A

NASA STEM Facilitation Kit

Sun-Earth-Moon Connections

NASA @ My Library

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.

Table of Contents

Getting Started

Section 1:

Activity Guides

Section 2:

Quick Facilitation Guides

Section 3:

Science Books

Section 4:

Section 1:

Getting Started

Thank you for taking the time to utilize *Kit A: Sun-Earth-Moon Connections*. This kit was developed to support the 2017 Total Solar Eclipse, but continues to be extremely engaging and relevant today!

With this kit your patrons will explore how eclipses happen, be able to safely observe the sun, and participate in fun hands-on activities around solar concepts.

Please visit www.starnetlibraries.org to learn more about the STAR Library Education Network (*STAR Net*), a hands-on learning network for libraries and their communities across the country. *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. Take advantage of the many resources and opportunities available through *STAR Net*, including:

- *STEM Activity Clearinghouse* (for activities and programs and valuable resources)
- Blogs (share success stories!)
- Forums (discuss promising practices)
- Webinars (online professional training)
- Workshops and meet-ups at library conferences (in-person professional training)
- Partnership Opportunities
- Information about upcoming national STEM Events
- *STAR Net* News (online newsletter)

How to Use This Resource

The Kit A binder was developed by *STAR Net*'s *NASA@ My Library* team to assist library staff in facilitating programs around exciting NASA science mission topics. Kit A is titled "Sun-Earth-Moon Connections", and focuses on activities and experiences that better help patrons to understand their place in space, and how the Sun and Moon impact our planet.

The binder is divided into 4 sections:

Section 1 contains a welcome letter and an inventory of all the items you'll need for Kit.

Section 2 contains selected Activity Guides that describe how to use the materials in the Kit (UV Kid, Moon Skits) or ones that can be done with materials you already have lying around or can be purchased at low cost (e.g. Wind Streamer). Our goal for providing all the necessary materials for selected activities is to encourage library staff to try new activities that require unique materials (e.g. UV beads, IR thermometer). 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 Quick Facilitation Guides that will help staff be better prepared to use the STEM tools used in this kit (e.g. Tablet, Sunoculars, IR thermometer). These guides are meant to provide a quick introduction to the 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 books, as well as suggestions for how to tie the books and activities together. This section also contains scripts that will help you facilitate NASA's tactile books.

If you'd like to explore more hands-on activities around this and other content areas, please visit our *STEM Activity Clearinghouse* (clearinghouse.starnetlibraries.org/). Use search tools to filter activities by content area, age group, time to complete activity, time needed to prep activity, cost associated with activity materials, difficulty level (by content), cost associated with activity materials, difficulty level (by content), or mess level. Or, view featured collections of activities.

There are many STEM educational resources available to use in programs. We hope that you will give our hands-on activities 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!

Inventory Checklist - Kit A: Sun-Earth-Moon Connections

Activity Materials

UV Kid
- 1 bag of UV beads, 1 bag of pony beads, 2 UV flashlights, 1 package of pipe cleaners

Taking Earth's Temperature
- 1 Infrared Thermometer

Sorting Games: How Big? How Far? How Hot?
- 3 sets of cards in a plastic bag (color-coded by set)

Jump to Jupiter
- 1 each: Solar System Lithograph Set, fake fruit, bags of table salt, sea salt, sugar, flour, a wooden bead, a pony bead, peppercorn and fine sand

Modeling Meaningful Eclipses
- 1 foldable yardstick, 2 clips, Moon and Earth beads

STEM Tools

- 1 Tablet
- 1 Green Screen Kit (in a separate box)
- 2 Sunoculars
- 1 Rechargeable battery set

Books

- Getting a Feel for Eclipses (NASA)
- Mars Exploration Program (NASA)
- Oh Say Can You Say What's the Weather Today (Dr. Seuss)
- Miscellaneous (100 NASA Stickers and 10 plastic NASA bags)

Section 2:

Activity Guides

Recommended STEM Activity Clearinghouse Resource

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.

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

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!

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.

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)

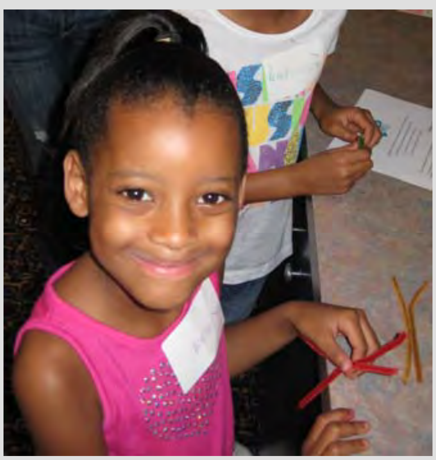
For Each Group of 10–15 Children

- ☐ 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).

---

[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.

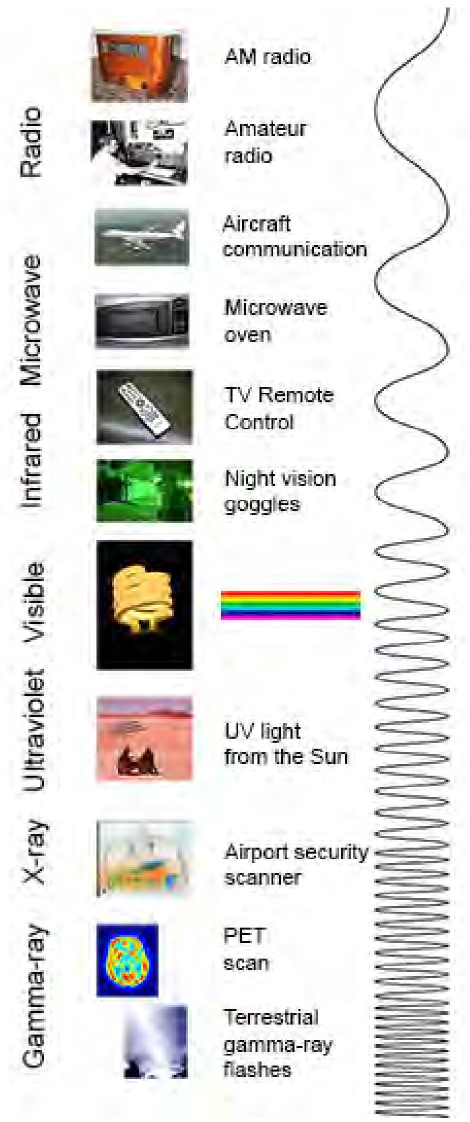
UV Kid!

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!

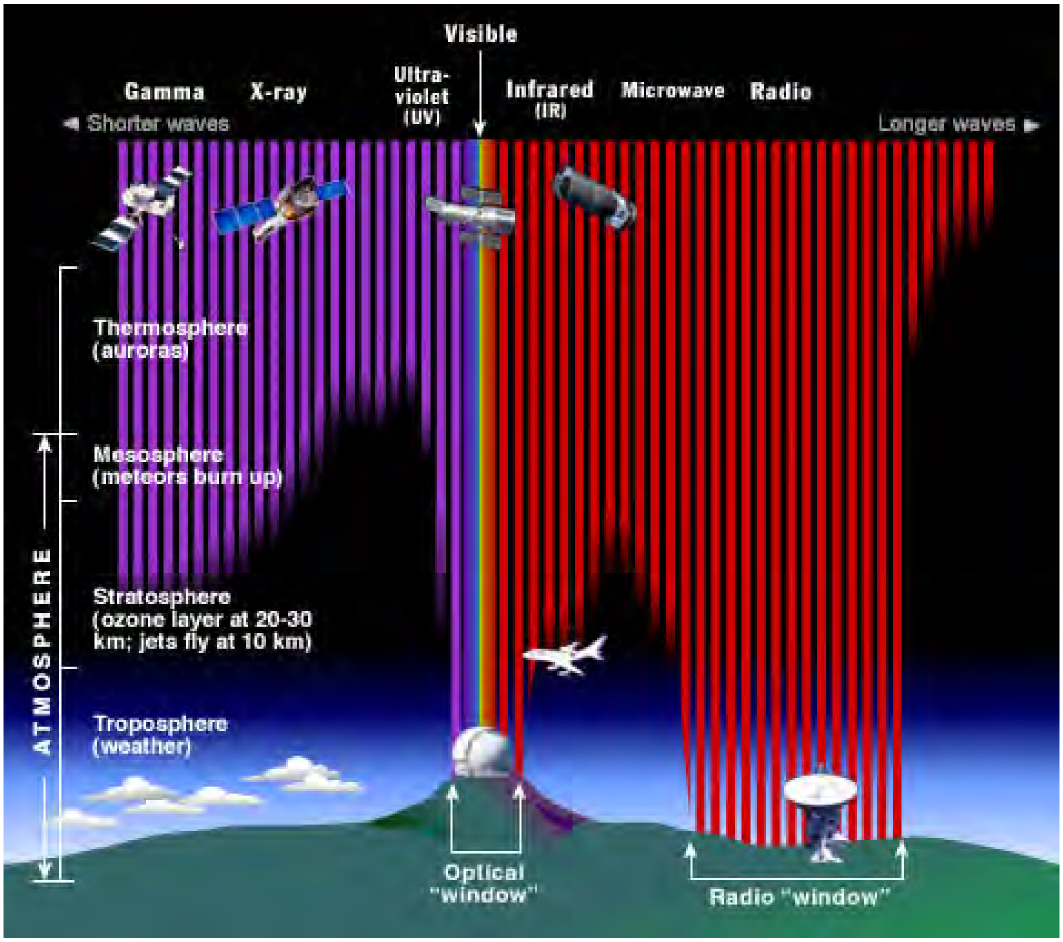
Our Sun also produces cosmic radiation. Cosmic rays are very-high-energy, fast-moving particles (protons, electrons, and neutrinos) that can damage DNA, increasing the risk of cancer and causing other health issues. Cosmic rays have such high energy that it is difficult to design shielding that blocks 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.



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.

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

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.

Overview

Taking Earth's Temperature

Participants are introduced to a type of energy, infrared radiation, which we can't see with our eyes but we can feel as heat. Then, they explore their outdoor environment using an infrared thermometer (also known as an IR thermometer) to measure the temperatures of concrete, asphalt, grass, and bare soil. Participants consider how the temperatures of different surfaces might have an influence on a global scale.

Credit: Space Science Institute

Key Concepts

- By taking careful measurements, patrons can record differences in temperature between concrete, asphalt, grass, soil, and other surfaces in their local environment.
- NASA takes measurements of Earth from space, using satellites. (Scientists refer to this as "remote sensing.")
- By taking measurements of Earth from space, NASA scientists study changes in Earth's dynamic systems – to help us learn more about climate, weather, and even the health of our crops!

Intended Audience:
Families or other mixed-age groups
School-aged children
Tweens
Teens
Adults

Preparation Time:
10-20 minutes

Activity Time:
10-20 minutes

Materials

- 1 or more infrared thermometers
- Batteries (fully charged)
- Optional: 1 thermometer (to compare with air temperature) per 6 learners
- Optional: paper, pencils or pens, and clipboards to record observations

Tip: Infrared thermometers can be purchased from various online retailers starting at around $25 and up. Some example models include: Etekcity Lasergrip 800, Kintrex IRT0421, and Omega OS543. You may be able to borrow infrared thermometers from heating and cooling specialists or auto mechanics. Infrared thermometers are commonly used in those jobs.

Ideally, have one infrared thermometer for every two to four participants, or combine this activity with other activities as learning stations. See below for related activities.

Preparation

- Decide if you want the laser pointer on. Most infrared thermometers have an optional laser pointer to help you see where you are pointing the thermometer. You may turn the laser pointer off and/or cover it with tape. Alternatively, allow the use of the laser pointer to take aim, but make sure that facilitators are monitoring their use.
- Test that the infrared thermometer is measuring accurately. This can be done by testing the temperature of ice water. Ice water should be 32° F (0° C). An infrared thermometer is measuring correctly if it reads the temperature of the ice water bath within the range of 28-36° F (+/- 2° C). If the infrared thermometer shows a temperature of more than 36° F (+2° C), or less than 28° F (-2° C), try changing the battery. If the calibration still is off, the thermometer needs to be replaced.

Credit: Space Science Institute

- Go outside and take note of the different types of surfaces that participants could measure. Look for a bare soil, short grass, tall grass, concrete, asphalt, sand, forest litter, or other types of surfaces. Make sure to have a safe route for participants to enter and exit the building. A satellite image of your location might be helpful (you can see satellite imagery of your location using Google Maps Satellite View).

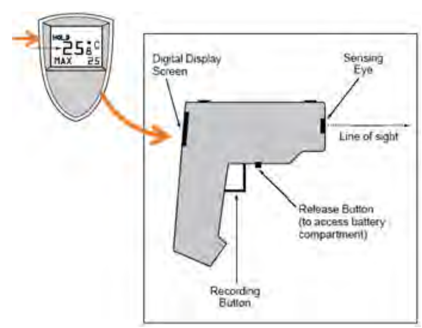
Procedure

1. Set the stage. Say:

- Imagine that you are outside on a hot day and you are barefooted. What surfaces would you want to walk on and why? Why are some surfaces cool to your touch? Why are some hot to your touch? Where did the hot surfaces get their energy? Those surfaces received this energy from the Sun and can become quite hot.
- All matter (you, a table, cars, apples, and the ground) emits energy. At the temperatures we usually experience in our daily life on Earth, that energy is emitted as infrared radiation. We can use a special infrared-detecting thermometer to measure this energy and tell us the temperature of the object.
- Warmth rising off Earth's landscapes influences – and is influenced by – weather and climate patters. Scientists track these changes using information from satellites. Satellite information can also help commercial farmers choose which crops need extra water during the summer to cope with the heat or find where to look for frost damaged crops in the winter.
- You can use an infrared thermometer to measure the infrared energy (heat) coming from different surfaces outside.

2. Demonstrate how to use the infrared thermometer.

- **Warn participants that the laser beam should NOT be aimed directly at eyes** or off surfaces where it could reflect into anyone's eyes.
- Hold your arm at arm's length and point the instrument at the ground. Briefly press the Recording Button to record the temperature.
- Be sure to have the instrument's Sensing Eye pointed directly at the surface you want to measure. Be careful to not inadvertently record the temperature of your shoe or the surface in your own shadow.



3. Give participants time to try measuring various surfaces with the infrared thermometer.
See the facilitation guide, *Using an Infrared Thermometer to Measure Surface Temperatures from Afar*, for tips.

4. Invite participants to go outside and investigate what happens to different surfaces when they are exposed to the Sun.

- Once outside, look for a bare soil, short grass, tall grass, concrete, asphalt, sand, forest litter, or other surfaces to measure. (Any surface can be used!)

Procedure (continued)

- Optional: invite participants to draw a map of the area and note where they took their observations and record their temperature measurements.
- Prompt participants to take different measurements that will help them investigate questions such as:
  - How does surface temperature compare with current air temperature?
  - How do the temperatures compare for different surfaces?
  - How does surface temperature vary with surface soil color?
  - How does surface temperature change for different cover types (grass vs. asphalt for instance) on a cloudy day?
  - How does the surface temperature change for different cover types when it is wet versus when it is dry?

5. **Conclude.**
   Have a discussion about how the temperatures of different surfaces might have an influence on a global scale. Explain that NASA and other scientists use temperature measurements of different surfaces to help them answer the following science questions:
   - How do urban areas affect the temperature around them?
   - What is the contribution of changing land use and land cover on local energy budgets?
   - How are land surface temperatures changing over the long-term?
   - How accurate are data from NASA satellites?

Connections to Other Kit Materials

- Begin with open-ended exploration with the infrared thermometer. See the facilitation guide, *Using an Infrared Thermometer to Measure Surface Temperatures from Afar*, for tips.
- Introduce the infrared thermometer along with the *Oh Say Can You Say What's the Weather Today?: All About Weather* book.
- Encourage adults to extend the learning at home on their mobile devices by downloading the GLOBE Observer app at https://observer.globe.gov/about/get-the-app. Adults and their families can use the app to note what types of clouds are in the sky, then share their observations online through the app. GLOBE Observer cloud observations are helping NASA scientists understand clouds from below (the ground) and above (from space).

Connections to Other *STAR_Net* Activities

- Please visit the *STEM Activity Clearinghouse* at www.clearinghouse.starnetlibraries.org and check out the "Earth Science" and "Weather and Citizen Science" collections to find other remote sensing and Earth observing activities!

