Americans ☐ Alaska Natives ☐ American Indians ☐ Hispanics and Latinos ☐ Native Hawaiians and Pacific Islanders ☐ People with Disabilities ☐ Economically Dsisadvantaged ☐ Women and Girls ☐ Rural Audiences ☐ None ☐ Other (please describe): Please share how you specifically reached out to these underserved groups:
Please share any other special promotional efforts used for this program:	

NASA @ My Library STAR net Science-Technology Activities & Resources For Libraries

Evaluation Survey

Program Description

Who led or co-led the program (check all that apply):	☐ Library Staff ☐ Library Volunteers ☐ Local Science Experts (e.g., individuals from local astronomy clubs, planetariums, unversities) ☐ Other (please describe):
If you brought in a local science expert:	Please describe who they were and what they did at the program: Did your State Library help connect you with the local science expert? ☐ Yes ☐ No
Which items from the kit did you use? (check all that apply):	☐ Modeling Meaningful Eclipses ☐ UV Kid ☐ Sorting Games: How Big? How Far? How Hot? ☐ Jump to Jupiter ☐ Books from the *NASA@ My Library* Kit ☐ Sunoculars for Solar Viewing
Which of these additional resources did you use? (check all that apply):	☐ *STAR Net STEM Activity Clearinghouse* (clearinghouse.starnetlibraries.org) ☐ Other professionally created materials/programs (please describe): ☐ Other Source (e.g., other resources provided by your State Library; please describe): ☐ None
If you visited the online *STAR Net STEM Activity Clearinghouse*:	What was helpful? What could be improved? Do you plan to use the Clearinghouse for additional STEM programs ☐ Yes ☐ No
Do you have any stories or quotes from patrons that you'd like to share?	

Evaluation Survey

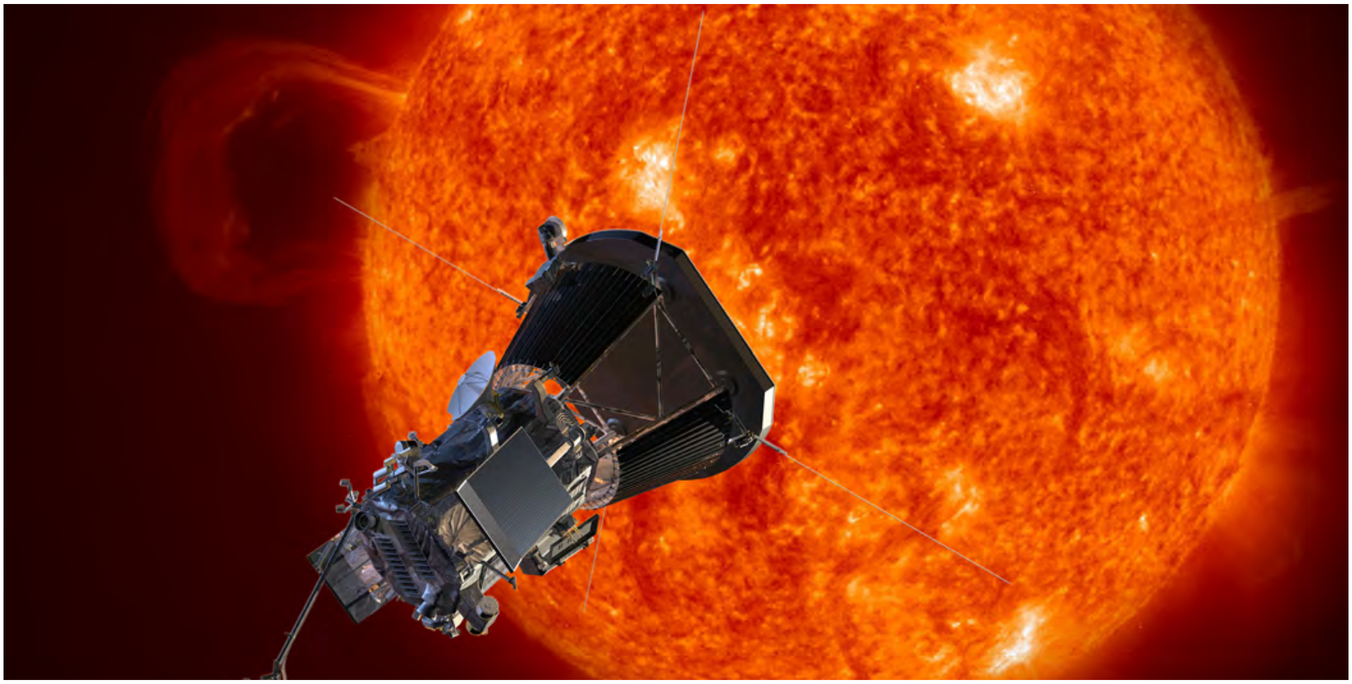
Public Library Experiences with Kit Resources

How satisfied or not satified were you with the following:	Not Satisfied	Slightly Satisfied	Moderately Satisfied	Very Satisfied	Extremely Satisfied	Not Applicable
The kit reservation process	☐	☐	☐	☐	☐	☐
State Library support in the use of the kit	☐	☐	☐	☐	☐	☐
State Library assistance in accessing other resources such as Earth and space science experts	☐	☐	☐	☐	☐	☐

How much do you agree or disagree with the following:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The kit was easy to use	☐	☐	☐	☐	☐
I would be interested in receiving more kits like this one	☐	☐	☐	☐	☐
Our library patrons appeared to enjoy the program	☐	☐	☐	☐	☐

Is there anything else you would like us to know about your program or your experience using the kit?

NASA Mission Spotlight: Parker Solar Probe



Credit: NASA

NASA's Parker Solar Probe is scheduled for launch on July 31, 2018, from Cape Canaveral Air Force Station, Florida. The spacecraft will explore the Sun's outer atmosphere and make critical observations that will answer decades-old questions about the physics of how stars work. The resulting data will improve forecasts of major space weather events that impact life on Earth, as well as satellites and astronauts in space.

Parker Solar Probe Gets Its Revolutionary Heat Shield

Credit: Applied Physics Lab/NASA

Sept. 25, 2017. Engineers install the revolutionary heat shield that will protect the first spacecraft to fly directly into the Sun's atmosphere. This thermal protection system is made of a 4.5-inch-thick carbon composite that will reach temperatures of 2,500 F while at the Sun.

Mission Website:
http://parkersolarprobe.jhuapl.edu/

Section 2:

Activity Guides

Modeling Meaningful Eclipses (Yardstick Eclipse Demonstration)

Using a large and small ball, a yardstick, and other simple materials, participants explore the vast distance between the Earth and Moon. Advanced learners use these materials to explore further: they use bright light (such as from the Sun) to model how solar and lunar eclipses happen. If it is too cloudy to use sunlight as the light source, use a very bright light, like an LED flashlight, instead. Be sure to practice this activity before your program – it is a bit tricky to get the "Moon" and "Earth" balls to line up correctly the first time. Check out the how-to video at https://youtu.be/gccoj9T9ycg for a demonstration.

Credit: Space Science Institute

Content Area:
- Astronomy and Space

Age Group:
- Family
- Early Elementary
- Tweens (9-12)
- Teens
- Adults

Time to Complete Activity:
20-40 minutes

Time Needed to Prep Activity:
10-20 minutes

Cost Associated with Materials:
$5-$10

Difficulty Level:
Medium

Mess Level:
Low

Key Concepts

- The distance between the Earth and Moon is large compared to their sizes.
- Models can be used to answer questions, such as: "What is the difference between a solar and a lunar eclipse?" and "When can you see an eclipse?"

Build a Program with Related Resources

STEM ACTIVITY Clearinghouse

Consider setting the stage with explorations of the Moon's phases through activities such as *Lunar Phases: A Dance Under the Sun and Moon Over My Town*. Explore the sizes of the Moon and Earth further through the activity, *Big Sun, Small Moon*, and create a model of the solar system with *Jump to Jupiter*. Consider using Sunoculars alongside this activity.

Have learners use their sense of touch by exploring the NASA tactile book, *Getting a Feel for Eclipses*. The book includes tactile graphics that illustrate the interaction and alignment of the Sun with the Moon and Earth. NASA tactile books are designed to bring NASA's discoveries to those who are visually impaired or blind, and can also help sighted learners.

Use the tablet to add digital games and interactives to your program! Find hidden features on the Sun using Solar Vision, or give patrons a chance to try *Star Maze*.

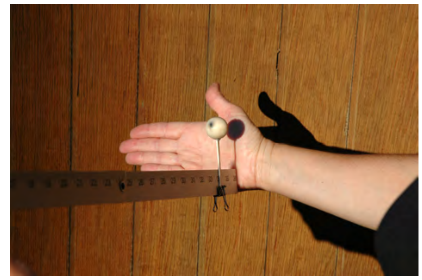
Add Your Review of This Activity

There are many STEM educational resources available to use in programs. We hope that you will give this activity a try! Then, **help others find the "best of the best" by writing a review** on the STEM Activity Clearinghouse. Email your favorite activities directly to a colleague!

Originating Source:
Modeling Meaningful Eclipses (Yardstick Eclipse Demonstration) was developed by the Astronomical Society of the Pacific and is part of the NASA portfolio of educational resources available through NASAWavelength.org.

Modeling Meaningful Eclipses

Use questions to deepen eclipse understanding



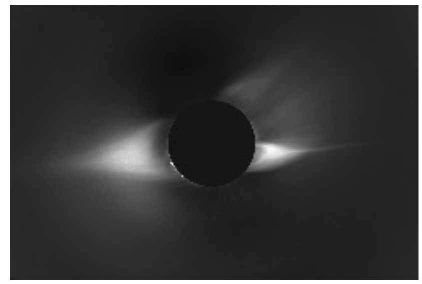


Photo Credit Fred Espenak

About the Activity

Using simple materials, participants create 3D models of the Earth, Moon and Sun and demonstrate solar and lunar eclipses. This method uses 3 steps that allow learners to engage, explore, and make meaning.

Topics Covered

- What is the difference between a solar and a lunar eclipse?
- When can you see an eclipse?

Participants

Use this activity with families, the general public, and school or youth groups ages 7 and up.

Location and Timing

Investigate Modeling Eclipses outside while the Sun is out or in a room with one bright light. Depending on level of investigation, can take between 20 - 45 minutes.

Materials Needed

The Sun or a bare light bulb if inside
An image of a solar or lunar eclipse (included or use your own)

Per group of 3-4:

- 1 Yard/Meter stick
- 1” (2.5cm) ball on a toothpick
- ¼" (7 mm) bead on a toothpick
- Binder clips to attach toothpicks to the yard stick 30 inches (75 cm) apart

(Optional) Eclipse glasses- see Helpful Hints

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: *Why Does the Moon Have Phases?*

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.

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

Modeling Meaningful Eclipses

If you don't have time for this thorough exploration, see a quick demo here: *[Why Do Eclipses Happen?]*

Note to Facilitator:

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) **Make Meaning** – see how a model relates to what they observe

Detailed Activity Description

1) Engage – pique their interest

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

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?"

