B

NASA STEM Facilitation Kit

Be a NASA Detective: Expanding Your Senses

NASA @ My Library

STAR net

Science-Technology Activities & Resources For Libraries

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Section 1:

Getting Started

The *NASA@ My Library* team is very excited about the release of its newest kit, called *Kit B: Be a NASA Detective – Expanding Your Senses*. Kit B focuses on how scientists learn about phenomena that we can't see with our naked eye, or even with optical telescopes, and the tools that scientists use to make these observations. Major content areas in this kit include: magnetism, meteorite and planetary geology, data collection, data processing, and the properties and characteristics of light. The kit includes a meteorite sample set, digital microscope, thermal camera, magnet science mini-kit, and supplies required to complete a selection of the highlighted activities. The Kit B binder includes many facilitation guides and other valuable resources.

There are many opportunities for using Kit A and Kit B as part of the following 2018 NASA science events we are promoting: **Earth Day** (April), **Insight Mars Lander Launch** (May), **Parker Solar Probe Launch** (July/August), and **International Observe the Moon Night** (October). There are several other important events to be aware of: **Engineers Week** (February) and **Lights on Afterschool** (October). The latter event is the only nationwide event celebrating afterschool programs and their important role in the lives of children, families and communities. This event is led by the Afterschool Alliance. It's a wonderful opportunity to let your many stakeholders know about the important work you are doing as part of the *NASA@ My Library* program and other STEM programs that you offer.

Don't forget to actively participate in the STAR Library Network (*STAR Net*), a hands-on learning network for libraries and their communities across the country (www.starnetlibraries.org). *STAR Net* focuses on helping library professionals build their STEM skills by providing "science-technology activities and resources" (STAR) and training to use those resources. Take advantage of the many resources and opportunities available through *STAR Net*, including:

- A vibrant online community of 7,500 members, all invested in bringing STEM learning experiences to library patrons
- Large hands-on library exhibits, on national tours: *Discover Space*, *Discover Earth*, and *Discover Tech*
- A small exhibits program (*Explore Earth*, *Explore Tech*, and *Explore Space*), which includes six double-sided graphic panels, a computer kiosk, and activities for a Discover Station
- *STAR Net*'s *STEM Activity Clearinghouse* – an online, interactive repository that packages each of 100+ STEM hands-on activities with tips on implementation in the library setting; links to related content and online video clips and suggested books
- Online and in-person training for library staff, which introduces them to the STEM content of the exhibits, and guides them in developing complementary programming
- Webinars demonstrating hands-on activities and providing tips and resources from NASA educators, Afterschool Alliance researchers, library associations, museum educators, and more
- Learning research programs led by Dr. Robert Jakubowski (Datum Advisors), Dr. Robert Tai (University of Virginia), and Dr. Amanda Durik (Northern Illinois University)
- Blogs, a monthly newsletter, and social media updates with tips and timely information on special events, *STAR Net* conference and webinar presentations, and funding opportunities
- A collection of resources from across the STEM learning and library fields about STEM learning in libraries, collaboration, diversity, and the importance of evaluation.

How to Use This Resource

Kit B was developed by *STAR Net*'s *NASA@ My Library* team to assist library staff in facilitating programs around exciting NASA science mission topics. Kit B is titled "Be a NASA Detective: Expanding Your Senses", and focuses on activities and experiences that help patrons (and library staff!) be more comfortable using the tools of science, and making predictions based on their observations. This kit focuses on things we can't see with our normal vision, but stay tuned for Kit C, where patrons will get to experience a telescope and binoculars to further their observational abilities!

The binder is divided into 4 sections:

Section 1 contains a welcome letter, an inventory of all the items you'll need for this kit, and background information from NASA missions and the included kit activities.

Section 2 contains selected Activity Guides that describe how to use the materials in the Kit (*Investigating the Insides*, *Space Rock Sherlock*) or ones that can be done with materials you already have lying around or can be purchased at low cost (e.g., *Recipe for a Planet/Moon*). 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., meteorites, thermal infrared camera). 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 included in this kit (e.g., thermal camera, digital microscope, and tablet apps). These guides provide a quick introduction on how to use these unique tools, which should help staff facilitate the activities in Section 2 or create their own unique programs (e.g., a NASA Saturday event).

Section 4 includes a list of suggested books for kit, as well as other suggestions for how to tie the books and activities together. This section also contains links to 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* (http://clearinghouse.starnetlibraries.org).

Activity Materials

Investigating the Insides

- Ornament balls, magnets, marbles, paper clips, pony beads, heat packs, infrared thermometer (from Kit A)

Space Rock Sherlock

- Meteorite or Meteorwrong kit, laminated challenge cards, dry erase markers, beaker, scratch plate, streak plate

Magnet Madness

- Magnetic Science Kit, Magnetic Earth globe, unclamped staples

STEM Tools

- 1 Scale
- 1 Digital Microscope
- 1 Thermal Infrared Camera
- 1 Flashlight

Books

- *Secrets of our Earth* (Carron Brown)
- *Ludwig the Space Dog* (Henning Lohlein) + 3D glasses
- *Getting a Feel for Lunar Craters* (National Aeronautics and Space Administration)

NASA Promotional Items

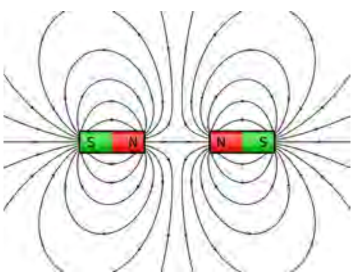
- “Seeing the Unseen” thematic posters from Universe of Learning
- 2018 calendar
- Lithos

What's a Magnet?

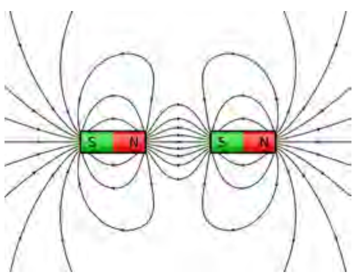
We encounter magnets all the time: there are probably some on your refrigerator right now! Magnets can attract or repel each other, as well as attracting iron and some other metals. Scientists would say that the magnet produces a *magnet field* that extends into the space around it. We can't see that field, but it's what allows it to affect objects at a distance.

Magnetism is all around us. Magnets and magnetism are very important in our everyday life: compasses, motors, sound systems, and high-speed transportation systems all require magnets to function. There's even magnetism in space: some planets, and even the Sun, produce enormous magnetic fields. And of course, we're surrounded by Earth's magnetic field. Without that, compasses couldn't work.

Magnets have 2 poles, called north and south. If the same pole of two magnets are placed near each other they will push away (repel), while if different poles are placed near each other they will pull together (attract). See diagrams below (Credit: Geek3).

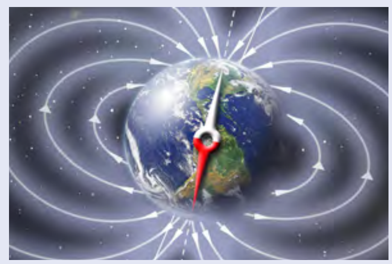


Magents Repel

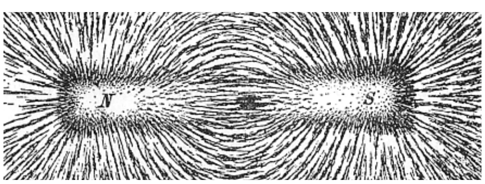


Magents Attract

Fun Fact



Earth is a Giant Magnet!
It too has a magnetic north and south pole. But unlike a bar magnet, Earth's magnetic field is created by electrical currents deep in its molten core. Credit: NASA



You can use iron fillings to show the magnetic field of a bar magnet. See photo on the left (Credit: Black and Davis).

Metals such as iron, nickel and cobalt are attracted to magnets, and some, like iron, can become magnets themselves. Most metals, however, are not attracted to magnets. These include copper, silver, gold, magnesium, and aluminum. Explore what objects in the library are attracted to the magnets you received in Kit B.

Electrically charged particles (negative and positive) interact strongly with magnetic fields. Explore this interaction on the *NASA@ My Library* tablet.

Fun Fact

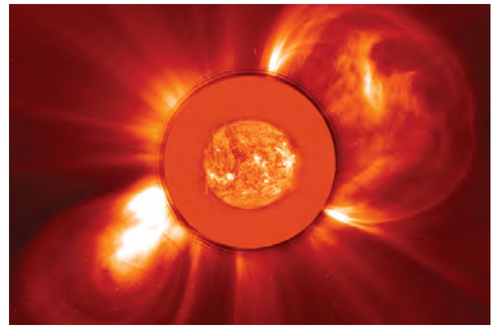
Magnetism is much stronger than gravity.
Use "Hovering Magnets" in the *Magentic Science Kit* to demonstrate that this is true.

Magnetic Fields in Space

Living in the Sun's Magnetic Field

The Sun's magnetic field stretches far beyond Earth to the edge of the Solar System. It's filled with the Solar Wind, a continuous stream of ionized gas, or plasma, that pours out of the Sun at 200 tons per second and a million miles per hour. This gas is made up of positive and negative electrically charged particles whose motions are guided by the Sun's magnetic field.

The shape on the right in the photo (to your right) is called a coronal mass ejection (CME). The hot, expanding plasma from the Sun is being shaped by the Sun's magnetic field.



Credit: NASA

Earth's Protective Shield

What happens when the Sun's magnetic field meets Earth's? The Sun's magnetic field and the Solar Wind combine to push and stretch Earth's magnetic field into a vast, comet-shaped region called the magnetosphere.

The magnetosphere and Earth's atmosphere protect us from the Solar Wind and other kinds of solar and cosmic radiation.

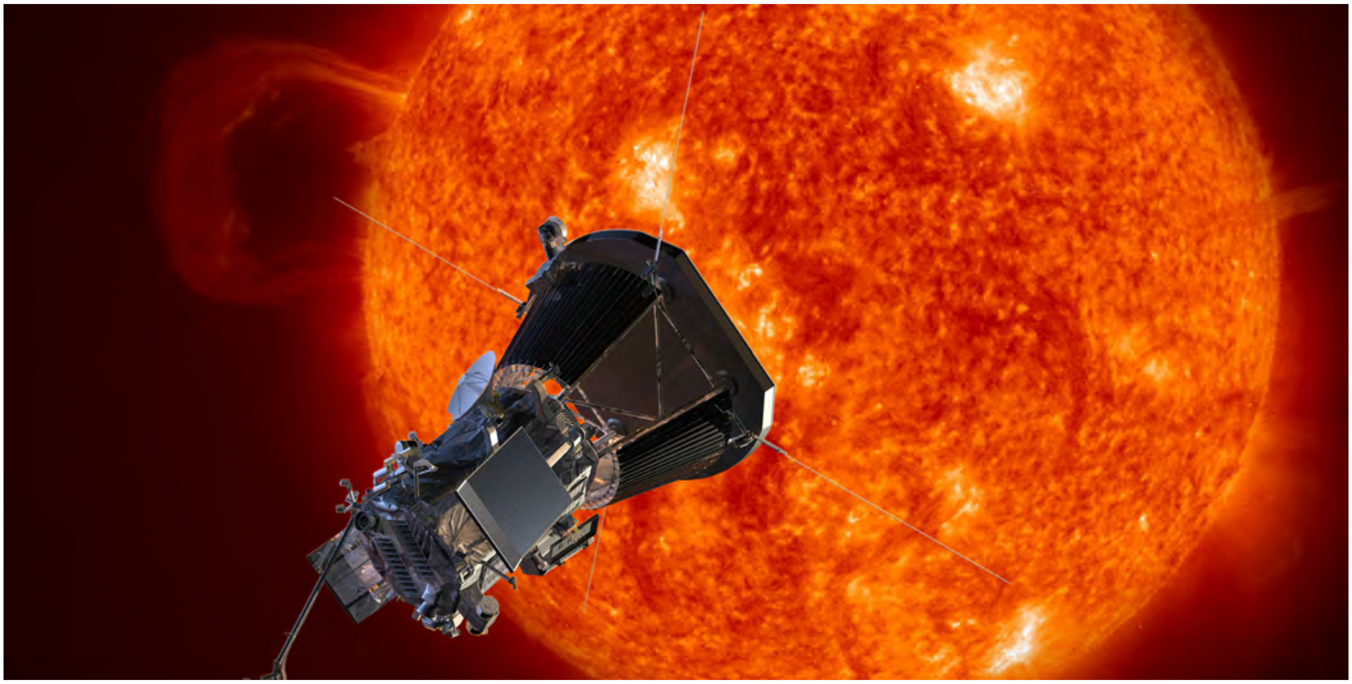
Credit: NASA

Cosmic Light Show

We can detect the magnetosphere's presence when charged particles from the Sun become trapped inside it and travel along its field lines. These high latitude regions can light up like a neon sign to create the mysterious and beautiful aurora. In the northern hemisphere, we also call them "Northern Lights."

Aurora taken from the International Space Station
Credit: NASA

NASA Mission Spotlight: Parker Solar Probe



Credit: NASA

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

Parker Solar Probe Gets Its Revolutionary Heat Shield

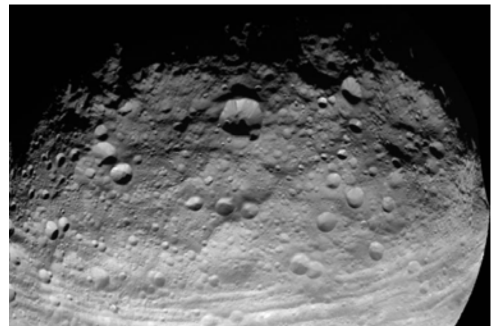
Credit: Applied Physics Lab/NASA

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

Frequently Asked Questions

What is the difference between a meteor, meteorite, and meteoroid? These three words all describe pieces of asteroids, comets, planets, or other space debris; but, these terms are subtly different in order to describe where the space rock is located in relation Earth or another planet. Meteoroids are travelling through space. Meteors have entered the atmosphere of a planet. The term "meteor" technically refers to the streak of light produced as space debris falls and is heated by friction with the atmosphere so that it glows. (You may have seen these and called them "shooting stars.")

If a space rock makes it to the ground, it is called a meteorite. Meteorites can range in size from a grain of sand to a couple of meters wide, though most are quite small.



This full view of the giant asteroid Vesta was taken by NASA's Dawn spacecraft on July 24, 2011, at a distance of 3,200 miles (5,200 kilometers). Vesta is the second largest body in the asteroid belt with an average diameter of 326 miles (525 kilometers). Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

Note that this terminology is not as important as the scientific skills of observation and using evidence to understand the world around them. **This activity intentionally uses the term "space rock" as a more accessible term to refer to meteorites**.

Why do scientists study space rocks? Space rocks are like time capsules – they provide scientists a glimpse into what our solar system was like when it first formed 4.6 billion years ago. Earth rocks have been weathered and changed by geologic processes, but scientists can find clues from long ago inside space rocks. Younger patrons tend to respond well to specific examples, such as: "Do rocks out in space have tornados or waves? What about wind? Ok, how about earthquakes and volcanoes crushing and melting the rocks? No? Well that's why we want to look at them. All those things do exist on Earth and have 'messed up' our clues!"

Although they're rare, lunar and Martian space rocks give scientists samples of places that are hard to reach!

Look for meteor showers during these times of the year:

January: Quadrantids
April: Lyrids
May: Eta Aquarids
July: Delta Aquariids
August: Perseids
October: Orionids
November: Leonids
December: Geminds

Frequently Asked Questions (continued)

What is the largest space rock to hit Earth? The largest space rock found on Earth was the Hoba meteorite found in Namibia. It weighs about 66 tons (132,000 pounds) and is 9 feet wide, 9 feet long, and 3 feet wide (2.74 meters x 2.74 meters x .9 meters). There are also numerous craters that were formed by impacts by large space rocks. It is estimated that the Chicxulub space rock was roughly 6 miles in diameter (10 km) and created a crater about 124 miles (200 km) in diameter; this was the impact event which is thought to have led to the extinction of the dinosaurs 66 million years ago.

Why are (almost) all space rocks attracted to a magnet? Approximately 95 percent of space rocks found on Earth are attracted to a magnet. This is because they contain metals, such as iron and nickel, that are attracted to a magnet. Meteorites are space rocks that have survived the journey all the way to the Earth's surface. Most space rocks burn up while entering Earth's atmosphere. If a space rock contains lots of metal like iron and nickel, then it is more likely to make it to the Earth's surface.

What about the other 5 percent? Some space rocks that make it to Earth, such as ones that come from Mars or the moon, do not contain metal. Or, they may contain some metal, but not enough to be easily detected. You can assume that non-metallic space rocks were probably much larger when they landed, or they wouldn't have survived otherwise!

Why are space rocks so dense? The stronger and denser the space rock is, the more likely it will survive the journey through Earth's atmosphere!

What is a fusion crust? As the space rock enter the atmosphere, it becomes hot and its outer layers begin to melt away or vaporize. When the space rock cools, the outer layer forms a thin, glassy layer. This is known as a "fusion crust."

What do scientists look for when they look at space rocks under powerful microscopes? Scientists are looking to see what minerals make up the space rock and how those minerals are structured and aligned. This gives them clues as to where it came from and what the environment was like when and where that space rock originally formed.

Are space rocks "magnetic" or are they "attracted to a magnet"? Permanent magnets, like refrigerator magnets, are magnetic. They attract metals like iron, nickel, and cobalt – including everyday objects like staples or paperclips or other magnets. Most space rocks that survive the journey to Earth have large amounts of metals like iron, so they are attracted to a magnet. Lodestone and magnetite are types of Earth rocks that are not just attracted to a magnet, but can also be magnetic and attract metals to themselves.

Frequently Asked Questions (continued)

What tools do NASA scientists use? NASA missions often use magnetometers to study a planet or object's magnetic field. NASA's NEAR Shoemaker (Near Earth Asteroid Rendezvous) mission's primary goal was to rendezvous with the minor planet 433 Eros (an S-class asteroid) approximately 196 miles (315 million kilometers) from Earth. It used a sophisticated magnetometer to study the asteroid's magnetic field.

Why are space rocks commonly found near the North and South poles and in deserts? Do more space rocks land there? No, space rocks do not land at the poles and in deserts more frequently than other places. The reason more space rocks are found in these locations is because they are less disturbed from weathering and erosion and more likely to survive and be seen in the white snow or light-colored sand.

How do geologists measure rock hardness? Certain rocks are harder than the other, since they contain different minerals. Scientists measure how hard rocks and minerals are by scratching them against common objects like glass. Geologists rate mineral hardness on a 1-10 scale. A glass plate has a hardness of 5.5. Quartz, the most common mineral on Earth's surface, has a hardness of 7. It can scratch a glass plate.

Vocabulary

Chondrules: Small, round mineral grains that are found in some space rocks. Chondrules are some of the oldest solid materials in the Solar System and were formed as molten drops in space collected onto a parent asteroid.

Porous: Having minute spaces or holes through which liquid or air may pass. An example of a porous rock is pumice.

Magnetometer: A tool that can measure the level of magnetization in an object or the direction and strength of a magnetic field. A compass is a very simple type of magnetometer.

Fusion Crust: As a space rock enters the atmosphere, it becomes hot and its outer layers begin to melt away or vaporize. When the space rock cools, the outer layer forms a thin, glassy layer. This is known as a "fusion crust."

Supporting Resources

Videos

- NASA – Using a Magnetometer to Study Mars
  https://goo.gl/vsrzsm

- NASA – Using Magnetometers to Study Other Planets:
  https://goo.gl/q8t6qh

- NASA – Magnetometry 101
  https://goo.gl/FDRS8C

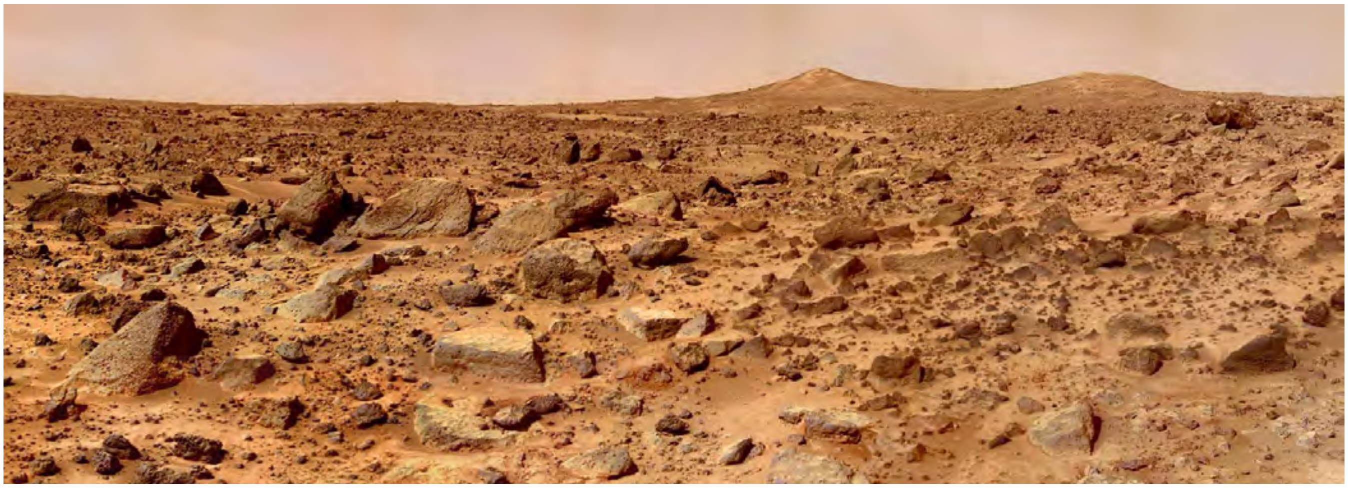
- SciShow Kids – Fun with Magnets!
  https://goo.gl/3XfRd6

Websites

- Washing University in St. Louis – What to Do If You Think You've Found a Meteorite:
  https://goo.gl/o5pwwz

- New Mexico University – How to ID a Meteorite
  https://goo.gl/kVYPkS

- Northern Arizona University – Meteorite Identification
  https://goo.gl/pEdaVF



Credit: NASA

Mars is a dry, desolate place without flowing water or vegetation. The surface is covered by fine, dusty sand, similar to a desert on Earth. Children may believe that because it is red-colored, Mars is hot. In fact, it is quite cold. Since it's farther from the Sun than Earth—about 78 million kilometers (48.5 million miles) farther out—it's also very cold at the surface. Average temperatures hover around -80 degrees Fahrenheit (-60 degrees Celsius), but the temperature can drop as low as -225 Fahrenheit (-153 degrees Celsius). Even at noon at the equator on a summer day, the warmest temperatures are usually only up to about 70 degrees Fahrenheit (about 20 degrees Celsius). The temperature drops dramatically just a few feet above the surface, so your feet would be much warmer than your head!