Extensions

Everyone can be a citizen scientist and share observations of their environment with NASA scientists! You can collect and share surface temperature measurements as part of a worldwide citizen science effort through *The GLOBE Program* (www.globe.gov). To join this effort, you'll need to become GLOBE Trained at:
http://www.globe.gov/get-trained/protocol-etraining

Then, follow the GLOBE Surface Temperature Protocol and enter the data into the GLOBE database.
http://www.globe.gov/documents/348614/7537c1bd-ce82-4279-8cc6-4dbe1f2cc5b5

Overview

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.

Key Concepts

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

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 **(marked with green dots on the back)**.
- 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 **(marked with blue dots on the back)**.
- 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 **(marked with red dots on the back)**.
- 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.

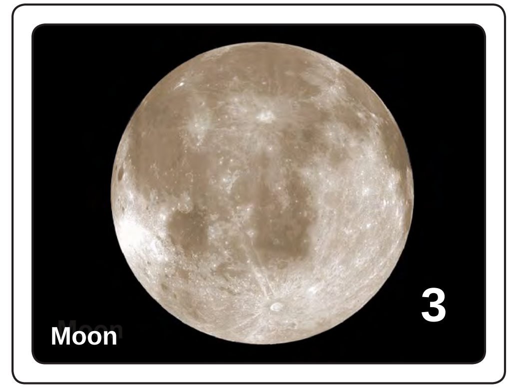
Connections to Other Kit Activities

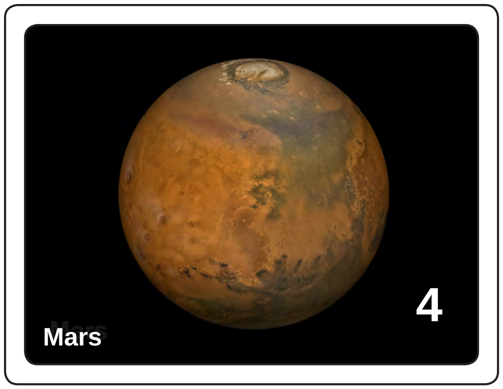
- This activity works well in a station activity with other kit items, and a good "get up and move" activity for story-time.

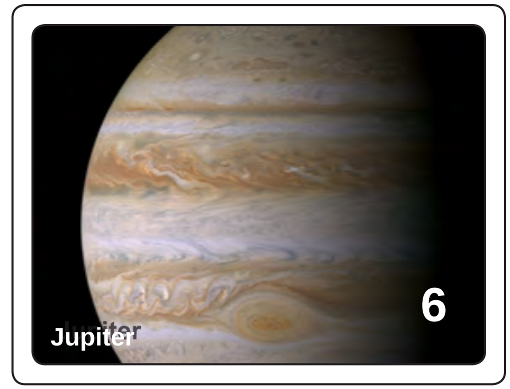
Connections to Other *STAR_Net* Activities

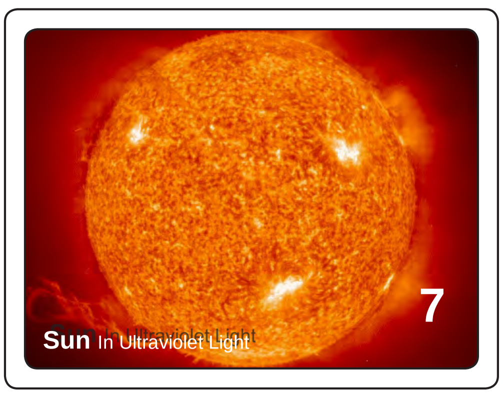
- This activity, adapted from activities developed by Cherri Morrow and Deborah Scherrer of the Standford Solar Center (SSC), can be found here: http://solar-center.stanford.edu/activities/HowBig/How_Big-Far-Hot-Old.pdf
- This activity can be found on the *STAR_Net STEM Activity Clearinghouse* at: http://clearinghouse.starnetlibraries.org/collections/Astronomy-Space/Sorting-Games-HowBig-HowFar-HowHot.pdf
- Go to iMeet Central (https://ssi.imeetcentral.com/nasamylibrarypartners/) to access digital files of the card set images so that you can print more cards.

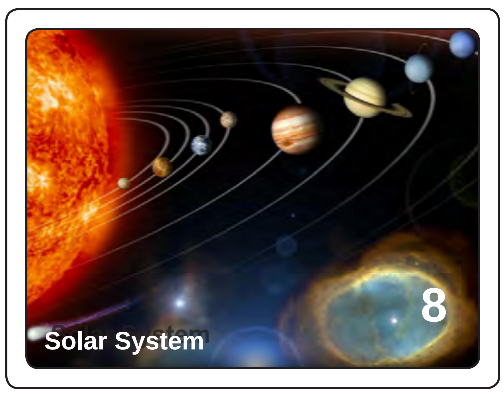
Sorting Game Cards - How Big?

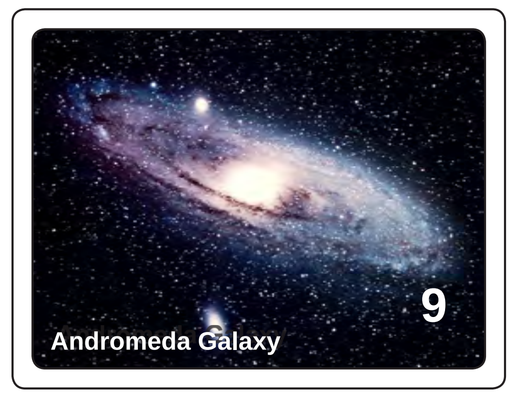




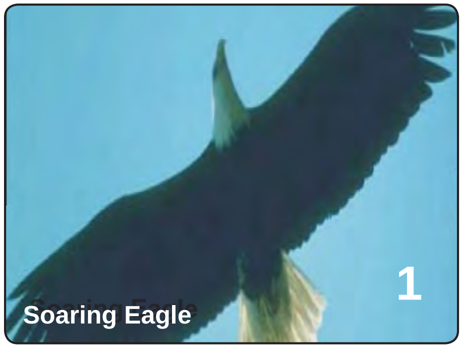


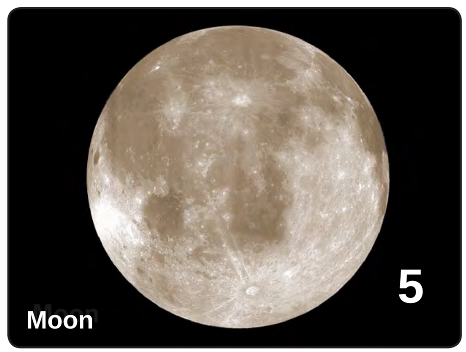


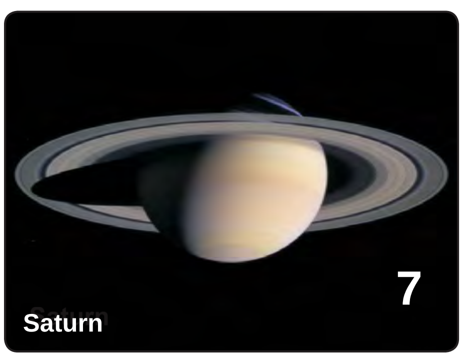




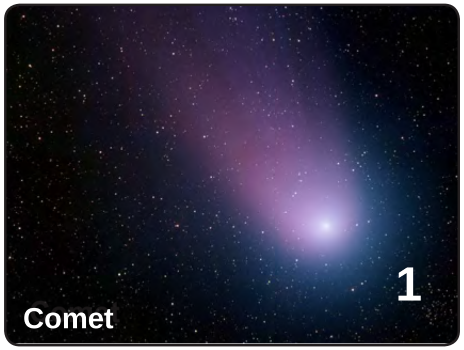
Sorting Game Cards - How Far?

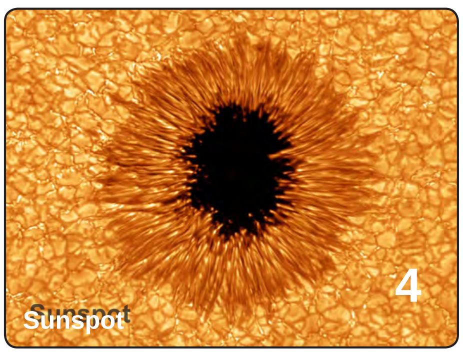


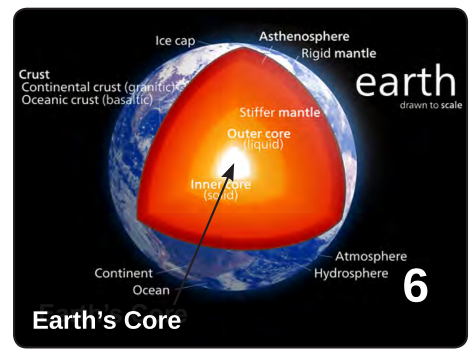


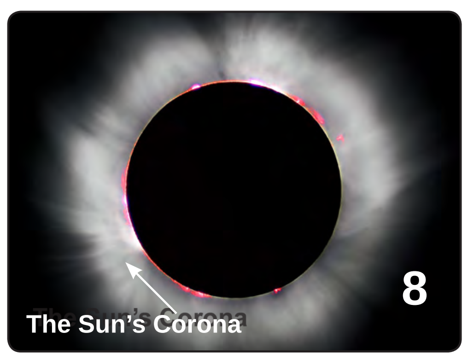


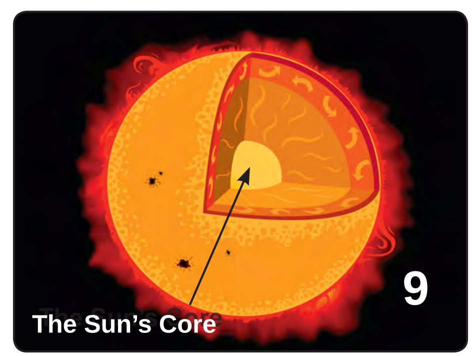
Sorting Game Cards - How Hot?











Recommended STEM Activity Clearinghouse Resource

Jump to Jupiter

Credit: American Library Association

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.

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

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

STAR★net Hands-on

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)

	Scaled Diameter	Scaled Average Distance from Sun	Scaled Average Distance from Sun	Number of Jumps Between Objects
Sun	100.0 mm			
Mercury	0.4 mm	14 feet	4 meters	4
Venus	0.9 mm	26 feet	8 meters	4
Earth	0.9 mm	35 feet	11 meters	3
Mars	0.5 mm	54 feet	16 meters	6
Asteroids (e.g. Ceres)	0.07 mm	98 feet	30 meters	13
Jupiter	10 mm	184 feet	56 meters	26
Saturn	8 mm	337 feet	103 meters	47
Uranus	4 mm	677 feet	206 meters	104
Neptune	4 mm	1061 feet	323 meters	117
Pluto	0.17 mm	1393 feet	425 meters	101
Alpha Centauri star system			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] - http://dictionary.reference.com/browse/ceres
Uranus [YOU'RE a nuss] - http://www.planetary.org/blogs/emily-lakdawalla/2009/1806.html
Haumea [hah-oo-may-ah] - http://starchild.gsfc.nasa.gov/docs/StarChild/solar_system_level2/haumea.html
Makemake [MAH-keh MAH-keh] - http://www.iau.org/news/pressreleases/detail/iau0806/
Eris [ee'-ris] - http://www.iau.org/news/pressreleases/detail/iau0605/

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 markers. -- 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, And a really enormous girth. I am mighty ________________________ and I'm over ten times as wide as Earth!	# Jumps: __________
I'm yellow and my ammonia haze covers each and every thing. I'm ________________________ and my beauty's found within my icy rings!	# Jumps: __________
Methane gas colors my atmosphere blue. 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.	# Jumps: __________
It takes me over sixty thousand days to go one whole year through! I'm the last giant planet. I'm ________________________, and just a little darker blue.	# Jumps: __________
With comets and other dwarf planets I orbit in an oval path Count the miles to get to ________________________, It will take a lot of math!	# Jumps: __________

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1421427. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Shadow Play

Young children are fascinated by shadows! In *Shadow Tracing*, children create and trace their shadows indoors and on the playground. In *Shifting Shadows*, the children trace shadows of playground equipment, then visit their tracings a few minutes later to discover how they've changed. Both activities are accompanied by high-quality videos that can be shown to the children to give them ideas about how to explore shadows.

Credit: Pixabay

Key Concepts

- An object's shadow changes size and shape as it is moved closer to, and farther from, a light source.
- Outside, objects have shadows that change in direction, size, and shape over time.
- The Sun changes position in the sky over time.

Build a Program with Related Resources

Search the STEM Activity Clearinghouse (clearinghouse.starnetlibraries.org) for other activities about the Sun, such as the activity *Sun Cookies*. Explore shadows related to the solar eclipse with the activity *Making an Eclipse Book* and by using pinhole projectors constructed out of boxes and other simple materials.

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!

Content Area:
- Astronomy and Space

Age Group:
- Family
- Early Elementary

Time to Complete Activity:
10-20 minutes

Time Needed to Prep Activity:
10-20 minutes

Cost Associated with Materials:
$1-$5

Difficulty Level:
Easy

Mess Level:
Low

Originating Source:
Shadow Tracing and *Shifting Shadows* were developed by WGBH and is part of the NASA portfolio of educational products available at www.pbslearningmedia.org/collection/buac.

PBS LearningMedia™

Shadow Tracing
Teaching Tips

Here are some ways to engage students with this video and with other activities related to making shadows and exploring how to make shadows change size and shape.

Safety Tips

If children are using flashlights indoors, remind them not to shine the light in anyone's eyes. If you are using a lamp for shadow tracing activities, remind children that the light bulb can get very hot; they should be careful not to touch it. If there is an electrical cord, try to position it so that no one will trip on it, and remind children to be cautious. When you are outdoors doing shadow experiments, remind children not to look directly at the Sun—it can cause harm to their eyes.

Viewing the Video
Use the following suggestions to guide students' viewing of the video.

Before:
Place a lamp, slide projector, or powerful flashlight on a table so that the light shines on an empty wall or screen. There should be enough space for children to position themselves between the light source and the wall so that they can make shadows with their hands. Darken the room and gather the children so that they are facing the wall.

Tell children that they are going to use their hands to make shadows. Ask a small group of children to make hand shadows that look like the heads of quacking ducks. Ask one child to move his or her hand toward the light source. What happens to that shadow? (As the hand moves closer to the light source, it blocks more of the light so that the shadow—the dark, hand-shaped area on the wall where there is no light—grows larger.) Ask a couple of children to move their "quacking duck" hands farther away from the light (closer to the wall). Discuss how those shadows change.

Through conversation and demonstration, guide children to describe what happens to shadows when an object blocking the light moves closer to and farther away from the light source. If possible, have them observe this phenomena for different objects, and use this pattern of observations to draw some general conclusions about how shadows act. Note that this conversation can help dispel some common student misconceptions about where a shadow comes from and what it is. Young children often think of a shadow as an entity or thing that comes out of an object or person, rather than the absence of light caused by an object or person blocking the light from falling on a surface.

Ask children if they know other animal shadows that they can make with their hands. Let a group of children demonstrate each hand shadow mentioned so that all children have a chance to make a shadow on the wall.

During:
As they view the video, ask students to watch for things that the children in the video do with shadows that are similar to what they themselves have done. They should also watch for some new, different things that the children in the video do with shadows that they think would be fun to try.

Use some of the following discussion questions. You may want to replay certain portions of the video so children can confirm or discover an answer:

- When the children were making hand shadows indoors, what happened to the shadow when the boy moved his hand closer to the light source (and farther away from the paper)?
- What happened to the shadow when the boy moved his hand farther away from the light source (and closer to the paper)?
- What animal hand shadows did the children in the video make? Show me with your hands how they made a rabbit. How did they make a coyote?
- When the two girls made the letter H with their bodies, at first the shadow didn't look like the letter H. Why not? What did the girls do to make the shadow look like the letter H?

After:
Reflect and discuss. Ask children:

- What light source did the children use to make shadows indoors?
- What light source did the children use to make shadows outdoors?
- What are some things that the children in the video did with shadows that are similar to what you have done?
- What are some new, different things that the children in the video did with shadows that you would like to try?