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

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

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:

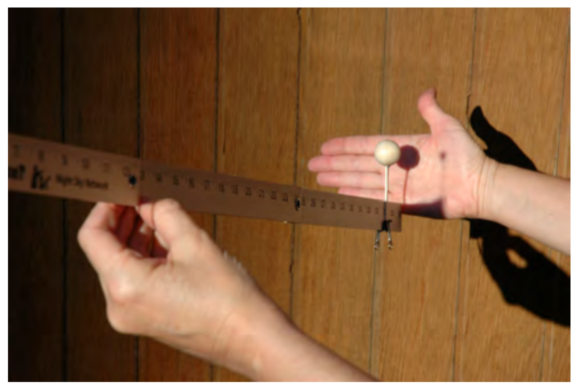
“How would you arrange the materials to recreate the earlier image of an eclipse?”

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.

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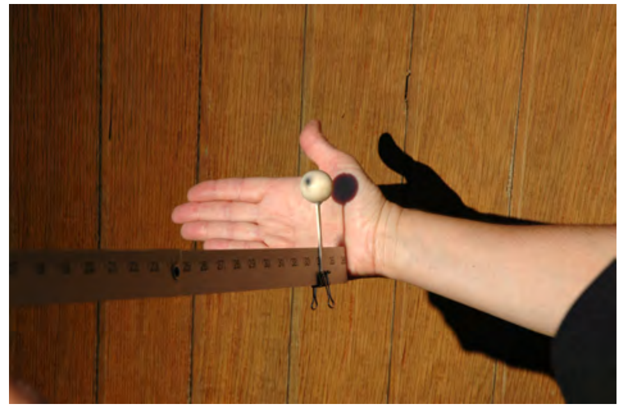
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

3) Make Meaning – learners now 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/new moon occur?" and "How often do we have lunar/solar eclipses?"
   - The materials for the *Why Don't Eclipses Happen Every Month?* activity may prove useful. Remember, don't answer every question. Encourage exploration. It is more powerful for the learner to discover phenomena 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.

Helpful Hints

Where to find materials

Eclipse Glasses:
- ASP: http://www.astrosociety.org click on "AstroShop"
- Search the internet for "eclipse glasses"
- From http://www.rainbowsymphony.com

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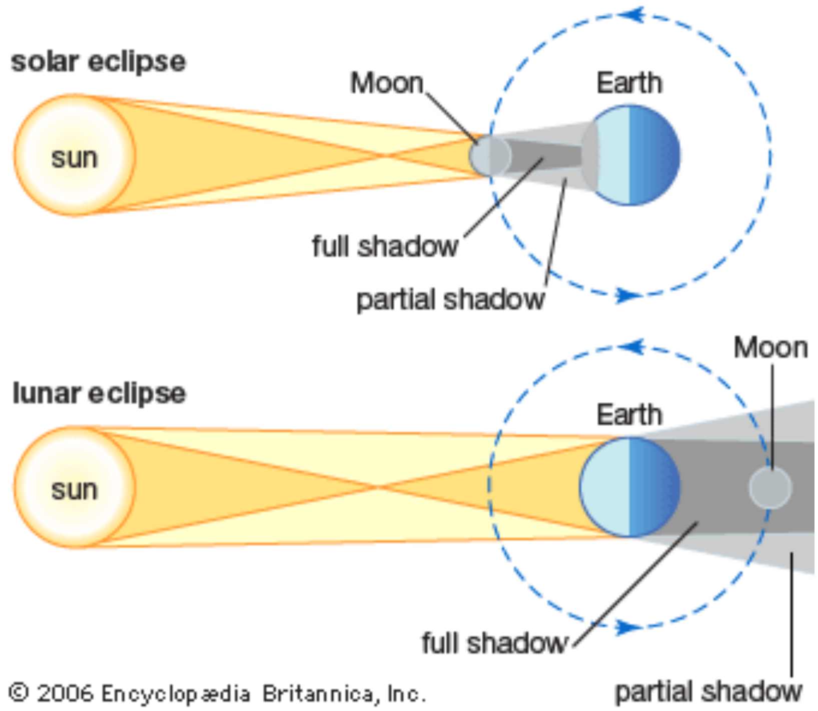
Additional astronomy activities can be found here: http://nightsky.jpl.nasa.gov

Background Information

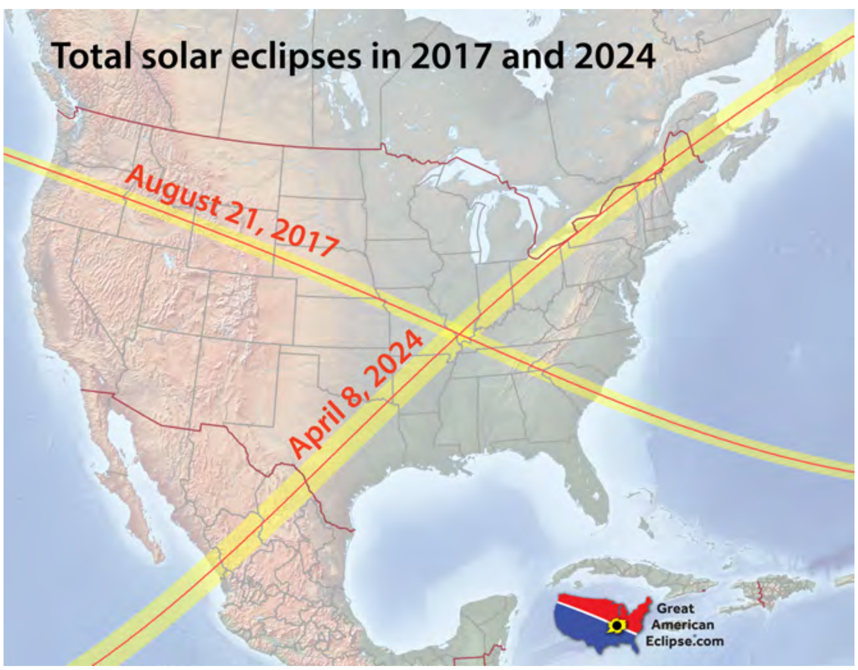
Eclipses

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



(illustration not to scale)

Upcoming Total Solar Eclipses in the USA:



Solar Eclipse **dates** around the world on the following page from:
http://eclipse.gsfc.nasa.gov/SEdecade/SEdecade2011.html

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

Schedule of upcoming *Lunar* Eclipses:

Date	Eclipse Type	Total Duration	Geographic Region of Eclipse Visibility
2016 Mar 23	Penumbral	-	Asia, Aus., Pacific, w Americas
2016 Sep 16	Penumbral	-	Europe, Africa, Asia, Aus., w Pacific
2017 Feb 11	Penumbral	-	Americas, Europe, Africa, Asia
2017 Aug 07	Partial	01h55m	Europe, Africa, Asia, Aus.
2018 Jan 31	Total	03h23m	Asia, Aus., Pacific, w N.America
2018 Jul 27	Total	03h55m	S.America, Europe, Africa, Asia, Aus.
2019 Jan 21	Total	03h17m	c Pacific, Americas, Europe, Africa
2019 Jul 16	Partial	02h58m	S.America, Europe, Africa, Asia, Aus.
2020 Jan 10	Penumbral	-	Europe, Africa, Asia, Aus.
2020 Jun 05	Penumbral	-	Europe, Africa, Asia, Aus.
2020 Jul 05	Penumbral	-	Americas, sw Europe, Africa
2020 Nov 30	Penumbral	-	Asia, Aus., Pacific, Americas

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

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

Method of Questioning Used Here

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/

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UV Kid

Kids love the creative aspects of *UV Kid*, and they're amazed to discover that, by using special (but inexpensive) ultraviolet-sensitive beads, they have their very own scientific UV detector! This activity has tested well in programs with ages as young as four (with help from older children or adults) up to about age 13.

Credit: American Library Association

Key Concepts

- Ultraviolet (UV) radiation comes from our Sun.
- While some UV radiation is necessary, too much can harm humans (and other living organisms).
- Engineers and scientists work to keep astronauts safe from UV radiation in space — just like we must protect ourselves from harmful UV radiation here on Earth!
- Scientific tools – like UV beads – enable observations we can't make with our senses.

Build a Program with Related Resources

STEM ACTIVITY Clearinghouse

Combine this activity with other hands-on activities relating to Earth science, the Sun, or healthy living. Use *UV Kid* to explore how Earth's atmosphere serves to protect us, and pair it with other activities relating to the atmosphere. *UV Kid* also provides excellent tips for healthy living by emphasizing the need for protection from the Sun's ultraviolet radiation. Consider using Sunoculars alongside this activity.

Use the tablet to add digital games and interactives to your program! Find hidden features on the Sun using *Solar Vision*, or give patrons a chance to try *Star Maze*.

Add Your Review of This Activity

There are many STEM educational resources available to use in programs. We hope that you will give this activity a try! Then, **help others find the "best of the best" by writing a review** on the STEM Activity Clearinghouse. Email your favorite activities directly to a colleague!

Content Area:
- Earth Science
- Astronomy and Space
- Health Science

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens (9-12)

Time to Complete Activity:
40 minutes to 1 hour

Time Needed to Prep Activity:
20-40 minutes

Cost Associated with Materials:
$1-$5

Difficulty Level:
Easy

Mess Level:
Low

Originating Source:
UV Kid was developed by the Lunar and Planetary Institute and is part of the NASA portfolio of educational resources available on NASAWavelength.org.

Explore!

UV Kid!

Overview

Children use common craft materials and ultraviolet (UV)-sensitive beads to construct a person (or dog or imaginary creature): UV Kid! They use sunscreen, foil, paper, and more to test materials that might protect UV Kid — and ourselves! — from being exposed to too much UV radiation.

Activity Time

60 minutes

Intended Audience

Families or other mixed-age groups, including children as young as 4 years old *with assistance from an older child, teen, or adult*
School-aged children ages 5–7 and 8–9
Tweens up to about age 13

Type of Program

☑ Facilitated hands-on experience
☑ Station, presented in combination with related activities
☐ Passive program
☐ Demonstration by facilitator

What's the Point?

- Ultraviolet radiation comes from our Sun
- While some UV radiation is necessary, too much can harm humans (and other living organisms)
- Engineers and scientists work to keep astronauts safe from UV radiation in space — just like we must protect ourselves from harmful UV radiation here on Earth!