The diameter of Mars is 6,800 kilometers across—about half the diameter of Earth. It has only ten percent the mass of Earth. Because of the small diameter and low mass, the surface gravity on Mars is only about 1/3 the gravity on Earth (0.38 to be exact). If you weighed 45 kilograms (100 pounds) on Earth, you would weigh 17 kilograms (38 pounds) on Mars.

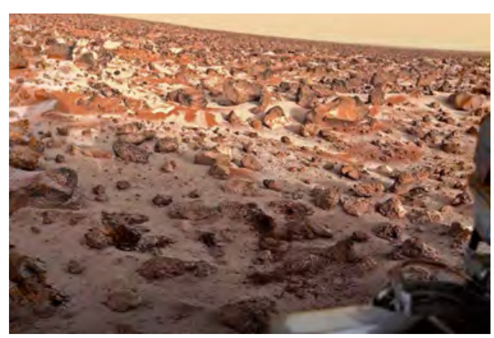
The thin atmosphere of Mars has very little oxygen, and unlike on Earth, its atmosphere does not trap much heat. The atmospheric pressure is 1/100 of Earth's. Huge sandstorms sometimes cover the face of the entire planet, but because of the low atmospheric pressure, the winds are very weak (just enough to stir up the dust). Mars has some of the same types of weather as on Earth, including dust devils, clouds, frost, and sunny days. It may even snow on Mars; NASA's Phoenix lander spotted what appeared to be a high-altitude snow storm in 2008. NASA's Mars Reconnaissance Orbiter observed dry-ice snow falling over the southern pole of Mars.

Note: The following images are all from the Space Stage App.

Mars is much colder than Earth because it is farther away from the Sun. Temperatures average a frigid -81 degrees Fahrenheit! Is your spacesuit well equipped to keep you warm?

URL: https://goo.gl/63fy97

Mars goes through extreme temperature changes from day to night due to a thin atmosphere and lack of water vapor. Average temperatures hover around -80 degrees Fahrenheit. Of course, temperatures vary based on seasons and distance from the equator.



NASA mission: Viking 2, 1979. Credit: NASA / JPL / Ted Stryk is licensed under CC BY-NC-SA 3.0

Destination Mars

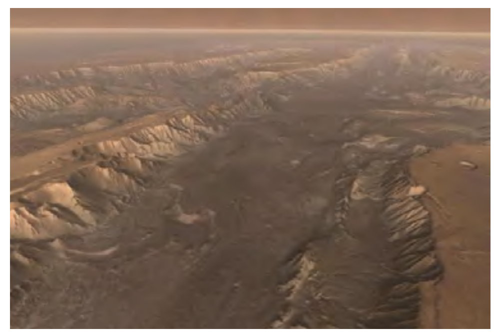
Sunsets on Mars look very different than on Earth! Dust in the Martian atmosphere allows blue light to pass through while other wavelengths get blocked. Twilight, the time when you can still see a soft light from the sun even though it's below the horizon, is much longer on Mars – it lasts for close to two hours! This is caused by sunlight reflecting off of dust high in the atmosphere.

NASA Mission: Curiosity Rover, 2015

Mars boasts some of the biggest features in the entire Solar System! It has the largest volcano, Olympus Mons, three times taller than Mt. Everest, and the deepest and widest canyon, Valles Marinaris, which is about as long as the United States is across, making it four times longer and, in places, four times deeper than the Grand Canyon!

URL: https://goo.gl/r4cH4Z

Valles Marineris is the largest canyon in the Solar System. Valles Marineris is sometimes called "The Grand Canyon of Mars," but this Martian canyon is much deeper, longer, and wider than its terrestrial counterpart. It could stretch across the entire United States! It is approximately 2500 miles long, 400 miles across, and 4 miles deep!



NASA/JPL/Arizona State University, "Flight Into Mariner Valley", 2006

Scientists believe that the canyon formed billions of years ago as the Martian crust cooled and cracked.

URL: https://goo.gl/tVNQaF

Rising approximately 18,000 feet above the surrounding Martian landscape, Mount Sharp is taller than any peak in the continental United States. Still, it's not even a quarter of the height of Olympus Mons, the tallest peak on Mars. Scientists study the mountain's layers to better understand early Martian environments.

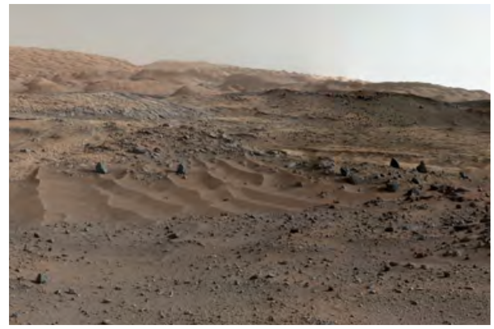
NASA mission: Curiosity Rover, 2015

URL: https://goo.gl/w2pWvY

Destination Mars

Studying the rocks, minerals, and landscapes on Mars's surface helps scientists better understand past Martian environmental conditions. This region on Mars likely had environmental conditions in its past that were suitable for supporting life.

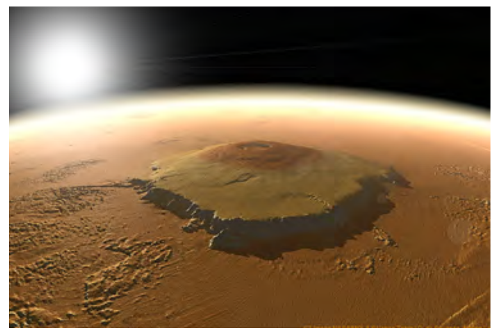
URL: https://goo.gl/os9Ac3



NASA Mission: Curiosity Rover, 2015

At over 90,000 feet tall, Olympus Mons is the largest known volcano in the entire Solar System. For perspective, Olympus Mons is three times as tall as Mt. Everest and as wide as the state of Arizona. Since the gravity on Mars is 62% lower than on Earth, climbing it should be a breeze!

URL: https://goo.gl/dnh2Zk



NASA/Mola Science Team/ O. de Goursac, A. Lark, 9 May 2012

Imagine what it would be like to go for a visit! Scientists and engineers are considering what it would take for humans to explore Mars. It's important to consider what a human would need to take with them just to step out onto the surface and take a quick glance around. If we want to visit the planet Mars and stay for any period of time, we have to consider the complexities involved in engineering an interplanetary 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 every day 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. A long mission to Mars would not only be dangerous, but very physically and mentally taxing on the participants. 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. Just to get to Mars would be an amazing feat for a human.

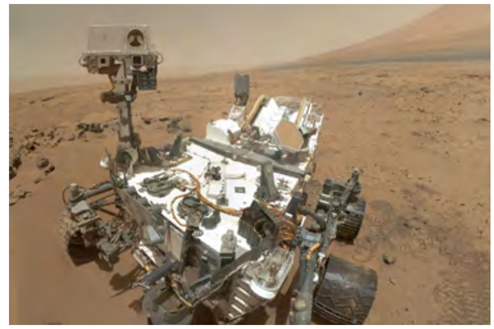
Once there, the shelter would have to be shielded from harmful radiation (e.g. from the Sun). Water and energy would have to be generated, and food would have to be grown. A trip to Mars would be for scientific research and that would include bringing transportation, digging equipment, and scientific instruments. To top it all off, some of the equipment would arrive needing assembly!

Destination Mars

Does the risk outweigh the benefit? Many would argue, "yes," yet there are many reasons to push the limits of our capabilities by exploring *farther* and *farther*, both on Earth and off.

NASA's Curiosity rover has many different tools to help it complete its mission, including a scoop that helps it collect rock samples.

URL: https://goo.gl/SeZ6kA



NASA mission: Curiosity Rover, 2012

Supporting Media

Videos, images, and websites can be incorporated before, during, or after Mars-related activities.

Green Screen Filming Tips

- "How Does a Green-Screen Work?"
  https://goo.gl/wbZu2e

Mars Background Information

- Mars in Minute: Is Mars Red Hot? (NASA JPL)
  https://goo.gl/wJmr2j

- Mars in a Minute: Is Mars Really Red? (NASA JPL)
  https://goo.gl/KXnyWe

- Mars 101 (National Geographic)
  https://goo.gl/mSrcHL

- Learn about Mars Facts with Pictures!
  https://goo.gl/woVuca

- The Mysteries of Life with Tim and Moby: Is there Life on Mars (Brain Pop)
  https://goo.gl/6RW6FV

- Mars Lithograph, NASA Educational Product LG-2013-07-569-HQ:
  https://goo.gl/aXmKSb

- Check out Rover POV: Five Years of Curiosity Driving on Mars to find out what driving NASA's Curiosity rover on Mars is like!
  https://goo.gl/4tYqsN

Near-real-time Weather Data

- Access to Mars weather updates from the Curiosity rover on Mars (cut and paste into browser)
  https://goo.gl/ChPXJo

- Access to weather website such as National Weather Service:
  https://goo.gl/YV8UGF

What's the Weather Like on Mars?

- Wispy Blue Clouds Over Mars:
  https://goo.gl/EYVaSv

- Clouds over the Eastern Martian Horizon:
  https://goo.gl/LzmLhx

- Clouds Sailing Overhead on Mars:
  https://goo.gl/f9Co3J

- Clouds Sailing Above Martian Horizon:
  https://goo.gl/JeGqii

- Frost at the Viking 2 landing site:
  https://goo.gl/8cfh3r

- The Serpent Dust Devil of Mars:
  https://goo.gl/HtMr2F

- NASA's Curiosity Sees Blue Sunset On Mars:
  https://goo.gl/QsWVs1

- Seasonal Cycles at Gale Crater (as measured by NASA's Mars rover Curiosity):
  https://goo.gl/5qYn3W

Mars Scenery

- Take a tour of Valles Marineris in NASA's Flight Into Mariner Valley video.
  https://goo.gl/8n959c

- Use NASA's Mars Trek website to get a firsthand view of the Martian surface!
  https://goo.gl/iB1VGH

Human Exploration of Mars

- Mars: Enduring the Journey (National Geographic)
  https://goo.gl/MRud3v

- Mars: How to get to Mars (National Geographic)
  https://goo.gl/z6taHs

- Today I learned how to transform Mars into our second home (National Geographic)
  https://goo.gl/CiZ25x

A Little About Mars

The Martian day, the time it takes Mars to spin once on its axis, is 24 hours and 40 minutes long, very similar in length to Earth's day. Its year is almost twice as long as Earth's, however. It takes Mars 687 Earth days to orbit the Sun. That path around the Sun is slightly more elliptical than Earth's, and the Sun is not exactly in the center of its orbital path.

Like Earth, Mars is tilted on its axis. This tilt, combined the elliptical orbit, contributes to seasons on Mars. Because Mars is closer to the Sun during its southern hemisphere summer, the summer in that hemisphere is warmer than the northern hemisphere summer.

Surface temperatures are cold — a warm summer day might reach 0°C (32°F), and winter at the poles can be as cold as –125 °C (–193°F), and its atmosphere is very thin. The atmospheric pressure at the surface of the planet is about 1/100th of that of Earth's. Mars' atmosphere is mostly carbon dioxide (95%), nitrogen (3%), and argon (2%), with trace amounts of other gases, like oxygen (0.15%). Earth's atmosphere is mostly nitrogen (77%) and oxygen (21%). The thin Mars' atmosphere offers little protection from dangerous incoming radiation, and, unlike Earth, Mars does not have an ozone layer to protect the surface from solar ultraviolet radiation.

Mars has massive dust storms — storms that can cover the entire planet! Wind speeds can reach 100 km/hour (62 miles/hour), stirring up the fine red dust. The dust gives the Martian sky a pinkish-tinge.

A dust storm obscures the surface features on Mars
Image Courtesy of: NASA/JPL/Malin Space Science Systems

The Martian atmosphere contains much less water vapor than Earth, making clouds a rarity on Mars. There is no liquid water present at the surface. There may be frozen water in the ground, and Mars has ice caps in its polar regions that are a combination of carbon dioxide and water ice.
Mars is about half the size of Earth. Because it has less mass, it has a smaller gravitational attraction. Surface gravity on Mars is less than 40% of Earth's. If you weighed 100 pounds on Earth, you would weigh 38 pounds on Mars.

How did Mars Form?

Mars formed at the same time our solar system formed, 4.6 billion years ago. Our solar system began when a cloud of dust and hydrogen and helium gases drifting in our galaxy started to condense and contract under its own gravity, forming a wide, flat, rotating disk. Most of the material collected in the center, condensing into a sphere of gas that eventually became our Sun. The remainder of the cloud formed a wide disk, swirling around the Sun, called the solar nebula. The rocky, terrestrial planets — Mercury, Venus, Earth, and Mars — all formed in the inner, hotter part of our Solar System, where metals and silicates were concentrated. Much of the gas and ice in the solar system could not exist as solids at the high temperatures in this region. So it was from the heavier materials that the rocky inner planets were made. The dust and particles collided, merged, and broke apart. Through the process of "accretion," these tiny particles formed larger and larger bodies, eventually becoming so massive that their gravity began to assist by attracting more and larger aggregates of material, speeding up the process of accretion. Because of this, the largest bodies grew the fastest, sweeping up material in their paths, and eventually becoming Mars and the other planets.

How has Mars Changed Through Time?
Mars has undergone several changes during its 4.6 billion year history — both inside and out!

Getting Organized Inside. Like all planets, Mars became hot as it formed, from the constant pummeling by impactors as it accreted, and from the radioactive decay of elements. Very soon after it formed, its interior melted or partially melted, and the materials making up Mars reorganized. The denser elements — iron and iron sulfide — separated from the more silicate-rich materials and sank to the interior, forming Mars' core. The silicate-enriched layer surrounding the core formed Mars' mantle. The least dense silicate materials formed the crust, perhaps crystallizing from a magma ocean that enveloped the planet. For the first few hundred million years, Mars probably had a magnetic field, generated by convection (fluid flow) in the molten core. As Mars cooled, the magnetic field died.

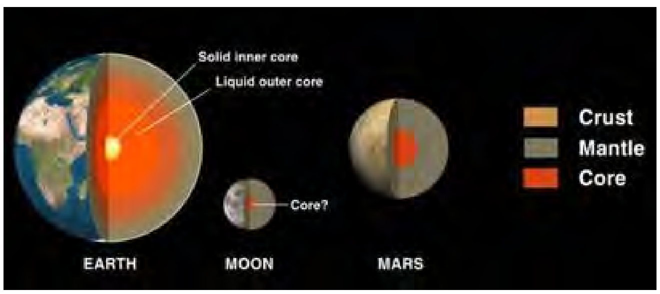
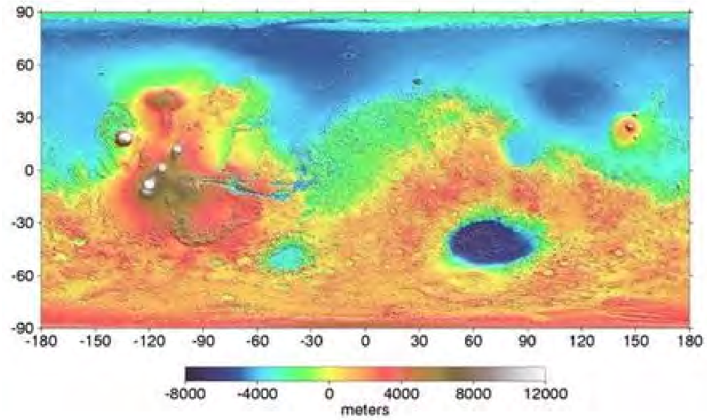


Image showing cross-sections of the Earth, Moon, and Mars.
The crust in each case is a very thin outer layer.

The Great Dichotomy — or Why There is Such a Big Difference Between the North and South. In short, scientists don't know, but they are investigating it! A quick look at elevations on Mars shows that the northern hemisphere is relatively low or deep and the southern hemisphere is high. The crust in the southern hemisphere is about 25 kilometers (15 miles) thicker than in the northern hemisphere, and this causes the southern highlands to be about 4 kilometers (2.5 miles) higher in elevation than the northern lowlands. This evidently happened in the first few hundred million years of Martian history. The interesting problem is understanding why the crust is thicker in the south than it is in the north. Some scientists suggest that the northern hemisphere low is a depression created either by one giant asteroid impact or by several big impacts. Others suggest that motions inside of the mantle of Mars, known as convection, may have concentrated crust into the southern hemisphere. More information, gathered by spacecraft and by astronaut explorers, will be needed to solve this mystery.

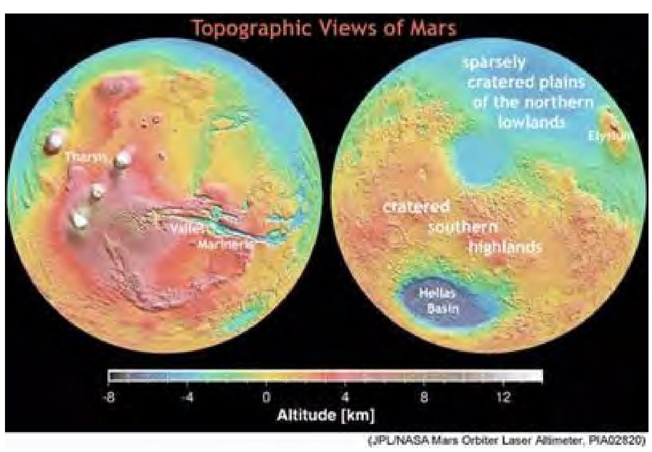


Mars Orbiter Laser Altimeter (MOLA) map showing elevations of the Martian Surface.
The northern hemisphere is low, while the southern hemisphere is high.

Making an Impact.   Like all terrestrial planets, Mars has been significantly cratered. Our early solar system was a messy place; asteroids and comets large and small abounded. These space rocks struck the planetary surfaces, adding more heat, breaking up the outer planetary layers, and creating large bowl shaped depressions of shattered rock. With time, much of this debris was accreted into the planets, leaving their orbital paths relatively clear. By about 3.8 billion years ago, the period of intense bombardment came to a close, and impacts — though continuing even today - became smaller and less frequent.

Scientists expect impacts to strike all parts of planetary surfaces equally. The Moon and Mercury are cratered across their surfaces. If large area on a planet is not cratered, scientists interpret that this surface is younger than the more cratered areas; it has not had time to accumulate a large number of impacts. In other words, something has happened to that surface to erode or fill up the craters (or, in Earth's case, to regenerate the crust all together). The hemispheres of Mars are very different. The rugged Southern Highlands record the long history of impact events. The Northern Lowlands also are heavily cratered, but somethng has covered or buried most of them. leaving the surface smooth. Scientists are unsure exactly why the north and south are so different. Perhaps the craters have been filled by lava flows or covered by sediment, or eroded by flowing water. This is one of the big mysteries about the Martian surface.

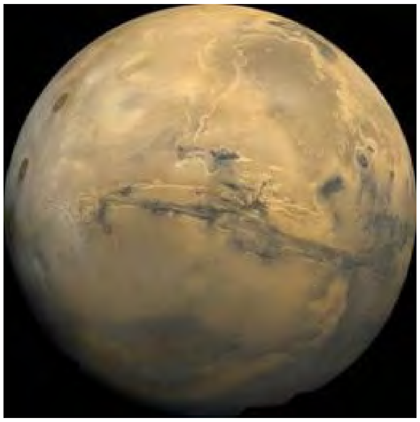
For more information on impacts and craters, visit [Impact Cratering].



Mars Orbiter Laser Altimeter (MOLA) maps show a distinction between Mars' hemispheres. The northern lowlands are about four kilometers lower in elevation than the more heavily cratered highlands of the southern hemisphere. [Image and caption courtesy of Planetary Science Research Discoveries].

Volcanism in a Big W ay. Early Mars was volcanically active, spewing lava across its surface, and water and carbon dioxide into its atmosphere. Much of this early history, recorded in the older Southern Highlands, is obscured by impact craters.

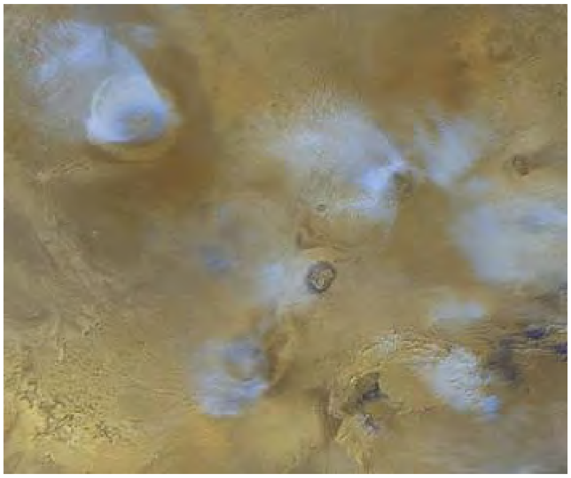
From about 3.5 billion years until more recently, the volcanic — and tectonic — activity has been concentrated around the Tharsis region near the equator. Tharsis is a huge bulge in the crust, capped by prominent volcanos. Some scientists suggest the bulge overlies a region of hotter than normal mantle. The high temperatures allowed the development of numerous large volcanos. These volcanos thickened the crust, causing Tharsis to be higher than other parts of Mars. The crust was pulled apart to form the immense canyon of Valles Marineris more than 3 billion years ago.