The activity suggestions below can help reinforce and extend children's learning.

- **Shadow Tracing Center.** Set up a table with a lamp or overhead light where children can trace and color shadows, like the children in the video did. Children can make simple hand shadows that look like animals, such as a rabbit, coyote, duck, snail, or flying bird. You might want to suggest that they try holding a coin, eraser, or other small object between their fingers to add to the shadow outline. Children can also trace the shadows of classroom toys and objects. Encourage children to experiment with moving their hands or objects closer to and farther from the light to change the size of the shadow.

- **Outdoor Shadow Fun.** In the video, two girls worked together to make a shadow that looked like the letter H. Encourage your students to work in pairs to create shadows that look like the letters H, A, E, M, N, W, and X. Remind students that, like the girls in the video, they may need to turn their bodies so that the shadow looks like the letter they are forming. Individual children may want to try making the letters F, L, P, T, and V. If possible, take photos of the children and the letter shadows that they make.

PBS LearningMedia

Shifting Shadows
Teaching Tips

Here are some ways to engage students with this video and with other activities related to exploring how the changing position of the sun in the sky causes the direction, size and shapes of shadows to change.

Safety Tips: *When outdoors doing shadow experiments, remind children not to look directly at the sun—it can cause harm to their eyes. When using flashlights, remind children not to shine the light in anyone's eyes.*

Before:
Ask children to share prior knowledge and experiences in a group discussion: *How do outdoor shadows change during the day? Why do they change? How is your shadow different when you are outdoors in the early morning (or late afternoon) compared to when you are outside at noon? What are some ways we could investigate how shadows change during the day outside on our playground?*

Use a flashlight and an object (for example, a cup or a glue stick) to demonstrate how the changing position of the sun in the sky causes the direction, size, shape of shadows to change. Place the object on a flat surface (table, floor, etc.) Using the flashlight as the sun, move it in an arc over the object, starting with sunrise (low to the left), to noon (directly overhead), to sunset (low to the right). Have children describe the shadow at different times of day and explain how and why the shadow changes.

If possible, head outside to the playground or other safe paved outdoor area to trace the shadows of some stationary objects with chalk. Children can also trace the shadow of a classmate, being sure to trace around the classmate's feet so that he or she can stand in the same position later in the day to compare where the new shadow falls. Write the time of day next to the shadows. Ask children to predict how the direction and size of the shadows will be different when they return to the same area later in the day.

You may want to watch the video "Shifting Shadows" (/resource/buack2-sci-shiftshadows/shifting-shadows/) before you return to the playground to compare shadows. Tips for recording and comparing shadows at a second time of day are provided in the **After** section below.

During:
In the "Shifting Shadows" video, children trace shadows in the playground at different times of the day. As they watch the video, ask children to pay attention to how the shadows change. Then ask some of the following discussion questions. You may want to replay certain portions of the video so children can confirm or discover an answer.

- *In the video, what happened to the shadows on the playground?*
- *What did the children do with the chalk? Why did they do that?*
- *Toward the end of the video, the girl traces the boy's shadow. Is the boy's shadow taller than the boy, the same height, or shorter?*
- *A while later, the boy checks to see how his shadow has changed. Is his new shadow taller or shorter than the shadow tracing made earlier? Challenge question: Do you think these two shadow tracings were made in the*

morning or the afternoon? Why do you think so? [Hint: At what time of day are shadows the shortest?]

After:
Reflect and discuss. Ask children:

- *In the video, what did children observe about shadows and how they changed during the day?*
- *Why do you think the shadows changed? What is the light source outside that makes the shadows? Does the Sun stay in the same place in the sky throughout the day, or does it move?*
- *If we go outside and compare the shadows on the playground now to the ones we traced earlier, do you predict that the shadows will be taller or shorter? Why do you think so? [Hint: What time did we trace the first shadows? What time is it now?]*
- *Did the video give you any ideas about other shadow activities you think our class should try outside?*

The activity suggestions below can help reinforce and extend children's learning.

1. **Head to the playground.** If possible, go back to the playground and compare current shadows with the shadows that you traced earlier. Have children recall their predictions. Were they correct? Discuss how the shadows have changed. *Do the changes look similar for all of the shadows? How has the size of the shadows changed? Are they all taller/longer or shorter? Why do you think that is?*
   You may want to use a different color of chalk to trace the new shadows. Write the time of day next to the new shadow tracings. If you wish, plan to return to the playground a third time during the day and compare the three shadows.
2. **Watch another PEEP video.** To continue investigating and discussing how shadows change during the course of a day, you may want to view the PEEP animated story video "Go West Young Peep" (/resource/buack2-sci-westpeep/go-west-young-peep/).
3. **Make a sundial.** Before the invention of clocks and watches, people used the Sun and shadows to tell time. Your students can build a simple sundial—a Sun-and-shadow clock—with a paper plate, a sharpened pencil, a lump of clay or play dough (optional), and markers. See the Make a Sundial handout for directions. Note that it is important that students use a rock or other object to hold down their sundials and ensure that they do not rotate. If you are in the northern hemisphere (above 30°N), you may want to point out that the noon shadow always points north. It is interesting to note that the sundial will work differently as the seasons change—the lengths of the shadows will change.

Explore Some More:
Moonbear's Shadow. The picture book *Moonbear's Shadow* by Frank Asch explores the concept of how the direction of shadows changes during the day with the changing position of the Sun in the sky. Share the story with the children. Then act out the first scene and the final scene together, using a toy bear with a fishing pole, a blue paper pond, and a flashlight Sun.

Recommended STEM Activity Clearinghouse Resource

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*.

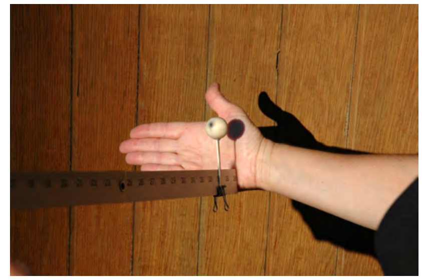
Add Your Review of This Activity

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



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.

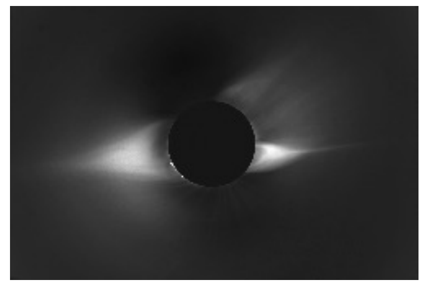


Photo Credit Fred Espenak

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.

Modeling Meaningful Eclipses

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

<u>Note to Facilitator:</u>

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

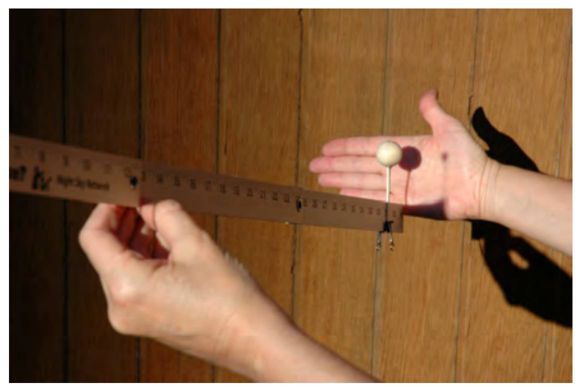
To Do:
Hand out materials to groups of 2-3. If possible, use the actual Sun in the model. If not, have a single bright light source and no other lights in the room.

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.

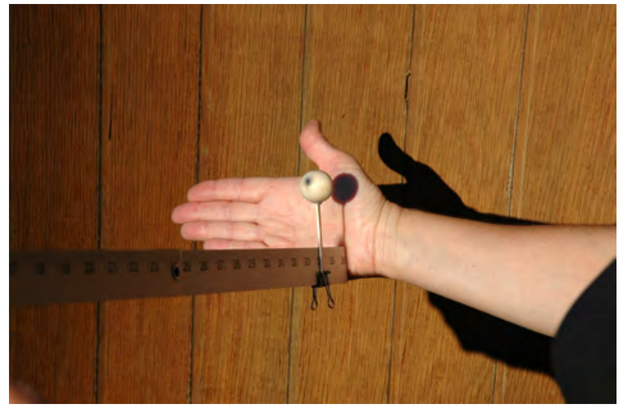
Questions that encourage conversation:
“How were you able to make a solar eclipse with the materials?”
“How were you able to make a lunar eclipse with the materials?”
“What did you observe in your model when you made a (solar/lunar) eclipse?”

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.

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

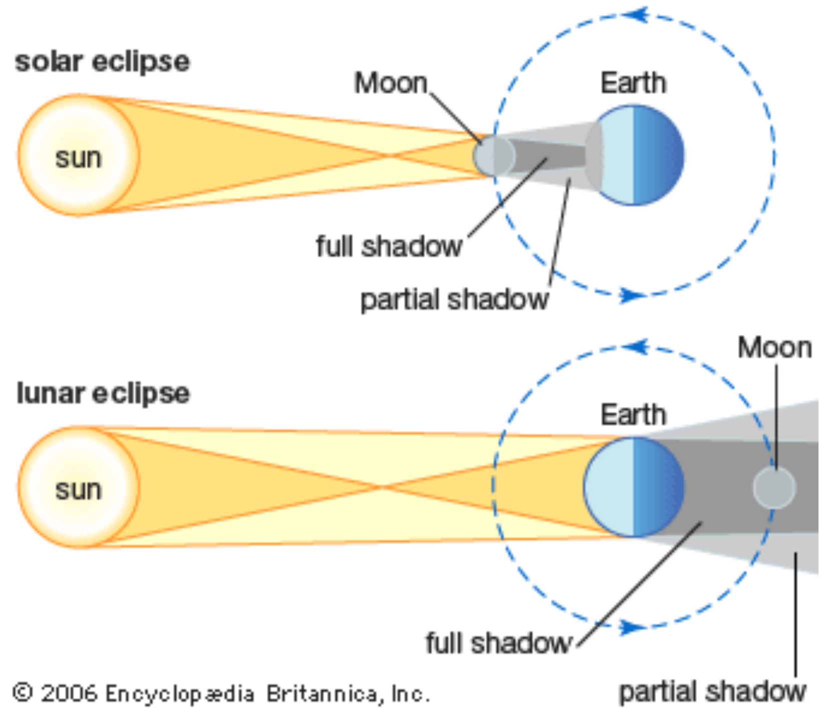
Where to find materials

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

Background Information

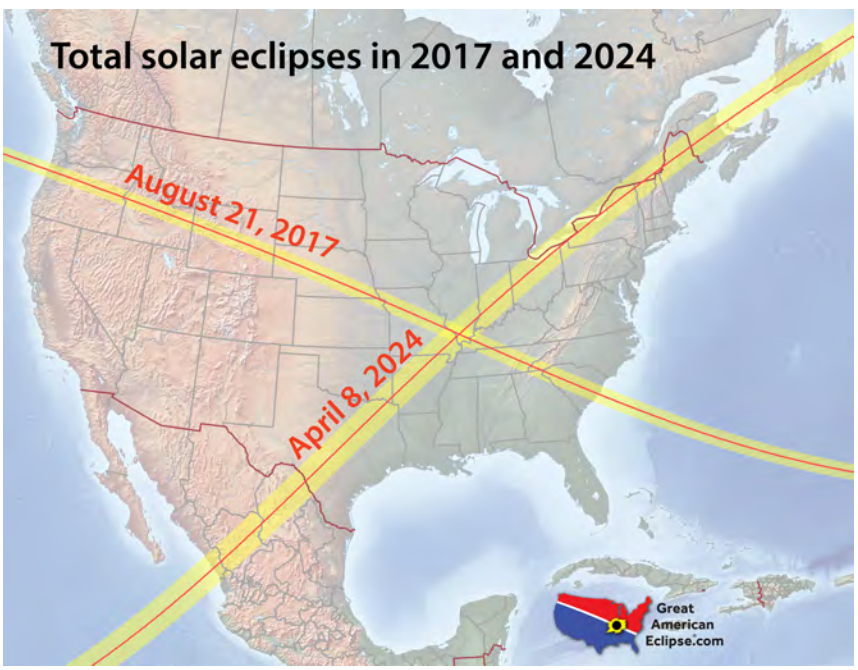
Eclipses

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

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/

Wind Streamer

Children enjoy creating a weather tool out of craft materials that they can take home with them.

Watch the how-to video at https://www.youtube.com/watch?v=vIAHXC5z6ug&t=8s for a brief introduction of the materials required and a demonstration of how to use the wind streamer to measure the wind's direction.

Credit: TLL Temple Memorial Library, Diboll, TX

Key Concepts

- Weather on Earth is always changing, but scientists — and children — can watch and use tools to note the different types of weather.
- Scientists use tools to measure wind direction (in addition to wind speed, temperature, and precipitation).

Build a Program with Related Resources

This simple activity works well as a learning station alongside other weather- and Earth science-related activities. Visit the "STAR_Net Hands-on Activities" collection on the STEM Activity Clearinghouse (clearinghouse.starnetlibraries.org) for more field-tested activities, or browse activities in the "Earth Science" content area.

Introduce this activity with the *Oh Say Can You Say What's the Weather Today?: All About Weather* book.

Encourage caregivers to extend the learning at home on their mobile devices by downloading the GLOBE Observer app at https://observer.globe.gov/about/get-the-app. Families can use the app to note what types of clouds are in the sky, then share their observations online through the app. GLOBE Observer cloud observations are helping NASA scientists understand clouds from below (the ground) and above (from space).

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

Age Group:
- Family
- Early Elementary
- Upper Elementary

Time to Complete Activity:
10-20 minutes

Time Needed to Prep Activity:
10-20 minutes

Cost Associated with Materials:
$1-$5

Difficulty Level:
Easy

Mess Level:
Low

Originating Source:
Wind Streamer 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.

WIND STREAMER

Overview

Children create a wind streamer out of common materials and use it to determine the wind's direction.

Activity Time

15 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

Type of Program

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

What's the Point?

- Weather on Earth is always changing, but scientists — and children — can watch and use tools to note the different types of weather.
- Scientists use tools to measure wind direction (in addition to wind speed, temperature, and precipitation).

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 that is exposed to any breeze or wind

Materials

For the Facilitator

- ☐ *Brief Facilitation Outline* page
- ☐ 1 navigational compass

For Each Group of 10-15 Children

- ☐ 40-60 meters (45-66 yards) or more of crepe paper, in a variety of colors
- ☐ 10-15 (dinner-size) paper plates

A product of the Science-Technology Activities and Resources for Libraries (*STAR_Net*) program.
Visit our website at www.starnetlibraries.org for more information on our educational programs.
Developed by the Lunar and Planetary Institute/Universities Space Research Association
September 2015

- ☐ 5-8 copies of the *Wind Streamer Graphic and Instructions* (depicting a compass rose), printed in color or in black and white and cut in half
- ☐ Craft supplies and tools, such as:
    - ☐ Rulers
    - ☐ Glue or tape
    - ☐ Crayons and / or colored pencils
    - ☐ Markers

Supporting Media

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

Books

Weather
Mike Goldsmith, Kingfisher, 2014, ISBN: 978-0753471326
Readers lift flaps to discover the answers to weather-related questions. Appropriate for ages 3-6.

Weather
Catriona Clarke, Usborne, 2006, ISBN: 978-0794512538
Surprising facts and rich illustrations make this book an appealing introduction to weather. There are clear descriptions of the water cycle, clouds, and lightning, as well as sections about weather scientists and how weather affects animals. Appropriate for ages 6-8.

Websites

Weather Wiz Kids
http://www.weatherwizkids.com/kids-questions.htm
Answers to questions submitted by children about weather are posted here. Children ages 8 and up, as well as younger children with the help of an adult, may enjoy looking for answers to their own questions on this list. Some examples include "Why does it rain?" and "Why do clouds float?"

Handouts and Visual Aids

Weather Diary
www.naturedetectives.org.uk/download/weather_diary.htm
The large grid layout and images on this simple weather journal may appeal to ages five to eight. Show the children how to note the wind's direction in their journals.