Facility Needs

☐ 3 or more tables
☐ Optional: 15–20 chairs arranged at the table(s) for groups or families to sit together
☐ An outdoor area close by that has both shady and sunny spots, if possible

Materials

For the Facilitator

☐ *Facilitator Background Information* (below)
☐ *Brief Facilitation Outline* (below)

LUNAR AND PLANETARY INSTITUTE
Explore! Health in Space
Lunar and Planetary Institute, Contribution Number 1365
Universities Space Research Association (USRA)
www.lpi.usra.edu/explore

For Each Group of 10–15 Children

- ☐ 30–45 UV beads, available in craft stores as well as through online retailers such as:

  Educational Innovations
  www.teachersource.com

  Steve Spangler Science
  www.stevespanglerscience.com

- ☐ 20–30 *non*-UV pony beads
- ☐ 20–30 chenille sticks in a variety of colors, including at least white, tan, and brown to reflect a diversity of skin colors
- ☐ 3 or more pairs of scissors
- ☐ Various common materials to test for "protecting" UV Kid from UV radiation, such as:
  - ☐ 15 or more sheets of construction paper (in various colors)
  - ☐ 15 or more sheets of copy paper (preferably reused)
  - ☐ 1 roll of aluminum foil
  - ☐ 1 roll of plastic wrap (in various colors)
  - ☐ 5 pairs of paper sunglasses (may be obtained from an optometrist)
  - ☐ 1 (1 oz.) bottle of sunscreen, SPF 30
  - ☐ 1 (1 oz.) bottle of sunscreen, SPF 50
  - ☐ 1 pair of sunglasses that block 99% or 100% of UVB and UVA rays, meet American National Standards Institute Z80.3 blocking requirements, or provide UV 400 protection (since the UV-protective coating is clear, the lenses can be light- or dark-colored)
  - ☐ 1 roll of masking tape
  - ☐ 10 or more strips of cloth
  - ☐ Optional: containers of water

The UV-sensitive beads used in this activity serve as UV radiation detectors. They change color when exposed to UV radiation from the Sun or from UV lights. The brightness of the color corresponds to the intensity of the UV radiation. When shielded from UV sources, or when exposed to light that does not contain UV radiation — such as indoor light bulbs — the beads remain white. The beads are designed for multiple use and, according to the manufacturers, will change color up to 50,000 times.

A child at Sterling Municipal Library (Baytown, Texas) created a UV Kid using beads and chenille sticks. Later in the program, she took her creation outdoors to observe that the special "UV beads" change colors when exposed to UV radiation in direct sunlight and even in shade!

Credit: Sterling Municipal Library and the Lunar and Planetary Institute.

Supporting Media

Websites

NASA's Spot The Station
http://spotthestation.nasa.gov
As the third-brightest object in the sky, the International Space Station is easy to see if you know when to look up. Use NASA's Spot The Station service to find upcoming sighting opportunities for several thousand locations worldwide. Plus, sign up to receive notices of opportunities via e-mail or text message!

International Space Station
www.nasa.gov/mission_pages/station
Find information about the space station, its international crew, and how they live and work in space.

Tour of the Electromagnetic Spectrum
http://missionscience.nasa.gov/ems
Explore the amazing world beyond the visible! Text and images introduce electromagnetic waves, where they come from, how they behave, and how scientists use them. In addition to the website, a book is available for download as a PDF, and there is a companion video. Appropriate for ages 12 and up.

Handouts

SunWise Program (U.S. Environmental Protection Agency)
http://www2.epa.gov/sunwise
The EPA's SunWise Program offers a toolkit and a variety of downloadable resources in English and in Spanish, some of which offer fun comparisons to the sun-safety habits of animals.

Preparation

Six months before the activity

- Prepare and distribute publicity materials for programs based on this activity. If possible, build on the children's knowledge by offering multiple science, technology, engineering, art, and mathematics (STEAM) programs.
- Order UV beads and other materials that may not be readily available.
- Review the *Facilitator Background Information*.
- Plan for any introductory activities or extensions that you'd like to incorporate with this activity. Consider using an "icebreaker" activity to help the children get to know each other.
- For young children, plan to provide assistance with cutting and threading the beads on the chenille sticks. Consider allowing extra time for this activity for young children.
- Create a UV Kid to serve as an example for the children to follow.

The day before the activity

- Place the example UV Kid where everyone can access it.
- Arrange the materials on the tables so that participants can access them.

Activity

1. Share ideas and knowledge.

- Introduce yourself. Help the children learn each other's names (if they don't know each other already).
- Frame the activity with the main message: Engineers work to keep astronauts safe from UV radiation in space — just like we must protect ourselves from harmful UV radiation here on Earth!

Humans need UV radiation because our skin uses it to manufacture vitamin D — vital for maintaining healthy bones. About 10 minutes of Sun each day allows our skin to make the recommended amount. However, too much UV exposure causes the skin to burn and leads to wrinkled and patchy skin, skin cancer, and eye damage.

On Earth, we are protected by our atmosphere from most UV radiation coming from the Sun. The ozone layer absorbs much of the UV, but some still gets through. We can protect ourselves by covering with clothing and using sunscreen.

In space there is no atmosphere to protect astronauts from UV radiation. Astronauts have to provide their own protection in the form of space suits, helmets with protective visors, and space stations. While these measures work very well for protecting against UV radiation, the higher-energy radiation is not completely blocked. Even with protective shielding, astronauts onboard the International Space Station receive a daily dosage of radiation about equal to eight chest X-rays! Astronauts wear special radiation detectors — dosimeters — that help determine how much exposure they have had to radiation.

- Invite the children to talk about what they already know about UV radiation, what they've experienced at home, and how they protect themselves in their daily lives. Use open-ended questions and invite the children to talk with you and each other.

Use discussion to help them start to think about prior experiences and build new understandings about UV radiation and ways to protect ourselves from it, both on Earth and in space. Some conversation-starters are:

- Have you ever had a sunburn?
- What do you think causes sunburns?
- How do you protect yourself from getting sunburned?

For older children, guide the conversation toward identifying the Sun as the source of UV energy or radiation. Clarify that this energy is invisible to our eyes and we cannot feel it, but it still affects our bodies. As necessary, explain that Earth's atmosphere blocks much of the Sun's UV light. The ozone layer in our upper atmosphere forms a protective sphere, absorbing much of the UV energy.

2. Guide the children in each creating a person or creature with a built-in UV-radiation "detector." Explain that they will incorporate UV beads, which are made from a special pigment that is very sensitive and turns colors when exposed to UV rays. With the help of UV Kid, they will investigate the source of UV radiation and how we can best protect UV Kid — and ourselves! — from it. Have the children follow these steps to create a UV Kid (and make their own variations, if they'd like!):

a. Cut two pipe cleaners in half.
b. Fold one piece in half; these will be his/her legs.
c. Connect a second piece to the legs to make his/her torso.
d. Thread the beads onto his/her torso, alternating UV with non-UV beads. Slide all the beads toward UV Kid's legs.
e. Twist the third piece around the torso above the beads to make his/her arms.
f. Form a circle with the last piece and use it for his/her head.

3. Observe UV Kid's UV radiation detectors (i.e., the UV beads) indoors, in shade, and finally, in full sunlight. Encourage the participants to discuss their predictions first, then their observations, with each other and with you. Be thoughtful about your approach and keep the UV beads covered when walking outside to a shady spot. After making observations, "reset" the beads by covering them for about one minute and have a discussion to predict what will happen in full sunlight. After moving to full sunlight, continue making observations and discussing possible explanations for those observations.

The color of the UV beads remain white or creamy indoors. In shade, the UV beads become lightly colored, indicating that, even in the shade, there is some UV radiation reaching the detectors and our skin. In full sunlight, the UV beads become deeply colored, reacting to the intensity of the UV radiation to which they are being exposed.

Allow the children's thinking to be shaped by the experience — refrain from giving any of your own conclusions or expectations. Encourage them to talk to each other (in pairs or small groups) as they note their observations and form predictions about how the UV beads will change in the different settings. Ask questions to help them explain their conclusions, e.g., that the UV beads become brightly colored in full sunlight because UV radiation from the Sun is falling on them. Some children may say light caused them to change, and others may say heat. Remind them of their observations about the beads inside; the beads were white, even though they were in the light of the room. Ask them what happened to their beads when they brought them back inside; the beads changed from a colored state in the Sun back to white in the room light. Light does not affect the beads. If it is heat that causes the change, invite the children to hold beads in their fists; the beads do not change color when heated. They can also heat the beads with a hair dryer. The cause of the change comes from the Sun; it is from the part of the Sun's spectrum we do not see or feel directly.

4. **Test two materials to see if they protect UV Kid from UV radiation.** Once indoors, continue making observations about the beads' appearance and discussing possible explanations for those observations. Generate ideas for how the children might prevent the beads from changing again in full sunlight. Use everyday experiences, such as wearing clothing, using sunscreen, using umbrellas, or staying inside, to consider how UV Kid — and astronauts in space — can similarly protect themselves. Invite the children to thoughtfully test different materials:

    a. Make a construction paper poncho or shirt to cover the top UV bead.
    b. Select two additional materials and use them to cover other UV beads.
    c. Take UV Kid into full sunlight and observe how the UV beads do or do not change.
    d. In pairs or small groups, discuss ideas for why some materials protect UV Kid better than others and share those ideas with the whole group.

5. **Conclude.** Summarize that we encounter UV radiation every day from sunlight. While some UV radiation is necessary for our health, too much can harm humans (and other living organisms). Overexposure to UV radiation causes the skin to burn, sometimes badly (ouch!!). Extreme or excessive burning of the skin can lead to skin cancer. UV radiation can harm our eyes, as well. Engineers and scientists test materials — just like the children did — to find ways to keep astronauts safe from UV radiation in space. On Earth, we can protect ourselves from harmful UV radiation by wearing protective clothing, using sunscreen, wearing sunglasses, not staying out in the Sun for extended periods, and not expecting the shade to protect them. Challenge the group to continue testing UV Kid's protective materials in other settings, such as inside a car or outdoors on cloudy days.

Extension

Challenge the participants to use craft items to construct and decorate a space capsule for UV Kid! Offer a variety of building materials, such as:

- *Miscellaneous craft and everyday items:* Straws, aluminum foil, plastic wrap (of all colors), old CDs, pipe cleaners, toothpicks, wire, wire cutters, Legos®, construction paper (variety of colors, including black), tinsel, ribbon, fabric, gauze, wood dowels/skewers, rubber bands, shiny streamers, etc.
- *For spacecraft body:* Pint-sized milk containers, coffee cans, soup cans (tape all sharp edges), disposable cups, empty (clean) Play-Doh® containers, black plastic or biodegradable seedling (plant) trays, paper towel tubes, empty egg cartons, cereal boxes, 2-liter soda bottles, different-sized Styrofoam blocks, other empty plastic or cardboard containers/boxes, etc.
- *Other:* Use your imagination and best judgment for providing safe, fun, and readily available materials!

Offer illustrations of the engineering design process (The Works or Design Squad are good options), and encourage the participants to iteratively test and change their designs — just like professional engineers do!

Correlation to Standards

Next Generation Science Standards[1]

Performance Expectations

3-5-ETS1-3. Engineering Design. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
4-PS3-2. Energy. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- •When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (UV, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

PS3.B: Conservation of Energy and Energy Transfer

- Light also transfers energy from place to place.

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects.
- Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

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[1] Excerpted from NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

Nature of Science: Scientific Investigations Use a Variety of Methods

- Science investigations use a variety of methods and tools to make measurements and observations.

Science and Engineering Practices

Asking Questions and Defining Problems

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.

Planning and Carrying Out Investigations

- Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- Make predictions about what would happen if a variable changes.
- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meets the goals of the investigation.

Science and Engineering Practices: Analyzing and Interpreting Data

- Analyze and interpret data to provide evidence for phenomena.
- Analyze and interpret data to determine similarities and differences in findings.
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Constructing Explanations and Designing Solutions

- Apply scientific ideas to solve design problems.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.
- Apply scientific ideas or principles to design an object, tool, process, or system.
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Explore!

UV Kid!