Over 3000 km long and up to 8 km deep, Valles Marineris would stretch from Los Angeles, California to Washington, D.C. if it occurred on Earth. Image courtesy of NASA and the U.S. Geological Survey.

Olympus Mons, the tallest volcano in our solar system, began forming about 1 billion years ago. Scientists do not really know how young the most recent volcanic activity is on Mars. Certainly, some volcanos have erupted in the last 100 million years. Although that sounds like a long time, it is within the last 2% of our solar system's history! Some lava flows are so fresh and have so few craters, that they may be less than 100,000 years old. It is likely that some martian volcanos will erupt again in the future.

Olympus Mons, and the other volcanos of the Tharsis region, are 100 times more massive than volcanos on Earth! These volcanos are so large because Mars' outer layer does not move relative to the mantle underneath — the surface of Mars is stationary. The volcanos remain over chambers of molten rock and grow as lava flow after lava flow after lava flow pours out of the interior, each adding to the volcano.
For more information on volcanism, please visit Volcanism.

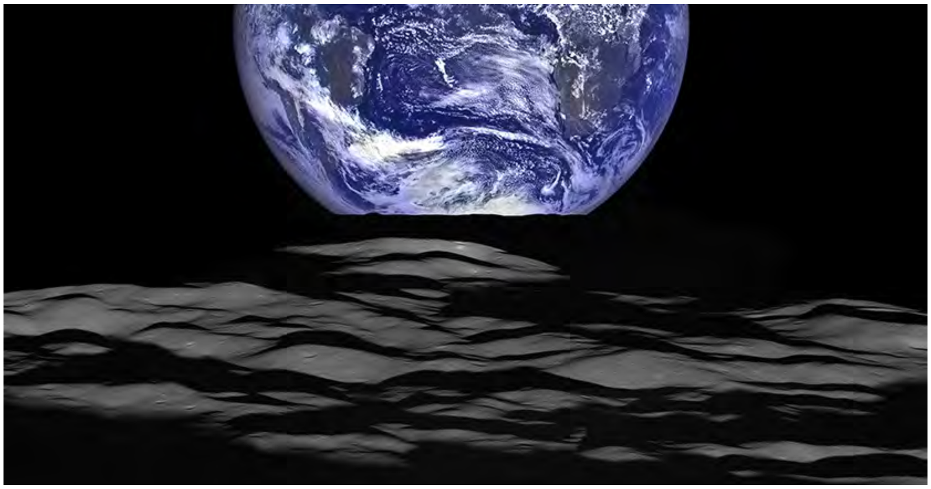


Olympus Mons (upper left) and volcanos on the Tharsis bulge. The white features are clouds. Image courtesy of NASA/JPL/MSSS

Moving Plates. There is no evidence that plate tectonics — the movement of rigid plates (lithosphere) on a mobile upper mantle (asthenosphere) — is occurring now on Mars. Mars lacks the pattern of features, such as chains of volcanos, long ridges, or folded mountains, that would be expected if plate tectonics were occurring or recent. All evidence is that Mars has had a stationary outer layer for at least the last 3 billion years, when the Tharsis region began to form. Recently, some scientists have speculated that Mars had plate tectonics in its early history, based on magnetic patterns in the Southern Highlands recorded from orbiting spacecraft. This is another area for scientific exploration.

Planets

Earth's Moon: In Depth



On July 5, 2016, the moon passed between NOAA's DSCOVR satellite and Earth.

The fifth largest moon in the solar system, Earth's moon is the only place beyond Earth where humans have set foot. The brightest and largest object in our night sky, the moon makes Earth a more livable planet by moderating our home planet's wobble on its axis, leading to a relatively stable climate. It also causes tides, creating a rhythm that has guided humans for thousands of years. The moon was likely formed after a Mars-sized body collided with Earth.

Quick Facts

- Radius: 1,079.6 miles | 1,737.5 kilometers
- Distance from Earth: 238,855 miles | 384,400 kilometers

More Stats >

Earth's only natural satellite is simply called "the moon" because people didn't know other moons existed until Galileo Galilei discovered four moons orbiting Jupiter in 1610.

Size and Distance

With a radius of 1,079.6 miles (1,737.5 kilometers), the moon is less than a third the width of Earth. If Earth were the size of a nickel, the moon would be about as big as a coffee bean.

The moon is farther away from Earth than most people realize. The moon is an average of 238,855 miles (384,400 kilometers) away. That means 30 Earth-sized planets could fit in between Earth and the moon.

The moon is slowly moving away from Earth, getting about an inch farther away each year.

Earth's moon compared to Earth

Orbit and Rotation

The moon is rotating at the same rate that it revolves around Earth (called synchronous rotation), so the same hemisphere faces Earth all the time. Some people call the far side — the hemisphere we never see from Earth — the "dark side," but that's misleading. As the moon orbits Earth, different parts are in sunlight or darkness at different times. The changing illumination is why, from our perspective, the moon goes through phases. During a "full moon," the hemisphere of the moon we can see from Earth is fully illuminated by the sun. And a "new moon" occurs when the far side of the moon has full sunlight, and the side facing us is having its night.

The moon makes a complete orbit around Earth in 27 Earth days and rotates or spins at that same rate, or in that same amount of time. Because Earth is moving as well — rotating on its axis as it orbits the sun — from our perspective, the moon appears to orbit us every 29 days.

Formation

The leading theory of the moon's origin is that a Mars-sized body collided with Earth about 4.5 billion years ago. The resulting debris from both Earth and the impactor accumulated to form our natural satellite 239,000 miles (384,000 kilometers) away. The newly formed moon was in a molten state, but within about 100 million years, most of the global "magma ocean" had crystallized, with less-dense rocks floating upward and eventually forming the lunar crust.

Structure

Earth's moon has a core, mantle and crust.

The moon's core is proportionally smaller than other terrestrial bodies' cores. The solid, iron-rich inner core is 149 miles (240 kilometers) in radius. It is surrounded by a liquid iron shell 56 miles (90 kilometers) thick. A partially molten layer with a thickness of 93 miles (150 kilometers) surrounds the iron core.

The mantle extends from the top of the partially molten layer to the bottom of the moon's crust. It is most likely made of minerals like olivine and pyroxene, which are made up of magnesium, iron, silicon and oxygen atoms.

The crust has a thickness of about 43 miles (70 kilometers) on the moon's near-side hemisphere and 93 miles (150 kilometers) on the far-side. It is made of oxygen, silicon, magnesium, iron, calcium and aluminum, with small amounts of titanium, uranium, thorium, potassium and hydrogen.

Long ago the moon had active volcanoes, but today they are all dormant and have not erupted for millions of years.

Surface

With too sparse an atmosphere to impede impacts, a steady rain of asteroids, meteoroids and comets strikes the surface of the moon, leaving numerous craters behind. Tycho Crater is more than 52 miles (85 kilometers) wide.

Over billions of years, these impacts have ground up the surface of the moon into fragments ranging from huge boulders to powder. Nearly the entire moon is covered by a rubble pile of charcoal-gray, powdery dust and rocky debris called the lunar regolith. Beneath is a region of fractured bedrock referred to as the megaregolith.

The light areas of the moon are known as the highlands. The dark features, called maria (Latin for seas), are impact basins that were filled with lava between 4.2 and 1.2 billion years ago. These light and dark areas represent rocks of different composition and ages, which provide evidence for how the early crust may have crystallized from a lunar magma ocean. The craters themselves, which have been preserved for billions of years, provide an impact history for the moon and other bodies in the inner solar system.

If you looked in the right places on the moon, you would find pieces of equipment, American flags, and even a camera left behind by astronauts. While you were there, you'd notice that the gravity on the surface of the moon is one-sixth of Earth's, which is why in footage of moonwalks, astronauts appear to almost bounce across the surface.

The temperature reaches about 260 degrees Fahrenheit (127 degrees Celsius) when in full sun, but in darkness, the temperatures plummets to about -280 degrees Fahrenheit (-173 degrees Celsius).

Atmosphere

The moon has a very thin and weak atmosphere, called an exosphere. It does not provide any protection from the sun's radiation or impacts from meteoroids.

Potential for Life

The many missions that have explored the moon have found no evidence to suggest it has its own living things. However, the moon could be the site of future colonization by humans, though there are no immediate plans to do so.

Moons

Earth's moon has no moons of its own.

Rings

The moon has no rings.

Magnetosphere

Geologist-Astronaut Harrison Schmitt worked next to a huge, split boulder at geology Station 6 on the sloping base of North Massif during the third Apollo 17 extravehicular activity.

The early moon may have developed an internal dynamo, the mechanism for generating global magnetic fields for terrestrial planets, but today, the moon has a very weak magnetic field. The magnetic field here on Earth is many thousands of times stronger than the moon's magnetic field.

Exploration

Human beings have studied the moon for millennia, watching its phases change and observing eclipses — both solar and lunar. During a solar eclipse, our moon moves between Earth and the sun and blocks the sunlight. In a lunar eclipse, Earth blocks the sun's light that normally lights up the moon, so we see Earth's shadow over the face of the moon. From Earth, we see the moon get dark and often turn red. This happens because Earth's atmosphere scatters blue and green light while it bends yellow, orange and red wavelengths toward the moon.

The moon is the most explored body in our solar system besides Earth, having been visited by numerous spacecraft from multiple space agencies around the world. It's also the only place besides Earth where human beings have set foot.

Significant Dates:

- 1609: Thomas Harriot becomes the first person to use a telescope aimed at the sky and sketches the moon. Later he made the first maps of the moon.
- 1610: Galileo Galilei publishes scientific observations of the moon in Sidereus Nuncius(Starry Messenger).
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- 2003: The European Space Agency's SMART-1 lunar orbiter inventories key chemical elements.
- 2007-2008: Japan's second lunar spacecraft, Kaguya, and China's first lunar spacecraft, Chang'e 1, both begin one-year missions orbiting the moon; India's Chandrayaan-1 soon follows in lunar orbit.

- 2008: The NASA Lunar Science Institute is formed to help lead NASA's research activities related to lunar exploration goals.
- 2009: NASA's Lunar Reconnaissance Orbiter and LCROSS launch together, beginning the U.S. return to lunar exploration. In October, LCROSS was directed to impact a permanently shadowed region near the lunar south pole, resulting in the discovery of water ice. LRO is still exploring the moon from orbit.
- 2011: Twin GRAIL spacecraft launch to map the interior of the moon from crust to core, and NASA begins the ARTEMIS mission to study the moon's interior and surface composition. After a successful mission, the twin GRAIL spacecraft were directed to impact the moon in 2012.
- 2013: NASA launches LADEE to gather detailed information about the structure and composition of the thin lunar atmosphere. The successful mission ended in April 2014.
- 14 December 2013 : China becomes the third nation to safely land an robotic spacecraft on the moon with the touchdown and deployment of Chang'e 3's Yutu rover.

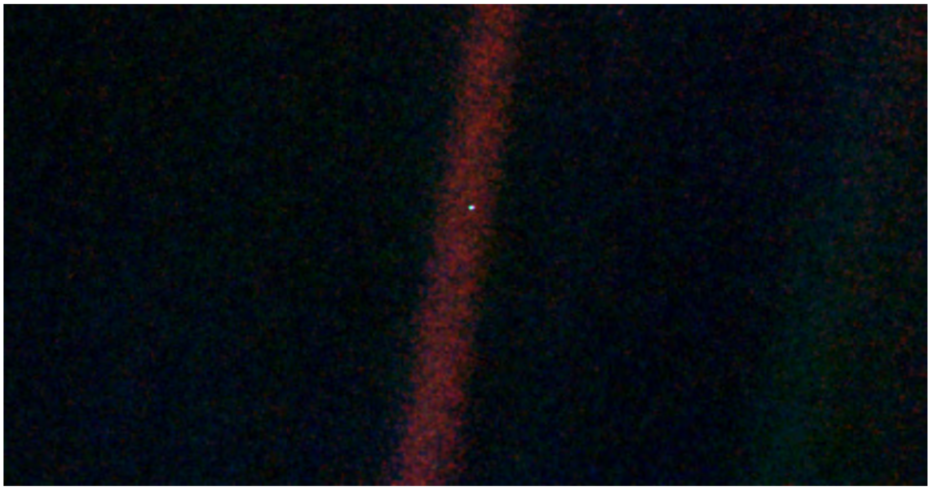
Pop Culture

Our lunar neighbor has inspired stories since the first humans looked up at the sky and saw its grey, cratered face. Some observers saw among the craters the shape of a person's face, so stories refer to a mysterious "man in the moon." Hungrier observers compared its craters to cheese and dreamed of an entire sphere made of delicious dairy products.

The moon made its film debut in a 1902 black and white silent French film called Le Voyage Dans la Lune (a trip to the moon). And a year before astronauts walked on the moon, 2001: A Space Odyssey (1968) told the story of astronauts on an outpost on the moon. Decades later, it is still widely regarded as the best science fiction movie ever made.

In reality, while we do not yet have a moon colony, spacecraft have left lots of debris on the lunar surface, and astronauts have planted six American flags on the moon. But that doesn't mean the United States has claimed it; in fact, an international law written in 1967 prevents any single nation from owning planets, stars, or any other natural objects in space.

Earth: In Depth



Voyager 1's view of Earth from a distance of about four billion miles (6.4 billion km).

Earth is the third planet from the sun and the fifth largest in the solar system. Just slightly larger than nearby Venus, Earth is the biggest of the terrestrial planets. Our home planet is the only planet in our solar system known to harbor living things.

The name Earth is at least 1,000 years old. All of the planets, except for Earth, were named after Greek and Roman gods and goddesses. However, the name Earth is an English/German word, which simply means the ground.

Quick Facts

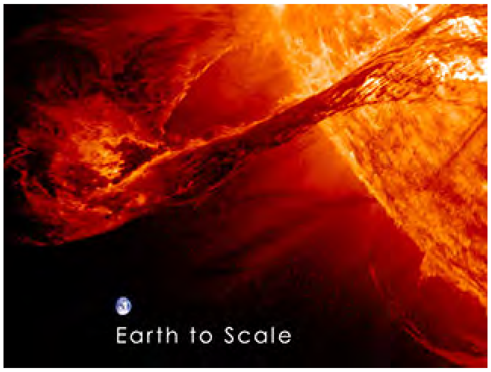
- Day: 23.9 hours
- Year: 365.25 days
- Radius: 3,959 miles | 6,371 kilometers
- Planet Type: Terrestrial
- Moons: 1

More Stats >

This page provides a brief overview of our home planet. For a comprehensive look at Earth, visit NASA's Earth Science Division.

Size and Distance

With a radius of 3,959 miles (6,371 kilometers), Earth is the biggest of the terrestrial planets, and the fifth largest planet overall.



Earth compared to the sun.

From an average distance of 93 million miles (150 million kilometers), Earth is exactly one astronomical unit away from the sun because one astronomical unit (abbreviated as AU), is the distance from the sun to Earth. This unit provides an easy way to quickly compare planets' distances from the sun.

It takes about eight minutes for light from the sun to reach our planet.

Orbit and Rotation

As Earth orbits the sun, it completes one rotation every 23.9 hours. It takes 365.25 days to complete one trip around the sun. That extra quarter of a day presents a challenge to our calendar system, which counts one year as 365 days. To keep our yearly calendars consistent with our orbit around the sun, every four years we add one day. That day is called a leap day, and the year it's added to is called a leap year.

Earth's axis of rotation is tilted 23.4 degrees with respect to the plane of Earth's orbit around the sun. This tilt causes our yearly cycle of seasons. During part of the year, the northern hemisphere is tilted toward the sun and the southern hemisphere is tilted away. With the sun higher in the sky, solar heating is greater in the north producing summer there. Less direct solar heating produces winter in the south. Six months later, the situation is reversed. When spring and fall begin, both hemispheres receive roughly equal amounts of heat from the sun.

Formation

When the solar system settled into its current layout about 4.5 billion years ago, Earth formed when gravity pulled swirling gas and dust in to become the third planet from the sun. Like its fellow terrestrial planets, Earth has a central core, a rocky mantle and a solid crust.

Structure

Earth is composed of four main layers, starting with an inner core at the planet's center, enveloped by the outer core, mantle and crust.

The inner core is a solid sphere made of iron and nickel metals about 759 miles (1,221 kilometers) in radius. There the temperature is as high as 9,800 degrees Fahrenheit (5,400 degrees Celsius). Surrounding the inner core is the outer core. This layer is about 1,400 miles (2,300 kilometers) thick, made of iron and nickel fluids.

In between the outer core and crust is the mantle, the thickest layer. This hot, viscous mixture of molten rock is about 1,800 miles (2,900 kilometers) thick and has the consistency of caramel. The outermost layer, Earth's crust, goes about 19 miles (30 kilometers) deep on average on land. At the bottom of the ocean, the crust is thinner and extends about 3 miles (5 kilometers) from the sea floor to the top of the mantle.

Surface

Like Mars and Venus, Earth has volcanoes, mountains and valleys. Earth's lithosphere, which includes the crust (both continental and oceanic) and the upper mantle, is divided into huge plates that are constantly moving. For example, the North American plate moves west over the Pacific Ocean basin, roughly at a rate equal to the growth of our fingernails. Earthquakes result when plates grind past one another, ride up over one another, collide to make mountains, or split and separate.

Earth's global ocean, which covers nearly 70 percent of the planet's surface, has an average depth of about 2.5 miles (4 kilometers) and contains 97 percent of Earth's water. Almost all of Earth's volcanoes are hidden under these oceans. Hawaii's Mauna Kea volcano is taller from base to summit than Mount Everest, but most of it is underwater. Earth's longest mountain range is also underwater, at the bottom of the Arctic and Atlantic oceans. It is four times longer than the Andes, Rockies and Himalayas combined.

Atmosphere

Near the surface, Earth has an atmosphere that consists of 78 percent nitrogen, 21 percent oxygen, and 1 percent other gases such as argon, carbon dioxide and neon. The atmosphere affects Earth's long-term climate and short-term local weather and shields us from much of the harmful radiation coming from the sun. It also protects us from meteoroids, most of which burn up in the atmosphere, seen as meteors in the night sky, before they can strike the surface as meteorites.

Potential for Life

Earth has a very hospitable temperature and mix of chemicals that have made life possible here. Most notably, Earth is unique in that most of our planet is covered in water, since the temperature allows liquid water to exist for extended periods of time. Earth's vast oceans provided a convenient place for life to begin about 3.8 billion years ago.

Some of the features of our planet that make it great for sustaining life are changing due to the ongoing effects of climate change. To find out more visit our sister website, climate.nasa.gov.

Moons

quarter moon is visible in this oblique view of Earth's horizon and airglow, recorded with a digital still camera on the final mission of the Space Shuttle Columbia.

Earth is the only planet that has a single moon. Our moon is the brightest and most familiar object in the night sky. In many ways, the moon is responsible for making Earth such a great home. It stabilizes our planet's wobble, which has made the climate less variable over thousands of years.

Earth sometimes temporarily hosts orbiting asteroids or large rocks. They are typically trapped by Earth's gravity for a a few months or years before returning to an orbit around the sun. Some asteroids will be in a long "dance" with Earth as both orbit the sun.

Some moons are bits of rock that were captured by a planet's gravity, but our moon is likely the result of a collision billions of years ago. When Earth was a young planet, a large chunk of rock smashed into it, displacing a portion of Earth's interior. The resulting chunks clumped together and formed our moon. With a radius of 1,080 miles (1,738 kilometers), the moon is the fifth largest moon in our solar system (after Ganymede, Titan, Callisto and Io).

The moon is farther away from Earth than most people realize. The moon is an average of 238,855 miles (384,400 kilometers) away. That means 30 Earth-sized planets could fit in between Earth and the moon.

More on Earth's Moon >

Rings

Earth has no rings.

Magnetosphere

Our planet's rapid rotation and molten nickel-iron core give rise to a magnetic field, which the solar wind distorts into a teardrop shape in space. (The solar wind is a stream of charged particles continuously ejected from the sun.) When charged particles from the solar wind become trapped in Earth's magnetic field, they collide with air molecules above our planet's magnetic poles. These air molecules then begin to glow and cause aurorae, or the northern and southern lights.

The magnetic field is what causes compass needles to point to the North Pole regardless of which way you turn. But the magnetic polarity of Earth can change, flipping the direction of the magnetic field. The geologic record tells scientists that a magnetic reversal takes place about every 400,000 years on average, but the timing is very irregular. As far as we know, such a magnetic reversal doesn't cause any harm to life on Earth, and a reversal is very unlikely to happen for at least another thousand years. But when it does happen, compass needles are likely to point in many different directions for a few centuries while the switch is being made. And after the switch is completed, they will all point south instead of north.

Exploration

Earth is made up of complex, interactive systems that create a constantly changing world that we are striving to understand. From the vantage point of space, we are able to observe our planet globally, using sensitive instruments to understand the delicate balance among its oceans, air, land and life. NASA satellite observations help study and predict weather, drought, pollution, climate change, and many other phenomena that affect the environment, economy and society.

This is a small sampling of the history of exploration of Earth from space. For more, visit NASA's Earth Science Division

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Pop Culture

Storytellers explore the nature of our planet and possible alternate realities in many books, movies and television shows. The iconic Planet of the Apesfilm (and many sequels) takes place in a future in which astronauts "discover" a planet inhabited by highly intelligent apes and primitive humans, only to realize later, much to their dismay, that — spoiler alert! — it was Earth all along.

In the long-running and re-booted television series Battlestar Galactica, tired survivors of a war with highly evolved robots called Cylons are on a quest to find Earth, a long-lost colony.

In other stories, Earth has been abandoned or destroyed, such as in the Joss Whedon series Firefly or the book and its film adaptation The Hitchhiker's Guide to the Galaxy. In the animated feature Titan A.E., Earth has been destroyed by an alien species, but a well-placed planet builder recreates it and all the species that live on it.

Section 2:

Activity Guides

Recommended STEM Activity Clearinghouse Resource

Investigating the Insides

This space-themed activity uses the senses and scientific tools to engage learners of all ages! NASA scientists were involved in the development and testing of this activity, and they appreciated how it reflects the nature and practice of science.