Preparation

Beginning 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. See the STAR_Net resources listed at http://community.starnetlibraries.org/resources for ideas.
- 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.
- Plan to provide verbal and / or written instructions for creating a wind streamer.
- For young children, plan to provide assistance with gluing and cutting. Consider allowing extra time for this activity for young children.
- Create a wind streamer to serve as an example for the children to follow, then take it outdoors to prepare to answer the children's questions about using it. Use the navigational compass to identify the north from your location. Orient the wind streamer as described in step three and practice noting the direction of the wind.

The day before the activity

- Print color copies of the *Wind Streamer Graphic and Instructions* and cut them in half. Set them out, along with the crepe paper, paper plates, and craft supplies and tools.
- Place the example wind streamer where everyone can access it.

Activity

1. **Share ideas and knowledge.**
   - Introduce yourself and the library. Help the children learn each other's names (if they don't already).
   - Frame the activity with the main message: Weather on Earth is always changing, but scientists — and children — can watch and note the different types of weather.
   - Invite the children to talk about what they already know about weather, what they've experienced at home and their ideas for how they might detect or measure it. Use open-ended questions and invite the children to talk with you and each other.

Young children have built an understanding of weather through direct experiences with wind, clouds, rain and snow, and heat and cold. Use discussion to help them start to think about these prior experiences and build new understandings about the tools that scientists use to understand wind (and more broadly, changes in weather). Some conversation-starters are:

- What is today's weather like?
- What would be the opposite type of weather? What other kinds of weather are there?
- How does the weather affect what you do every day?
- Do you think that today's weather "normal" for this season?
- What do you think the weather will be like tomorrow and why?
- What kinds of weather instruments have you seen at your home or in the community? Does your family have a wind vane or wind chime at home? A thermometer? A rain gauge?

2. **Guide the children in building a wind streamer. Explain that scientists use tools to detect the wind's direction and the children will be making their own tool, a wind streamer, to use at home.** Have the children follow these steps:
   a. Color the wind graphic and cut it out along the black circle.
   b. Prepare the plate, **starting with the bottom, flat side:**
      i. Draw a large, straight cross through the center of the bottom side of the plate.
      ii. At each of the four ends of the cross, and about 1.5 cm (less than an inch) from the edge of the plate, cut a small hole.
      iii. Cut four crepe paper streamers, each measuring about 1 meter (or about the length of a child's outstretched arms) in length.
      iv. Thread each streamer through a different hole and tie it to the edge of the plate.
   c. Glue or tape the colored wind graphic on the bottom of the plate so that the compass rose lines up with the cross. Glue or tape the instructions onto the plate for easy reference by an adult helper or parent at home.

The children may have ideas about what causes wind, including that clouds or trees cause the wind. For young children, it is important that they observe wind, rather than try to explain or model where it comes from.

Older children and parents may be interested in a deeper explanation. Wind is simply air molecules in motion. The Sun's light heats Earth's surface, and that heat is passed to air touching the ground. The warm air becomes less dense and rises. As cold air moves in to replace the rising air, we feel wind.

3. **Demonstrate how the children will use their new tools at home!** Hold the example wind streamer horizontally in front of you, so that the plate is parallel to the ground. Grasp the edge of the plate near the letter "S" and turn to face north so that the "N" on the wind streamer is pointing to the north. Demonstrate that the wind will push the streamers toward one of the cardinal directions noted on the plate. Remind the children that they may have heard weather forecasters on television say that "the wind is blowing out of the north." Emphasize that a wind blowing *from* the north blows the crepe paper to the south.

The cardinal directions marked on the face of the wind streamer may lead some to refer to it as a "compass." The wind streamer is more like a wind sock or wind vane than a compass! Gently guide children and their families toward the use of "wind streamer" (or another related term) instead of "compass" to avoid confusion. (A compass needle is a tiny magnet, and the north or south pole of the needle line up with Earth's magnetic field.) The wind streamer will not help them find North — but it will help them determine the wind's direction!

4. **Conclude.** Summarize that we can detect and measure the ever-changing weather with weather instruments. Encourage the children to take their creations home with them and use

them to note changes in weather over the course of a day, a week, or a season. Invite them to return to share their findings with you.

Correlation to Standards

National Science Education Standards

Grades K-4
Earth and Space Science - Content Standard D
Changes in the Earth and Sky

- Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

Science and Technology – Content Standard E
Understandings About Science and Technology

- Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

Extensions

If desired, expand this activity to include other weather tools. Find instructions and materials lists at websites such as:

- ***Rain Gauge****,* National Wildlife Federation
  www.nwf.org/Kids/Your-Big-Backyard/Fun/Outdoors/Science/Rain-Gauge.aspx

Explore wind even further through projects such as:

- ***Wind Turbine Tech Challenge***, STAR_Net
  http://community.starnetlibraries.org/resources
  Participants build a model wind turbine, then explore and test common materials to identify a modification that would enable their model to better catch the wind.

- ***4-H Grab and Go: Kites,*** University of Illinois
  http://howtosmile.org/record/3442
  This instruction sheet describes how to fold a kite and then modify the design to help the kite fly better. For younger children, provide pre-folded kites for them to decorate and fly.

References

Make a Wind Streamer, Miami Museum of Science

"Weather Unit," American Geological Institute
www.k5geosource.org/2activities/1invest/weather/index.html#wclk

WIND STREAMER

Brief Facilitation Outline

1. **Share ideas and knowledge.**
   - Introduce yourself and the library. Help the children learn each other's names (if they don't already).
   - Frame the activity with the main message: Weather on Earth is always changing, but scientists — and children — can watch and note the different types of weather.
   - Invite the children to talk about what they already know about weather, what they've experienced at home and their ideas for how they might detect or measure it. Use open-ended questions and invite the children to talk with you and each other.

2. **Guide the children in building a wind streamer.** Explain that they will be making one kind of instrument, a wind streamer, for detecting the wind's direction. Have the children follow these steps:
   a. Color the wind graphic and cut it out along the black circle.
   b. Prepare the plate, **starting with the bottom, flat side:**

      i. Draw a large, straight cross through the center of the bottom side of the plate.

      ii. At each of the four ends of the cross, and about 1.5 cm (less than an inch) from the edge of the plate, cut a small hole.

      iii. Cut four crepe paper streamers, each measuring about 1 meter (or about the length of a child's outstretched arms) in length.

      iv. Thread each streamer through a different hole and tie it to the edge of the plate.

   c. Glue or tape the colored wind graphic on the bottom of the plate so that the compass rose lines up with the cross. Glue or tape the instructions onto the plate for easy reference by an adult helper or parent at home.

3. **Demonstrate how the children will use their new tools at home!** Hold the example wind streamer horizontally in front of you, so that the plate is parallel to the ground. Grasp the edge of the plate near the letter "S" and turn to face north so that the "N" on the wind streamer is pointing to the north. Demonstrate that the wind will push the streamers toward one of the cardinal directions noted on the plate.

4. **Conclude.** Summarize that we can detect and measure the ever-changing weather with weather instruments. Encourage the children to take their creations home with them and use them to note changes in weather over the course of a day, a week, or a season. Invite them to return to share their findings with you.

A product of the Science-Technology Activities and Resources for Libraries (*STAR_Net*) program.
Visit our website at www.starnetlibraries.org for more information on our educational programs.
Developed by the Lunar and Planetary Institute/Universities Space Research Association
September 2015

Activity Materials to Print

WIND STREAMER

Measure the Wind's Direction!

1. Go outside on a breezy day.
2. Hold the wind streamer out flat in front of you.
3. Hold the edge of the plate near the letter "S" and turn to face north so that the "N" on the wind streamer is pointing to the north.
4. Watch the wind push the streamers! Note the cardinal direction that is opposite the direction that the streamers are pointing. For example, a wind blowing *from* the north blows the streamers to the south.

WIND STREAMER

Measure the Wind's Direction!

1. Go outside on a breezy day.
2. Hold the wind streamer out flat in front of you.
3. Hold the edge of the plate near the letter "S" and turn to face north so that the "N" on the wind streamer is pointing to the north.
4. Watch the wind push the streamers! Note the cardinal direction that is opposite the direction that the streamers are pointing. For example, a wind blowing *from* the north blows the streamers to the south.

Overview

Moon Skits: How's the Weather?

Participants write a script and act out a brief (30-60-second) skit about the "weather" at a fictitious settlement on the Moon. Use a green filming backdrop and Space Stage app to capture videos of the skits – using real images of the Moon as the backdrop!

Credit: Space Science Institute

Key Concepts

After doing this activity, participants will be able to describe the lunar environment, including temperature fluctuations and what day and night are like.

Credit: NASA

Recommended Ages:
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

Preparation Time:
20-40 minutes

Activity Time:
30 minutes to 1-2 hours

Background Information

Many different countries would like to establish a base on the Moon to do science and possibly even live for short periods of time, but the Moon is very different from the Earth. The temperatures range from an incredibly hot 253 degrees Fahrenheit (122 Celsius) in the Sun to an incredibly cold -387 degrees Fahrenheit (-233 Celsius) in the shadows or at night!

A crater on the Moon, called Hermite, holds the record for the coldest constant temperature in the solar system: -415 degrees Fahrenheit (–248 degrees Celsius). Sunlight never reaches the floor of the crater.

A full day on the Moon lasts about two weeks and nighttime lasts about another two weeks. (The Earth takes 24 hours to rotate, which is why we have about 12 hours of daylight and 12 hours of darkness.)

Since the Moon doesn't have an atmosphere like Earth, light from the Sun doesn't scatter – and the stars are visible during the daytime! Fun fact: The Earth has phases as seen from the Moon. While the Sun would appear to rise and set (over the course of a month), Earth would appear fixed in the sky to visitors on the surface of the Moon.

Materials

- Script-writing materials:
  - Template for writing a script (below)
  - Moon factoids (below), cut into segments
  - Tape and/or glue
  - Colored pencils or crayons
- Green Screen set up on its stand (see the Green Screen Setup and Calibration Guide)
- Tablet and Space Stage App (see the Tablet Setup and Tips Guide)
- Optional (recommended): props and costumes, such as astronaut costumes; mittens or gloves; snow boots; ski masks; snow suits; umbrellas; sunglasses

Tip: avoid the color green

- Optional (recommended): projector and videos to provide background information
  - "How Does a Green-Screen Work?"
    https://www.youtube.com/watch?v=A0h_BVLRSeI
  - NASA | Tour of the Moon
    https://www.youtube.com/watch?v=2iSZMv64wuU

Preparation

1. When promoting the activity, emphasize that participants will need to avoid wearing green-colored clothing.
2. Gather materials.
3. Set up the Green Screen and provide a tablet with the Space Stage app preloaded on it. Have props and costumes available nearby.
4. Optional: Set up projector and videos.
5. Cut Moon factoids (below) into segments and have them available along with the script templates, colored pencils and/or crayons, and tape and/or glue.

Procedure

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already).
- Explain to the participants that they will create skits about an imagined visit to the Moon, beginning with writing scripts and ending with filming their skits in front of a Green Screen.
- Introduce the technology required for the activity. Find out what the participants know about Green Screens and their use in TV and film. Show a short video with tips on using Green Screens (see above for a recommended video).
- Have a discussion about what the audience already knows about what it's like on the Moon and what they would like to learn. Show short videos about what it would be like to be a visitor to the Moon's surface (see above for recommended videos).

Procedure (continued)

2. Explain to the participants that they will write a skit in groups and provide information to get them started. Say:

- You are visiting a Moon base, and you are going to video chat home to friends and family back on Earth. Your friends and family ask, "How's the weather?"
- Pick interesting things about the Moon to talk about in your skit, such as:
  - What the temperature is like.
  - Whether the base will be dark (nighttime) or light (daytime) for the next few days.
  - What is visible in the sky.
- The skit can only be 30-60 seconds long.

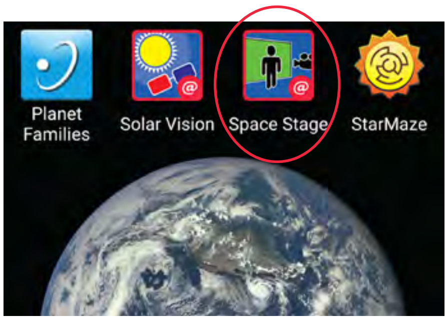
3. If time allows, invite participants to practice their skits.

Coach the participants in presentation skills. Encourage them to take time to pause and take a breath between sentences, smile (if appropriate in the skit), keep arms relaxed at their sides, and look directly at the tablet's camera.

4. Using a Green Screen and a tablet with the Space Stage app, have participants playact their video chats.

Have the person holding the tablet speak the parts of friends and family on Earth, while the person on camera speaks the parts of a visitor to the Moon. Guide participants in using the app, as needed.

<u>**Tips on using the Space Stage app:**</u>

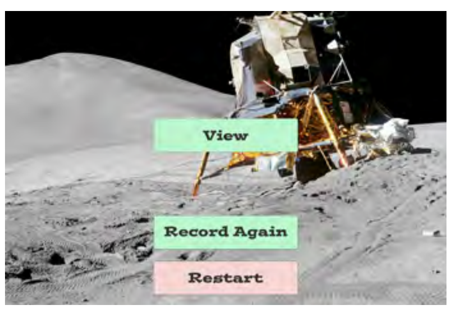


Tap on the Space Stage icon to open the app. Note: Available apps and background wallpaper will vary.

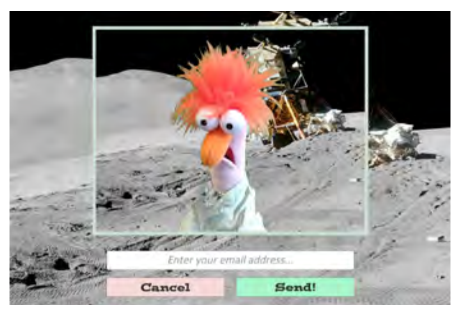
Select an image from the provided image set as a backdrop for their "video chat."

Act out the script.

Use the additional options to select the front- or rear-facing camera on the tablet, and add "stickers" to the video scene.



View the video or record a new one.



Invite adult participants to enter an email address in order to receive the video file.

Connections to Other Kit Materials

Tour the Moon or Mars with Google Earth (see the activity guide within Section B of the binder)

Connections to Other *STAR_Net* Activities

Build a Space Colony
http://clearinghouse.starnetlibraries.org/index.php?id_product=64&controller=product

Lunar Phases: A Dance Under the Sun (ages 10 and up)
http://clearinghouse.starnetlibraries.org/index.php?id_product=82&controller=product&search_query=lunar&results=31

Extensions

In-depth skit development:
Check out novel ways that teachers are using Green Screens and video editing apps in their classrooms. These ideas are useful for extending this activity into a camp or all-day workshop, with more time to storyboard the script, create props, and practice presentation skills.

"Create a Green Screen Video in Your Classroom," by Lindsey Petlak, Scholastic
http://www.scholastic.com/teachers/blog-posts/lindsey-petlak/create-green-screen-video-your-classroom.html

"Student-Produced Weather Report," by Susan M., Common Sense Education
https://www.commonsense.org/education/lesson-plans/student-produced-weather-report

References

Permission to use existing text and modify NASA's MAVEN Mission's Red Planet: Read, Write, Explore! Lessons 4 and 5 provided by the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics.
http://lasp.colorado.edu/home/maven/education-outreach/for-educators/red-planet/

Common Core for English Language Arts

Writing

- W.2.2. Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section.
- W.3.2., 4.2, 5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- W.4.9., 5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Speaking and Listening

- SL.2.2. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.
- SL.3.2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
- SL.2.4, 3.4., 4.4, 5.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
- SL.4.5., 5.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.

Participant Sheet

You are visiting a Moon base. You are calling home to friends and family and they ask, "How's the weather?" Here are some ideas of what to tell them:

- What the temperature is like.
- Whether the base will be dark (nighttime) or light (daytime) for the next few days.
- What is visible in the sky.

Write your script here. Add Moon factoids to your skit by gluing the words onto this sheet.

Moon Factoids

Hi	Grandma	Grandpa
	Mom	Dad

It's me, ______________________________
(name)

hot	sunlight	253 degrees Fahrenheit (122 Celsius)
cold	shadows	-414 degrees Fahrenheit (-248 Celsius)
Earth	Earth has a cresent shape	Earth looks like a half-circle
day	night	two weeks

a crater near the north pole of the Moon
is the coldest place in the Solar System

Overview

Moon Skits: Space Adventure Travel Corporation Commercials

Participants write a script and act out a brief (30-60-second) commercial convincing tourists to come to the Moon for a visit. Use a green filming backdrop and Space Stage app to capture videos of the skits – using real images of the Moon as the backdrop!