Facilitator Background Information

Light and heat are part of the spectrum of energy — or radiation — our Sun provides. We can “see” light and we can “feel” heat. Yet our Sun also produces other types of energy that we can’t see or feel. Radio waves, microwaves, UV rays, X-rays, and gamma-rays are all parts of the spectrum of electromagnetic energy — or radiation — from the Sun.

Radio waves, microwaves, visible light, and infrared radiation have relatively long wavelengths and low energy. Ultraviolet rays, X-rays, and gamma-rays have shorter wavelengths and higher energy. These shorter wavelengths are so small that these wavelengths interact with human skin, and cells, and even parts of cells — for good or for bad!

Our Sun also produces cosmic radiation. Cosmic rays are very-high-energy, fast-moving particles (protons, electrons, and neutrinos) that can damage DNA, increasing the risk of cancer and causing other health issues. Cosmic rays have such high energy that it is difficult to design shielding that blocks them. Cosmic rays do not only come from our Sun, but from other places in our galaxy and universe. Earth’s magnetic field extends into space beyond the atmosphere, and provides some protection to astronauts aboard the International Space Station from cosmic rays.

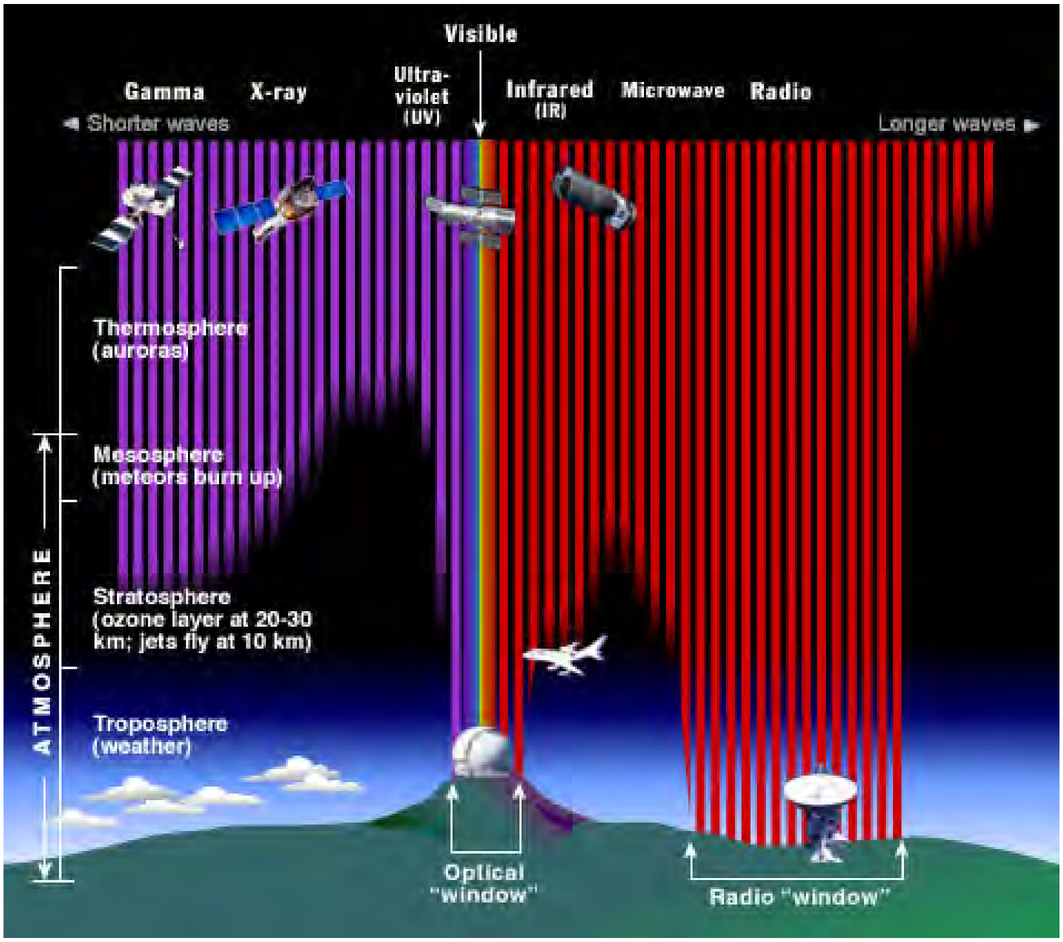
From low-energy radio waves (shown at the top) to high-energy X-rays and gamma rays (shown at the bottom), we encounter different parts of the electromagnetic spectrum in our daily lives.

Credit: NASA

Earth’s atmosphere protects us from most of the high-energy cosmic, gamma, and X-ray radiation — and much of the UV portion of the spectrum (UVB and UVC). Some UV radiation still gets through the atmosphere (UVA and a bit of UVB). Humans need UV radiation because our skin uses it to manufacture vitamin D, which is vital to maintaining healthy bones. About 10 minutes of Sun each day allows our skin to make the recommended amount of vitamin D. However, too much exposure to UV causes the skin to burn and leads to wrinkled and patchy skin, skin cancer, and eye damage. We can protect ourselves by covering up, limiting our time in the Sun, and using sunscreen.

LUNAR AND PLANETARY INSTITUTE

Explore! Health in Space
Lunar and Planetary Institute, Contribution Number 1365
Universities Space Research Association (USRA)
www.lpi.usra.edu/explore



Earth's atmosphere prevents high-energy gamma and X-rays, as well as much of the UV portion of the spectrum, from reaching the ground. As this illustration shows, only some UV radiation, visible light, and some radio waves reach Earth's surface. Other types of radiation reach various levels of Earth's atmosphere before they are blocked.

Credit: Space Telescope Science Institute/John Hopkins University/NASA

In space there is no atmosphere to protect astronauts from UV radiation — or from X-rays and gamma rays, or even more dangerous cosmic rays. Astronauts have to provide their own protection in the form of space suits and spacecraft. They work in spacecraft that have special shielding, wear special suits when they work outside of the spacecraft, and even have special visors to protect their eyes. NASA tests different materials and coatings for spacecraft and space suits to protect the astronauts. These measures work very well for protecting against UV radiation, but the higher-energy radiation is not completely blocked. Even with protective shielding, astronauts onboard the International Space Station receive a *daily* dosage of radiation equal to about eight chest X-rays! Astronauts wear instruments, called dosimeters, that monitor how much radiation each of them has received. Once they reach certain levels, they do not continue to work in space.

UV Kid!

Brief Facilitation Outline

1. Share ideas and knowledge.

- Introduce yourself. Help the children learn each other's names (if they don't already).
- Frame the activity with the main message: Engineers work to keep astronauts safe from UV radiation in space — just like we must protect ourselves from harmful UV radiation here on Earth!
- Invite the children to talk about what they already know about UV radiation, what they've experienced at home and how they protect themselves in their daily lives. Use open-ended questions and invite the children to talk with you and each other.

2. Guide the children in each creating a person or creature with a built-in UV-radiation "detector." Explain that they will incorporate UV beads, which are made from a special pigment that is very sensitive and turns colors when exposed to the UV rays. With the help of UV Kid, they will investigate the source of UV radiation and how we can best protect UV Kid — and ourselves! — from it. Have the children follow these steps to create a UV Kid (and make their own variations, if they'd like!):

a. Cut two pipe cleaners in half.
b. Fold one piece in half; these will be his/her legs.
c. Connect a second piece to the legs to make his/her torso.
d. Thread the beads onto his/her torso, alternating UV with non-UV beads. Slide all the beads toward UV Kid's legs.
e. Twist the third piece around the torso above the beads to make his/her arms.
f. Form a circle with the last piece and use it for his/her head.

3. Observe UV Kid's UV radiation detectors (i.e., the UV beads) indoors, in shade, and finally, in full sunlight. Encourage the participants to discuss their predictions first, then their observations, with each other and with you. Be thoughtful about your approach and keep the UV beads covered when walking outside to a shady spot. After making observations, "reset" the beads by covering them for about one minute and have a discussion to predict what will happen in full sunlight. After moving to full sunlight, continue making observations and discussing possible explanations for those observations.

4. Test two materials to see if they protect UV Kid from UV radiation. Once indoors, continue making observations about the beads' appearance and discussing possible explanations for those observations. Generate ideas for how the children might prevent the beads from changing again in full sunlight. Use everyday experiences, such as wearing clothing, using sunscreen, using umbrellas, or staying inside, to consider how UV Kid — and astronauts in space — can similarly protect themselves. Invite the children to thoughtfully test different materials:

a. Make a construction paper poncho or shirt to cover the top UV bead.
b. Select two additional materials and use them to cover other UV beads.

c. Take UV Kid into full sunlight and observe how the UV beads do or do not change.
d. In pairs or small groups, discuss ideas for why some materials protect UV Kid better than others and share those ideas with the whole group.

5. **Conclude.** Summarize that we encounter UV radiation every day from sunlight. While some UV radiation is necessary for our health, too much can harm humans (and other living organisms). Overexposure to UV radiation causes the skin to burn, sometimes badly (ouch!!). Extreme or excessive burning of the skin can lead to skin cancer. UV radiation can harm our eyes, as well. Engineers and scientists test materials — just like the children did — to find ways to keep astronauts safe from UV radiation in space. On Earth, we can protect ourselves from harmful UV radiation by wearing protective clothing, using sunscreen, wearing sunglasses, not staying out in the Sun for extended periods, and not expecting the shade to protect us. Challenge the group to continue testing UV Kid's protective materials in other settings, such as inside a car or outdoors on cloudy days.

Sorting Games: How Big? How Far? How Hot?

Image 2016 ALA Conference Credit: ALA

This *NASA@ My Library Activity Guide* will help library staff facilitate these sorting activities in large or small groups, with patrons from Pre-K to adult. These simple and engaging activities introduce younger patrons to concepts such as size, distance, and temperature, and allow older patrons to explore these concepts further. They are excellent engagement activities for learners to begin thinking about our place in space.

Ages – Pre-K to family/adult

Materials List – 3 card decks in Kit A

Activity Time – 10-30 minutes

Type of Program – Stations, stand-alone activity, ice-breaker activity

Key Concepts

How Big?

- There are many different types of objects in the Universe.
- These objects have different physcial sizes and can be organized relative to one another by their size.

How Far?

- There are many different types of objects in the Universe.
- They are located at various distances from us and can be organized by their relative distance from Earth.

How Hot?

- Temperature is an important property of an object.
- Objects on our planet and in our Universe have widely different temperatures and can be organized by their average temperature.

Simple Instructions - How Big?

- This is the card deck with the Lions on top (**color-coded, green**).
- Relative size is usually easier for people than relative distance (see How Far?).
- Ask participants to each grab a card (or a few, if you have a small group) and line up in the correct order for the objects (from smallest to largest)
- The correct order for this activity is: Lions, International Space Station, Moon, Mars, Earth, Jupiter, Sun, Solar System, Andromeda Galaxy (see images at the end of this guide).

Simple Instructions - How Big? (continued)

- When participants get stuck, consider providing the following hints (remember, you're a "guide on the side" – you don't need to provide correct answers, just start a discussion!):
  - The International Space Station is slightly larger than length of a football field.
  - Earth and Mars have the same amount of dry land mass but what extra does Earth have? Answer is water.
  - 1 million Earth's would fit inside the Sun.