Credit: Space Science Institute/NCIL

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- There's more to the universe than meets the human eye.
- Magnetism is all around us.
- Models help us understand things we can't directly observe.

Content Area:
- Astronomy and Space

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens
- Teens
- Adults

Time to Complete Activity:
20-40 minutes

Time Needed to Prep Activity:
20-40 minutes

Difficulty Level:
Medium

Mess Level:
Low

Build a Program with Related Resources

Consider introducing the idea that planets have magnetic fields using the *Magnetic Globe.*

Develop the key concepts around using scientific tools and magnetism with the *Magnet Science Kit*. Or, continue practicing this type of "scientific" detective work with *Space Rock Sherlock*.

Use this activity to explore how scientists learn about the interiors of planets with scientific tools on spacecraft, then model what planets look like on the inside with the edible activity, *Recipe for a Planet*.

Attract audiences by incorporating technology into this activity! Demonstrate how to use the Magnetometer app (see Section 3) and *Thermal Infrared Camera*, then provide these tools for patrons.

Need more ideas? Visit the "STAR Net Hands-on Activities" collection on the STEM Activity Clearing-house for more field-tested activities, or browse activities in the "Astronomy and Space" content area.

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:
Investigating the Insides 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.

STAR net

Hands-on

Tested & Approved STEM Activities

Investigating the Insides

Activity Guide

STAR net
Science-Technology Activities & Resources For Libraries

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
January 2018

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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.

Investigating the Insides

Activity Time

Up to 40 minutes, this activity can also be modified to serve as a short simple engagement.

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 5 and up
Tweens
Teens
Adults

Overview

Investigate the composition of unseen materials, using a variety of tools, as an analogy to how scientists discover clues about the interiors of planets using spacecraft.

Type of Program

- ☑ **Facilitated hands-on experience**
- ☑ **Station, presented in combination with related activities**
- ☐ Passive program (if instructions are provided)
- ☐ Demonstration by facilitator

What's The Point?

- **The interior of a planet cannot be studied directly; scientists must infer the composition and structure from their observations.**
- **Different instruments provide different forms of indirect evidence.**
- **Scientists use their observations (evidence) and to build on what they already know about the universe.**
- **Scientific explanations are built on existing evidence and models. New technologies help scientists find new evidence and construct new models. Science advances when these are incorporated into our knowledge of the universe.**
- **Models offer a useful way to explore properties of the natural world.**

Materials

Facility needs:

- ☐ A freezer if "planets" will include cold or frozen materials

For participant or group of 3-4 participants:

- ☐ Optional: 1 copy of *Investigating the Insides* worksheet and pencil
- ☐ Optional: poster-sized paper and markers to record observations as a group

For each group of 20 to 30 participants:

- ☐ 5 to 7 "planets" (or "asteroids") to be filled with assorted materials (listed below) made from large plastic eggs or balls plastic "jumbo egg containers" (at least 3 inches wide)
  OR fillable craft ornament (at least 80 millimeters wide)
  OR 10 to 14 extra-large, dark colored balloons

Optional Materials to include in "planets":

- ☐ A handful of small objects such as beads or pieces of gravel or marbles (for each of 3 planets)
- ☐ A handful of small metal objects such as paper clips or ball bearings (for each of 2 planets)
- ☐ Magnets (round or elongated, such as cow magnets, for 2 planets)
- ☐ Small balloons filled with water
- ☐ Outer covering to hide the contents, such as aluminum foil or other materials

Optional instruments for studying "planets" or "asteroids":

- ☐ 2 magnets or other instruments for detecting metal
- ☐ 2 compasses or paper clips or Magnaprobes (https://www.arborsci.com/magnaprobe.html) to test for magnetic fields
- ☐ Optional: electronic devices with magnetometer apps to test for magnetic fields (such as the Space Science Institute Magnetometer app)
- ☐ 2 small scales (such as postage scales)
- ☐ Optional: 2 ear thermometers, or liquid crystal temperature strips (available where aquarium supplies are sold), or infrared thermal cameras that work with smartphones and tablets (such as a Seek Thermal Compact camera)

Preparation

Before the activity

- Review the background information (at the bottom of this activity).
- If using the magnetometer app or the thermal camera, review the notes on these items within the background information.
- Practice using any technology, including compasses, temperature strips, ear thermometers, tablets, and cameras.
- Prepare the "planets." For each, include two different types of materials: for instance, one might include a magnet and 5 beads, another might include paper clips and a small tied balloon filled with water.
- If using oversized plastic eggs or balls, tape them closed when finished and wrap them in aluminum foil or other materials to keep the contents hidden.
- If using balloons to make the "planets:"
  – stretch out the balloons
  – place one balloon inside of another of a different color
  – place desired objects inside of the inner balloon (dampening the balloon if needed to keep objects from sticking in its neck)
  – partially inflate the inner balloon and tie a knot in the balloon's neck, then partially inflate the outer balloon and tie a knot in its neck.
- If desired, place one or more of the "planets" into a freezer.
- **Optional:** use a marker to number each "planet" and make a note for yourself about what is inside each "planet."

Activity

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already know each other).

- Invite the participants to share their thoughts on what planets are made of, and how we study planets.

Facilitator's Note: As much as possible, encourage the participants to offer their own ideas as well as questions, and to share their ideas in response to others' questions. This model can be used to answer questions such as:
- What is a planet?
- What tools to we use to study planets?
- How do we study what's inside a planet?

Take personal note of participants' expressed concepts and be prepared to address misconceptions at the end of this activity, particularly the common belief that gas giant planets like Jupiter are simply composed of gases without any structure. See the background information for more details.

2. Share that spacecraft can take measurements of a planet (or moon or asteroid) to help determine what's inside.

Examples might include the Juno mission orbiting Jupiter and the InSight mission that will land on Mars.

- Magnetometers work like a compass to study a planet's magnetic field.
  (See https://www.youtube.com/watch?v=ITPizr7Pqgg for more info about Jupiter's magnetic field.)
- Cameras and sensors can study planets in visible light and other wavelengths, to help determine what the outside of a planet is made of.
- Missions orbiting a planet or moon can track slight changes in their orbits due to changes in the gravitational pull by the object, which provides clues about the gravity field and the layers and densities below.

While some of these instruments will provide clues about the inside of planets, none of them will be able to see inside the planet.

3. Show the "planets" created beforehand and tell the children that they are going to explore how we study planets, using models.

- What's a model?
- How does a planet compare with these models? We can only see the surfaces or outer layers of planets, just like we can only see the outside of these models.
- What are some ways we can determine what is inside of these "planets"? We can feel their weight and shake them. We can use tools like thermometers, scales, magnets, and compasses to learn more about what's inside.

4. Demonstrate the tools available and give everyone time to explore them.

- Demonstrate how thermometers or infrared "thermal" cameras can be used to measure temperatures.
- Demonstrate how scales can be used to measure weight.
- Demonstrate how a magnet can show whether there is a metal inside, such as iron ball bearings or paper clips.

Activity (continued)

- If magnetometers, compasses, or even paper clips have been provided, show how they can be used to measure the presence of a magnetic field. For instance, paper clips will be attracted to a "planet" that has a magnet inside. A compass or magnetometer will show changes in magnetic field direction or intensity, helping to demonstrate the magnetic field's orientation.

(See Background Information for further tips on some of these tools.)

Facilitator's Note: This activity serves as an open-ended engagement activity on how we study the planets. Scientists are able to directly observe some of a planet's characteristics, such as location in the solar system, size, mass, density, gravity, external composition, and more. Telescopes and tools that measure invisible wavelengths of light, called spectrometers, allowed scientists a closer look at the planets' external compositions.

Scientists study the interiors through models they create, which are based on a planet's observable characteristics. Earth's interior is studied in part through seismic data. The giant planets and Earth all have magnetic fields, which are detectable by the radio signals they emit. Magnetic fields are generated deep within planets, so they provide clues to the internal structure and composition. Orbiting spacecraft experience slight variations in their trajectories that help scientists understand a planet's gravity well. By measuring the gravitational pull, scientists can tell more about how a planet's heavy material is distributed in its interior. That information will help them make educated inferences about a planet's composition.

5. **Divide the participants into small groups and provide each with one or two "planets" to investigate using their senses and the tools in the room.** They must be careful not to break or pop the planets.

- Have each team record their observations and form a hypothesis (on their student sheets or on poster-sized paper for the entire group to see) about what is inside their "planet."

- If time permits, invite them to exchange planets with other groups and compare their hypotheses.

Activity (continued)

6. One at a time, invite each group to share their observations with the others.

- Did they infer that the materials are solid, sloshy (liquid), or primarily gas?
- Were the materials light or heavy?
- Do the materials attract metal, indicating a magnetic field?
- Are they cold or hot?
- What was the group's hypothesis for the make-up of their planet, and how did it compare to other groups'?

Conclusion

Ask the participants to compare their models to planets.

- How are the planets like the models? We can't see inside a planet or inside the models. We inferred what was inside.
- What tools did you use to tell what was inside your planet?
- Can scientists do all of these things to a distant planet? Can they shake it, or pick it up, or weigh it? No.
- How might a scientist study a planet? What kind of tools should a spacecraft have to study a planet? They can see if the planet has a magnetic field with something like a compass or magnet. They can measure its mass by seeing how much it pulls on an object like a spacecraft. The strength of a planet's gravitational pull for its size can help scientists understand whether gases, liquids, or solids make up the planet's insides. They can examine the outside to study its composition.

Share with the children that scientists can never see exactly what is a planet or how its inside materials are arranged. Scientists cannot "pop" the planet to see if they are right! Their interpretation is based on the evidence they gathered. Their interpretation may be altered in the future as more evidence is collected, or new instruments are created.

Correlations 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 models to describe and/or predict phenomena.
- Evaluate limitations of a model for a proposed object or tool.

Analyzing and Interpreting Data

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

Constructing Explanations and Designing Solutions

- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.

Engaging in Argument from Evidence

- Support an argument with evidence, data, or a model.

Crosscutting Concepts

Structure and Function

- Students observe the shape and stability of structures of natural and designed objects are related to their function(s).

The Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Scientists use drawings, sketches, and models as a way to communicate ideas.

Facilitator Background Information

Earth has a global magnetic field, which we can detect with smartphones and compasses to help us navigate. This magnetic field is generated from the electric current caused by the flow of molten metallic material within its outer core.

Like the Earth, several of the planets in our solar system have global magnetic fields. Mercury, Jupiter, Saturn, Uranus, and Neptune have magnetic fields, detectable with compasses. Each of these planets' magnetic fields originate from processes deep in their interiors. Scientists can use data from these fields to infer what the planet is like inside. Inside of Jupiter, Saturn, Uranus, and Neptune, the planets' gases are crushed to such incredible pressures that they are forced beyond the common states of liquid, solid, or gas that we find on Earth. One such a layer inside Jupiter and Saturn is *metallic* hydrogen, and the electric current caused by swirling movements in this substance produces an enormous magnetic field.

A common misconception is that the giant planets, sometimes referred to as "gas giants," are solely made of gases. Jupiter, Saturn, Uranus, and Neptune do have thick atmospheres of gas, but inside they have layers made of highly compressed fluids and they likely have solid cores.

The Juno mission in orbit around Jupiter is using sophisticated instruments (https://goo.gl/tNkfwX) to spy deep into Jupiter's atmosphere and to infer its interior structure and composition. Similarly, the MESSENGER mission (https://goo.gl/MahSbB) used observations to determine that Mercury has a large core with an inner, middle, and outer layer, as well as a thin mantle and crust, with large amounts of iron sulfide instead of iron-nickel like Earth's. The GRAIL mission (https://goo.gl/WsBfGb) used the Moon's gravitational field to map interior structures. The InSight mission (https://goo.gl/9yMU3s) will land a probe on Mars to use instruments, including seismometers, to infer Mars' interior structure and composition.

Tips for Using Tools

Different tools will be appropriate for different participant ages.

- Children ages 5 to 7 can use magnets and their senses, but may not be able to make inferences using data from scales, magnetometers, and thermometers. They may also have difficulty using some of the technology and apps, but might still enjoy observing the images from an infrared camera.

- Children ages 8 to 12 can be shown how to use scales, magnetometers, and thermometers. They may have difficulty inferring whether a "planet" that attracts a magnet, but not a paper clip, has a magnetic field.

- Participants older than 12 may enjoy determining how to use the technology for themselves, as well as making inferences based on their observations.

Activity Tools

The Space Science Institute's Magnetometer App
This app would best be used by participants comfortable with both the concept of a magnetic field and comfortable with graphs; possibly ages 10 and up.

When opened and initiated, the app will generate a graph, indicating how the magnetic field intensity is changing over time. The graph automatically scales to fit the data. Intensities ranging between 0 and 120 fall within error ranges and can be ignored; participants can note whether the intensity increases significantly higher (between 200 and 1000) as the tablet or smartphone is moved close to and around their "planet," indicating that their planet has a magnetic field.

The Seek thermal infrared camera
This camera and app have a variety of modes. Setting the app to "Hi/Lo Mode" will automatically provide the highest and lowest temperatures in the camera frame, which may be the most useful mode for this activity.

Participants should be allowed to view objects other than their planet models first (such as ice cubes, a cup of warm water, or their faces) to learn the significance of the colors and how the camera works.

For participants younger than 10, program facilitators may want to use the camera themselves in real time, taking pictures of different objects based on the participants' requests and then showing or even printing the images for the participants.

Depending on the size of the group, older participants might be able to use the camera responsibly; facilitators should use common sense with this, as with any technology, and monitor the camera's use.

Activity Worksheet

As a scientist, you are going to use various tools and senses to study what is inside of a model of a planet.

Use your senses! What do you feel and hear when you pick up and move the "planet"?

The planet seems ____

____

Investigate with tools (such as a scale, a magnet, a paper clip, a magnetometer, a thermal heat sensor).

Tool Used	My Observations

(HINTS: is the planet heavy or light? Is there more than one thing inside of it?
What does it sound like? Is it magnetic? Is it attracted to a magnet?)

Based on my observations, I **infer** that there is or are ______________________________

____ inside my planet.

Recipe for a Comet

This activity uses dry ice and household ingredients to create a model of a comet. The dry ice makes this activity a dramatic crowd-pleaser! View a how-to video on creating a model comet at https://www.youtube.com/watch?v=PiV2yDEK0TU.

Credit: Space Science Institute/NCIL

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- Models help us understand things we can't directly observe.
- Space Rocks provide clues to our origins.

Build a Program with Related Resources

Attract audiences by incorporating technology into this activity! Demonstrate how to use the *Thermal Infrared Camera*, then provide the camera and tablet for participants to measure the temperatures of the model comet.

Is a comet or meteor shower currently visible in your night sky? Use the Night Sky Planner (https://goo.gl/wxBikQ) to see which objects are bright, and In the Sky (https://goo.gl/iSwKDx) to check out all of the comets! The bits of comets that fall off when they get close to the Sun are what often cause meteor showers here on Earth. When that happens, we are passing through the trail where a comet once passed. Visit https://goo.gl/1VdYUj to find out which comets produce some of the annual meteor showers.

Combine this activity with activities from Kit A: Sun-Earth-Moon Connections. In particular, the *Sorting Games* are great icebreakers, and the game, *How Hot?*, puts the temperatures of comets into context with other objects in our Solar System. Use *Whip Up a Moon-Like Crater* to explore how comets and asteroids have collided with the Moon over the eons and created some enormous craters.

Need more ideas? Visit the "STAR Net Hands-on Activities" collection on the STEM Activity Clearinghouse for more field-tested activities, or browse activities in the "Astronomy and Space" content area.

STEM ACTIVITY Clearinghouse

Add Your Review of This Activity

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Content Area:
- Astronomy and Space
- Chemistry

Age Group:
- Family
- Upper Elementary
- Tweens
- Teens
- Adults

Time to Complete Activity:
10-20 minutes

Time Needed to Prep Activity:
10-20 minutes

Difficulty Level:
Medium

Mess Level:
Medium

Originating Source:
Recipe for a Comet 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.

STAR net Hands-on

Tested & Approved STEM Activities

Recipe for a Comet

Activity Guide

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Recipe for a Comet

Activity Time

15 minutes for constructing the comet model, followed by 5 to 10 minute interactions. As a station, this activity could continue for two hours until the dry ice is gone.

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 5 and up
Tweens
Teens
Adults

Overview

Create a "comet" using dry ice and household ingredients and use (optional) tools to observe how it models the features of a real comet.

This activity is revised from "Making a Comet in the Classroom" by Dennis Schatz.

Type of Program

- ☑ **Facilitated hands-on experience for teens and/or children under close supervision**
- ☑ **Station, presented in combination with related activities**
- ☐ Passive program
- ☑ **Demonstration by facilitator**

What's The Point?

- **Comets are made of many different materials or "ingredients" — including complex organic molecules necessary for life.**
- **The icy materials in comets spray gas and dust as they heat up.**
- **Models can be used to answer questions about the solar system.**

Materials

Facility needs:

- ☐ A freezer and cooler to keep the dry ice cool before use (it will still sublimate, turning from a solid into a gas, but at a slower rate)

CAUTION:
This activity uses dry ice (frozen carbon dioxide). This substance is extremely cold—never touch dry ice with bare hands. Facilitators need to use caution while handling the material, and ensure that participants who are handling the ice use thick work gloves or insulated rubber gloves.

For each demonstration or each facilitated group:

- ☐ 5 pounds of dry ice (purchased the day of or the day before the activity and stored well-wrapped in a freezer before use)
- ☐ Mallet
- ☐ Eye protection
- ☐ Thick work gloves or insulated rubber gloves
- ☐ Plastic bowl (large)
- ☐ Paper or cloth grocery bag
- ☐ 13 gallon garbage bag
- ☐ Pie pan or flat tray
- ☐ 1 liter (34 ounces) of water
- ☐ 1 cup of sand or soil
- ☐ Dash of ammonia
- ☐ Dash of organic materials, such as rubbing alcohol or corn syrup
- ☐ Strong flashlight
- ☐ (Optional) a printed image of a comet
- ☐ (Optional) tools for making additional observations, such as magnifying glasses, cameras, scales, an ear thermometer, or infrared thermal cameras that work with smartphones and tablets (such as a Seek Thermal Compact camera).

Photos and information about comets are at the NASA Solar System Exploration website. You may want to print copies of "Comets vs. Asteroids!", a colorful comet factsheet for tweens and teens.

Preparation

The day before the activity

- Purchase the dry ice, wrap it in thick insulation (such as dense cloth or paper) and place it in the freezer.

- Set up the demonstration table in a well-lit area.

Is a comet currently visible in your night sky? Use the Night Sky Planner to see which objects are bright, and In the Sky to check out all of the comets! This demonstration is helpful for explaining why comets have tails as they approach the Sun.

Activity

1. Share ideas and knowledge.

- Introduce yourself. Help the participants learn each other's names (if they don't already know each other).

- Show the participants a picture of a comet, and frame the activity with the main message: Comets contain ingredients that may have been crucial for early life on Earth.

- Explain that they will be building a model of a comet, using different ingredients.
  - Invite the participants to describe the different types of models that they have made or seen.
  - Can participants describe of other models that are smaller than the original? (For example, they might mention toy cars.)
  - Can participants describe of other models that behave like the original? (They might mention a toy helicopter or a paper airplane that flies, for instance.)
  - Share that this model is not only much smaller than a real comet, but that it isn't using exactly the same materials from a real comet; you will be substituting some of the ingredients. But it will behave like a comet.

- Share that some of the ingredients in comets are important for life!

As much as possible, encourage the participants to offer their own ideas as well as questions, and to share their ideas in response to others' questions. This model can be used to answer questions such as:
- What shape is a comet?
- Where do we see comets?
- What ingredients might be in a comet?
- It's cold in space far from the Sun - what would the temperatures do to the ingredients of a comet?

2. Make the comet's nucleus. This is the icy core that heats up as the comet approaches the Sun.

If this activity is being done as a facilitated, hands-on experience, take precautions that the participants are safe while handling the materials. Dry ice is extremely cold—participants who are handling the ice should use thick work gloves or insulated rubber gloves.

Dry ice is frozen carbon dioxide. When the dry ice warms up, the carbon dioxide changes directly from a solid (the dry ice) into a gas (the carbon dioxide). This process is called "sublimation." Dry ice and frozen water are key ingredients in comets.

a. Crush the dry ice. Facilitators should either select a mature participant to crush the dry ice, or do so themselves. (If done ahead of time, be aware that crushed dry ice will sublimate faster.)
- Ask the participants to describe dry ice; have they seen it before, and do they know what it is?
- Why is dry ice more common in the outer solar system than it is on Earth? (It is much colder in the outer solar system, because of the Sun's greater distance, and dry ice forms at very cold temperatures.)
- The selected participant or the facilitator should put on safety glasses and gloves, place the dry ice inside the paper or cloth grocery bag, and use the mallet to crush it to a fine-grained consistency. (The finer the texture, the better.)

b. Line the large plastic bowl with the plastic garbage bag.

c. Invite participants to pour the following liquid ingredients into the garbage bag: half of the water, ammonia (warn the children about the strong smell!), the organic material (syrup or cornstarch or alcohol), and the sand or soil. Explain that each of the materials mixed into the model represents the actual ingredients of comets.

Comets are made of rock and dust and various frozen gases: water, carbon monoxide, carbon dioxide, methane, and ammonia. Scientists have also found complex organic molecules, including ethyl alcohol and a type of sugar, in comets.

- What does the water represent? (Regular water; there is plenty of water in our outer solar system.)
- What does the sand represent? (Rock or dust; comets are mostly ice but do have rock and dust grains.)
- What does the syrup (or cornstarch or alcohol, if used) represent? (This represents organic molecules found in comets—these are the ingredients that living things are made of.)
- Share that we have found organic molecules in comets, and invite the participants to share why this might be important.