Credit: Space Science Institute

Key Concepts

After doing this activity, participants will be able to describe what a human settlement on the Moon might include, such as greenhouses to grow food, protection from the Sun, and water recycling, in order to survive the harsh lunar environment.

Recommended Ages:
Families or other mixed-age groups, including children as young as 8 years old *with assistance from an older child, teen, or adult*
School-aged children
Tweens up to about age 13

Preparation Time:
20-40 minutes

Activity Time:
45 minutes to 1-2 hours

Background Information

The Moon is very different from the Earth. There is no air to breathe, so you would have to have shelter that provided oxygen. You would need to bring food and have a plan to grow it on the surface. You would also have to bring a supply of water, because even though water ice has been found on the Moon, you would have to locate it, find a way to collect it with machinery and filter it before you drank it. Solar radiation is a problem on the Moon since there is no atmosphere. Earth's atmosphere shields us from most harmful radiation coming from the Sun.

If we want to visit the Moon and stay for any period of time, we have to consider the complexities involved in engineering the journey and what a human needs to survive and thrive in a completely different environment. Along with our basic requirements of food, water, clothing, shelter, and oxygen, what else do we use and do everyday that makes us not only able to survive, but keeps us happy and healthy, both mentally and physically, on Earth? These are questions scientists and engineers have when trying to design a space mission involving humans, whether they are simply going into orbit around Earth, staying for awhile in the International Space Station, or traveling farther out into space.

Humans require a lot to keep them alive, and that makes sending humans into space both risky and expensive. Huge amounts of equipment are required to provide radiation protection, oxygen, waste removal, food, and exercise equipment. In space, muscles degrade, bones deteriorate, and the heart shrinks.

Once there, the shelter would have to be shielded from harmful radiation. Water and energy would have to be generated, and food would have to be grown. A trip to the Moon would be for scientific research and that would include bringing transportation, digging equipment, and scientific instruments.

Materials

- Script-writing materials:
  - Template for writing a script (below)
  - Space colony factoids (below), cut into segments
  - Tape and/or glue
  - Colored pencils or crayons
- Green Screen set up on its stand (see the Green Screen Setup and Calibration Guide)
- Tablet and Space Stage App (see the Tablet Setup and Tips Guide)
- Optional (recommended): props and costumes, such as astronaut costumes; mittens or gloves; snow boots; ski masks; snow suits; umbrellas; sunglasses
- Optional: materials for creating foreground scenery, props, and costumes, such as construction paper, foam sheets, felt, aluminum foil, foam core, swim noodles, cardboard, canvas drop cloths, flexible tubing, sheets, clean and empty 2-liter bottles, white painter suits, as well as scissors, glue, and duct tape
- Optional (recommended): projector and videos to provide background information
  - "How Does a Green-Screen Work?" https://www.youtube.com/watch?v=A0h_BVLRSeI
  - NASA | Tour of the Moon https://www.youtube.com/watch?v=2iSZMv64wuU
  - NASA BEST: Living on the Moon https://www.youtube.com/watch?v=TNrhADcTNBk
  - Back to the Moon for Good https://www.youtube.com/watch?v=OkivPFtLOj4

Preparation

1. When promoting the activity, emphasize that participants will need to avoid wearing green-colored clothing.
2. Gather materials.
3. Set up the Green Screen and provide a tablet with the Space Stage app preloaded on it. Have props and costumes available nearby.
4. Optional: Set up projector and videos.
5. Cut space colony factoids (below) into segments and have them available along with the script templates, colored pencils and/or crayons, and tape and/or glue.

Procedure

1. Share ideas and knowledge.
- Introduce yourself. Help the participants learn each other's names (if they don't already).
- Explain to the participants that they will create "commercials" for a fictitious travel company, beginning with writing scripts and ending with filming their skits in front of a Green Screen.
- Introduce the technology required for the activity. Find out what the participants know about Green Screens and their use in TV and film. Show a short video with tips on using Green Screens (see above for a recommended video).
- Show videos about colonizing the Moon (see above for recommended videos). Allow some time for participants to discuss what they viewed. Encourage open-ended discussion on what things people would need and what they would want to have for a trip to Moon and on a Moon base. For example:
  - What do you use every day that you couldn't live without?
  - What do you do for fun on Earth? Would it be challenging to do this on the Moon?
  - What could you live without that you could leave at home?
  - Would you need to travel around the planet to explore? How would you get around?
  - Do you need to communicate with Earth when you are on the Moon? How?
  - How do you create power on the Moon to run your electronics and equipment?

2. Explain to the participants that they will write a skit in groups and provide information to get them started. Say:

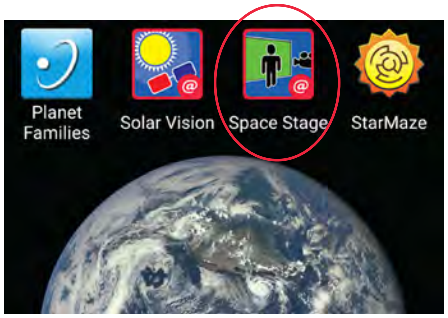
- Imagine that you are living in the year 2040, and you work for the Space Adventure Travel Corporation in their advertising office. Your main job is to convince people from Earth to visit the Moon. There are new bases, with habitats that maintain temperature, provide air to breathe, protect from radiation, and have running water. Although it's no Hilton, it's a fun place to go for a visit! Your advertising office has been given the task of creating a new advertisement.
- Pick interesting things about the Moon to talk about in your skit, such as:
  - What the trip to the Moon will be like (for example, you could describe the ship and how it usually only takes about three days to travel there)
  - Where tourists will stay once they get to the Moon (use what you know about the Moon, but also your imagination!)
  - Fun activities you could do on the Moon (for example: science activities, travel to destinations, recreational sports in lower gravity, etc.)
  - A description of safety features provided for a stay on the Moon
- The skit can only be 30-60 seconds long.

3. Optional: Groups may choose to create scenery, props, and costumes using common materials and craft supplies.

4. Optional: Invite participants to practice their skits. Coach the participants in presentation skills. Encourage them to take time to pause and take a breath between sentences, smile (if appropriate in the skit), keep their arms relaxed at their sides, and look directly at the tablet's camera.

5. Using a Green Screen and a tablet with the Space Stage app: Have participants playact their commercials. For each group, have one person hold the tablet and film the skit, while the rest of the group presents their commercial. Guide participants in using the app, as needed.

Tips on using the Space Stage app:

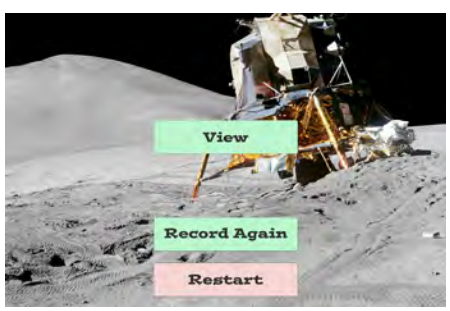


Tap on the Space Stage icon to open the app. Note: Available apps and background wallpaper will vary.

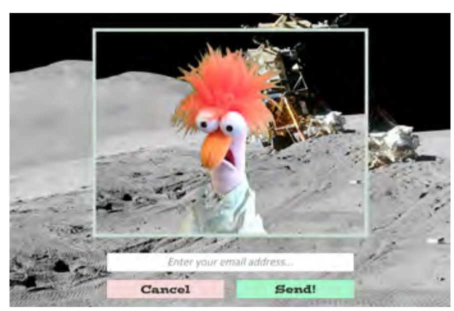
Select an image from the provided image set as a backdrop for their "video chat."

Act out the script.

Use the additional options to select the front- or rear-facing camera on the tablet, and add "stickers" to the video scene.



View the video or record a new one.



Invite adult participants to enter an email address in order to receive the video file.

Connections to Other Kit Materials

Tour the Moon or Mars with Google Earth (see the activity guide within Section B of the binder)

Connections to Other *STAR_Net* Activities

Build a Space Colony
http://clearinghouse.starnetlibraries.org/index.php?id_product=64&controller=product

Lunar Phases: A Dance Under the Sun (ages 10 and up)
http://clearinghouse.starnetlibraries.org/index.php?id_product=82&controller=product&search_query=lunar&results=31

Extensions

In-depth skit development:
Check out novel ways that teachers are using Green Screens and video editing apps in their classrooms. These ideas are useful for extending this activity into a camp or all-day workshop, with more time to storyboard the script, create props, and practice presentation skills.

"Create a Green Screen Video in Your Classroom," by Lindsey Petlak, Scholastic
http://www.scholastic.com/teachers/blog-posts/lindsey-petlak/create-green-screen-video-your-classroom.html

"Student-Produced Weather Report," by Susan M., Common Sense Education
https://www.commonsense.org/education/lesson-plans/student-produced-weather-report

References

Permission to use existing text and modify NASA's MAVEN Mission's *Red Planet: Read, Write, Explore! Lessons 4 and 5* provided by the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics.
http://lasp.colorado.edu/home/maven/education-outreach/for-educators/red-planet/

Common Core for English Language Arts

Writing
- W.2.2. Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section.
- W.3.2., 4.2, 5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
- W.4.9., 5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Speaking and Listening
- SL.2.2. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.
- SL.3.2. Determine the main ideas and supporting details of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.
- SL.2.4, 3.4., 4.4, 5.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.
- SL.4.5., 5.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.

Participant Sheet

You are living in the year 2040, and you work for the Space Adventure Travel Corporation. Your main job is to convince people to visit the Moon. There are new bases on the Moon with habitats that maintain temperature, provide air to breathe, protect from radiation, and have running water. Create a commercial convincing people to visit the Moon. Here are some ideas of what to talk about:

- What the trip to the Moon will be like (for example, you could describe the ship and how it usually only takes about three days to travel there)
- Where tourists will stay once they get to the Moon (use what you know about the Moon, but also your imagination!)
- Fun activities you could do on the Moon (for example: science activities, travel to destinations, recreational sports in lower gravity, etc.)
- A description of safety features provided for a stay on the Moon

Write your script here. Add space colony factoids to your skit by gluing the text onto this sheet.

Space Colony Factoids

Moon	stars	Sun
Earth	no atmosphere	no water
phases	cresent	first quarter
far side	craters	mountains
water ice	recycled water	air to breathe
greenhouse	temperature	radiation
spacesuit	health	Moon rover
jump	hiking	dune buggy races
astronomy	geology	measurements

takes three days to get to the Moon

Overview

Tour the Moon or Mars with Google Earth

Participants use the Google Earth computer software to explore the landscapes in their own area on Earth before "visiting" the same latitude and longitude on the Moon or Mars. They use the Google Earth computer software's built-in tools to experience global perspectives of the Earth and the Moon or Mars, as well as "tour" different landscapes, view 3D models of spacecraft, and read information about the various locations.

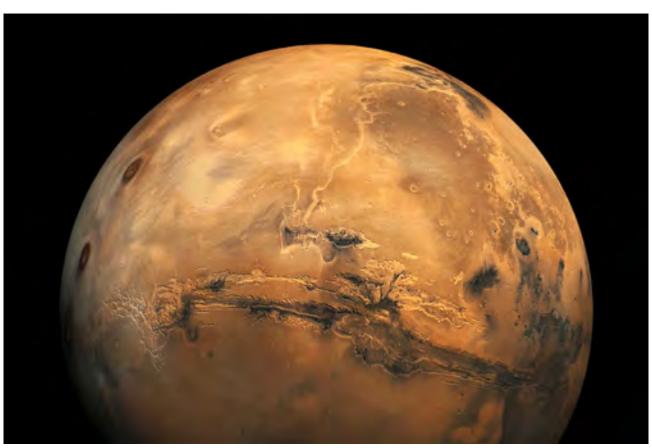
Credit: NASA

Key Concepts

After doing this activity, participants will be able to generally describe the Moon's global appearance and some features on its surface.

Background Information

The Google Earth software allows learners to move back and forth between a global perspective and views of landscapes on the surface. The combination of these two perspectives provides context for exploring how the Moon and Mars are different from – and similar to – Earth. This activity is intended to be flexible and can set the stage for other activities.



Credit: NASA

Recommended Ages:
Families or other mixed-age groups, including children as young as 8 years old *with assistance from an older child, teen, or adult*
School-aged children
Tweens
Teens
Adults

Preparation Time:
40 minutes to 1 hour

Activity Time:
20-40 minutes

Materials

- Google Earth 5 or above, downloaded from www.google.com/earth/
- Optional (recommended): projector and video to provide additional information:
  - NASA | Tour of the Moon https://www.youtube.com/watch?v=2iSZMv64wuU
  - Note: Consider facilitating this activity in a computer lab, where participants can view a projected image of Google Earth on a large screen, while also controlling their own experience at a computer. Google Earth can also be projected onto a screen setup in a community room or other programming space.

Preparation

1. Watch a tutorial on using Moon in Google Earth at https://www.google.com/earth/explore/showcase/moon.html.
2. Install Google Earth 5 or above from www.google.com/earth/.
3. Open Google Earth, type your city and state into the search field, or specifically search for your location by entering the name of your location into the search field.
4. In Google Earth, find the icon that looks like a pushpin on the top bar. Click on the pushpin icon. A window will open. At the top, it will say "Name" with a field box that says "Untitled Placemark." Re-name the Placemark with the name of your location or city and state. The pin is located at the exact latitude and longitude of your location on Earth.
5. Locate the icon that looks like Saturn on the top toolbar and select "Moon" or "Mars" from the drop-down menu. Practice the procedure below to provide a streamlined "tour" of points of interest on the Moon or Mars.

Procedure

1. Share ideas and knowledge.
- Introduce yourself. Help the participants learn each other's names (if they don't already).

2. In Google Earth, explore your area of Earth with program participants to provide context for touring landscapes on other worlds.
- Discuss what the area looks like, making note of major geologic features including lakes, oceans, and streams.
- Facilitate discussion about features in the city or surrounding area.

3. Use your Placemark to begin your tour of the Moon or Mars:
- In Google Earth, on the top bar, click on the symbol that looks like Saturn and select "Moon" or "Mars" from the drop-down menu.
- The pin that you put into Google Earth marking your location on Earth will also appear on the world that you have chosen.
- In the left "Layers" bar, check the boxes "Featured Satellite Images" and "Place Names."
- Zoom into the surface to locate the pin, and discuss the major differences visible on the surface compared with the same latitude and longitude as on Earth. Icons will appear on the surface indicating spacecraft imagery, the locations of landers, or information about geologic features. Click on these icons as desired.

Facilitate a conversation with the participants about their observations. For example, in Google Moon, discuss the major differences visible on the lunar surface. Icons will appear on the surface indicating spacecraft imagery, the locations of Apollo landers, or information about geologic features.

Additionally, at your same latitude and longitude, are you on the side of the Moon visible from Earth, or the far side of the Moon? Discuss with your participants by using the imagery provided in this activity.

Procedure (continued)

• You can check or un-check layers from the left bar to unclutter your view, or to add data to the view.
• If you wander too far away from your Placemark, double click on the name of your Placemark in the left-hand bar.
• If you wish to return to Earth in Google Earth, you may do so at any time by clicking on the icon that looks like Saturn in the top bar, and selecting Earth from the drop-down menu.
• You can check or un-check layers from the left bar to unclutter your view, or to add data to the view.

4. Conclude the tour with a short video that provides more in-depth information (see above for recommendations).

Connections to Other Kit Materials

How Big? How Far? How Hot? Sorting Games

Jump to Jupiter

Moon Skits: How's the Weather and Space Adventure Travel Corporation Commercials

Connections to Other *STAR_Net* Activities

Build a Space Colony
http://clearinghouse.starnetlibraries.org/index.php?id_product=64&controller=product

Planet Party
http://clearinghouse.starnetlibraries.org/index.php?id_product=62&controller=product&search_query=planet+party&results=1

Recommended STEM Activity Clearinghouse Resource

Whip Up a Moon-Like Crater

Kids find this activity to be very engaging! Again and again, they drop rocks or balls into a pan layered with flour and cocoa powder to create "impact craters" Check out the how-to video, https://www.jpl.nasa.gov/edu/teach/activity/make-a-crater, for tips on helping participants connect what they are seeing in the flour/cocoa to the craters they have seen on the Moon.