Frequently Asked Questions:

- Why do the Sun and the Moon appear to be the same size in the sky?
  The diameter of the Sun is 400 times greater than the diameter of the Moon. But the Sun is 400 times farther from Earth. That is why you can see a total eclipse of the Sun, during which the Moon blocks the light from the Sun.
- What are the differences between a planet and a star?
  A star is much bigger and much more massive. A star shines with its own light; a planet reflects light from a star. Planets orbit around stars.
- What is the difference between our Solar System and a galaxy?
  Our Solar System has a star at its center called the Sun. There are eight planets that orbit around the Sun and many other objects like asteroids. The Sun is the only star in our Solar System. On the other hand, there are about a trillion stars in the galaxy pictured (Andromeda), and many of them likely have their own planets! Could life exist on any of these planets? Is there life beyond Earth?

Simple Instructions - How Far?

- This is the card deck with the Soaring Eagle on top **(color-coded, blue)**.
- Ask participants to grab a card (or a few if you have a small group) and line up in the correct order for the objects (from closest to farthest away from Earth).
- The correct order for this activity is: Eagle, Jet, Aurora, Hubble Space Telescope, Moon, Sun, Saturn, Orion Nebula, Andromeda Galaxy (see images at the end of this guide).
- If participants are getting stuck, consider providing the following hints (remember, you're a "guide on the side" – you don't need to provide correct answers, just start a discussion!):
  - Eagles can fly very high (about 10,000 feet) though jets can fly higher (about 35,000 feet).
  - Aurora's happen in the highest levels of Earth's atmosphere (about 100 miles up).
  - The Hubble Space Telescope is in space and orbits Earth about 350 miles about the surface.
  - The Moon is 240,000 miles, the Sun is 93 million miles, and Saturn is 1 billion miles from Earth.
  - Constellations are all made up of stars within our own Milky Way Galaxy. Distances at this scale are measured in light-years, the distance light travels in one year (about 6 trillion miles).

Frequently Asked Questions:

- Why do the Sun and the Moon appear to be the same size in the sky?
- The diameter of the Sun is 400 times greater than that of the Moon, but the Sun is 400 times farther from the Earth than the Moon. That is why you can see a total eclipse of the Sun, during which the Moon blocks the light from the Sun.
- How far from Earth's surface are auroras?
  Auroras are found from 95-190 kilometers (about 60-120 miles) above Earth's surface.

Simple Instructions - How Far? (continued)

- How far from Earth's surface is the International Space Station?
- The International Space Station orbits around Earth at a distance of 600 kilometers (373 miles).
- How far from Earth is the Sun?
  The Sun is 1 Astronomical Unit = 150,000,000 kilometers (93 million miles) from Earth.
- How far from Earth is Saturn?
  From 9 AU to 11 AU (about 1 billion miles away). It depends on which side of the Sun Saturn is, relative to Earth.
- How far away are the stars we see at night?
  That depends on the star. The brightest stars of the Big Dipper, for example, are between 70 and 100 light-years from Earth. A light-year is about 10 trillion kilometers (6 trillion miles). 10 trillion = 10,000,000,000,000. But the stars we see at night are well within our own Milky Way galaxy.
- How far away is the galaxy in the image from Earth?
  The Andromeda Galaxy, M31, is more than 2 million light-years from Earth.

Simple Instructions - How Hot?

- This is the card deck with the sunspot on top **(color-coded, red)**.
- Ask participants to grab a card (or a few if you have a small group) and line up in the correct order for the objects (from coldest to hottest)
- The suggested "correct" order is: Comet's surface (171 °F; 77 °C), Lava (1,832 °F; 1,000 °C), Meteor (3,100 °F; 1,700 °C), Sunspot (6,332 °F; 3,500 °C), Sun's Surface (9,932 °F; 5,500 °C), Earth's Core (10,832 °F; 6,000 °C), Lightning Bolt (52,232 °F; 29,000 °C), Sun's Corona (3.6 million °F; 2 million °C), Sun's Core (27 million °F; 15 million °C). Remember though, there is a large variance in temperatures, and the discussion is more important than the right answers (see images at the end of this guide).
- If participants are getting stuck, consider providing the following hints (remember, you're a "guide on the side" – you don't need to provide correct answers, just start a discussion!):
  - Comets absorb and reflect solar light, they don't have any light (or heat) source of their own.
  - Sunspots are cooler than the rest of the Sun's surface.
  - Lava can melt metal, but dissipates heat so quickly it can flow through tubes without re-melting them.
  - The Earth's core is actually hotter than the Sun's surface!
  - Lightning bolts can be up to 5x hotter than the surface of the Sun!

Frequently Asked Questions:

- How hot is lava?
  Up to 2,000 °F, depending on its speed and composition
- Is the Sun's atmosphere (corona) the coolest part of the Sun?
  No! It's actually one of the hotter parts, hotter than the surface and sunspots. The reason is still a mystery, but it may have something to do with the Sun's changing magnetic fields.

Round 2 - Advanced Instructions

- For all 3 sets of cards, you'll notice participants sharing information they know about the images. Instead of following the simple instructions described here, ask participants to line up in a different order.
- Ask them to come up with their own order, but if they get stuck suggest average age of object, date discovered, etc.
- Also suggest sorting into groups, rather than a linear order. For example, participants could sort into groups based on man-made vs nature-made. This is a great introduction to categorization and taxonomy for younger participants, and a great ice-breaker/conversation starter for older participants.
- For an even trickier exercise, mix all 3 card sets together to see what participants can come up with! But be sure to return all cards back into their set. The color dots on the back will help keep the card decks organized.

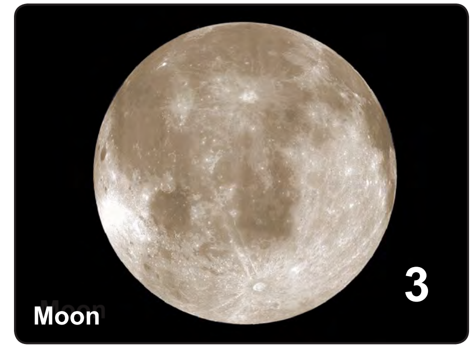
Connections to Other Kit Activities

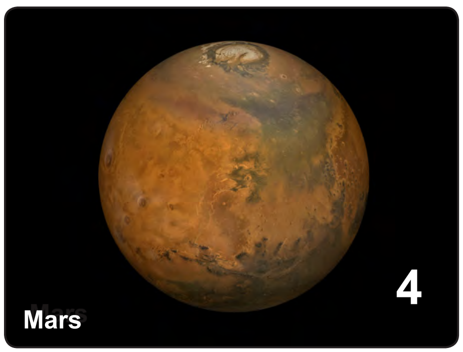
- This activity works well in a station activity with other kit items, and a good "get up and move" activity for story-time.

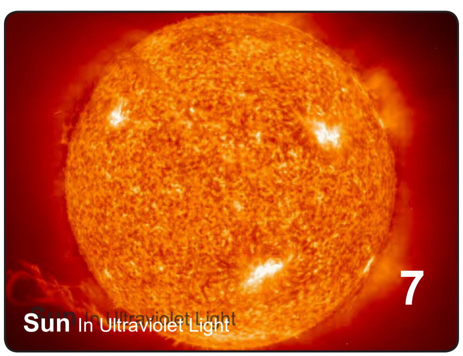
Connections to Other *STAR Net* Activities

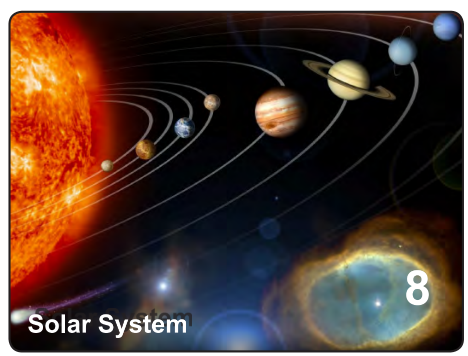
- This activity, adapted from activities developed by Cherri Morrow (Space Science Institute) and Deborah Scherrer (Standford Solar Center), can be found here: https://goo.gl/fNKJd3
- This activity can be found on the *STAR Net STEM Activity Clearinghouse* at: https://goo.gl/KT7Tq4

Sorting Game Cards - How Big?

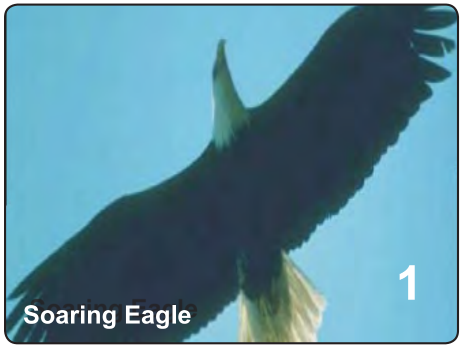


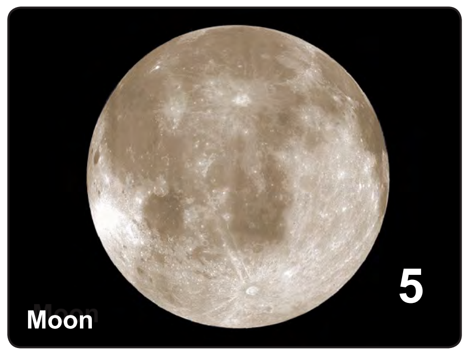


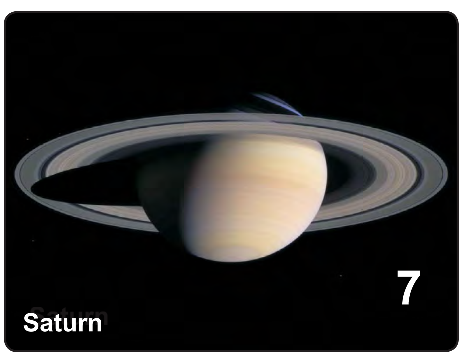


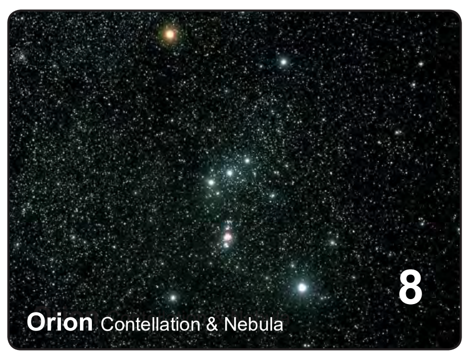


Sorting Game Cards - How Far?