Life is not required to make organic molecules, but life is made up of organic molecules. Most scientists do not think that comets have any forms of life. However, comets could have been a source for the building blocks of life, and could have delivered them to Earth through impacts early in the history of our planet.

d. Carefully add in half of the crushed dry ice and select a mature participant to mix it well with other ingredients by kneading the outside of the garbage bag, using the gloves and taking care not to touch any leaks. The dry ice will create a cool, cloudy vapor that is safe to touch.
  - *What is the cloud made of?* (It's made of water vapor, coming from the water in the comet nucleus.)
  - *What does the cloud represent?* (It represents the gases coming out of the comet.)
  - Invite the participants to share their ideas about the gases coming out of the comet nucleus—why this happens, when it happens, and what it causes. (The comets outgas as they heat up, as they approach the Sun. The gases are pushed away from the Sun by the solar wind, forming a tail.)

e. Add in the rest of the dry ice and again invite a mature participant to again mix it well by kneading the outside of the garbage bag.

f. Invite participants to add in the rest of the water. The water/dry ice slush will start to thicken as the dry ice freezes the water.

g. Invite a mature participant to close the garbage bag around the comet and shape it into a ball. It may be necessary to add a bit more water if the comet ball does not stick together. If participants have a hard time creating a solid comet, suggest that they form it like a snowball. They shouldn't press too lightly, or too hard.

h. Invite questions and additional ideas from participants:
  - *How is the model of the comet nucleus like a real comet nucleus?* (It's made of similar materials, gives off gas, and is similar in shape.)
  - *How stable is the comet nucleus—will it last a long time, like a rock, or a short time, like an ice cube?* (Comets can stay frozen if they stay far from the Sun, but if they approach the Sun they will start to fall apart.)

Optional: Comet behavior--Outgassing.
This part of the demonstration can be repeated with new participants up to two hours after the comet nucleus has been created.

a. Holding the flashlight, carefully blow on or fan the comet model from about a foot away. Turn out the lights to create a more dramatic visual effect.

Carbon dioxide is colorless and invisible. The bubbles and jets are water vapor that has condensed into a small cloud due to the cold of the dry ice.

b. Invite the participants to share what they see, and what they think is causing it.

c. Share that as comets approach the Sun, they are heated, and that particles from the Sun will also blow on the comet, pushing the gases and dust away from the Sun into a tail.

Optional: Invite participants to use tools to investigate the comet nucleus.

Note: After the comet nucleus has been adequately mixed and formed, the dry ice is much safer to handle; however, ***participants interacting with the model should still wear gloves as a safety precaution.***

- If magnifying glasses or cameras are available, demonstrate how they can be used to make observations, and if participants are old enough, allow them to use them (with supervision).
- Demonstrate how a scale can be used to measure the weight of the nucleus, and measure it periodically to determine whether it changes as the comet outgasses.
- Demonstrate how thermometers or infrared "thermal" cameras can be used to measure temperatures of the different parts of the nucleus, and if participants are old enough, allow them to use these tools with supervision. (*See Background Information for further tips on some of these tools.*)

3. Conclude.

Draw on the participants' observations and reflections to share the important role of comets:

- What are comets made of?
- What happens to comets as they get closer to the Sun?
- Where else do we find water and organic materials in our Solar System?
- What role do water and organic materials play for life on Earth?

Planetary scientists are still examining the role comets have played in Earth's formation and history, and in the formation of life. While some have suggested that comets are the source of water on Earth, recent research suggests that Earth's water formed with the planet rather than being delivered later by comets. But the impacts of comets and asteroids have played a significant role in Earth's history, and may have delivered complex organic molecules, the ingredients for life, to our planet.

Correlations 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.

PS1.B Chemical Reactions

- Heating and cooling substances cause changes that are sometimes reversible and sometimes not.

Science and Engineering Practices

Asking Questions and Defining Problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.

Developing and Using Models

- Develop and/or use models to describe and/or predict phenomena.
- Evaluate limitations of a model for a proposed object or tool.
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

Analyzing and Interpreting Data

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

Constructing Explanations and Designing Solutions

- Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.

Engaging in Argument from Evidence

- Support an argument with evidence, data, or a model.

Correlations to the Next Generation Science Standards

Crosscutting Concepts

Structure and Function

- Students observe the shape and stability of structures of natural and designed objects are related to their function(s).

Cause and effect: Mechanism and explanation

- Students routinely identify and test causal relationships and use these relationships to explain change.

Stability and Change

- Students measure change in terms of differences over time, and observe that change may occur at different rates. Students learn some systems appear stable, but over long periods of time they will eventually change.

The Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Scientists use drawings, sketches, and models as a way to communicate ideas.
- Scientists search for cause and effect relationships to explain natural events.

Facilitator Background Information

Tips for Using Tools

Different tools will be appropriate for different participant ages.

Note: After the comet nucleus has been adequately mixed and formed, the dry ice is much safer to handle; however, ***participants interacting with the model should still wear gloves as a safety precaution.***

- Children under 7 may be too young to interact directly with the comet model but can add some of the ingredients and observe it after it's formed.
- Children ages 8 to 12 can be shown how to use scales and thermometers.
- Participants older than 12 may enjoy determining how to use the technology for themselves, with supervision.

The Seek thermal infrared camera

This camera and app have a variety of modes. Setting the app to "Hi/Lo Mode" will automatically provide the highest and lowest temperatures in the camera frame, which may be the most useful mode for this activity.

Participants should be allowed to view objects other than the comet nucleus first (such as ice cubes, a cup of warm water, or their faces) to learn the significance of the colors and how the camera works.

For participants younger than 10, program facilitators may want to use the camera themselves in real time, taking pictures of different objects based on the participants' requests and then showing or even printing the images for the participants.

Depending on the size of the group, older participants might be able to use the camera responsibly; facilitators should use common sense with this, as with any technology, and monitor the camera's use.

Space Rock Sherlock

Participants become detectives as they use scientific instruments and "challenge cards" to find genuine space rocks amongst a collection of rocks. Challenge cards are split into three difficulties: "Junior Investigator" (easy), "Astro-Explorer" (medium), and "Super Sleuth" (hard).

Credit: Space Science Institute/NCIL

Key Concepts

- NASA scientists use tools to observe everything from Earth to exoplanets.
  - Different tools are used to observe objects of different sizes and types
  - Different tools used on the same object can provide us with new information
- Magnetism is all around us
  - Magnets are tools we use in everyday life, but their behavior can also be used to describe phenomena in the world around us
- Space Rocks are clues to our origins
  - Space Rocks provide us with information about the history and formation of our solar system
  - Space Rocks can tell us about places humans haven't been yet (like Mars or the outer solar system)

Recommended Ages:
Pre-K
Early Elementary
Upper Elementary
Tweens
Teens

Preparation Time:
5-10 minutes

Activity Time:
20-40 minutes

Materials

- ☐ Something to record observations
  - Observation sheets (template included), chart paper, or white board
- ☐ Utensils to write or draw
  - Colored pencils, crayons, or dry-erase markers
- ☐ Kit of Mystery Rocks
- ☐ Magnet
- ☐ Paper Clip
- ☐ Hand Lens
- ☐ Digital Microscope
- ☐ Ceramic Streak Plate
- ☐ Glass Scratch Plate
- ☐ Tablet with Magnetometer App
- ☐ Digital Scale
- ☐ Measuring Cylinder
- ☐ Pitcher of Water
- ☐ Plastic Tablecloth
- ☐ Paper Towels (for cleanup)

Space Rocks

Campo del Cielo (labeled as #2)

- The Spanish, during their South American conquest, first discovered Campo del Cielo meteorites in 1576. The actual meteorite fall probably occurred 3,000 to 5,000 years ago. It is estimated that 50 metric tons has been recovered over the years.
- Campo del Cielo means "field of heaven."
- Strongly attracted to a magnet
- Streak: none/barely noticeable
- Does not scratch glass
- Approximate Density: 5.5 - 6.5 g/mL

NWA (Northwest Africa) 869 (labeled as #5)

- Example stony meteorite, formally called Chondrite L3-6
- First found in 2000 in Africa's Sahara Desert region by nomads; one of the largest recoveries to date
- Lightly attracted to a magnet
- Streak: none/barely noticeable. Slight red color (due to rust), if there is any streak at all.
- Does not scratch glass
- Approximate density: 2.5 - 3.5 g/mL

NWA 869 Slice (labeled as #6)

- Example stony meteorite, formally called Chondrite L3-6
- Slices show the sample's internal matrix as well as a number of the rock's interesting characteristics
- Approximate density: 2.5 – 3.5 g/mL

Zag (labeled as #10)

- Example stony meteorite, formally called Chondrite H3-6
- In August 1998, a meteorite fall was witnessed on a mountain near Zag, Morocco
- Lightly attracted to a magnet
- Streak: none/barely noticeable
- Does not scratch glass
- Approximate density: 3.5 - 4.5 g/mL

Earth Rocks

Pumice (labeled as #7)

- Mt. Shasta, CA
- Porous igneous rock that forms during volcanic pyroclastic eruptions
- Not attracted to a magnet
- Streak is color of rock. A light- colored piece of pumice will leave a light-colored streak on a darker plate, while a red piece of pumice will leave a red streak
- Does not scratch glass
- Approximate density: .25 - .50 g/mL. This rock is so light that it will often float on water)

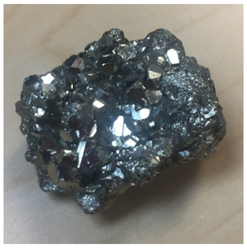
River Rock (labeled as #9)

- Formed as water washes over rock, river rocks are usually found along large river & lake shores
- "River Rock" describes the process through which these rocks got their smooth shape. They may be any type of rock that can withstand water erosion.
- Most are not attracted to a magnet
- Most do not streak; some will
- Some will scratch glass, some will not
- Density will vary depending on type

Indochinite (Tektite) (labeled as #3)

- Not a meteorite, but fused glass which was formed from a space rock impact
- The likely impact point was somewhere in Indochina some 780,000 years ago. This kind of fused glass forms from an impact's ejected material. The powerful energy from the collision heats material and sends it flying. As it returns to Earth, it cools, forming these glassy, blob-shaped tektites.
- Dark color
- Chinese tektites are known as Lei-gong-mo, which means "Thunder God Ink-black Stone"
- Not attracted to a magnet
- Streak: none
- Does not scratch glass
- Approximate density: 1.5-2.5 g/mL

Pyrite (labeled as #8)



- Naturally-occurring iron sulfide Earth mineral.
- Commonly referred to as Fool's Gold
- Not attracted to a magnet
- Streak: noticeable and dark
- Will scratch glass
- Approximate density: 4.5-5.5 g/mL

Lodestone (labeled as #4)

- Naturally-magnetized rock; also known as the mineral magnetite
- Often mistaken for meteorites
- Attracted to a magnet and has its own weak magnetic field (will attract metal)
- Streak: noticeable and dark
- Will not scratch glass
- Approximate density: 4.5-5.5 g/mL

Anorthosite (labeled as #1)

- Uncommon igneous rock that solidified from underground magma. This rock consists mostly of the mineral feldspar.
- One of the oldest rocks found on the Moon
- Not attracted to a magnet
- Streak: white
- Will scratch glass with enough force
- Approximate density: 3-4 g/ML

Facilitation Options

- The challenge cards each present a physical characteristic and can be used individually. If you are discussing a specific feature of space rocks, Earth rocks, and fossils, such as density or magnetism, then you may just want to use that individual challenge card with your group.

  Tip: This option is useful if you are short on time or if you want to just discuss one of the rock/meteorite properties.

- If you have a large group, then you can give individuals or pairs one mystery rock and their own set of cards to explore. You may want to set up "stations" for each challenge card and the materials. Patrons will take their mystery rock from station to station, exploring each challenge card with the corresponding instruments.

  Tip: This option allows patrons to explore many different properties and instruments. It limits patrons to just one mystery rock.

- With a large group, you can also assign patrons to a station with challenge card and materials. Rotate the mystery rocks through each station, giving patrons equal time to explore each mystery rock.

  Tip: This option allows patrons to explore all the mystery rock. It limits patrons to just one physical property and one instrument.

- With a smaller group or one-on-one session, you can have patrons use all mystery rocks to explore all challenge cards within their difficulty level.

  Tip: This option requires more time than the others.

  Tip: With a smaller group, assign patrons roles such as "recorder," "experimenter," and "helper." Have them alternate between roles for each card.

- Modify the activity so that young patrons—or older patrons who need extra help--can use their senses of touch and sight to make observations. Have your younger patrons sit in a circle, handle the rocks, and make observations about each rock. Invite younger patrons to sort rocks into groups, such as a group of heavy rocks, a group of dark rocks, etc.

  Next, invite patrons to make guesses about which rocks they think came from space. Walk them through some of the Junior Investigator and Astro-Explorer tests, like the magnetism, sturdiness, scratch, streak, and crust color tests, before telling them about each rock.

  Warning: The magnet inside of the kit, as well as some of the "mystery rocks," are small and are a choking hazard. Never let children under three handle small items that may be a choking hazard.

Facilitation Tips

- If a participant makes it through all challenge cards, then they can use their observations to identify their mystery rock by using the "What's In Your Kit" section of the activity guide.

- This activity is mainly an exercise in the process of science and not an identification guide for meteorites. Meteorites have different compositions, sizes, and appearances. Meteorite identification is best left to the experts (such as your local rock hound club or natural history museum).

- This activity will encourage patrons to observe and "think like a scientist." The end result – whether the mystery rock was formed on Earth or in outer space – isn't as important as the process to get there. If the patron can use scientific instruments to make an accurate observation about a mystery rock, then the activity is a success!

- The first step to this activity should involve patrons making observations with their naked eye. When you hand them a mystery rock, ask "What's the first thing you notice?" There are no right or wrong answers to this question. It is meant to get patrons in the "observational" mindset.

- For younger audiences, try setting a scene to draw patrons in. Use dialogue such as, "I've gotten all my rocks and meteorites jumbled together. Can you help me figure out which is which?" or "Someone gave me this box and told me that there were rocks and meteorites in here; but, they didn't tell me which ones were which. Can you all help?"

- Be a "guide on the side," rather than a "sage on the stage." You do not need to provide correct answers, just give patrons an opportunity to observe, test, and explore in a safe environment and have a caring adult (you!) available to explore alongside them!

- Don't be afraid to say, "I don't know!" It's one of the most commonly used phrases in science! Be honest if you don't know their answer. Brainstorm with patrons on ways that you could figure out the answer.

- Don't rub the magnet on the mystery rocks. This could change the mystery rock's magnetic properties!

- Observation sheets should stay at the stations, so that patrons have a chance to contribute to each one. Include crayons, colored pencils, or other writing utensils that allow patrons the chance to be creative. If available, chart paper or a whiteboard and markers also provide a great communal recording experience.

Observation Sheet

Mystery Rock #1	Mystery Rock #2
Mystery Rock #3	Mystery Rock #4
Mystery Rock #5	Mystery Rock #6
Mystery Rock #7	Mystery Rock #8
Mystery Rock #9	Mystery Rock #10

Magnet Test (Junior Investigator)

Credit: Space Science Institute/NCIL

Most space rocks are attracted to a magnet. Is yours?

What You'll Need:

- ☐ Magnet
- ☐ Paper clips
- ☐ Mystery rocks
- ☐ Observation Sheet

What to Do:
Move a magnet slowly towards the mystery rock until it is almost touching. Does the rock move? Does it stick to the magnet? Does a paperclip stick to the mystery rock?

What's Happening:
Most space rocks will move toward or stick to a magnet. This is because they have lots of metal like iron in them.

Tricky mystery rock: Some Earth rocks, like magnetite or lodestone, also stick to magnets. These Earth rocks can do something that space rocks can't do: a paperclip will move toward or stick to them. These Earth rocks are magnetic.

Observations
Use the observation sheet to write down what you observed!

Sturdiness Test (Junior Investigator)

Meteorites travel fast on their journey to Earth. They need to be sturdy to survive the trip! Could your mystery rock survive the trip?

Meteoroids enter Earth's atmosphere at very high speeds.
Credit: NASA

What You'll Need:

- ☐ Mystery rocks
- ☐ Senses (sight and touch)
- ☐ (optional) Hand-lens or Digital Microscope
- ☐ Observation Sheet

What to Do:

Rub your fingers along the surface of a mystery rock. Does it feel like it would break apart easily, or does it feel strong and solid?

Use a hand lens or microscope to look at the mystery rock up close. Is it full of holes or does it look strong and solid?

What's Happening:

Any space rocks that travel through the atmosphere and land on Earth travel VERY fast – more than 20 miles per second! Space rocks that are lightweight, brittle, weak, or crumbly explode or vaporize during this journey. They do not make it to the Earth's surface. Only strong, solid space rocks make it all the way to the ground.

Observations

Use the observation sheet to write down what you observed!

Crust Color (Junior Investigator)

Meteoroids travel so fast through Earth's sky that their outer layer melts! This gives meteorites a dark crust. Is your mystery rock a dark color or a light color?

What You'll Need:

- ☐ Mystery Rocks
- ☐ (optional) Hand-lens or Digital Microscope
- ☐ Observation Sheet

What to Do:
Look at the color of the mystery rock. Does it have a light color or a dark color?

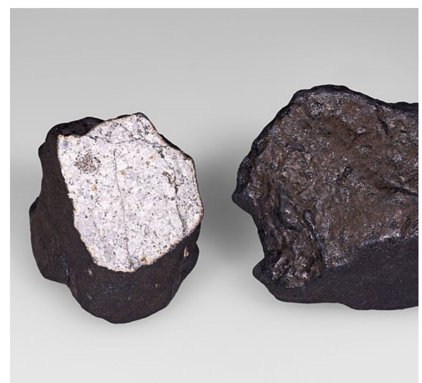
Look at the dark-colored mystery rock. Is the rock dark all the way through, or is it dark only on the outside?

What's Happening:
Space rocks that are weak, snap apart easily, or are full of many small holes usually explode or vaporize as they fall to Earth. Stronger space rocks survive falling through Earth's atmosphere, but the trip through the sky melts their outer layer. Some meteorites get a dark crust (called a "fusion crust") while others can look like metal. Light-colored rocks are almost never meteorites.

Tricky mystery rock: Some Earth rocks are a dark color, and some Earth rocks even have a crust…

Observations
Use the observation sheet to write down what you observed!

This Martian meteorite, nicknamed "Black Beauty", is over 2.1 billion years old! Note the dark crust.
Credit: NASA



Two pieces of the Chelyabinsk meteorite, part of a space rock that exploded over Russia in 2013
Credit: Didier Descouens, CC BY-SA 4.0

Streak Test (Junior Investigator)

Rocks may leave powder, or a "streak", when scratched against a special tool called a "streak plate." This powder can be a different color than the rock! Meteorites normally leave a very thin, small streak or no streak at all. Does your mystery rock leave a streak? What does it look like?

The streak of lodestone (left), a stony meteorite (middle), and pyrite (right)
Credit: Space Science Institute/NCIL

What You'll Need:

☐ Mystery Rocks
☐ Streak Plate (or unfinished piece of ceramic tile)
☐ Observation Sheet

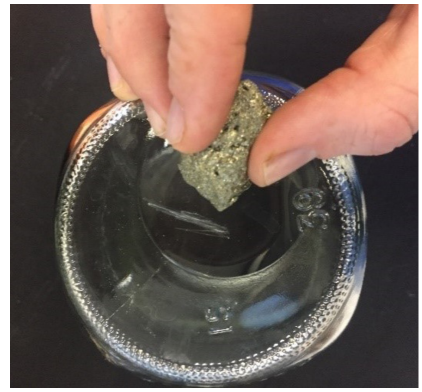
What to Do:
Rub the mystery rock on a streak plate. Does it leave a streak? If so, what color? Is it thick or thin?

What's Happening:
A "streak" is the powder that a rock leaves behind when scratched on a surface – like a crayon! The color of a rock's streak may be completely different than the rock's actual color. Not all rocks leave streaks.

Some Earth rocks, such as hematite or magnetite, leave dark streaks when scratched against a ceramic tile. Hematite leaves a red-brown streak and magnetite leaves a black streak. Space rocks do not leave thick streaks.

Observations
Use the observation sheet to write down what you observed!

Scratch Test (Astro-Explorer)



Pyrite is hard enough to scratch glass.
Credit: Space Science Institute/NCIL

Scientists measure how hard rocks are by scratching them against special tools. Meteorites do not have the minerals that are hard enough to scratch glass. Can your mystery rock scratch glass?

What You'll Need:
☐ Mystery Rocks
☐ Glass Scratch Plate
☐ Observation Sheet

What to Do:
Try to scratch the glass plate with your mystery rock. Did your mystery rock leave a scratch on the glass plate or not?

What's Happening:
Certain rocks are harder than the other, since they contain different minerals. Scientists measure how hard rocks and minerals are by scratching them against common objects like glass. Not all rocks can scratch a glass plate. Meteorites will not normally scratch a glass plate.

Observations
Use the observation sheet to write down what you observed!

Look for Patterns and Shapes (Astro-Explorer)

Credit: Basilicofresco, CC BY 2.0

Look at your mystery rock with a microscope. Do you see any shapes or patterns?

What You'll Need:

☐ Mystery Rocks
☐ Microscope
☐ Observation Sheet

What to Do:
Look at your mystery rock through a microscope. Do you see any shapes? Do you see any patterns?

What's Happening:
Scientists use microscopes to see the shapes and patterns of the minerals inside the rock.

Rocks are made up of different minerals. Minerals are made from elements (such as silicon, oxygen, aluminum, or iron) and occur naturally as crystals. This means that the atoms that make up these minerals are arranged in a unique pattern. That pattern repeats itself again and again and gives the mineral its shape!

Meteorites sometimes have the same types of shapes and patterns as Earth rocks – but the stuff they are made of is different.

Some meteorites have tiny, round grains that are not found in Earth rocks. These special round grains are called "chondrules." Chondrules formed and cooled in space before becoming part of an asteroid, and later, falling to Earth as a meteorite. They are some of the oldest "stuff" in the solar system!

Observations
Use the observation sheet to write down or draw what you observed!