Credit: NASA Jet Propulsion Laboratory Education

Key Concepts

- The Moon is covered in circular features, called impact craters.
- Impact craters are formed when space rocks smash into the surfaces of the Moon, Mars, and even Earth.
- Impact craters have different features based on the space rock's size (mass), speed, and the angle at which it struck the surface

Build a Program with Related Resources

STEM ACTIVITY Clearinghouse

Combine this activity in learning stations with other hands-on activities relating to the Moon and Mars. Visit the "Moon" collection on the STEM Activity Clearinghouse (clearinghouse.starnetlibraries.org) or browse activities in the "Astronomy and Space" content area. Be sure to have a good plan for crowd control – this is sure to be a popular activity! Or, set up multiple pans and provide small groups of participants plenty of time to test different variables, such as how the crater left behind by a ping-pong ball compares to the crater from a golf ball. Provide copies of the data collection sheet that is provided as part of the activity.

Have learners use their sense of touch by exploring the NASA tactile books, *Getting a Feel for Lunar Craters and Mars Exploration Program*. The books include tactile graphics that illustrate the landscapes of the Moon and Mars, including their craters. NASA tactile books are designed to bring NASA's discoveries to those who are visually impaired or blind, and can also help sighted learners.

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:
- Astronomy and Space
- Mathematics

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

Time to Complete Activity:
20-40 minutes

Time Needed to Prep Activity:
20-40 minutes

Cost Associated with Materials:
$1-$5

Difficulty Level:
Easy

Mess Level:
Medium

Originating Source:
Impact Craters was developed by the American Museum of Natural History and is part of NASA Educational Product EG-2008-09-48-MSFC, available through NASAWavelength.org.

Impact Craters

In this activity, participants will explore what happens when a meteorite, asteroid, or other object hits the Moon. They will explore what features the impacts create by dropping balls of different sizes and weights from different heights.

Age Level
5-14

Time Frame
45 minutes

Materials
- NASA photographs of craters on the Moon and Mars
- One large tub or box, such as a large dishpan
- A large bag of flour (enough to fill the box 1-2 inches deep)
- Fine cocoa powder or sand
- Sieve
- Two same-size balls of different weights, such as a marble, gumball, or mothball; two same-weight balls of different sizes, such as a rubber ball and golf ball
- Yard stick
- Small rulers
- Tooth picks
- 3x5 index card to smooth the surface of the powder
- Newspaper
- Data chart for each participant

Preparation
1. Fill the pan with flour to a depth of 1-2 inches (2.5-5 centimeters). Tap the pan to settle the flour and smooth the surface.
2. Using the sieve sprinkle a fine layer of cocoa or sand evenly and completely over the flour.
3. Sprinkle another layer of white flour on top of the cocoa or sand.
4. Spread newspaper on the floor and place the pan on top of the newspaper.

Adapted from NASA's Make a Crater Activity:
http://lunar.arc.nasa.gov/education/activities/active15a.htm

Impact Craters (continued)

Exploration

Note: You may want to simplify the activity according to the age and ability of your participants. As you conduct the activity, use the questions in the Wrap-up section to guide their understanding.

1. Display the NASA photographs of craters on the Moon and Mars. Call on volunteers to identify the parts of a crater (most craters have deep central depressions, raised rims, and a blanket of ejected material, ejecta, surrounding them). Ask what factors might affect a crater's appearance (the nature of the surface, and the speed, size, and mass of the object making the impact). Tell participants they are going to explore how craters are made.
2. Distribute a data sheet to each participant, and have them record data for each test. Have them gather around the box, standing several feet away from it. Begin with the balls that are similar in size, but different weights. Before a ball is dropped have a volunteer ready with the yardstick to measure each height. Have another volunteer take one of the balls and drop it from three different heights. Call on other volunteers to measure the diameter of each crater, its depth (using a toothpick), and the distance the ejecta traveled after the impact (from the edge of the crater). Repeat the test using the other ball that is similar in size.
3. If necessary, smooth out the top layer and sprinkle more cocoa or sand and then flour. Then repeat the above procedure with the balls that are similar in weight, but different sizes.
4. After testing, have participants analyze and discuss their data. You may want to use the following questions to guide their understanding:
    - How did crater size change when balls of different mass (i.e., weight) were dropped from the same height?
    - How would you state the general relationship between a ball's mass and the crater size?
    - How did the size of the balls affect the crater sizes?
    - How would you state the general relationship between a ball's size and the crater size?
    - How did the different speeds of the balls affect the crater sizes?
    - How would you state the general relationship between a ball's speed and the crater size?

Wrap-Up

Call on volunteers to share what conclusions they can draw from the analysis of their data. Encourage them to cover these points:

- The higher the ball's starting point, the greater its velocity at impact.
- The greater an object's velocity, the larger its impact crater.
- When dropped from a given height, the greater the mass, the larger the crater.
- When dropped from a given height, the greater the volume, the larger the crater.

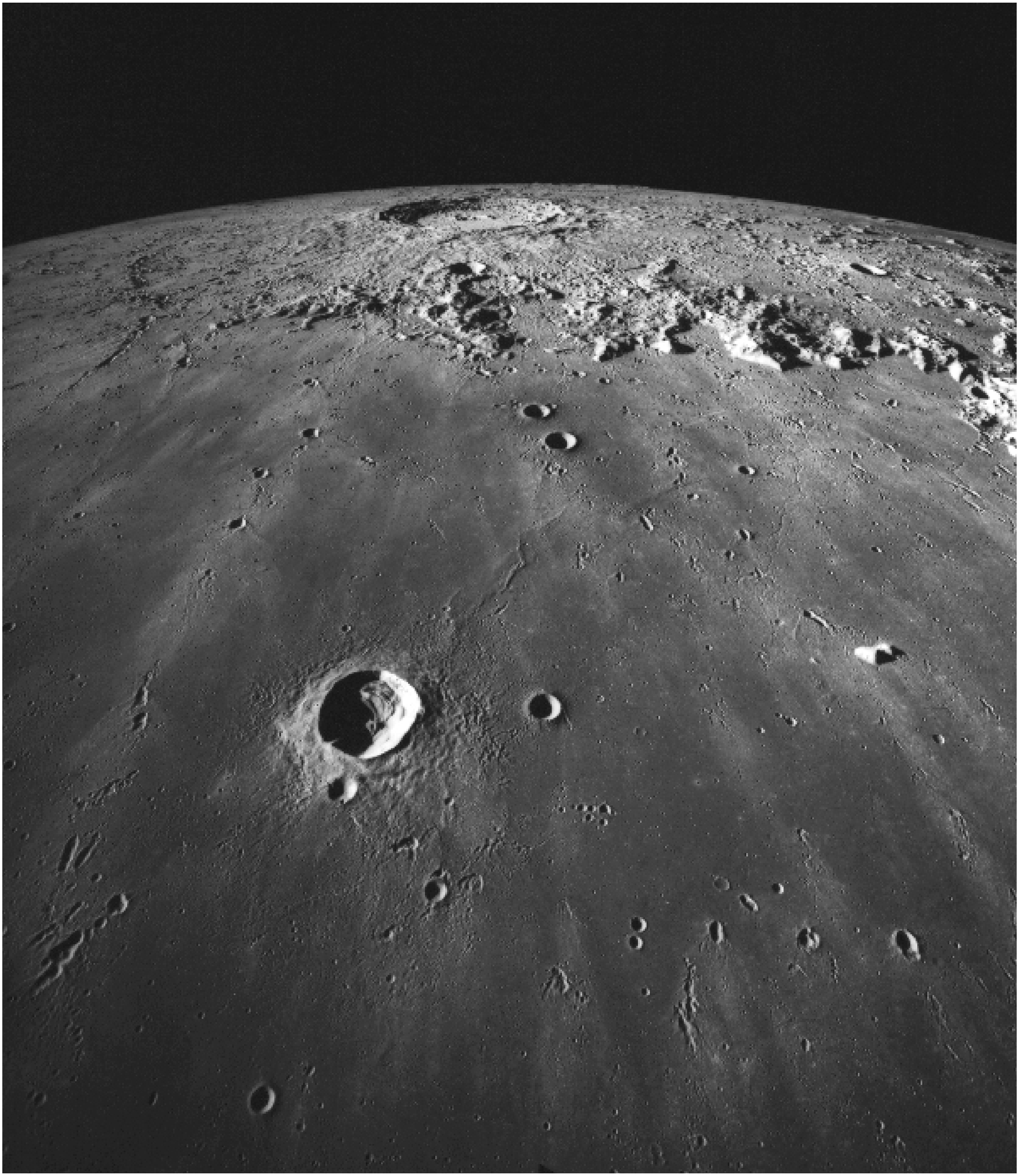
Impact Craters Data Sheet

Record your findings in these charts.

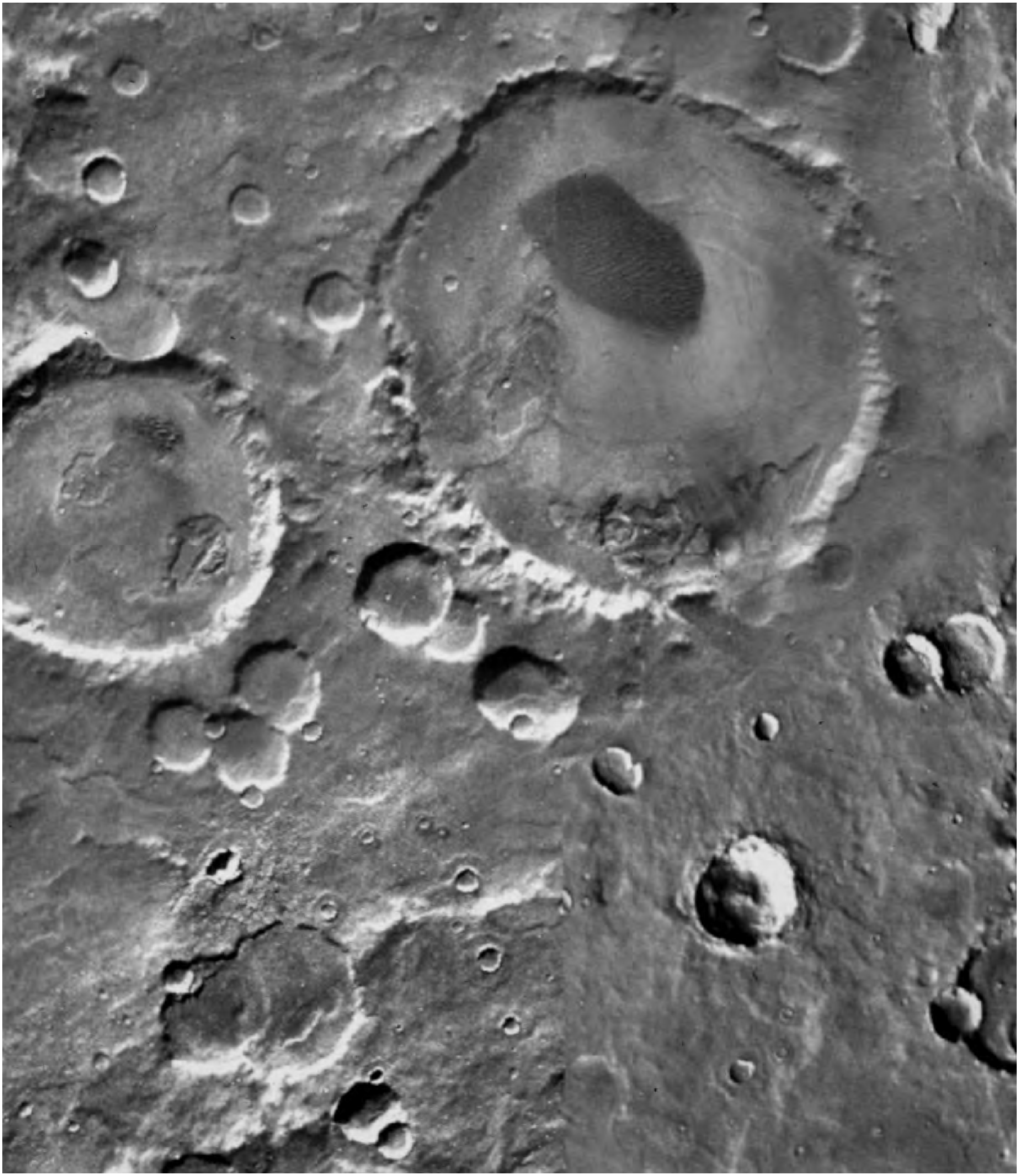
Balls of same size but different weight	HEIGHT of drop	WIDTH of crater	DEPTH of crater	DISTANCE ejecta traveled
TEST 1 Ball 1				
TEST 2 Ball 1				
TEST 3 Ball 1				
TEST 4 Ball 2				
TEST 5 Ball 2				
TEST 6 Ball 2				

Balls of same weight but different size	HEIGHT of drop	WIDTH of crater	DEPTH of crater	DISTANCE ejecta traveled
TEST 1 Ball 1				
TEST 2 Ball 1				
TEST 3 Ball 1				
TEST 4 Ball 2				
TEST 5 Ball 2				
TEST 6 Ball 2				

Craters on the Moon



Craters on Mars



Section 3:

Quick Facilitation Guides

Tablet Contents

Credit: Space Science Institute

The apps on the tablet will be updated over time, so the following list may be incomplete. The apps themselves will be pushed directly to the tablet.

Updates of this document will be available on the iMeet Central project management portal.

Space Stage

Space Stage is a green screen activity that lets you put yourself into a NASA image. At launch there are only lunar images, but we'll be adding new destinations over time. Space Stage can be used in two ways: in a "lightly facilitated" mode, and in conjunction with the "Moon Skits" activities. Both modes require a green screen such as the one included in the kit (see the set-up instructions elsewhere in this manual).

In the "lightly facilitated" mode, users can either just take still photo selfies of themselves (which can be emailed), or record full videos using scripts they create. Basic information on each photo location is included in the app. Videos cannot currently be shared.

Credit: Space Science Institute

Key Concepts
- In the Lightly Facilitated mode, several Key Concepts are listed for each image (travel time, temperature, atmosphere, etc.)
- See the Moon Skit activities for a complete description of their Key Concepts

Solar Vision

Solar Vision lets you explore the Sun using several different "filters", representing the types of instruments NASA uses on spacecraft like the Solar Dynamics Observatory: visible light, x-ray, ultraviolet, etc. It also lets you explore the features you're likely to see during a total solar eclipse. In both cases, you can use the app in an "Exploration" mode, or use a "Find the Features" mode that challenges you to find specific features.

Credit: Space Science Institute

Key Concepts
- The Sun can be viewed using many different wavelengths/filters.
- Different features can be seen depending on the filter used, such as solar prominences and strong magnetic field regions called sunspots.
- A number of features will be visible only at totality during a solar eclipse, including the solar corona, and planets like Mercury and Jupiter that wouldn't normally be visible during the day.

Star Maze

Star Maze is a simple maze game that includes short facts about stars as clues for solving the maze. Depending on a star's mass, light takes hundreds of thousands of years to get from the core of a star to its surface. Players can select three different types of stars, including one like our own. They start in the core and race their magical particle of light through a maze to the surface of the star, collecting letters along the way. Once they reach the surface, players learn how quickly their photon of light traveled through the star's layers.

Credit: Space Science Institute

Key Concepts
- Stars come in different types/sizes
- Stars have different layers. Fusion produces photons in the core which must then work their way out of the star.

Planet Families

Planet Families is a solar system simulator. This app is very free-form: players can make any solar system they like, even with multiple stars. Comets can be launched by swiping across the screen.

Credit: Space Science Institute

Key Concepts
- All objects gravitationally attract all other objects: planets pull on each other just as stars pull on planets.
- Solar systems are not necessarily stable: large planets can destabilize other planets, and multiple star systems are only stable under certain conditions.
- Comet tails always point away from the star, because it's the solar wind (not their motion) that blows the gas away from the comet's core.

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

Using an Infrared Thermometer to Measure Temperatures from Afar

This *NASA@ My library Facilitation Guide* provides tips on using the Infrared Thermometer (also known as an IR Thermometer), and provides suggestions for engaging activities. The infrared thermometer offers an engaging way for learners of all ages to take measurements of the environment around them.