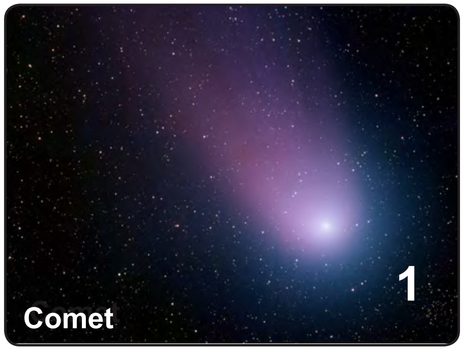


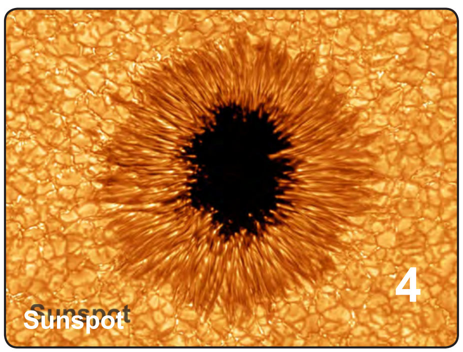


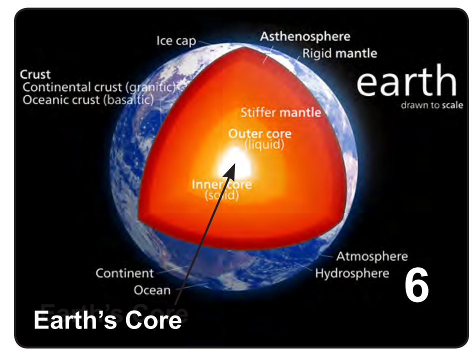


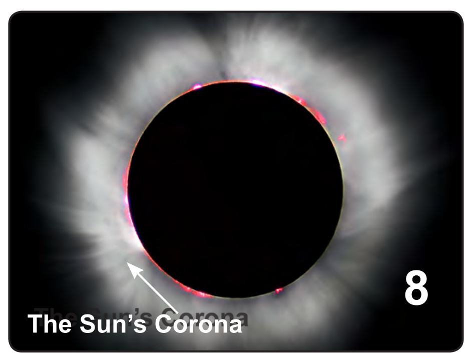


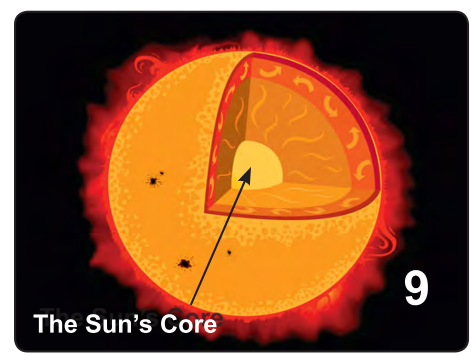
Sorting Game Cards - How Hot?











Recommended STEM Activity Clearinghouse Resource

Jump to Jupiter

It can be a challenge to find the space to set up this scale model of the solar system, but it is a rewarding experience for those who make room in a hallway or along the edge of a parking lot to set up the "Sun" and at least five of the "planets." There are multiple suggestions for modifying this activity to meet your needs. Kids love the high-energy task of jumping from "planet" to "planet," and as the immense scale of the solar system is revealed, participants of all ages experience unforgettable "aha" moments. This activity is ideal for children ages 8 and up as written, but it can be easily modified to be a "solar system walk" for tweens, teens, and adults.

Watch the how-to video at https://www.youtube.com/watch?v=4dm8P-w700s for a brief introduction of the materials required and an example of how the solar system "course" can be set up.

Credit: American Library Association

Content Area:
- Astronomy and Space
- Physics
- Mathematics

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens (9-12)
- Teens
- Adults

Time to Complete Activity:
40 minutes to 1 hour

Time Needed to Prep Activity:
20-40 minutes

Cost Associated with Materials:
$1-$5

Difficulty Level:
Easy

Mess Level:
Low

Key Concepts

- The solar system is a family of eight planets, an asteroid belt, several dwarf planets, and numerous small bodies such as comets in orbit around the Sun.
- The distance between planets is large compared to their sizes.
- Models can be used to answer questions about the solar system.

Build a Program with Related Resources

STEM ACTIVITY Clearinghouse

This activity provides an introduction to the solar system and can be used as a jumping-off point (pun intended!) for other space science activities, including those in the Kit. Explore the sizes of the Moon and Earth further through the activity, Modeling Meaningful Eclipses (Yardstick Eclipse). Consider using Sunoculars alongside this activity.

Add digital games and interactives to your program! Players enjoying making their own solar systems with the tablet app, *Planet Families*. Install the NASA's Eyes on the Solar System app (http://eyes.jpl.nasa.gov) onto library computers or project the app onto a screen for patrons to learn about Earth, our solar system, and the universe beyond, as well as the NASA spacecraft exploring them.

Add Your Review of This Activity

There are many STEM educational resources available to use in programs. We hope that you will give this activity a try! Then, **help others find the "best of the best" by writing a review** on the STEM Activity Clearinghouse. Email your favorite activities directly to a colleague!

Originating Source:
Jump to Jupiter was developed by the Lunar and Planetary Institute and is part of the *STAR_Net* portfolio of field-tested activities developed for public library programs.

Jump To Jupiter

The Jump to Jupiter course begins at a grapefruit-sized "Sun," Participants jump (or pace out) the distances to Mercury, Venus, Earth, Mars, Jupiter, and more, visiting a marker for each planet. Many parking lots are large enough to hold the markers out to "Jupiter." -- Credit: Enid Costley, Library of Virginia

Overview

Participants jump through a course from the grapefruit-sized "Sun," past poppy-seed-sized "Earth," and on to marble-sized "Jupiter" — and beyond! By counting the jumps needed to reach each object, children experience first-hand the vast scale of our solar system.

Activity Time

45-60 minutes.

Intended Audience

Families or other mixed-age groups, including children as young as 5 years old with assistance from an older child, teen, or adult
School-aged children ages 8-9
Tweens up to about age 13
Teens and adults with modifications

Type of Program

☑ **Facilitated hands-on experience**

☐ Station, presented in combination with related activities

☑ **Passive program (if instructions are provided at the start of the course)**

☐ Demonstration by facilitator

What's The Point?

- **The solar system is a family of eight planets, an asteroid belt, several dwarf planets, and numerous small bodies such as comets in orbit around the Sun.**
- **The four inner terrestrial planets are small compared to the four outer gas giants.**
- **The distance between planetary orbits is large compared to their sizes.**
- **Models can be used to answer questions about the solar system.**

Materials

Facility needs:

- ☐ A large area, such as a long hallway, a sidewalk that extends for several blocks, or a football field (see Preparation section for setup options)

For each group of 20 to 30 participants:

- ☐ A variety of memorable objects used to represent the Sun and planets, including:
  - ☐ 1 (4 inch) grapefruit or pomegranate
  - ☐ 1 (1 centimeter) wooden bead
  - ☐ 1 pony bead
  - ☐ 2 peppercorns
  - ☐ 2 table salt or sugar crystals
  - ☐ 2 sea salt crystals
  - ☐ 1 pinch of fine sand
  - ☐ Optional: 1 pinch of pollen, milled flour or corn, or gelatin
- ☐ 1 set of solar system object markers created (preferably in color) from:
  - ☐ 1 set of Our Solar System lithographs (NASA educational product number LS-2013-07-003-HQ)

  AND/OR
  - ☐ Optional: Posters created by the participants

  AND
  - ☐ 12 (3′) stakes **OR** ☐ 12 traffic cones **OR** ☐ 12 sign stands

For each child:

- ☐ 1 "Jump to Jupiter" poem (below)
- ☐ 1 pencil or pen

For the facilitator:

- ☐ Measuring wheel

  OR
- ☐ 1 meter- or yard-stick
- ☐ Mallet or heavy object (for placing stakes in the ground)
- ☐ Tape
- ☐ Examples of the objects used in the solar system scale model course:
  - ☐ 1 (approximately 4-inch-wide) grapefruit or pomegranate
  - ☐ 1 (approximately 3/8-inch-wide) wooden bead
  - ☐ 1 pony bead
  - ☐ 1 peppercorn
  - ☐ 1 table salt or sugar crystal
  - ☐ 1 sea salt crystal
  - ☐ 1 pinch of fine sand
  - ☐ Optional: 1 pinch of pollen, milled flour or corn, or gelatin

Supporting Resources

Consider setting up a digital device (such as a computer or tablet), speakers, and access to the Internet to display websites or multimedia before or after the activity.

Books:

Becker, Helaine, and Brendan Mullan. Everything Space. Washington, D.C.: National Geographic Children's Books, 2015. (ISBN-13: 978-1426320743)

Brake, Mark. How to Be a Space Explorer: Your Out-of-This-World Adventure. Oakland, CA: Lonely Planet Publications, 2014. (ISBN-13: 978-1743604342)

Couper, Heather, Robert Dinwiddie, John Farndon, Nigel Henbest, David W. Hughes, Giles Sparrow, Carole Stott, and Colin Stuart. The Planets. New York, NY: DK Publishing, 2014. (ISBN-13: 978-1465424648)

Enrich this activity by providing sources of information about the Sun, planets, dwarf planets, and asteroids in the form of signs, lithographs, books, and/or websites. -- Credit: Lunar and Planetary Institute

Video Clip:

How big is the solar system? This video shows relative sizes of the planets and how far they really are from the Sun:
https://www.youtube.com/watch?v=MK5E_7hOi-k

Podcast:

Solar System Exploration What's Up podcast: what spacecraft and celestial events are happening each month are described in this video podcast http://solarsystem.nasa.gov/news/category/whatsup

Games, apps, and simulations:

NASA's Eyes on the Solar System: learn about our home planet, our solar system, the universe beyond, and the spacecraft exploring them with this downloadable application: http://eyes.jpl.nasa.gov

A Stunning Scale Model of Our Solar System, Drawn in the Desert. On a dry lakebed in Nevada, a group constructed a model by drawing circles in the desert around a 1.5 meter Sun and a marble-sized Earth. Video: http://www.theatlantic.com/video/index/417309/our-place-in-the-universe/

A tediously accurate scale model of the solar system. Scroll to explore: http://joshworth.com/dev/pixelspace/pixelspace_solarsystem.html

How big is the solar system? This video shows relative sizes of the planets and how far they really are from the Sun: https://www.youtube.com/watch?v=MK5E_7hOi-k

Images:

NASA Solar System Exploration
http://solarsystem.nasa.gov

Planetary PhotoJournal (NASA/JPL)
http://photojournal.jpl.nasa.gov

Preparation

Advanced Planning Tips:

- **If possible, incorporate additional science, technology, engineering, art, and mathematics (STEAM) activities into the event. See the STAR_Net resources listed at www.starnetlibraries.org for ideas.**
- **Prepare and distribute publicity materials for programs based on this event.**
- **Pull supporting resources out of circulation to feature during the program.**

- Refer to Table 1 (below) for a list of memorable objects used to represent the Sun and planets, along with their diameters, distances from the "Sun," and the approximate number of jumps between the objects at a scale of 1 inch:350000 kilometers.

A football field, for example, would contain the entire model out to the orbit of Pluto if the course doubles back on itself six times. You may be able to modify the course to fit inside by using only the inner planets. The activity works best if the first five planets from the Sun, from Mercury to Jupiter, are included to illustrate the scale of our solar system. If you must omit some of the solar system objects, provide a wall or other area to display information about them.

- Set up a solar system course in an outside area or in a long hallway. The course does not have to be in a straight line! The course may fold back on itself. (Uranus is half way between the Sun and Pluto, so have the participants turn back at the Uranus marker.) It is helpful to have the grapefruit "Sun" visible at the beginning of the course so that participants may look back at it (at least from the "Earth" marker). Mark each object's position with a stake, traffic cone, or sign stand.