Detecting Magnetic Fields with a Magnetometer App (Super Sleuth)

Credit: Space Science Institute/NCIL

We use compasses to detect the invisible magnetic field of the Earth. NASA spacecraft use an even more sensitive tool, called a magnetometer, to study the magnetic fields of asteroids and planets. Use the Magnetometer app on a tablet to study space rocks – just like NASA studies asteroids in space!

What You'll Need:

☐ Mystery Rocks
☐ Tablet with Magnetometer app
☐ Observation Sheet

What to Do:
Run the magnetometer app and hold the tablet next to the mystery rock. Watch as the measurements are plotted as a graph. Does the measurement go above 200 units? If so, you have a magnetic rock. (If the measurement is between 1 and 120, it can be ignored. Magnetism is all around us, and the magnetometer is always detecting a low level of magnetic fields.)

What's Happening:
Magnetometers are like electronic compasses. They can also detect how strong a magnetic attraction is. Magnetic rocks act just like the magnet you might use on your refrigerator to hold a sheet of paper against the steel door. Lodestone and magnetite are types of Earth rocks that are magnetic. The magnetometer measures 200 units or higher for these rocks.

Tricky mystery rock: Meteorites are not magnetic rocks and the magnetometer will not give you a high measurement (200 units or higher) for these rocks. Most meteorites DO have metals like iron and nickel, so they are attracted to magnets. But, they will not attract other metal, like lodestone or magnetite will.

Observations
Use the observation sheet to write down what you observed!

Weighing, Floating, and Sinking (Super Sleuth)

Meteorites are very heavy for their size. This means that they are "dense." Measure your rock's weight compared to its size. Is it dense?

Credit: Outlook xp; CC BY-SA 4.0

What You'll Need:

☐ Mystery Rocks
☐ Digital Scale
☐ Measuring Cylinder
☐ Pitcher of Water
☐ Plastic Tablecloth
☐ Paper Towels (for cleanup)
☐ Observation Sheet

What to Do:

Measuring density is a multi-step process.

1) Weigh your mystery rock in grams using the scale: _________ g

2) Fill a cylinder or beaker with enough water to cover your mystery rock. Measure how much water is in the cylinder: __________ mL

3) Next, put your mystery rock in the cylinder or beaker and measure how high the water rose: ________ mL

4) Do some simple math to see how high the water level rose. For example: if the water level rose from 50 ml to 75 mL, then the difference is 25 mL. __________ mL

5) Density is the weight of the rock for its size. Calculate the mystery rock's density by dividing your rock weight (step 1) by how much the water level rose (step 3): ____________ g/mL

6) See how your rock compares to the densities of Earth rocks and space rocks. Find the closest match.

<u>Approximate Densities of Rocks in the Kit</u>

- Magnetite/Lodestone: 4.5-5.5 g/mL
- Pumice: .25-.50 g/mL
- Pyrite: 4.5-5.5 g/mL
- NWA meteorite: 2.5-3.5 g/mL
- Campo meteorite: 5.5-6.5 g/mL
- Tektite: 1.5-2.5 g/mL

What's Happening:

Meteorites are normally denser than Earth rocks. They must be strong and sturdy to survive the fall through Earth's atmosphere!

Observations

Use the observation sheet to write down what you observed!

How's the Weather on Mars?

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

Credit: Space Science Institute/NCIL

Key Concepts

After doing this activity, participants will be able to:

- Describe how the weather conditions on Mars are generally cold and dry
- Convey factual information about Mars to family, friends, and peers in a fun and engaging way

Recommended Ages:
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 8-9
Tweens up to about age 13

Preparation Time:
1-2 hours

Activity Time:
20 minutes

Materials

- Script-writing materials:
  - Mars Factoids (below), cut into segments and tape and/or glue
  - How's the Weather on Mars? Realistic Script (below)
  - How's the Weather on Mars? Silly Script (below)
  - Colored pencils or crayons
  - Chart paper or dry erase board (and markers)
- Green Screen set up on its stand (see the Green Screen Setup and Calibration Guide in Section 4)
  Tip: avoid wearing the color green
- Tablet and Space Stage App (see the Tablet Setup and Tips Guide in Section 4)
- Optional (recommended): props and costumes, such as astronaut costumes; mittens or gloves; snow boots; ski masks; snow suits; umbrellas; sunglasses; sunscreen; a fan for wind; Styrofoam peanuts for snow
- Optional: Puppets or puppet making supplies such as googlie eyes, paper lunch sacks, socks, cardstock, popsicle sticks, colored markers, yarn, scissors, glue etc.
- Computer, speakers, projector, projection screen, and access to the Internet to provide background information

Preparation

1. When promoting the activity, emphasize that participants will need to avoid wearing green-colored clothing.

2. If possible, arrange to have at least one older child, teen, or adult available to help the groups write their scripts and hold the tablet during filming.

3. Gather materials.

4. Set up the Green Screen and provide a tablet with the Space Stage app preloaded on it. Have props and costumes available nearby.

5. **Optional:** Set up projector with videos and websites. From the National Weather Service, make note of any recent weather events in your town/area.

6. Cut Mars factoids (below) into segments and have them available along with the script templates, colored pencils and/or crayons, and tape and/or glue.

7. Print out the *How's the Weather on Mars?* Realistic and Silly Scripts.

Tip: If you do not have a Green Screen, create your own backdrop of Martian landscapes by projecting a NASA image of the surface of Mars.

Procedure

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

2. Explain to the participants that they will create skits about an imagined visit to Mars, beginning with writing scripts and ending with filming their skits in front of a Green Screen.

   Adapt this for younger children by introducing the activity as a puppet show where the puppets are astronauts exploring Mars. Structure the activity to use brainstorming and discussion in small groups, in place of script-writing. See below for suggestions.

3. 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 Screen.

4. Explore sources of information on Mars and its weather by viewing short videos and photos about Mars, reading books, and/or visiting weather websites. Discuss recent weather at your location, and compare that to conditions on Mars, as reported by the Mars rover, Curiosity. Talk about what the participants thought was interesting. Optional (recommended): Post these ideas on a chart or dry erase board (or similar) for participants to incorporate into their scripts.

5. Explain to the participants that they will be writing a fictional weather report explaining to people on Earth what the weather is like on Mars, and comparing Mars weather to weather back in their hometown. Participants should pretend they are talking to someone back on Earth (a friend, or relative). The weather report will be 30-60 seconds long and should include information the participants have learned about Mars. Refer to the National Weather Service web site (www.weather.gov), and read today's weather as an example.

6. Provide information to get them started. Say:
   - You are visiting Mars Base Alpha, 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 Mars to talk about in your skit, such as:
     -What the sky looks like
     -What you see on the ground and in the distance
     -Whether it's really *really* cold today or just chilly – or if it is warm today
     -What kinds of gear you must wear to keep yourself comfortable on Mars

7. Invite the participants to form small groups and create a script, using one or more sources of ideas:
   - Interesting facts listed on the chart paper or white board
   - Mars Factoids and What's the Weather Like on Mars? Realistic Script (see at the end of this guide)
   - What's the Weather Like on Mars? Silly Script (see at the end of this guide)

8. If time allows, practice the skits and coach the participants in their 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.

9. Using a Green Screen and a tablet with the Space Stage app, have participants playact their weather reports. Have the person holding the tablet speak the parts of friends and family back on Earth, while the person on camera speaks the part of an astronaut on Mars. Guide participants in using the app, as needed.

Adaptations

Alternate idea (especially for younger children): Use or have participants make puppets to produce their skits! This would be a helpful adaptation for participants uncomfortable in front of the camera, plus making puppets would be fun! Work in small groups (with assistance from an older child, teen, or adult) to talk about different types of weather on Mars and how it is much colder than Earth – but there is sometimes wind, frost, or sunny days – like here on Earth! Have them select or create puppets to "explore Mars." Brainstorm stories in small groups about their puppets and what they might say about the weather on Mars. Film the puppet shows using the Space Stage app and a green screen.

Note: If the participants wear green, they can hold up the puppets, and won't be visible, or the puppet could be held up with string or popsicle sticks in front of the camera. Attempt it first before suggesting to participants to help with trouble shooting the best position to place the puppets.

Connections to Other Kit Materials

Stay tuned for more Mars activities in Kit C!

Recommended Extension Activities

- Mars Match Game
  https://goo.gl/EeHbZa
- Trip to Mars
  https://goo.gl/AfrguA
- NASA Space Place Loopy Legends
  https://goo.gl/p29E62

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.
https://goo.gl/9pGA9S

About the MAVEN Mission

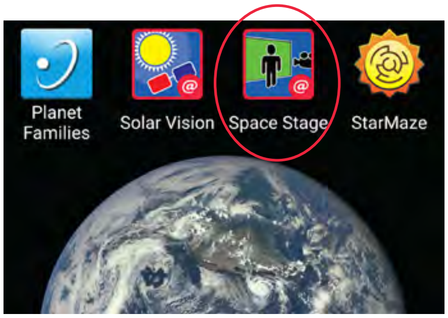
The Mars Atmospheric and Volatile EvolutioN (MAVEN) mission to Mars has instruments onboard to explore why Mars and Earth evolved in such different ways. One of the goals of the MAVEN mission is to get very accurate measurements of Mars' atmosphere. These measurements enable scientists to determine what happened to Mars' atmosphere throughout history since Mars is thought to have been warmer and wetter in the past.

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.3.7, 4.7, 5.7 Conduct short research projects that build knowledge about a topic.

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.

Space Stage App Tips



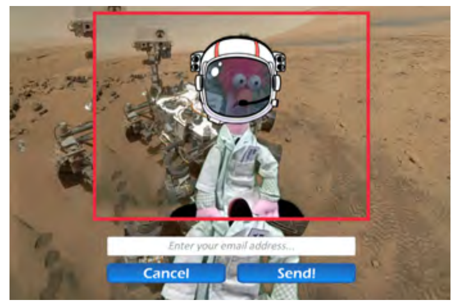
Tap on the Space Stage icon to open the app. Note: Available apps and background wallpaper will vary.

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.

This is (name), reporting to your from (part of Mars).		
The temperature is warmer at my feet than at my head.		
Warm	Very cold	Cold
70 degrees Fahrenheit (20 degrees Celsius)	-195 degrees Fahrenheit (-125 degrees Celsius)	-80 degrees Fahrenheight (-60 degrees Celsius)
Windy	Dust storm	Dust devils
Clear	Daytime	Nighttime
Blue sunrise	Mid-day	Blue sunset
Icy	Snow	Dry
Pink sky	Thin clouds	Ground
Brown	Grey	Red

How's the Weather on Mars? - Realistic Script

You are visiting a Mars Base Alpha. 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 sky looks like
- What you see on the ground and in the distance
- Whether it's really really cold today or just chilly – or if it is warm today
- What kinds of gear you must wear to keep yourself comfortable on Mars
- How the weather compares to the weather back in your hometown on Earth

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

How's the Weather on Mars? - Silly Script

Hi, ______________________ (PERSON IN THE ROOM), It's me, ______________________ (NAME), I hear the

weather is ______________________ (TYPE OF WEATHER) there in ______________________ (HOMETOWN) today.

It's a ______________________ (ADJECTIVE) day on Mars! The sky is ______________________ (COLOR) with

lots of ______________________ (NOUN). The ground is covered in ______________________ (COLOR)

______________________ (NATURAL OBJECTS). It's as cold as a ______________________ (FAVORITE FROZEN FOOD)!

Our thermometer read minus ______________________ (NUMBER) degrees Fahrenheit. I definitely

wouldn't be walking around Mars without my ______________________ (TYPE OF OUTDOOR CLOTHING) on today!

I'm ______________________ (VERB ENDING IN "ING") back to Base ______________________ (NAME OF FAMOUS PERSON IN HISTORY).

My friend, ______________________ (FAMOUS MOVIE STAR), promised to cook some

______________________ (ADJECTIVE) ______________________ (HEALTHY FOOD) - my favorite!

Mars Adventure Travel Corporation

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

Credit: Space Science Institute/NCIL

Materials

- Script-writing materials:
  - Mars Adventure Travel Corporation Realistic Script (below)
  - Space Colony Report Silly Script (below)
  - Colored pencils or crayons
  - Chart paper or dry erase board (and markers)
- Green Screen set up on its stand (see the Green Screen Setup Guide and Calibration Guide in Section 4)
  Tip: Avoid wearing the color green
- Tablet and Space Stage App (see the Tablet Setup and Tips Guide in Section 4)
- **Optional (recommended):** props and costumes, such as astronaut costumes; mittens or gloves; snow boots; ski masks; snow suits; umbrellas; sunglasses; sunscreen; a fan for wind; Styrofoam peanuts for snow
- **Optional:** Craft supplies for making costumes or props, such as large cardboard boxes, cardstock, scraps of fabric, colored markers, yarn, scissors, glue etc.
- Computer, speakers, projector, projection screen, and access to the Internet to provide background information

Recommended Ages:
School-aged children ages 8-9
Tweens up to about age 13
Teens

Learning Goals:
After doing this activity, participants will be able to:

- Describe the environment on Mars
- Describe ways that people can work and play on the surface of Mars

Preparation Time:
20 minutes

Activity Time:
1-2 hours

Preparation

1. When promoting the activity, emphasize that participants will need to avoid wearing green-colored clothing.

2. If possible, arrange to have at least one older child, teen, or adult available to help the groups write their scripts and hold the tablet during filming.

3. Gather materials.

4. Set up the Green Screen and provide a tablet with the Space Stage app preloaded on it. Have props and costumes – or the craft supplies to make them – available nearby.

5. Print out the Space Colony Report Silly Script, which may help some students create a script.

Tip: If you do not have a Green Screen, create your own backdrop of Martian landscapes by projecting a NASA image of the surface of Mars.

Procedure

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

2. Explain to the participants that they will create skits about an imagined visit to Mars, beginning with writing scripts and ending with filming their skits in front of a Green Screen.

3. 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.

4. Explore sources of information on Mars and possible future human exploration by viewing short videos and photos about Mars, reading books, and/or visiting NASA websites.

5. 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 Mars and on a Mars base. (10 minutes)
   Example discussion questions:

   - 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 Mars?
   - 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 Mars? How?
   - How do you create power on Mars to run your electronics and equipment?

Optional (recommended): Post these ideas on a chart or dry erase board (or similar) for participants to incorporate into their scripts.

Procedure (continued)

6. Explain to the participants that they will be writing and filming a 30-60-second commercial or report. Provide information to get them started. Say:

   You are living in the year 2060, and you work for the Mars Adventure Travel Corporation in their advertising office. Your main job is to convince people from Earth to visit Mars. There are new bases on Mars, 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.

7. Invite participants to form small groups and create a script, using one or more sources of ideas:
   a. Interesting facts and ideas listed on the chart paper or white board
   b. Mars Adventure Travel Corporation Realistic Script (see at the end of this guide)
   c. Space Colony Report Silly Script (see at the end of this guide)

8. If time allows, practice the skits and coach the participants in their 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.

9. Using a Green Screen and a tablet with the Space Stage app, have participants playact their skits. Guide participants in using the app, as needed.

Connections to Other Kit Materials

Stay tuned for more Mars activities in Kit C!

Recommeded Extension Activities

- The Space Place at NASA game, "Let's Go to Mars," has students load items into a Mars-bound rocket
  https://goo.gl/quRHQX

- Mars Match Game
  https://goo.gl/EeHbZa

- Trip to Mars
  https://goo.gl/AfrguA

- NASA Space Place Loopy Legends
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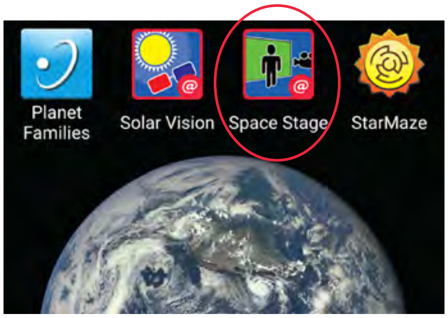
Writing

- 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.

Space Stage App Tips



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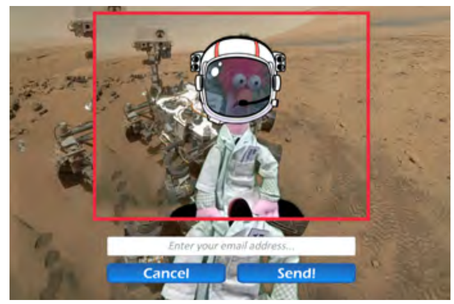


Invite adult participants to enter an email address in order to receive the video file.

Mars Adventure Travel Corporation - Realistic Script

Convince tourists to visit Mars! You are living in the year 2060, and you work for the Space Adventure Travel Corporation in their advertising office. There are new bases on Mars with habitats that maintain temperature, provide air to breathe, protect from radiation, and have running water. Create an advertisement convincing people to visit the Red Planet. Here are some ideas of what to talk about:

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

Write your script here.

Space Colony Report - Silly Script

NASA Headquarters, this is ______________________________ reporting to you live from
YOUR NAME

______________________________ on Mars. We have been living at our base, Base
PLACE YOU LIKE TO VISIT

______________________________ , for ______________________________. We are
NOUN (PERSON, PLACE OR THING) TIME (WEEKS, MONTHS, YEARS)

growing some ______________________________ and ______________________________ in our greenhouse.
LIVING THING FAVORITE FOOD

We have been exploring Mars in our ______________________________ and collecting lots of
TYPE OF VEHICLE

____
NOUN (PERSON, PLACE OR THING)

We have named a ______________________________ after the famouse
NATURAL FEATURE (MOUNTATIN, CANYON)

______________________________, ______________________________
TYPE OF JOB PERSON IN THE ROOM

Recommended STEM Activity Clearinghouse Resource

Recipe for a Planet and Moon

Kids love creating the sweet treats in these activities! In Recipe for a Planet, participants create edible models of Earth and Mars and compare their features. Recipe for a Moon provides the additional recipe for creating a model of Earth's Moon, in addition to tips for explaining how the Moon became so different from our own planet.

Before the program, inform participants about all of the ingredients that will be used so that caregivers are aware of potential allergy concerns for their children (we recommend you hold on to the packaging so caregivers can read it if requested).

Key Concepts

- Models help us understand things we can't directly observe.

Build a Program with Related Resources

Combine this activity in learning stations with other hands-on activities relating to the Moon and Mars. Have the Green Screen and tablet available for participants to make *Moon Skits* or *Mars Skits* (How's the Weather? and Space Adventure Travel Corporation Commercials).

Take a closer look at the surfaces of Mars or the Moon through the STEAM activity, *Art and the Cosmic Connection*.

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.

Need more ideas? Search for "Moon" and "Mars" resources on the STEM Activity Clearinghouse or browse activities in the "Astronomy and Space" content area. 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), or mess level. Or, view featured collections of activities.

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!

Credit: Space Science Institute/NCIL

Content Area:
- Earth Science
- Astronomy and Space

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens
- Teens

Time to Complete Activity:
40 minutes to 1 hour

Time Needed to Prep Activity:
10-20 minutes

Difficulty Level:
Easy

Mess Level:
High

Originating Source:
Recipe for a Planet and *Recipe for a Moon* were developed by the Lunar and Planetary Institute and is part of the NASA portfolio of educational resources available on NASAWavelength.org.

Recipe for a Planet

Overview

Recipe for a Planet is a 45 minute activity in which children ages 8 to 13 build edible models of Earth and Mars to compare their sizes and illustrate their internal layers.

What's the Point?

- Mars is about half the size of Earth.
- Mars and Earth have internal layers, including cores, mantles, and crust.
- Earth has a solid inner core and molten outer core; Mars most likely has a molten core.
- Surface features on a planet provide clues to their internal processes.
- Volcanos on a planet's surface suggest that the interior of the planet is – or was recently – sufficiently hot to create magma, molten rock.
- Models are tools for understanding the natural world.
- Models — such as the children are using here — can be tools for understanding the natural world.
- Geologists use comparisons between features on Earth and other planets, like Mars, to help them identify differences in how the features may have formed or changed.

Materials

For each child:

- One GSI Journal: Mars Inside and Out Or One GSI Journal Part 2: Inside Mars
- One pencil

For each team of 3 to 4 children (or for each individual child if you prefer that they make their own planets):

- 10-12 mini chocolate chips and 3-4 regular size chocolate chips
- 2 teaspoons of green sprinkles or "jimmies"
- 4 teaspoons of blue sprinkles or "jimmies"
- 3 teaspoons of red sprinkles or "jimmies"
- 4 tablespoons of red icing
- 1 small paper cup
- 1 donut hole, preferably chocolate
- 6 pre-packaged Rice Krispies Treats
- 3 zip lock baggies
- 2 cardboard plates
- 1 ruler
- 1 pair of scissors
- 1 sturdy plastic knife
- Several wet wipes or damp paper towels
- Recipes for Earth and Mars

For the group:

- Butcher paper, newspapers, or disposable table cloths for the activity area (optional)

For the Facilitator:

- Background information

Preparation

You may need to modify this activity for children with dietary restrictions.

- Make copies of the global images of Earth and Mars.
- Place the different colors of sprinkles in separate baggies. Place both sizes of chocolate chips in a baggie. Place the red icing in the small paper cup.
- This is a fun, but messy activity! If possible, tell the children ahead of time to wear an old shirt or apron, or you may wish to provide trash bags for them to wear.

Activity

1. Introduce the activity by dividing the children into teams of 3 to 4 and explaining that each team will create edible models of Earth and Mars. Invite them to share what they know about Mars:

- Are Earth and Mars the same size? Which is bigger?
- What color is Mars from space? What about Earth?
- Does Mars have several land masses — or continents — like Earth?
- Does Mars have oceans like Earth?
- Do Earth and Mars have volcanos? What differences in the volcanos can they recall from earlier activities?
- Does Earth have layers inside? Can they name some of those layers?
- What is the inside of Earth like? Children may say there is a molten layer under the surface; this is an important misconception that will be examined in the activity.
- Does Mars have layers inside? What might they be like
- Do you think Earth and Mars look similar on the inside?