Credit: Space Science Institute

Key Concepts

- Most objects in nature have characteristics that can be measured (e.g. mass, size, electrical charge, temperature).
- Scientists use many different tools to measure the world around them.

Ages – Families, Elementary-aged children, Tweens, Teens, Adults

Materials List – Infrared Thermometer, objects of varying temperatures (e.g., ice water, a heating pad, sunny and shaded concrete)

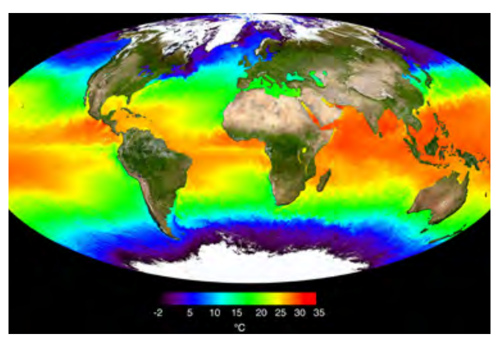
Activity Time – 5-30 minutes

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

Simple Instructions

How to operate the thermometer and suggested uses:

- Most infrared thermometers have an optional laser pointer to help you see where you are pointing the thermometer. Decide if you want the laser pointer on. **Warn participants that the laser beam should NOT be aimed directly at eyes or off surfaces where it could reflect into anyone's eyes**. You may turn the laser pointer off and/or cover it with tape. Alternatively, allow the use of the laser pointer to take aim, but make sure that facilitators are monitoring their use.
- The laser is only used to guide your aim, it is not actually taking the measurement. Consider doing this activity with the laser off first, so that participants do not get confused as to how the temperature is being measured.
- The IR Thermometer can take the temperature of objects at a distance. To determine the temperature of an object, simply point the thermometer in that direction (using the laser guide to confirm you're pointing correctly) and briefly press the button. The temperature will read out on the display.
- Some easy items to point the thermometer at are: people (mind the laser – do NOT point the device at someone's eye), air ducts, car exhausts, hot pavement, insulated coffee mugs, etc.
- Patrons will want to "play" with the infrared thermometer; it's exciting! If you're using the thermometer for a structured activity, consider giving them an opportunity to explore and play with it first.



Global Sea Surface Temperature (in IR) from NASA's Terra Satellite. Credit: NASA

Guiding Questions

- Ask participants what they already know about infrared thermometers. They may be aware that heating and cooling specialists and auto mechanics use them for their jobs.
- Ask participants who else may want to take temperature measurements from a distance. If a vet was checking in on an animal who was stressed and didn't want to be touched, would this tool help them do their job safely?
- Show images of what infrared detectors – like the infrared thermometer – can "see". A powerpoint presentation discussing this topic can be found on SlideShare, as well as on iMeetCentral.
- Ask participants, "*what is the thermometer 'seeing'*?," if they are having a hard time grasping what is happening. The pictures below illustrate a normal view of an object, and then a view taken with an infrared camera, which highlights the temperature changes being represented in the measurements being taken by the thermometer.

Credit: IPAC

Credit: Space Science Institute

Advanced Instructions - Taking Earth's Temperature

- Once you are comfortable using the IR Thermometer, consider facilitating the *Taking Earth's Temperature* activity (full write-up in Section 2 of the binder). This activity allows patrons to use the infrared thermometer, while also providing a context for why remote sensing is so vital to the work NASA does every day.

Connections to Other Kit Materials

- This device works well in a station activity with other kit items as a stand-alone exploration activity, and also pairs with the Taking Earth's Temperature activity.
- Introduce the infrared thermometer along with the *Oh Say Can You Say What's the Weather Today?: All About Weather* book.
- Encourage adults to extend the learning at home on their mobile devices by downloading the GLOBE Observer app at https://observer.globe.gov/about/get-the-app. Families can use the app to note what types of clouds are in the sky, then share their observations online through the app. GLOBE Observer cloud observations are helping NASA scientists understand clouds from below (the ground) and above (from space).

Connections to Other *STAR_Net* Activities

- Please visit the *STEM Activity Clearinghouse* at www.clearinghouse.starnetlibraries.org and check out the "Earth Science" and "Weather and Citizen Science" collections to find other remote sensing and Earth observing activities!

Section 4:

Science Books

Science Books

Four books have been suggested for the Sun-Earth-Moon Connections Kit. Below you will find the list of these books, as well as tips for use. Following this page, you will find "scripts" for the two NASA books to aid your facilitation of these items.

1) Getting a Feel for Eclipses (NASA)
This book explains details surrounding the 2017 total solar eclipse. Tactile (touchable) graphics provide an illustration of the interaction and alignment of the Sun with the Moon and the Earth. This book also includes suggested activities. This resource is suitable for use by the visually impaired (the following pages contain a "script" for a facilitator to explain the graphics, as braille descriptions are not included) and by the sighted.

Consider using this resource with the "Modeling Meaningful Eclipses" activity detailed in Section 2.

2) Mars Exploration Program (NASA)
This book gives an overview of Martian surface features and details about the journey of the Curiosity Rover on the Martian surface. This resource is suitable for use by the visually impaired (the following pages contain a "script" for a facilitator to explain the graphics, as braille descriptions are not included) and by the sighted.

Consider using this resource in combination with the "Impact Crater" activity, detailed in Section 2.

3) Oh Say Can You Say What's the Weather Today? (Dr. Seuss)
This fun book is perfect to read in small sections during story time. We recommend using the "Wind Streamer" activity, detailed in Section 2, in conjunction with this activity. Also, please peruse the "Earth Science", "Climate Change" and "Weather and Citizen Science" collections in the STEM Activity Clearinghouse (here: clearinghouse.starnetlibraries.org/) to find other great hands on activities.

4) Getting a Feel for Lunar Craters (NASA, coming soon!)
This book includes tactile graphics that illustrate the landscapes of the Moon, including their craters. This resource is suitable for use by the visually impaired (the following pages contain a "script" for a facilitator to explain the graphics, as braille descriptions are not included) and by the sighted.

Consider using this resource in combination with the "Impact Crater" activity, detailed in Section 2.

Getting a Feel For Eclipses

Solar Eclipses

For thousands of years, humans have observed the sky and wondered.. Particular alignments of heavenly objects were seen as signs or omens. Perhaps one of the most awe-inspiring and influential celestial events to occur is a solar eclipse. In the coming years, significant solar eclipses will be visible from the United States in 2017 and 2024 and from South America in 2019 and 2020. While this tactile book is focused on the 2017 eclipse it is also relevant for other future eclipses. Come and explore the world of eclipses with us!

What is a solar eclipse?

A solar eclipse occurs when the sunlight reaching the earth is blocked by the moon. It is important to understand some basics of the orbits of the earth and moon. The earth orbits, or revolves, about the sun. It takes about 365 days for the earth to revolve once around the sun. The moon orbits, or revolves, around the earth and takes about 29 ½ days to revolve once around the earth with respect to the sun (referred to as the moon's synodic period of revolution). As the moon orbits around the earth on nearly the same plane as the earth and sun; the moon is found between the earth and sun about every 29 ½ days (as shown on Tactile 1). When the moon is found there, it is called a "New Moon." A solar eclipse can only occur during the New Moon phase.

How often do solar eclipses occur?

Various types of eclipses occur four to seven times a year with most years only having four. However, the type of eclipse being explored with this book is known as a total solar eclipse which occurs somewhere on earth about every 18 months. The problem is that an observer is rarely in the right position on earth (or within the path of totality, Tactile 1 and Tactile 3) to witness the entire disk of the sun being blocked by the disk of the moon (Tactile 2). It is so rare that if the observer were to stay in one place on earth, he/she would only be found in the path of totality about once every 400 years!

You might be wondering why an eclipse doesn't occur every New Moon which occurs every 29 ½ days. The reason is that the orbital plane of the moon and earth is tilted by about 5° from the earth and sun orbital plane. This causes the moon's shadow to usually fall either above or below the earth.

How long do solar eclipses last?

"Totality," or when the disk of the sun is entirely blocked by the disk of the moon, can last up to eight minutes though most of the time totality lasts about two to three minutes along this so-called "path of totality." Totality for most of the United States on August 21, 2017 will last over

2 minutes. However, from the start of the eclipse in which the sun is partially eclipsed by the moon until the end of the eclipse when the disk of the moon no longer blocks any of the sun takes about 2 hours (as shown on Tactile 2). For example, during the eclipse of 2017 on the west coast in Oregon, the partial eclipse will begin about 9:05 am Pacific Daylight Time (PDT) and end about 11:36 am PDT. For that same location, totality will occur between10:16 am PDT to 10:18 am PDT. On the east coast in South Carolina the partial eclipse begins about 1:18 pm Eastern Daylight Time (EDT) and ends about 4:10 EDT. Totality along the east coast runs from about 2:46 pm EDT to 2:49 pm EDT. For complete details regarding specific times for specific locations across the United States and region check out this!

Although being in the path of totality and knowing specific times will make for a great experience, an observer should also pay attention to local weather forecasts to find a location within the path of totality where it will likely be clear skies!

Are solar eclipses dangerous to look at?

Yes! It is never safe to look at the sun without proper means of viewing it. During a total solar eclipse, for people in the “path of totality,” the only time to safely look at the event is during totality when the disk of the sun is entirely obscured by the disk of the moon. At this time, a layer of the sun’s atmosphere called the Corona is visible to the unaided/unprotected eye. As the middle graphic in tactile 2 illustrates, the Corona can be seen radiating around the sun while the central disk remains black. Normally, the photosphere of the sun’s atmosphere outshines the Corona. It is interesting to note that the Corona can extend out over 4 million km and can reach temperatures over 2 million degrees!

Aside from the few minutes of totality, it is never safe to look directly at the sun. Even an annular solar eclipse (as described in next section) can damage the eyes if it’s looked at directly without filters. It should be noted that it is never healthy to look directly at the sun and care should be taken to work with professionals who have some experience using proper methods of viewing eclipses of the sun.

What’s the difference between a total solar eclipse, an annular solar eclipse, and a partial solar eclipse?

During a *Total Solar Eclipse*, the moon completely blocks the sun. Even though the sun is about 400 times larger than the moon, the disk of each is about the same size in the sky as viewed from earth because of the distance each is from the earth. Given that information, which one is farther away and which is closer? Of course, Tactile 1 provides an answer, but be aware that it is NOT to scale by size and NOT to scale by distance.

The orbit of the moon around the earth is not a perfect circle but an ellipse. Therefore the moon is sometimes closer to the earth and sometimes farther. If the moon is farther from the earth during a New Moon phase then the disk of the moon is not large enough to cover the entire disk of the sun. When this occurs it is called an *Annular Eclipse*.

As expected, during a *Partial Solar Eclipse*, the moon only partially blocks the sun. Technically a Partial Solar Eclipse means that no viewer on Earth can be in the right location to witness totality. Practically speaking, however, the moon will "partially" block the sun for a large portion of Earth during a total solar eclipse or even an annular eclipse. For example, during the August 21st 2017 total solar eclipse the entire United States including Hawaii and Alaska can witness a partial eclipse by using proper viewing precautions. Tactile 3 outlines the contiguous United States and also the specific path of totality. The amount of obscuration that occurs gets less and less the farther an observer is from the path of totality.

2012 Mars Science Laboratory and Gale Crater Tactile Set

Nearly half way between the “Death Valley” (Hellas Basin) and “Mount Everest” (Olympus Mons) of Mars, the mysterious crater called Gale awaits further exploration by the rover Curiosity. Living up to its name’s sake, the rover is exploring Gale Crater after landing on Mars in August, 2012.

This set of tactile images will assist you in your exploration of this wonderful world on your own. Let’s start by exploring some of the planet’s most prominent features.

TACTILE ONE: A FACE OF MARS

Tactile one depicts one side of the round orb that orbits the sun at about 228,000,000 km from our Sun. As you move your fingers around the planet, first explore the rim that runs around the planet that defines the visible horizon of the round orb seen in the sky. The actual planet would come out of the plane of the tactile like half of a soccer ball. The back side of the soccer ball is not visible unless it rotates into view.

Mars is similar to Earth in many ways; however, many of its features are much larger than similar features on Earth. As you continue to explore the surface of Mars, you will notice a long groove running left and right, just below the middle of the tactile. This canyon on Mars is called Valles Marineris but dwarfs the Grand Canyon. If found on earth, it would stretch from the east coast to the west coast of the United States.

On the far left side about 2 finger widths from the end of Mariner Valley, notice a small bump. This bump represents one of three large shield volcanoes. The other 2 volcanoes can be found above the first, each separated by about 2 finger widths. These are known as the Tharsis Montes. Further around the rim of Mars, or to the west of the top volcano and out of view, is Olympus Mons, the “Mount Everest” of Mars.

TACTILE TWO: MARS at 180°

This tactile reveals Mars at 180 degrees longitude. We have rotated Mars to the right about 120 degrees from the first tactile. Therefore the 3 Tharsis volcanoes that were found on the left side of tactile one are now on the right side of this one.

Starting in the lower right hand corner, find the label for the Tharsis Montes. Montes (singular Mons) is the Latin word for mountains. Follow the guide line to the bump representing the middle volcano which is part of the Tharsis region on Mars. Just below and to the left, and above and to the right are 2 other shield volcanoes. These volcanoes range in height from 18 km to 14 km! For comparison, the highest volcano on Earth is about 9 km and Mount Everest is only about 8 km (5 miles) high.

Now find the upper right hand label for Olympus Mons. Follow the guide line to the bump representing the volcano Olympus Mons. How does it compare to the 3 volcanoes just explored? Olympus Mons is the largest known volcano in our solar system and rises about 21 km (14 miles)!

Further west, or to the left, of Olympus Mons is Elysium Planitia which is home to 3 more volcanoes. They are labeled in the upper left hand corner of this tactile. Ranging in height from 14 to 5 km, they are smaller than those found in the Tharisis region. These volcanoes can be used as a guide to find Gale Crater. Using the 2 upper volcanoes, strike a straight line down through them until you reach a rough portion of Mars. Gale Crater is found just to the right, or east. In the center of Gale Crater, you will easily feel the peak of Mount Sharp that is found near the center of the crater.

TACTILE THREE: GALE CRATER

Tactile three shows two views of the crater Gale where Curiosity is exploring. The top view represents a bird's-eye view from high above the crater. It would be how the crater would appear if we were soaring high above the crater looking down on it.

The second view on the bottom of the page is a cross-section view of Gale. Imagine this… if you slice an apple into two pieces and then observe the peel, edible part, and core; that would be the equivalent of a cross-sectional view of an apple. That is the same idea of what the bottom tactile represents… the view of the crater from the side including what's above ground and what's below ground.

Feel the top bird's-eye view. Start from the left hand side and trace your finger around the rim of the crater. Sighted assistance may help you determine the rim of the crater. On the tactile, the rim is about 10 cm across. If each cm on the tactile is approximately 15 km on Mars, what is the diameter of Gale Crater? In the middle of the crater, notice the odd shaped mound which is very prominent in Gale.

Now explore the bottom tactile representing the cross-section. Starting on the far left, trace your finger along the surface of Mars and notice that your finger eventually falls down onto the crater floor. Continue to trace your finger from left to right, and you will soon encounter a central mound, recently named Mount Sharp. After Mount Sharp, your finger will then fall back onto the crater floor and up the rim on the right side of the tactile, which then slopes off to the right. Go back to the central peak and explore it compared to the crater rim. Central peaks are not uncommon to craters as large as Gale, but what makes this one unique is that it is higher than the surrounding rim of the crater. Gale Crater has a central uplift area that is 5 km (3 miles) high! Central peaks form by the rebound of rocks that were highly compressed at ground zero of the impact. However, these peaks do not exceed the height of the crater rims. The following tactile illustrates how a central peak could end up being higher than the rim.

TACTILE FOUR: EVOLUTION OF CENTRAL PEAK

Tactile four consists of 3 idealized diagrams representing the geologic history of a central peak similar to the one in Gale. Starting with the top diagram, trace your finger from left to right across the crater and notice how the surface sinks to the floor of the crater and then up the right side to the surface again.

The second diagram represents the same crater that has been filled with various layers of sediments. Each horizontal "layer" represents many different periods of sedimentation over time.