Alternatively, use the following resources to create your own larger or smaller course. A larger course will make the planet representatives larger and easier to see. A smaller course may fit in tighter location, or even indoors, but the Pluto, Mercury, and Mars representatives quickly become too tiny to see with the naked eye as the course is scaled down.

- Use the Exploratorium museum's online calculator to automatically determine the scaled sizes of the planets and distances from the Sun, relative to the size of the Sun you provide.
- Partner with community institutions to create a solar system model for your neighborhood! Place a giant-pumpkin-sized "Sun" at a central location and place the "planets" at area landmarks. Participants can visit the "planets" in person, or they can use digital or physical maps to visualize their locations. See the NASA programming guide, Solar System in My Neighborhood, for tips. Or, use just a few of these food items to create a larger scale model of the Earth (grape), Moon (peppercorn), and Sun (pumpkin) in the NASA programming guide, Earth's Bright Neighbor.

Preparation (continued)

- Earth as a Peppercorn is a large-scale outdoor model of the solar system; "Pluto" is more than half a mile away from the "Sun."
- Give participants a choice of a variety of balls to use to create an even larger scale model of the Earth and Moon: How Big and How Far Is the Moon?

- Attach the "Our Solar System" lithographs for each solar system object to the appropriate stake, traffic cone, or sign stand.

Alternatively, invite the participants create their own course! Provide children ages seven and up with access to high-quality sources of solar system information and blank poster boards, paper, and craft materials. Have them create the markers that will be used in the course. Make sure they include accurate facts on each poster, and encourage creative representations of the planets and the information.

Have tweens and teens determine the scaled sizes of the solar system objects, as well as their relative distance from the Sun. Identify the solar system objects' actual sizes and distances from the Sun in current print and online resources. The Jump to Jupiter model uses a scale of 1 inch: 350,000 km. (Earth as a Peppercorn uses 1 inch: 100,000 miles.) The following conversion factors may be helpful:

1 yard = 36 inches
1 meter = 39.37 inches
1 mile = 5,280 feet
1 inch = 2.54 centimeters
1 kilometer = 0.62 miles

- Optional: The distances may be quite large, so you may want to have an adult present at each marker in the course. Additional adults and teens also can guide the children with questions and information and keep them moving to other markers.

- Become familiar with information about the objects that are in view, as well as current and future missions to explore them using the "Our Solar System" lithographs and reputable websites.

Preparation (continued)

	Memorable Representative	Scaled Diameter	Scaled Average Distance from Sun	Number of Jumps Between Objects
Sun	Grapefruit or pomegranate	4" (10 cm)	-	-
Mercury	Table salt or sugar crystal	1/100" (0.3 mm)	20' (6 meters)	6
Venus	Sea salt crystal	3/100" (1 mm)	35' (11 meters)	5
Earth	Sea salt crystal	4/100" (1 mm)	50' (15 meters)	4
Mars	Table salt or sugar crystal	2/100" (0.4 mm)	75' (23 meters)	8
Asteroids (e.g. Ceres)	Pollen, milled flour or corn, or gelatin	3/1000" (70 micrometers)	(41 meters)	18
Jupiter	Wooden bead	1/3" (1 cm)	255' (78 meters)	37
Saturn	Pony bead	1/3" (8 mm) (marble)	470' (143 meters)	65
Uranus	Peppercorn	1/10" (3 mm) (peppercorn)	945' (288 meters)	145
Neptune	Peppercorn	1/10" (3 mm) (peppercorn)	1,480' (452 meters)	164
Pluto	Fine sand	7/1000" (170 micrometers)	1,950' (593 meters)	141
Alpha Centauri star system	Grapefruit	-	1,800 miles (3,000 kilometers)	Roughly the distance between Washington, D.C. and Mexico City

Activity

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already).
- Frame the activity with the main message: Space is full of…SPACE!

Pronunciation Guide
Ceres [seer-eez]
Uranus [YOU'RE a nuss]
Haumea [hah-oo-may-ah]
Makemake [MAH-keh MAH-keh]
Eris [ee'-ris]

Activity (continued)

- Explain that the participants will use a scale model to explore the distances between solar system objects. Use open-ended questions and invite the participants to talk with you and each other about their prior experiences with scale models.

Direct the conversation toward the idea that a scale model has smaller parts but parts that are relatively the same size and distance to each other. Encourage children to consider how scale models like toy cars and play kitchen furniture allow us to play in ways that are impractical (or unsafe) with "real" cars or kitchen appliances. Encourage teens and adults to consider how models are used in architectural, engineering, and science professions. They might be familiar with the use of computer-based climate models to test questions relating to Earth's past, present, and future global climate. Or, they might mention that full-scale models are used in industrial design.

- Invite the participants to offer questions to the group about planets, the dwarf planets Ceres and Pluto, and asteroids in our solar system. As the participants name the different objects, ask them to choose the best representative — based on size — from the beads, salt crystals, etc. that were used to construct the solar system course.

As much as possible, encourage the participants to offer information and questions. This model can be used to answer questions such as:

- How do the planets compare in size?
- How does big does the Sun appear to be from Earth? From Jupiter?
- How does the distance between the Sun and Pluto compare to the distance between the Sun and the next closest star system (Alpha Centauri)?
- Which destination is closer for a spacecraft: Venus or Mars?
- Are some planets closer together than others?
- Could an accurate model of the solar system fit on my bookshelf at home?

2. Guide the participants as they explore the solar system scale model to answer their questions.

Leave the "Sun" at the beginning of the course for their reference.

a. Provide the meter- or yard-stick for the children to practice jumping that length.

b. Offer the "Jump to Jupiter" poem and pencils or pens. Ask the children to count the total number of (one-meter) jumps from the Sun it takes to get to each marker. Explain that the poem has a place for them to enter each distance.

c. Suggest that the participants find information about each solar system object by reading the signs.

Participants use one-meter jumps — or very large steps — to measure the distances between mark-ers. -- Credit: Lunar and Planetary Institute

Facilitators (adults or teens) standing at each marker can engage participants with questions such as:

- How many jumps did it take to arrive at this planet (or asteroid belt or Pluto)?
- How big does the grapefruit "Sun" look from here? Imagine what the real Sun would look like in the sky of this planet/dwarf planet!
- What do you think is happening to the temperature as you travel further away from the Sun?
- At the last marker of the course, compare the immense scale of our solar system to the even larger distances to other stars. At this scale, Alpha Centauri A would be slightly larger than a grapefruit and about 1,800 miles (3,000 kilometers) away — roughly the distance between Washington, D.C. and Mexico City!

3. Have the participants describe what they discovered by exploring the model.

Each person will have counted slightly different numbers of jumps between each marker. (Those who used careful, consistent 1-meter-long jumps will more closely match the actual measurements of the model.) Focus the conversation on the relative distances that everyone measured.

Using this model, the participants can answer any number of their own questions, such as:

- The inner terrestrial planets — Earth, Mercury, Mars, and Venus — are relatively close together. Venus is Earth's closest neighbor (after the Moon). The giant planets (Jupiter, Saturn, Uranus, and Neptune) get farther and farther apart.
- From each marker, the grapefruit "Sun" will look just like it does in the sky of that object. From "Earth," the real Sun appears to take up half a degree (or arc) in the sky. The grapefruit "Sun" appears to be the same size; it can be covered with a pinkie finger held at arm's length.

4. Remind the participants that the model isn't perfect.

In space, the planets are in motion as they orbit the Sun. Only rarely do four or more planets "line up." Have them imagine the circles that each planet would trace! Or, if desired, invite a few participants to carry a selection of planet models in large circles around the "Sun" to demonstrate their orbits.

5. Conclude.

Draw on the participants' discoveries to summarize the experience, and wrap up with the main message: Space is full of…SPACE! The planets are small compared to the Sun, and they are spread far, far apart. There is an enormous distance between the Sun and even the closest stars.

Correlation to the Next Generation Science Standards

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

Science and Engineering Practices

Developing and Using Models

- Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or pat terns in the natural and designed world(s).
- Identify limitations of models.

Analyzing and Interpreting Data

- Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and de signed world(s) in order to answer scientific questions and solve problems.

Using Mathematics and Computational Thinking

- Use counting and numbers to identify and describe patterns in the natural and designed world(s).

Crosscutting Concepts

Patterns

- Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

Scale, Proportion, and Quantity

- Natural objects exist from the very small to the immensely large.
- Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale.

The Nature of Science

Scientific Investigations Use a Variety of Methods

- Science investigations use a variety of methods and tools to make measurements and observations.

Jump To Jupiter

STAR net Hands-on

Brief Facilitation Guide

Download the full activity guide at www.starnetlibraries.org

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already).
- Frame the activity with the main message: Space is full of…SPACE!
- Explain that the participants will use a scale model to explore the distances between solar system objects. Use open-ended questions and invite the participants to talk with you and each other about their prior experiences with scale models.
- Invite the participants to offer questions to the group about planets, the dwarf planets Ceres and Pluto, and asteroids in our solar system. As the participants name the different objects, ask them to choose the best representative — based on size — from the beads, salt crystals, etc. that were used to construct the solar system course.

2. Guide the participants as they explore the solar system scale model to answer their questions. Leave the "Sun" at the beginning of the course for their reference.

a. Provide the meter- or yard-stick for the children to practice jumping that length.

b. Offer the "Jump to Jupiter" poem and pencils or pens. Ask the children to count the total number of (one-meter) jumps from the Sun it takes to get to each marker. Explain that the poem has a place for them to enter each distance.

c. Suggest that the participants find information about each solar system object by reading the signs.

3. Have the participants describe what they discovered by exploring the model.

4. Remind the participants that the model isn't perfect.

In space, the planets are in motion as they orbit the Sun. Only rarely do four or more planets "line up." Have them imagine the circles that each planet would trace! Or, if desired, invite a few participants to carry a selection of planet models in large circles around the "Sun" to demonstrate their orbits.

5. Conclude.

Draw on the participants' discoveries to summarize the experience, and wrap up with the main message: Space is full of…SPACE! The planets are small compared to the Sun, and they are spread far, far apart. There is an enormous distance between the Sun and even the closest stars.

Jump To Jupiter

My Poem:

I'm the one star in this special place.
You'll find me in the center.
Just guess my name to start this game,
Then you may surely enter……

Star's Name: ___________

I orbit fast, but s l o w l y turn,
With a 1,400-hour day!
I'm the first. My name is _________________________,

Jumps: ___________

Because my ghastly atmosphere is mainly CO_2,
It's like a scorching greenhouse of 900 degrees. It's true!
My name is _________________________, I'm yellow and the hottest,
And all I can say is, "Whew!"

Jumps: ___________

I'm glad I'm home to boys and girls,
Even though I do seem "blue",
I'm planet _________________________.
and a little larger than Venus (that's your clue!).

Jumps: ___________

I'm reddish-rust, with rocks and dust
And a 24-hour day.
I'm _________________________ and I am close in size
To Mercury, I'd say!

Jumps: ___________

I'm a band that's full of rocks and dust
That travel in between
the inner and outer solar system's planetary scene.
And because I'm a band of asteroids, I felt,
I should be called the _________________________.

Jumps: ___________

Jump To Jupiter

My Poem:

I'm full of gas, with colorful stripes, # Jumps:
And a really enormous girth.
I am mighty __________________________ and ___________
I'm over ten times as wide as Earth!