2. Before you begin, explain to the children that this is a fun and tasty — but messy — activity! Have them wash their hands before they start and remind them to not lick their fingers while they are working on their models. For now, they will just make the model — they will be invited to eat it at the end of the activity!

3. Create a model of Earth! Provide the materials to the teams and invite them to create a model of Earth.

Earth's inner metallic core: a donut hole
Earth's molten outer core: red icing
Earth's mantle: 3 1/2 Rice Krispies Treats
Earth's oceanic crust: blue sprinkles or "jimmies"
Earth's continental crust: 1/2 of a Rice Krispies treat covered in green sprinkles or "jimmies"

Have each team tear one of their Rice Krispies treats in half and set one half aside. Mash the other half together with 3 more Rice Krispies Treats so they make one "mega treat." Have them form the treat into a flat rectangle, about 4 inches by 6 inches. Starting in the center of the flattened "mega treat," smooth a thin sheet of the red icing to within one inch of each edge; they should use about half of the icing and save the rest for later. Place the donut hole in the middle. Gently wrap the Rice Krispies Treats around the donut hole — with the icing side against the donut hole — to form a ball. Roll it around and squeeze it to make it firm.

Invite the children to add continental and oceanic crusts to their Earth. Have them place their Earth sphere in the baggie with the blue sprinkles. Roll it around until it is thoroughly covered in blue. Remove and set it aside.

- Ask the children what they think the blue represents. Many of the children may say "the ocean." Clarify that in this model we are using blue to represent the thin crust under the ocean (oceanic crust).

Now invite them to make the continental crust — the land on Earth. Ask them to take the Rice Krispies Treat half they set aside earlier and flatten it into a thin layer. Have the children create four or five continent shapes, then gently press one side of each continent into the green sprinkles until covered. Have them gently press each continent onto the Earth sphere with the sprinkle side up. In reality, the thicker continental crust does not "sit" on top of the oceanic crust; both sit above the Earth's mantle.

- What do the green sprinkles represent? The crust, or land, that is above the ocean (the thicker continental crust).

4. Create a model of Mars. Provide the materials to the teams and invite them to create a model of Mars.

Mars' inner core: 2 tablespoons of red icing
Mars' mantle: 2 Rice Krispies Treats
Mars' crust: red sprinkles

Have the teams shape their Rice Krispies Treats into a rectangle about four inches by two inches. Place the red icing in the center and gentlywrap the Rice Krispies Treat around it, shaping it into a ball.

- What color is the surface of Mars from space? Mostly red.

Have the children place their Mars sphere in the baggie with the red sprinkles and roll it around until it is thoroughly covered in red. Remove and set aside.

5. Invite the children to examine and discuss their models.

- Which is larger? Earth.
- What features did they see on Earth and Mars in their earlier investigations? Channels, volcanos, and impact craters.
- How might they make their Earth and Mars more realistic? Their answers may include adding these features.

6. Revisit their crater ideas.

- Which has more craters? Mars.
- Which has bigger craters? Mars.
- How might the children add craters to their Earth and Mars? They can use their fingers to make impressions in the surface to represent giant impact craters.!

7. Revisit their volcano ideas and their findings from earlier activities.

- Which has more volcanos? Earth.
- Which has bigger volcanos? Mars.
- Is there a pattern to where the volcanos on Earth are? They are mostly in a line or chain. Sometimes they are in chains along continents or in the middle of oceans.

Invite the teams to add chocolate chip volcanos to their Earth and Mars models, based on their observations and what they learned in other activities. They may want to use the left-over red icing to help the chocolate chips stick.

- Where should small chocolate chip volcanos go? Earth.Facilitator Note: at the model Earth scale, these chocolate chips are really much too large!
- Where should the large chocolate chips go? Mars.
- Which will have more chocolate chip volcanos? Earth.
- Which planet has volcanos in chains? Earth.

8. Ask the children what volcanos tell us about a planet.

- What makes volcanos? Molten rock or magma coming from inside the planet.
- If the rock is melted, what does this mean about the temperature of the planet? It is hot enough to melt the rock!
- Earth has lots of active volcanos — like Hawaii, Mount St. Helens. Mount Erebus in Antarctica, and Mount Etna in Italy. What does that mean about its inside? Earth is very hot.
- On Mars, we have the volcanos, but there are fewer than on Earth — and we have never observed one erupting. What might this tell us about Mars? Mars has been hot enough to make volcanos, perhaps not very long ago, but it is not as hot as Earth.

Planetary scientists hypothesize that some of Mars' volcanos were active not very long ago, between 10 million years ago and a hundred million years ago. They suggest this because the volcanic rock around many of the volcanos is not heavily cratered; the surface appears fresh.

- What does the red icing represent? Melted or molten rock, or magma under the volcano.
- Is there a layer of melted rock under the Earth's crust in their model? No, just little pockets. This is an important point to make, as children often think there is a melted layer under Earth's crust that feeds magma to volcanos. If there were a molten layer everywhere, we might expect to see volcanos everywhere!
- Is there a melted layer anywhere in Earth — did they use the red icing for any layer? Yes, the red icing was used for the outer core. Earth's outer core is molten.

9. Have the children spend a few minutes talking in their groups about what the inside of their Earth and Mars model planets will look like if they cut them open. Invite them to draw their predictions if they wish.

10. Return to their models and have the teams carefully cut both Earth and Mars in half. Small children may need help cutting, and they may need to reshape the planets after cutting.

11. Invite the teams to examine the cross sections of their planets.

- Were their predictions correct about the interiors of Earth and Mars? Do the insides of the planets look like the children thought they would?
- What do the different layers represent? Refer to steps 3 and 4.
- In what ways are the interiors of Mars and Earth similar? They both have layers, with a central core, a middle mantle, and an outer crust. They both have magma chambers under the volcanos.
- In what ways are they different?
    - Earth has a layer of icing that represents the liquid molten outer core. Earth has a solid inner core.

      Share with older children that Earth's molten layer of material — iron and nickel - is very important. Convection (flow) of material in Earth's outer core creates Earth's magnetic field. This magnetic field protects us from dangerous particles from the Sun called solar wind. Without a magnetic field, these particles would wear away our atmosphere and dangerous radiation from the Sun would reach Earth's surface.

- Mars also has a molten core — but no solid inner core.

> Share with older children that because there is not convection within the liquid core, Mars does not have a magnetic field like Earth's. Without this protective magnetic field, solar wind has worn away the atmosphere of Mars, and dangerous radiation reaches its surface.

- In general, Earth has two different types of crust — thick crust where there is land (continental crust) and thin crust under the oceans (oceanic crust). On Mars, the crust is relatively thick everywhere.

Conclusion

Ask the children if they think the differences in the interiors of Mars and Earth are somehow related to the differences in their surface features. Give them a few minutes to discuss the possible relationship. You may wish to have them share some of their ideas and record them in their GSI Journals.

Recipe for a Planet
Earth

4	Rice Krispies Treats
1	donut hole
2	Tablespoons of red icing
2	Teaspoons green sprinkles in a baggie
4	Teaspoons blue sprinkles in a baggie

10-12	mini chocolate chips
1	ruler
1	plastic knife
1	cardboard plate

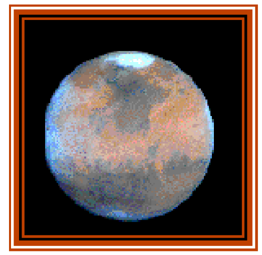
Wet wipes or *damp* paper towels

- Mash 3½ Rice Krispie Treats together to form a 4" x 6" rectangle. Set the other ½ treat aside.
- Smooth a thin sheet of red icing on top of the rectangle, leaving about an inch of space without icing around the edges. You will only need about half of the icing.
- Place the donut hole in the middle of the rectangle and gently wrap the treat around it. Form it into a ball, rolling it around to make it firm.
- Place your Rice Krispie Earth in the baggie with the blue sprinkles. Roll it around until it is covered in blue. This represents the Earth's *oceanic* crust!
- Take the half treat you set aside and flatten it into a *very thin* layer to form Earth's *continental* crust.
- Pinch off 4-5 nickel-size pieces to create your continents. Gently press *one side* of each continent into the green sprinkles until covered. Press the continents onto your Earth with the sprinkle side up.
- Add chocolate chip volcanos. Use the left-over icing to make them stick; the icing can be the magma that occurs in chambers under the volcanos!

~Serving size: 1 planet Earth~

Recipe for a Planet
Mars

2	Rice Krispies Treats	1	ruler
2	Tablespoons red icing	1	plastic knife
3-4	*regular* size chocolate chips	1	cardboard plate
3	Teaspoons red sprinkles in a baggie		Wet wipes or *damp* paper towels



- Shape the Rice Krispies Treat into a 2" x 4" rectangle.
- Place most of the red icing in a lump on top of the rectangle and gently wrap the treat around it. Form it into a ball, rolling it around to make it firm.
- Place your Rice Krispie Mars in the baggie with the red sprinkles. Roll it around until it is covered in red. This represents the crust of Mars!
- Add chocolate chip volcanos. Use the left-over icing to make them stick; the icing can be the magma that occurs in chambers under the volcanos!

~Serving size: 1 planet Mars~

Explore! Mars Inside and Out

www.lpi.usra.edu/education

GEOLOGIC SCENE INVESTIGATOR JOURNAL

PART II: Inside Mars

Investigator Name

GSI: INSIDE MARS – Summit Up

One of these pictures represents the tallest volcano on Earth. The other represents the tallest volcano on Mars.

This represents the tallest volcano on

______________________________ .

And THIS represents the tallest volcano on

______________________________ .

It's also the tallest volcano in the

____________________ ________________ !

GSI: INSIDE MARS – Cooling Cupcakes and Planets

Both of these cupcakes were **HOT** when they came out of the oven!! Which one do you think **COOLED** faster?

(circle one)

The BIG one, or  the SMALL one? 

Both of these planets were **REALLY HOT** when they formed!! Which one do you think **COOLED** faster?

(circle one)

The BIG one, or the SMALL one?

Why?

Which circle do you think represents Earth?

Which circle represents Mars?

Which is hotter inside today, Earth or Mars?
(Hint: Which planet still has lots and lots of active volcanos?)

GSI: INSIDE MARS – Differentiation Demonstration

What happens when you fill a bottle with gravel, syrup, and beads and shake it? After everything has settled, color and label the layers you observe (crust, mantle, core).

____

____

____

What happened after the bottle was shaken?

Why?

How might Mars have gotten its layers?

GSI: INSIDE MARS – Puzzling Patterns

What I observe about volcanos on Mars:

They are bigger / smaller (circle one) than volcanos on Earth.

There are more / fewer (circle one) volcanos on Mars than on Earth.

They do / do not (circle one) form chains.

What might cause the differences in volcanos on Mars and volcanos on Earth?

GSI: INSIDE MARS – Icing on the Plate

Why is Olympus Mons on Mars soooooooo much taller than Earth's tallest volcano, Mauna Kea?

GSI: INSIDE MARS – Recipe for a Planet

What does Mars look like on the inside?
What layers does it have?

What does Earth look like on the inside?
What layers does it have?

Recipe for a Moon

Overview

The Moon is made of cheese... no! Rice Krispies treats! Children ages 8 to 13 discover that the Moon, like Earth, is made up of layers of different materials through this 45-minute activity. They work in teams to make models of the interiors of the Moon and Earth. Common food items are used to construct the cores, mantles, and crusts of both planetary objects.

What's the Point?

- Models can be tools for understanding the natural world and for helping us to identify more questions.
- The planets are made of solids, liquids, and gases.
- The solid Earth is layered with a solid surface crust; hot, convecting solid mantle; and dense, metallic core. Its gaseous atmosphere is thin compared to these layers.
- The Moon is made of similar materials as Earth's crust.

Materials

For the group:

- Optional: butcher paper, newspapers, or disposable table cloths for the activity area
- Wet wipes or damp paper towels
- Additional plates for eating the treats, if desired
- Global images of Earth and the Moon
- Books about the Moon; possible selections are listed in the resources section and include:

The Moon
Seymour Simon, 2003, Simon & Schuster Children's Publishing, ISBN: 0689835639
An exploration of the Moon with fantastic images for children ages 7 to 10.

Earth and the Moon
Ron Miller, 2003, Twenty First Century Books, ISBN: 0761323589
Written for young teens, this book examines the formation and evolution of the Earth and Moon.

Exploring the Moon
Rebecca Olien, PowerKids Press, 2007, ISBN 1404234667
The Moon's beginning, layers, craters and more are explained in this easy-to-read book for 9–12 year olds. Images to illustrate the author's topic accompany the text.

The Moon: Earth's Companion in Space
Michael D. Cole, 2001, Enslow Publishers, ISBN 0766015106 Children ages 9 to 12 learn about lunar orbits and phases, human exploration, and the mystery about how our Moon formed.

Jump Into Science: Moon
Steve Tomecek, National Geographic Children's Books, 2005, ISBN 0792251237
Children go on a journey with a bug and a cat to discover the Moon's scientific history and concepts. This is a great book for ages 9–12.

- Art supplies, such as colored pencils, crayons, and markers
- A Peek into the Moon's Interior

For each team of two to four children (or for each individual child if you prefer that they make their own Earth and Moon):

- 5 Rice Krispies Treats®
- 1 donut hole
- 1 cinnamon candy (e.g. Red Hots)
- tsp. hot cocoa mix
- 1 tsp. powdered sugar
- 2 tablespoons of red icing
- 2 teaspoons green sprinkles in a baggie
- 4 teaspoons blue sprinkles in a baggie
- 10–12 mini chocolate chips
- 6 regular-sized chocolate chips
- 3 Zip–loc® baggies
- 1 small cups
- 1 ruler
- 1 spoon
- 1 plastic knife
- 1 cardboard plate
- Recipe for the Moon and Recipe for Earth

For each child:

- Recipe for a Moon comic panel
- His/her Marvel Moon comic book and binder clip
- 1 pencil or pen
- Optional: 1 copy of instructions for making an edible Moon at home

For the facilitator:

- Background information
- Shopping list

Preparation

You may need to modify this activity for children with dietary restrictions.

- Review the background information.
- Place the different colors of sprinkles in separate baggies. Place the mini- and regular-sized chocolate chips in separate baggies. Place the icing in a small cup.
- This is a fun, but messy activity! If possible, tell the children ahead of time to wear an old shirt or apron, or you may wish to provide trash bags for them to wear.
- Display several books about the Moon in a place where the children can page through them before and after the activity.
- If desired, provide copies of instructions for making an edible Moon at home with their families.

Activity

1. Introduce the activity by dividing the children into teams of three to four and explaining that each team will create edible models of the Moon and Earth. Invite them to share what they know about the Moon:

- How do Earth and the Moon compare in size? Which is bigger?
- Does Earth have layers inside? Can they name some of those layers?
- What is the inside of Earth like? Children may say there is a molten layer under the surface; this is an important misconception that will be examined in the activity.
- Imagine you could cut the Moon in half with a knife and look at it insides. Does the Moon have layers inside? What might they be like?

Remind them of their earlier findings about how the Moon formed from the Wham! Moon! activity. They modeled how the debris from the Giant Impact came together — accreted — into our Moon using Play-Doh. They saw that the Earth and Moon were made of similar materials.

- Do you think Earth and the Moon look similar on the inside?

2. Before you begin, explain to the children that this is a fun and tasty — but messy — activity! Have them wash their hands before they start and remind them to not lick their fingers while they are working on their models. For now, they will just make the model — they will be invited to eat them at the end of the activity! Provide the food materials and recipes to each team.

3. Create a model of the Moon! Provide the materials to the teams and invite them to follow the recipe for a Moon.

Moon's inner metallic core: 1 cinnamon candy
Moon's mantle: 1/4 Rice Krispies Treat
Moon's crust: hot cocoa mix mixed with powdered sugar

Have each team tear one off about one quarter of a Rice Krispies Treat and set aside the rest for Earth's continental crust. Have them place the cinnamon candy in the middle of the treat and gently wrap the treat around it. Form it into a ball, rolling it around to make it firm.

- Ask the children to compare the size of the mantle and core. What do they notice? The mantle is very thick compared to the small core.

Invite the children to create the Moon's dusty surface. Roll the treat in the hot cocoa and powdered sugar mix.

4. Create a model of Earth! Provide the materials to the teams and invite them to follow the recipe for Earth.

Earth's inner solid metallic core: a donut hole
Earth's molten (liquid) outer core: red icing
Earth's mantle: 4 Rice Krispies Treats
Earth's oceanic crust: blue sprinkles or "jimmies"
Earth's continental crust: 3/4 Rice Krispies Treat covered in green sprinkles or "jimmies"

Mash four Rice Krispies Treats together so they make one "mega treat." Have them form the treat into a flat rectangle, about 4 inches by 6 inches. Starting in the center of the flattened "mega treat," smooth a thin sheet of the red icing to within one inch of each edge; they should use about half of the icing and save the rest for later. Place the donut hole in the middle. Gently wrap the Rice Krispies Treats around the donut hole — with the icing side against the donut hole — to form a ball. Roll it around and squeeze it to make it firm.

Invite the children to add continental and oceanic crusts to their "Earths." Have them place their Earth spheres in the baggie with the blue sprinkles. Roll it around until it is thoroughly covered in blue. Remove and set it aside.

- Ask the children what they think the blue represents. Many of the children may say "the ocean." Clarify that in this model we are using blue to represent the thin crust under the ocean (oceanic crust).

Now invite them to make the continental crust — the land on Earth. Ask them to take the Rice Krispies Treat half they set aside earlier and flatten it into a thin layer. Have the children create four or five continent shapes, then gently press one side of each continent into the green sprinkles until covered. Have them gently press each continent onto the Earth sphere with the sprinkle side up. In reality, the thicker continental crust does not "sit" on top of the oceanic crust; both sit above the Earth's mantle.

- What do the green sprinkles represent? The crust, or land, that is above the ocean (the thicker continental crust).

5. Invite the children to compare their models to the global images of Earth and the Moon.

- Which is larger? Earth.

Ask the children to remember the Earth and Moon's long history from the activity Time Travelers. Many of the event cards described processes that changed their surfaces to form the features we see today.

Facilitator ’s Note: Physical processes have been at work during the 4.5-billion-year history of Earth and our Moon.

Early in its history, Earth formed continental and oceanic crusts. Through time, geologic processes changed the surface to form the familiar pattern of continents and oceans we observe today. Early in Earth's history, volcanos spewed gases — including water vapor and carbon dioxide — into the atmosphere. When things cooled down enough the water vapor condensed as liquid water in our oceans.

While the Moon never had oceans or an atmosphere or shifting plates to alter its surface, it did experience some of the same processes that altered Earth's surface: volcanism and impacts by asteroids and comets.

The heat from accretion caused the Moon, or at least its outer layer, to melt, creating a magma ocean. Eventually the crust cooled. For the first 600 million years of its existence, large asteroids continued to strike the Moon and the planets in our solar system, perhaps in waves of intense bombardment, creating the large basins and craters we see on the Moon. By 3.8 billion years ago, much of the "debris" in the solar system had been swept up into the planets and their moons, corralled into the asteroid belt, or relegated to the outer reaches of our solar system, and impact strikes were smaller and less frequent.

While cool on the outside, the interior was still hot. Molten rock would still rise to the Moon’s surface and break through cracks or erupt at volcanos. The lava filled the basin and crater floors — the low areas on the Moon. It cooled quickly, forming fine-grained, dark, volcanic rocks called basalt; basalt is the most common type of volcanic rock we find Earth. When you look at the Moon, you can see the large, somewhat circular, dark basins. These are the basalt-filled ancient impact basins. In spite of this exciting beginning and history, the Moon has been geologically inactive for at least the last billion years.

- What features do you see on Earth? Oceans and continents.
- What features do you see on the Moon? Large circular features — impact craters — and areas of light grey and dark grey.
- Which would have more impact craters, the Moon or Earth, and why? The Moon has more impact craters because the only thing that will wear them down are more impacts! On Earth, weather, water, earthquakes, lava flows, and life erode or cover impact craters. Old crust is destroyed and new crust formed through plate tectonics.
- Does Earth have volcanos? Yes. Does the Moon have volcanos? Accept all answers.
- What makes volcanos? Molten rock or magma coming from inside the planet.
- If the rock is melted, what does this mean about the temperature of the planet? It is hot enough to melt the rock!
- Earth has lots of active volcanos — like the volcanos of Hawaii and Mount St. Helens in Washington State What does that mean about Earth's inside? Earth is very hot.
- On the Moon, we see evidence of lava flows — lava filled the bottoms of the huge impact basins on the Moon — but there are few volcanos and they are no longer active. What might this tell us about the Moon? The Moon was once hot enough for molten rock to flow on its surface.
- How might they make their Earth and Moon more realistic? Their answers may include adding these features.

Invite the children to create craters in the crusts using their fingers. Fill in the largest impact basins on the Moon with regular-sized chocolate chips — pressed tip-down into the treat — to form the dark-colored regions, or maria, on the Moon.

Invite the teams to add mini chocolate chip volcanos to their Earth models. They may want to use the left-over red icing to help the chocolate chips stick.

Facilitator Note: At this scale, the chocolate chips — even the minis! — are really much too large!

- What does the red icing represent? Melted or molten rock, or magma under the volcano.
- Is there a layer of melted rock under the Earth's crust in their model? No, just little pockets. This is an important point to make, as children often think there is a melted layer under Earth's crust that feeds magma to volcanos. If there were a molten layer everywhere, we might expect to see volcanos everywhere!
- Is there a melted layer anywhere in Earth — did they use the red icing for any layer? Yes, the red icing was used for the outer core. Earth's outer core is molten.
- Is there a melted layer anywhere on the Moon? No, the Moon model has only solid layers. The dark rocks that fill the basins are evidence that the Moon’s interior was hot in the past.

Explain that scientists are still investigating the Moon's core. Further studies may show how large it is and whether it is liquid or solid.

6. Have the children spend a few minutes talking in their groups about what the inside of their the Moon and Earth models will look like if they cut them open. Invite them to draw their predictions if they wish.

7. Return to their models and have the teams carefully cut both the Moon and Earth in half. Small children may need help cutting, and they may need to reshape the planets after cutting.