The third diagram represents the same crater after a long period of erosion of the existing layers of sediments. Notice how the central uplift is indeed now higher than the surrounding crater rim. Notice also the gaps on the right and left side of the central uplift that show the absence of the eroded sediments.

It is likely that Gale Crater has experienced a similar history. Since Gale Crater is so old, compared to many of the other craters on Mars, it would have had time to experience this geologic evolution. If this is the case with

Gale Crater, the rover Curiosity will be perfectly situated to explore the geologic history of the region through the exposed layers.

For more detailed tactile information on cratering and crater types, please see

"Getting a Feel for Lunar Craters" NP-2011-05-733-HQ

TACTILE FIVE: CURIOSITY

Tactile five depicts a side view of the rover whose name is Curiosity. Curiosity is the largest rover ever sent to explore another planet. The small car-sized rover has many instruments on board to help scientists study Gale Crater. Starting in the lower right hand corner, find the word “wheel” and follow the line to one of the wheels of Curiosity. Two other wheels are found to the right of the labeled wheel. Two more wheels can be found to the left of the labeled wheel. Curiosity has 6 wheels in all, of which only 5 can be detected on this tactile. Can you find 5 wheels? The other would be hidden from view by the body of the rover. The body of Curiosity and some of its accompanying instruments are found above those wheels and are labeled for your exploration.
For further exploration and information please see
   http://www.nasa.gov/mars   keyword, curiosity

Published July 2012, this book is intended for users of all ages with particular support to those who are blind and visually impaired. For an audio file and accessible PDF of the text; or to request a Braille copy of the text, go to www.hapticallyspeaking.com
Support for this book comes from NASA.

Getting a Feel for Lunar Craters

www.nasa.gov

or

lunarscience.nasa.gov/

keyword: tactile craters

(for more resources and audio files)

Written by Dr. David Hurd

Edinboro University of Pennsylvania

Tactile illustrations by John Matelock

Produced by Haptically Speaking

hapticallyspeaking.com

Funding through NASA Lunar Science Institute

What is it about the Moon that is so inspirational to you? Maybe it conjures up stories of mythological beginnings? Does it stir up memories of the past? If you are blind, maybe it is the verbal descriptions you have heard about it. Maybe you have a memory of once seeing it or perhaps you can actually see it when it looms high and illuminates the dark sky.

For those with vision, the Moon often baffles us by being visible even during the day. It also intrigues us as we watch the visible portion of the round orb gradually change. These changing “phases” are due to the Moon’s revolution about the Earth and therefore the Moon’s change in position with respect to the Sun that illuminates it and the Earth that holds it in orbit. The phases bring the Moon to life and highlight the complex moonscape of hills and ridges and dark and light areas.

Whatever it is that draws you to the Moon, you can be sure that you are not the only one that has been fascinated with our nearest neighbor in space! For millennia, those who observed the sky wondered about the significance of our Moon, its origin and what has shaped and textured its landscape. As early as 300BC, observers began to use the Moon to make predictions about the scale of our solar system and expand our understanding of Earth’s place in the cosmos.

Today, our understanding of the Moon has been enhanced by human exploration, orbiting satellites, and increased technology and imaging that has enabled scientists to map the surface and subsurface. Soon, robotic missions will go to the Moon and return more rock samples and future explorers will once again place their footprints in the Moon's "soil" or regolith, just as the Apollo astronauts did over 40 years ago. Until then, we continue to learn more about the dynamics that have shaped the Moon's landscape by "viewing" the Moon through the eyes of instruments that uncover clues that lead us ever closer to understanding the Moon and its significance. This book is designed to give you the basics about the craters that are found on the Moon.

Tactile 1 – The Full Moon

Let's start our exploration by observing the overall appearance of a "Full" Moon. Study the lunar surface featured on Tactile 1. Note that the tactile number and title is centered at the top of each tactile. The scale of each tactile is found in the upper right-hand corner and represents how many kilometers each centimeter on the tactile represents. A centimeter bar found just below the scale will help remind you how big a centimeter is. It may be helpful for you to use your fingers and determine which of your fingers is closest to being a centimeter across so that you can use that finger on each tactile as a guide. But remember, each tactile has a different scale so your finger will represent a different amount of kilometers for each tactile.

On Tactile 1, move your hands around the outer perimeter of the Moon and you will feel a ridge line meant only to define the shape or outline of the Moon. The real Moon is actually a sphere, or like a ball. Here it is represented as a circle and the half you are exploring with your hands would come up “out” of the page towards you.

To give you some sense of scale, the Moon has a diameter of about 3,476 kilometers (km). This tactile is 20 centimeters (cm) in diameter, therefore, each cm = 174 km (you can arrive at that by dividing 3476 km by 20 cm). Note that this information is also given in the upper right hand corner of the page above the centimeter bar.

Do you notice the relatively smooth regions and the rougher regions? The smooth regions are those that appear darker than the surrounding region when looking at the Moon with the naked eye. These smooth areas are called maria (mare for just one), which is Latin for “seas” or “oceans”. They once were seas of molten lava called basalt that poured from the Moon’s interior and cooled to solid rock.

Find the mare near the middle labeled “A”. Now move your finger from left to right, horizontally through the Braille “A,” to get a better idea of the size of the mare. To the left of the “A” is a rough area and to the right of the “A” is a rough area. How many finger widths is it across? If you multiply your number of finger widths times 174 km, what is your prediction for how large that particular mare is? You probably got just over three finger widths or about 522 km (3 x 174). This is a mare called the Sea of Serenity. Since it is not perfectly round, it ranges from 522 km to 700 km across. If you measure just below the “A,” you will find it to be about four finger widths across. How did you do?

The rough regions or “highlands” are marked with many pocks or holes called craters. From samples returned to Earth by the Apollo astronauts, scientists were able to determine that the basalt is younger in age than the lighter colored rock found in the highland regions. If the maria are younger in age, why do you suppose they are smoother?

Explore Tactile 1 some more. From the center of the tactile graphic which is just below the “A” one finger width and to the left one finger width, trace your finger straight down to the six o-clock position. At the edge of the Moon, move two finger widths to the left and one up to find a large round crater that your finger tip will fit into. This is where our journey about craters really begins.

Craters come in two varieties. Some are formed by volcanic activity and others are formed by asteroids and comets traveling in space that collide with the Moon. Up until the late 1800's, most scientists believed that the craters on the Moon were formed by volcanism. However, in 1892, American geologist G.K. Gilbert postulated that craters on the Moon were formed by objects in space impacting the surface of the Moon. Gilbert used experimentation and his keen observations of debris fields to arrive at his conclusions.

The crater on Tactile 1 you just explored was formed by an impact with a large object sometime in the past. Impact craters can be further classified as simple or complex. Simple craters have a bowl-shaped depression with raised rims that are 15 kilometers (km) across or less. Complex craters are greater than 15km in diameter and have shallow, relatively flat floors, a raised central dome, and giant terraces around their walls. Some craters larger than 300km across have concentric rings rather than central mountains and are classified as impact basins.

Once again, find the crater located at the edge of the Moon tactile at the 6 o-clock position and two finger widths to the left and one up. This crater is called Tycho and was named after the great 16th century astronomer Tycho Brahe. The crater Tycho is about 85 km in diameter and is visible to the naked eye. Would it be considered a “simple” or “complex” crater?

Tactile 2 - Tycho

Turn to Tactile 2 in the book. Be sure and touch the centimeter bar in the upper right hand corner of the tactile and note the number above it to get an idea of the scale.

Tactile 2 shows two views of the crater Tycho. The tactile towards the top of the page represents a top-view or bird’s-eye view from high above the crater. This tactile shows how the crater would appear if we were soaring high above the crater looking down on it.

The second view on the bottom of the page is a cross-section view of Tycho. Imagine this… you slice an apple into two pieces and then observe the peel, edible part and core; that would be the equivalent of a cross-sectional view of an apple. That is the same idea of what the bottom tactile represents… the view of a crater from the side including what's above ground and what's below ground.

Now go back and feel the top bird's-eye view. Start from the left hand side and trace your finger around the rim of the crater. Sighted assistance may help you determine the rim of the crater. Now notice that the central uplift, right in the middle of the tactile, is very prominent in Tycho. This is evident in the top-view and is about 3 scale cm across. Using the scale for this tactile, about how wide is the central uplift?

The central uplift is also noticeable in the bottom tactile or cross-section. In the cross-section, the "surface" of the Moon trails off to the left and to the right of the hole representing the crater. Starting on the far left trace your finger along the surface of the Moon and notice that it rises up to a peak and then down into the crater floor. As you continue to sweep your fingers along the floor, you will notice the central uplift region that is found in the center of Tycho. Central peaks form by the rebound of rocks that were highly compressed at ground zero of the impact. The lines below the crater represent the fractured rock beneath the surface. Because the physical forces involved in an impact the size of Tycho and larger craters are so much more than the necessary forces to make rock fracture, the surface around an impact area behaves much like water! Therefore, scientists can learn a great deal about impacts by studying slow motion film of water droplets hitting a surface. Most of the same features seen in water droplets are also accounted for in impact basins, including the central uplift which is formed as debris in the middle is pushed up due to the slumping or "falling" of the sides of the crater shortly after impact.

Tactile 3 - Moltke

Tactile 3 presents a top-view and cross-section of the crater Moltke. This crater is 7km in diameter. What kind of crater is Moltke – simple or complex? Is there a central uplift? Using your "scale" finger on the cross-section view, what can be concluded about the depth of the crater with respect to its diameter, or its depth/diameter ratio? Taking into account the differences in scale, what can be said about the depth/diameter ratio of the crater in Tactile 3 compared to Tactile 2? In other words, are smaller craters deeper compared to their diameter or more shallow compared to their diameter, when compared to larger craters?

Tactile 4 – Schrodinger Basin

Tactile 4 represents a complex crater system that is so large, it is considered an impact basin which significantly alters the geology of the surrounding area. This particular basin is known as Schrodinger Basin and is 320 km in diameter! Notice that it has an uplift ring within the outer rim of the crater itself. This can be found on the bird's-eye view and the cross-section view.

Tactile 5 - Theophilus

Now it's your turn. Explore Tactile 5 and the corresponding scale. This is the crater called Theophilus. What is your estimate of the diameter of Theophilus? Would it be considered a complex or simple crater? On the cross-sectional view at the bottom of Tactile 5, explore the lines emanating down beneath the crater. These represent fissures and fractures where the underlying rock is cracked.

It is evident that craters come in many different sizes and that the features of craters are largely a function of the size of the object that makes the impact. But what about really large impacts? Could there be impacts that are even larger than Theophilus (Tactile 5) or even Schrodinger (Tactile 4)? Remember Schrodinger is 320 km in diameter! The answer is absolutely. In fact the largest impact basin known on the Moon, and possibly the solar system, is referred to as SPA or the South Pole Aitken basin. SPA was first discovered by Soviet probes in the early 1960s. Because of SPA's observable patterns being spread over such a large area, it was not recognized as an impact basin until years later.

Tactile 6 - SPA

The size of the basin is immense at approximately 2500 km across and about 12 km deep. That means that it stretches over nearly a quarter of the Moon. Tactile 6 is a tactile creation of SPA. Again, check out the scale under the title in the upper right hand corner of the tactile. As you explore the overall tactile, notice how different it feels than Tactile 1 which is a tactile of what we call the "near side" of the Moon.

Turn back and check out Tactile 1 again. Because the Moon makes one rotation for every revolution, the same side of the Moon always faces us. Therefore, observers from Earth always see the same side. It wasn't until probes and other missions flew around the Moon that the "far side" of the Moon was photographed and mapped. Do you notice how Tactile 6 does not have nearly as many smooth areas, or maria, as Tactile 1? Most scientists agree that this is because of a difference in crustal thickness. A thinner crust on the near side allowed much more outpouring of lava into basins than on the far side.

Although it is barely visible, chances are you will not be able to feel the large circle within the outer rim of the Moon that indicates SPA. This highlights the subtleties, or hidden characteristics, that scientists must often pick out from visual images.

Tactile 7 – Raised line diagram showing size of SPA to size of Moon

Now check out Tactile 7 where we have represented the outline of the Moon with a raised line. Notice also the inner raised line that represents the size of SPA without all the other details in Tactile 6. Using Tactile 7 as a guide go back and explore Tactile 6 and see if you can discover the SPA basin. Tactually, it is virtually impossible to find, however, with sighted assistance it may be recognizable.

All the craters explored in this book are real examples of craters found on the Moon. These impacts occurred a long time ago, and we rarely are able to see an impact "live." So what really happens when a large object impacts the Moon, or any other solar system object for that matter?

Computer modeling and studies of impact craters on Earth have allowed us to better understand the dynamics of what happens during an impact. Keep in mind that objects are typically moving about 20 km/s when they impact the Moon and that the angle of impact will affect cratering also. It should likewise be noted that the object that impacts the Moon does NOT leave behind a crater the same size as the object. Estimates put the size of the crater left behind by a typical impact at 10 to 20 times larger than the object itself! That is why even a relatively small object can do a lot of damage when it impacts the Moon, or for that matter, the Earth.

To better understand impact events, we have divided impacts into 3 stages based on a book by Bevin French (1998) *Traces of Catastrophe: A Handbook of Shock-Metamorphic Effects in Terrestrial Meteorite Impact Structures.*

Tactile 8 – Impact Stages

The 3 stages include compression, excavation and modification. Explore Tactile 8 to get a better idea about what happens at each stage. Each of these are cross-section views. The horizontal line on each of the three stages represents the Moon's surface. Starting on the left and moving to the right, allow your finger to trace along the Moon's surface until you find the point of impact.

Stage 1 is the initial impact and compression of the surface. Notice the one dot in the crater that represents the object impacting the Moon. Also notice the lines below the crater representing compression cracks below the Moon's surface.

Stage 2 represents the displacement of the material, which excavates the crater. During this stage, debris (called *ejecta*) is thrown out of the growing crater and falls back to the lunar surface as an *ejecta blanket*, including long *ejecta rays*. On the tactile, you will find lines and bumps above the crater floor representing the ejecta being thrown out of the crater. The lines below the crater floor represent further cracking and fracturing occurring below the surface. Eventually the debris being thrown from the crater will fall back to the surface and form ejecta rays. Ejecta rays extend out from the crater Tycho and can be seen with binoculars from Earth. Go back to Tactile 1 and see if you can discern the ejecta rays emanating outwards from Tycho. Note that sighted assistance may be necessary for this observation.

Stage 3 includes the modification of the crater shortly after impact. Once again, starting on the far left of the bottom tactile and moving to the right, notice the layer, or blanket, of material on the surface of the Moon, but you find no debris above the crater since it has all settled back down to the surface.

Although not all impacting has the same effect due to angle of incidence, speed at which the object strikes, size, and composition of impacting object; these 3 stages are usually found to some degree or another.

Final Impacts to Ponder

It is interesting to note that SPA is thought to be formed from an object moving at a relatively slow speed with respect to the motion of the Moon and at a high angle of incidence, thus accounting for the relatively shallow crater formed.

What a sight that would have been to witness such an event from Earth! Aren't you glad you weren't on the Moon when that occurred? It is humbling to realize that the Moon has been hit so many times in the past and yet, is Earth immune? Why is it that we don't find as many impact craters on the Earth? What factors would prevent us from finding craters on Earth? Impacts and cratering are an inevitable part of the evolution of any planetary body – it has happened in the past and will continue to mold landscapes in the future. This book has highlighted some of the most common types of craters and has allowed you to explore what these craters are like. For more information on cratering, please see Bevan French's book, *Traces of Catastrophe*, which is available online http://www.lpi.usra.edu/publications/books/CB-954/CB-954.intro.html, or one of several web sites that may explain this process in more detail such as…

The Earth Impact Database: http://www.unb.ca/passc/ImpactDatabase/index.html

and

NASA's Remote Sensing Tutorial – Impact Craters: http://rst.gsfc.nasa.gov/Sect18/Sect18_1.html

Acknowledgements:

Special thanks to the following for their support:

Doris Daou, NASA's Lunar Science Institute

Ruth Netting, NASA Headquarters

Cass Runyon, College of Charleston

Special thanks to the following for their reviews:

Center for Educational Technologies (cet.edu),

Ken Quinn – Tactile Graphics Consulting

Silvia Buzzanco