I'm yellow and my ammonia haze # Jumps:
covers each and every thing.
I'm __________________________ and my beauty's ___________
found within my icy rings!

Methane gas colors my atmosphere blue. # Jumps:
My axis is tilted so I spin on my side.
I'm __________________________! Next to Saturn, I'm small, ___________
Compared to neighbor Neptune, I'm a little wide.

It takes me over sixty thousand days # Jumps:
to go one whole year through!
I'm the last giant planet. I'm __________________________, ___________
and just a little darker blue.

With comets and other dwarf planets # Jumps:
I orbit in an oval path
Count the miles to get to __________________________, ___________
It will take a lot of math!

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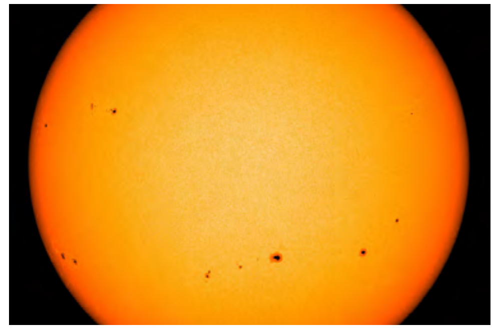
Section 3:

Quick Facilitation Guides

Sunoculars for Solar Viewing

This *NASA@ My library Facilitation Guide* will help library staff facilitate science tools like the Lunt mini-Sunoculars in large or small groups, or by individuals. The Sunoculars are suitable for use by teens (with supervision) and adults. Sunoculars are certified safe for solar viewing, and are made with high quality materials and filters. The Sunoculars are not a toy. Patrons with astigmatism should use their seeing glasses when using the Sunoculars. Those who wear glasses should try viewing the Sun through the Sunoculars – both with and without their glasses – to determine what's best for them. **Never look at the Sun without proper solar filters.**



The Sun's surface in 2012. Credit: NASA / Solar Dynamics Observatory

Key Concepts

- Sunoculars offer an introduction to the types of tools scientists use to study the Sun.
- Sun watchers (with eye protection) can see the Sun change over time. The Sun can look different from hour to hour, day to day, and year to year. Features, called sunspots, appear and disappear over a matter of hours (or months!) and as the Sun rotates.
- Sun observers must protect their eyes using Sun-safe viewing products.

Credit: Valley of the Tetons Public Library

Ages – Teen (13+) with adult supervision to adult

Materials List – Lunt mini-Sunoculars, Facilitation Guide to the Sunoculars

Activity Time – 5-30 minutes

Type of Program – Stations, stand-alone activity, facilitated activity, outdoor activity

Simple Instructions

- **Warning: Never look at the Sun without proper eye protection. Make sure that participants – especially children – know not to use "regular" binoculars to look at the Sun. Follow the manufacturer's safety instructions.**

Keep participants safe with these tips from NASA: (https://eclipse2017.nasa.gov/safety):

The only safe way to look directly at the uneclipsed or partially eclipsed sun is through special-purpose solar filters, such as "eclipse glasses" (example shown at left) or handheld solar viewers. Homemade filters or ordinary sunglasses, even very dark ones, are not safe for looking at the Sun. Always inspect your solar filter before use; if scratched or damaged, discard it. Read and follow any instructions printed on or packaged with the filter. Always supervise children using solar filters.

Do not look at the uneclipsed or partially eclipsed sun through an unfiltered camera, telescope, binoculars, or other optical device.

- A bright sunny day is needed in order to view the Sun with the Sunoculars. It will be difficult to view the Sun on a cloudy day due to the strong filters on the Sunoculars.
- Identify the Sun's location in the sky without looking at the Sun directly.
- Hold the Sunoculars up to your eyes, look toward the Sun keeping your eyes looking through the eyepieces. You may find that all you see is blackness. It may take a few minutes to find the Sun by looking through the Sunoculars because of the strong filters helping to protect your eyes. Practice!
- Discourage patrons from focusing the eyepieces, they are difficult to change, and the existing settings should work fine for most people.
- For the facilitator: IF they become unfocused, focus the eyepieces individually to start. This a little different from typical binoculars, where a center knob and the right-eyepiece are used to focus, but it allows for sharper focus.
- Once you have both eyepieces focused, then you will be able to start observing. The Sun will appear orange in color.

Frequently Asked Questions:

- Why can I view the Sun and eclipses with these binoculars and not with regular binoculars?
  Special solar filters on the front lenses block out harmful solar radiation, such as infrared and ultra-violet light, making it 100% safe for solar viewing.
- How magnified is the Sun in the Sunoculars?
  The Sun is six times magnified in the Sunoculars. They are 6x30, which means they have six times the magnification with 30 mm-wide lenses (aperture).
- Why does the Sun look like a featureless circle?
  The Sun goes through periods when many features, such as sunspots, can be seen on its surface. During other periods, the Sun's surface appears smooth. These cycles follow an 11-year pattern. Scientists are still learning more about the Sun in order to explain why we see an 11-year cycle of solar activity and relative quiet.
- What are the black dots/regions I see?
  These are sunspots and are cooler areas on the Sun. In fact, these areas are about 2,700 ° F cooler than the surface of the Sun (9,900 ° F). They are magnetic disturbances that typically occur in pairs.
- How long do sunspots last?
  Sunspots can last several hours, days, or even months!
- Why do the Sun and the Moon appear to be the same size in the sky?
  The diameter of the Sun is 400 times greater than that of the Moon, but the Sun is 400 times farther from the Earth than the Moon. That is why you can see a total eclipse of the Sun, during which the Moon blocks the light from the Sun.
- How far from Earth is the Sun?
  The Sun is 1 Astronomical Unit = 150,000,000 kilometers (93 million miles) from Earth.

Guiding Questions

While larger groups take turns with the Sunoculars, consider engaging the rest of the group with the following suggestions and questions:

- The Sun has features like sunspots. Sunspots are cooler than the surrounding area and so appear darker to our eyes. Sunspots are regions of strong magnetic fields.) Sunspots change shape slowly and appear to move across the surface of the Sun because the Sun actually rotates, like Earth, but not as fast. See if you can find any sunspots on the Sun today.
- If clouds are passing in front of the Sun: What happens to the air temperature when the sun goes behind the clouds? How quickly can you detect a change? Is the answer the same with the air as with the ground? (Consider using the infrared thermometer!)

Advanced Activities

- Keep a log of the number of sunspots you see over time and how they change over the course of 1-month.
- Look for sunspots that have produced solar flares (you will need to go to the Internet to find out if flares have occurred).
- Observe for longer periods of time to view changes in characteristics as Earth orbits around the Sun.

Connections to Other Kit Materials

Sunoculars are ideal for watching solar eclipses in 2017 and 2024, but they can also be used to observe the Sun over time and see how it changes.

Combine Sun observations with hands-on activities, such as:
- *Sorting Games: How Big? How Far? How Hot?*
- *Modeling Meaningful Eclipses (Yardstick Eclipse Demonstration)*
- *Jump to Jupiter*
- *Using an Infrared Thermometer to Measure Temperatures from Afar*
- *Taking Earth's Temperature*

Have learners use their sense of touch by exploring the NASA tactile book, *Getting a Feel for Eclipses*. The book includes tactile graphics that illustrate the interaction and alignment of the Sun with the Moon and Earth. NASA tactile books are designed to bring NASA's discoveries to those who are visually impaired or blind, and can also help sighted learners.

Use the tablet to add digital games and interactives to your program! Find hidden features on the Sun using *Solar Vision*, or give patrons a chance to try *Star Maze*.

Connections to Other *STAR_Net* Activities

- Big Sun, Small Moon:
  http://clearinghouse.starnetlibraries.org/index.php?id_product=71&controller=product
- Pinhole Projectors:
  http://clearinghouse.starnetlibraries.org/index.php?id_product=139&controller=product

Section 4:

Science Books and Related Resources

Science Books

Three books have been included in the *Sun-Earth-Moon Connections* kit. Below you will find the list of books, as well as tips for use.

1) Moonbear's Shadow (Frank Asch)

Suitable for use during story time for pre-k to grade 3 audiences in a smaller group setting

Moonbear tries to get rid of his shadow throughout the day, but then befriends his shadow so they can help each other catch a fish. Helps younger patrons learn about shadows and the Sun. Use the Modeling Meaningful Eclipses activity in conjunction with this book.

2) Oh Say Can You Say What's the Weather Today? (Dr. Seuss)

Suitable for use during story time for pre-k to grade 3 audiences in a smaller group setting

This fun book is perfect to read in small sections during story time. We recommend using the Sorting Games activity, UV Kid! activity, and Jump to Jupiter activity, detailed in Section 2, in conjunction with this book. Also, please peruse the "Earth Science", "Climate Change" and "Weather and Citizen Science" collections in the STEM Activity Clearinghouse (http://clearinghouse.starnetlibraries.org/).

3) Getting a Feel for Lunar Craters (National Aeronautics and Space Administration)

Suitable for individual use by any age, or in a group or station setting

This hands-on book allows users to explore the shape and texture of lunar craters, as well as the processes that form them. To access related audio files, text, descriptions and other resources in multiple formats, please visit: goo.gl/e77gez or scan the QR code on the cover of the book!

Web Links to Kit Materials

Below you will find a list of web links to resources for your kit.

Modeling Meaningful Eclipses Activity
Yardstick Eclipse Activity from the Astronomical Society of the Pacific – $35.00 for set of 5
https://goo.gl/24yFgx

UV Kid! Activity
UV Beads from Amazon- $6.99 for pack of 500 beads
https://goo.gl/mtPS5t

Pony Beads from Amazon- $5.69 for pack of 1000 beads
https://goo.gl/rspbnH

Chenille Sticks from Amazon- $4.00 for 100 sticks
https://goo.gl/Z5VrNv

UV flashlight from Amazon- $8.99 and includes 3 AAA batteries
https://goo.gl/PqoKRH

Sorting Games Activity
27 cards and 3 answer keys from the STEM Activity Clearinghouse - free download. Color printed and laminated in 7mm plastic at Staples- $45
https://goo.gl/t5BK86

Jump to Jupiter Activity
Our Solar System Lithograph Set from NASA.org – free download. Color printed and laminated in 7mm plastic at Staples- $50
https://goo.gl/s9Ce2s

Various household items as representative of the planets from local grocery store- $3-5.

Web Links to Kit Materials

Sunoculars
(2) from Lunt $29.95 ea.
https://goo.gl/FHMa16

Moonbear's Shadow book – Frank Asch
Hardcover from Amazon $11.98
https://goo.gl/cBT51U

Oh Say Can You Say What's the Weather Today? book – Dr. Seuss
Hardcover from Amazon $9.05
https://goo.gl/vB2rmZ

Getting a Feel for Lunar Craters book –NASA
Text-only and audio versions available for download
https://goo.gl/LKwM6f

Uline Reclosable Vinyl Envelopes for activity materials
Size: 10"x13", $72 for box of 50, model#S-7713
https://goo.gl/o9rokX

Container Store Circulation Bin
19 qt. Weathertight Tote Clear $9.99 ea., SKU#: 10060956, 17-1/2" x 11-3/4" x 8" h
https://goo.gl/AFyBEm