8. Invite the teams to examine the cross sections of their planets and draw what they see, comic-book style, in their Recipe for a Moon comic panel. Show them the Sneak Peek into the Moon's Interior and ask them to label the layers in their drawings with the terms: crust, mantle, and core, including a note about Earth's inner and outer core. Instruct the children to add the Recipe for a Mooncomic panel as the next page in the Marvel Moon comic book by clipping the book together at the upper left corner.

- Were their predictions correct about the interiors of Earth and the Moon? Do the insides look like the children thought they would?
- What do the different layers represent? Refer to steps 3 and 4.
- In what ways are the interiors of the Moon and Earth similar? They both have layers, with a central core, a middle mantle, and an outer crust. They both have volcanic rock on their surfaces.
- Are they made of similar materials? Yes!

As the children saw in Wham! Moon!, pieces of Earth mixed with pieces of an impactor to come together — accrete — to form the Moon.

- In what ways are they different? Earth has a layer of icing that represents the liquid molten outer core. Earth has a solid inner core.

The cores of the Earth and Moon are both metallic. The Moon's core is much smaller relative to its size, when compared to Earth. This is one line of evidence that supports the Giant Impact hypothesis. The small planetary body struck Earth in a glancing blow, which stripped part of the outer layers of the impacting object and Earth to form the Moon. Earth's dense core was left intact, and the core of the small planetary body was absorbed by the Earth. The Moon was born with much less iron and other heavy elements to form its core.

Facilitator ’s Note: The children may have many misconceptions about Earth's interior. They may believe the crust floats on a molten layer, but as modeled in this activity, only the outer core is liquid. Pieces of Earth's crust do move on top (giving rise to earthquakes), but they are riding a layer of solid — but ductile — rock.

Share with older children that Earth's molten layer of material — iron and nickel — s very important. Convection (flow) of material in Earth's outer core creates Earth's magnetic field. This magnetic field protects us from dangerous particles from the Sun called solar wind. Without a magnetic field, these particles would wear away our atmosphere and dangerous radiation from the Sun would reach Earth's surface.

The Moon does not have a magnetic field like Earth's. Without this protective magnetic field, dangerous radiation reaches the Moon’s surface.

- In general, Earth has two different types of crust — thick crust where there is land (continental crust) and thin crust under the oceans (oceanic crust). On the Moon, the crust is thick everywhere.

- How do these models represent the Moon and Earth? Their overall sizes and the thicknesses of their layers are approximately to scale. Each layer is made of different materials.
- How do they not represent the Moon and Earth? They are smaller and made of different materials than real planets.

Add that scientists dont yet have accurate measurements on the diameter of the Moon's core, thickness of the mantle, and depth of the surface.

10. Discuss how scientists study the surface and interior of the Moon.

- How do the children think scientists study the surface of the Moon? The children may have ideas about studying rocks or taking pictures of the landscape. They may know that spacecraft collect data from orbit around the Moon. They may recall that during the Apollo mission, the astronauts conducted experiments on the lunar surface and brought rocks back to Earth.

Spacecraft take photographs of surface features and measure how their orbits are affected by the Moon's gravitational pull. Instruments left on the lunar surface by Apollo astronauts measured moonquakes and revealed clues about the organization of the Moon's interior. Moon rocks brought back by the Apollo missions changed how scientists thought about the Moon's formation and changes over time. It was only by examining those rocks that they hypothesized the Moon must have formed from the Earth's crust through a giant impact. Some rocks were formed in the mantle and brought to the surface during the Moon's ancient volcanic period, and others were thrown out of deep holes (craters) created by ongoing impacts. Using computer models, scientists now have a better idea of how the Moon's interior settled into layers after the giant impact. Future missions, such as NASA's Gravity Recovery and Interior Laboratory - GRAIL — mission will collect data to help scientists better understand the Moon's interior.

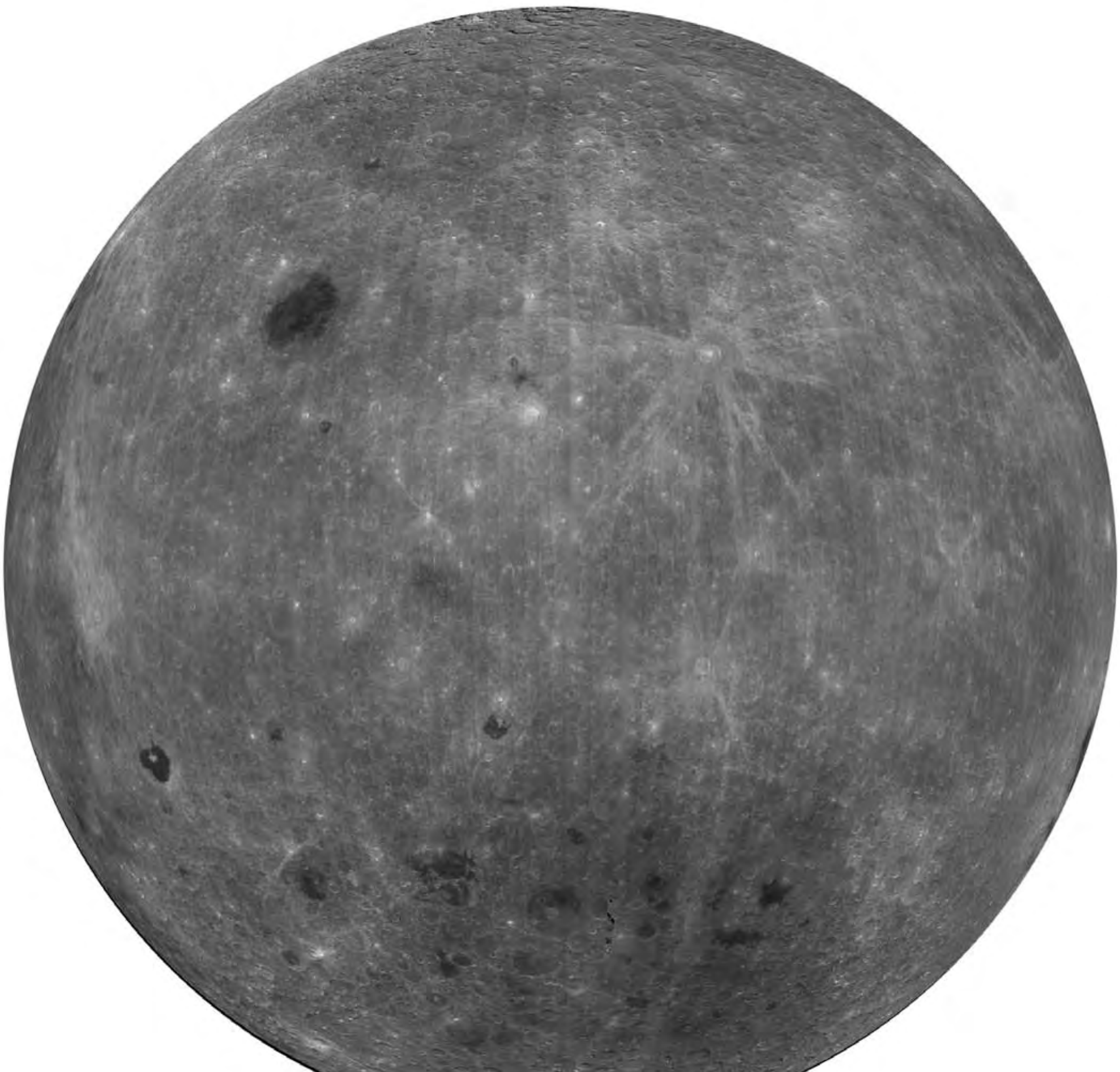
Conclusion

Invite the children to eat the treats while they consider how Earth and the Moon are similar and how they are different. Invite them to consider the similarity of the Earth’s mantle and the Moon's as they bite the Rice Krispies treats.

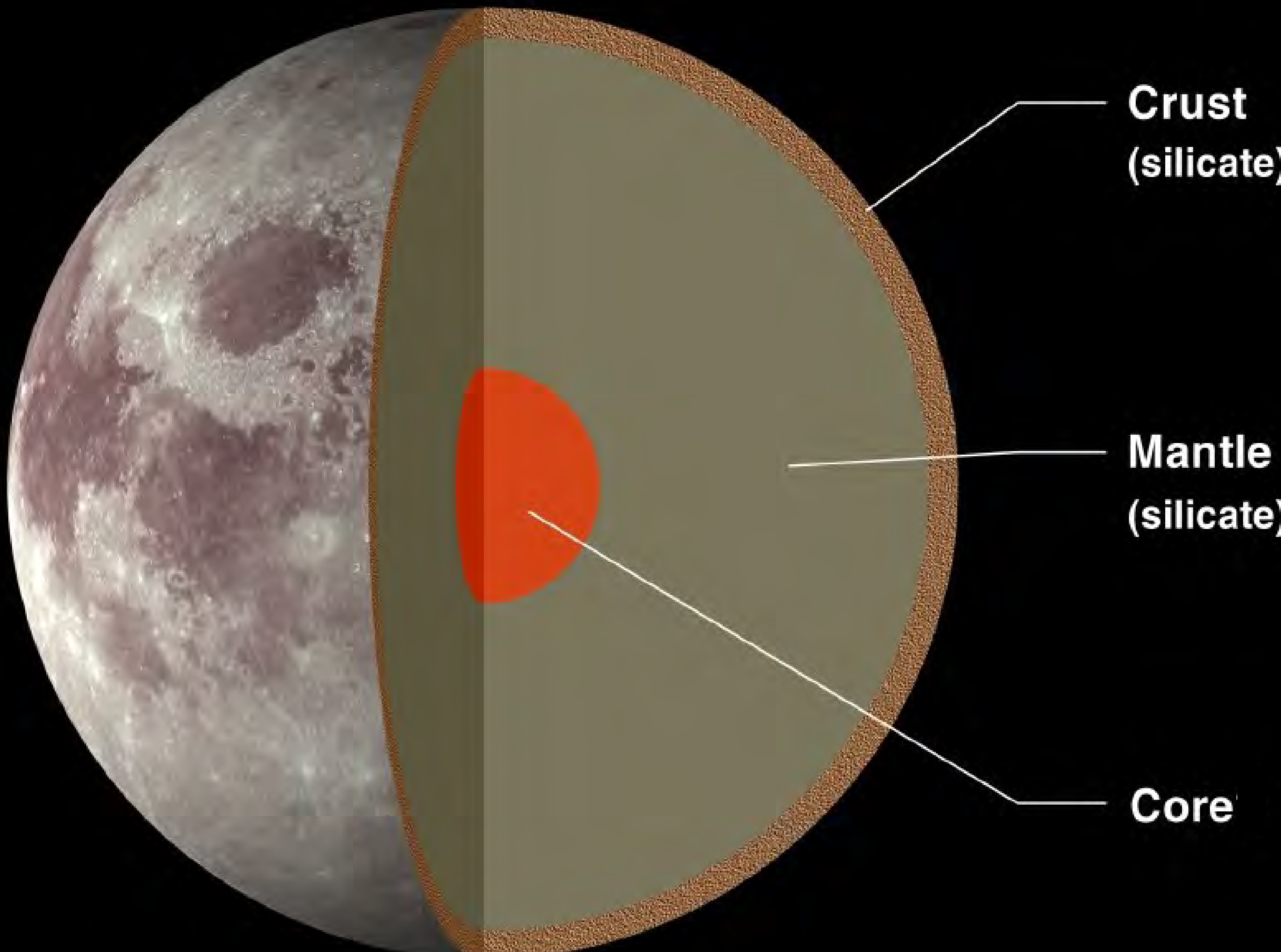
- Do they prefer their chocolate "lava flows" as low, flat plains, like on the Moon, or spread out as volcanos across the surface, like on Earth?
- What do they think scientists will learn about the Moon's "cinnamon candy" core after the GRAIL mission sends more information about the Moon back to Earth?

Lunar Nearside

Lunar Farside



A Peek into the Moon's Interior



Credit: Lunar and Planetary Institute

Recipe for the Moon

$\frac{1}{4}$ Rice Krispies Treat	
1 cinnamon candy	1 plastic knife
1 tsp hot cocoa mix	1 ruler
1 tsp powdered sugar	1 cardboard plate
6 regular-sized chocolate chips	Wet wipes or damp paper towels

- You will only need a small piece of a Rice Krispies Treat for the Moon, so tear about one quarter off and set the rest aside to use for the Earth's continental crust.
- Place one cinnamon candy in the middle of the treat and gently wrap the treat around it. Form it into a ball, rolling it around to make it firm.
- Add the powdered sugar and cocoa mix to a baggie and work them together until the color turns gray.
- Roll the treat in the cracker and powdered sugar mix to make the Moon's crust.
- Create *lots* of craters in the crust using your fingers.
- Push the chocolate chips, tip down, into the largest holes to form the dark-colored regions, or maria, on the Moon.

~Serving size: 1 Moon~

Recipe for Earth

4 $\frac{3}{4}$ Rice Krispies Treats
2 tablespoons red icing
2 teaspoons green sprinkles in a baggie
4 teaspoons blue sprinkles in a baggie
1 donut hole

10-12 mini chocolate chips
1 ruler
1 plastic knife
1 cardboard plate
Wet wipes or damp paper towels

- Mash four Rice Krispies Treats together to form a 4" x 6" rectangle. Keep the leftovers from the Moon recipe off to the side for later.
- Smooth a thin sheet of red icing on top of the rectangle, leaving about an inch of space without icing around the edges. You will only need about half of the icing.
- Place the donut hole in the middle of the rectangle and gently wrap the treat around it. Form it into a ball, rolling it around to make it firm.
- Place your Rice Krispies Earth in the baggie with the blue sprinkles. Roll it around until it is covered in blue. This represents the Earth's oceanic crust!
- Take the leftover treat you set aside and flatten it into a very thin layer to form Earth's continental crust.
- Pinch off five nickel-size pieces to create your continents. Gently press one side of each continent into the green sprinkles until covered. Press the continents onto your Earth with the sprinkle side up.
- Create a few craters in the crust using your fingers.
- Use the left-over icing to stick chocolate chips, tip up, on the surface. The chocolate chips are "volcanos" and the icing represents the magma that occurs in chambers under them!

~Serving size: 1 planet Earth~

Earth's Western Hemisphere

Earth's Eastern Hemisphere

Make a UV Detector

This brief activity uses the surprising property of tonic water to fluoresce (glow) in sunlight to introduce participants to the idea that human eyes aren't able to see everything – including UV light from the Sun.

Invite participants to download the *Solar Vision* app (scigames.org) to explore near-real-time NASA images of our Sun. Encourage caregivers to *Make a UV Detector* and related activities at home using the DIY Sun Science app from https://goo.gl/g3kRT2

Credit: Space Science Institute/NCIL

Content Area:
- Astronomy and Space
- Physics

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens
- Teens
- Adults

Time to Complete Activity:
Under 10 minutes

Time Needed to Prep Activity:
Under 5 minutes

Difficulty Level:
Medium

Mess Level:
Low

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- There's more to the Universe than meets the human eye.

Build a Program with Related Resources

Try another activity that uses tonic water, *Reflections on Ice*, to build on the idea that human eyes aren't able to see everything – but NASA spacecraft have tools to help us expand our senses as we explore the Universe.

Combine this activity with activities from Kit A: Sun-Earth-Moon Connections. In particular, demonstrate how to use the *Solar Vision* app to explore the Sun and its features. Use the make-and-take activity, *UV Kid*, to provide each participant with a UV detector that they can take home. While you are outside, have young children try *Shadow Play* and have older children make temperature measurements with *Taking Earth's Temperature*.

Need more ideas? Browse activities in the "Astronomy & Space" content area on the STEM Activity Clearing-house (http://clearinghouse.starnetlibraries.org).

STEM ACTIVITY Clearinghouse

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:
Make a UV Detector was developed by the Lawrence Hall of Science and is part of the NASA portfolio of educational resources available on NASAWavelength.org.

DIY
SUN SCIENCE

Make a UV Detector

How can a clear liquid glow blue in sunlight?

Description

On a bright, sunny day, use tonic water to detect ultraviolet (UV) light from the Sun.

Age Level: 7 and up

Materials

- two clear cups (plastic or glass)
- tonic water
- tap water
- flashlight
- black piece of paper
- pen
- two index cards
- tape
- hardcover book

Time

Preparation: 5 minutes
Activity: 5 minutes
Cleanup: 5 minutes

Step 1

Use your pen and paper to make two signs: "Tonic Water" and "Tap Water." Tape these signs next to each other at the top of the sheet of black paper, and tape the black paper to a hardcover book. Place one cup under each sign.

Step 2

Fill each cup to the brim with the kind of water noted on the label. While you're indoors, shine a bright flashlight at both full cups. Do you see any color difference between the cups?

Step 3

Bring your black piece of paper outside, in full sunlight. Prop up the book so that the paper is vertical. Place the two cups in front of the paper. Now what colors are the two liquids?

What's Going on?

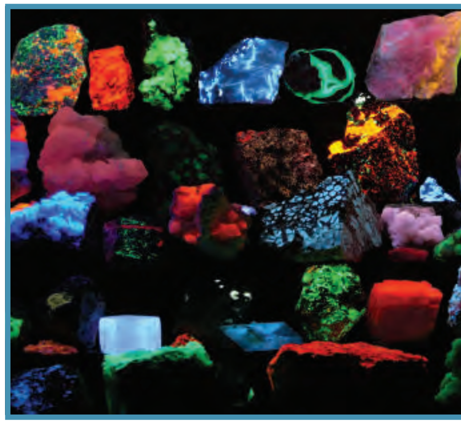
Indoors - no UV light
Both cups look the same

Outdoors - UV light
Tonic water glows blue

We can see visible light emitted by the Sun. The Sun also emits light we can't see, including ultraviolet light. Quinine is a substance found in tonic water that is sensitive to ultraviolet light and can absorb ultraviolet light we can't see and then re-emit visible blue light we can see. This process of converting ultraviolet into visible light is called fluorescence.

When you shined a flashlight at the cups of water indoors, the tonic water did not fluoresce and glow blue. That's because flashlights and everyday household lights do not emit a significant amount of ultraviolet light.

Examples of fluorescence



Fluorescence is also common in rocks and minerals. This image shows mineral specimens that are fluorescing. Some minerals appear a different color than others because of the different fluorescent elements present in each mineral.

Learn More

For more info and other activities, visit:

LawrenceHallofScience.org/do_science_now/diy_sun_science

Credits

This project was supported by NASA under award number NNX10AE05G. Any opinions, findings, conclusions or recommendations expressed in this program are those of the author and do not reflect the views of NASA.

THE LAWRENCE HALL OF SCIENCE

The DIY Sun Science app allows families and educators to investigate and learn about the Sun at home, at school, or anywhere you go! The app features thirteen hands-on investigations, as well as images and videos.

Image 7, Hannes Grobe.

Reflections on Ice

Credit: Space Science Institute/NCIL

Participants enjoy the overall effect of using different tools to explore ice in a darkened room. The activity mimics how NASA scientists study ice on our own planet.

Note: The ice must be prepared the day before. Libraries with no access to a freezer have successfully used a cooler to store the ice.

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- There's more to the universe than meets the human eye.

Content Area:
- Earth Science
- Physics

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens
- Teens

Time to Complete Activity:
40 minutes to 1 hour

Time Needed to Prep Activity:
10-20 minutes

Difficulty Level:
Medium

Mess Level:
Medium

Build a Program with Related Resources

Try another activity that uses tonic water, *Make a UV Detector*, to build on the idea that human eyes aren't able to see everything – but NASA spacecraft have tools to help us expand our senses as we explore the universe.

Combine this activity with the *Taking Earth's Temperature* activity from Kit A: Sun-Earth-Moon Connections. Encourage teens and adults to be citizen scientists using the GLOBE Observer app from https://observer.globe.gov/about/get-the-app. Both activities highlight how NASA scientists use tools to observe different aspects of Earth.

Need more ideas? Browse activities in the "Earth Science" content area on the STEM Activity Clearinghouse (http://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), or mess level. Or, view featured collections of activities.

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:
Reflections on Ice was developed by the Lunar and Planetary Institute.

Modified from: Ice in the Solar System, Investigating Ice Worlds.

Overview

To build an understanding of how scientists study ice properties remotely children ages 8 to 13 observe ice through different wavelengths of light. In this 60 minutes of exploration, teams of children travel to three ice stations and examine the ice with blacklights, flashlights, and colored lenses to discover that there is more to ice than meets the eye!

What's the Point?

- Scientists use different wavelengths or types of light to investigate and reveal the presence and type of ice on a planet or moon.
- In addition to water ice (frozen H_2O), there are other ices on the surfaces of outer planetary worlds.

Materials

For each child

- Ice investigation sheets:
  - Shine a Light on Ice
  - Color Coded Ice
  - Visible or Invisible?
- A pencil

For each group of two to three children

- 1 Amazing Electromagnetic Spectrum cartoon

For the group:

- 12 flashlights
- 2 UV lights (blacklights) (These may be purchased for under $20 each. UV light bulbs do not work as well)
- 1 sheet each of red, blue, and green colored gel (colored filters).

- 4 (6" wide and 2" deep or larger) containers (such as pans or trays) to hold water
- 1 box of food coloring (red, yellow, green, and blue)
- 1 ice cube tray
- 1 small spoon
- 1 bottle of tonic water (preferred) or 2 sheets of white copier paper (alternate)
- 6 sheets of cardstock
- Tape
- Paper
- Water
- Access to freezer
- Access to a dark room for the group activity
- Marker

For the facilitator:

- Background information

Preparation

- The activity, as presented, includes a total of 6 ice stations and can be used comfortably with six groups of four to six children. Each station contains one type of ice observation. Alter the number of stations as needed based on the number of children participating.
- Gels are inexpensive and may be purchased from a variety of locations, including theatrical supplies stores and online at Stage Spot.com, StageProductionStore, and Premier Lighting & Production Company. Recommended gel colors are Roscolux red (#27), blue (#83), and green (#91). Gels come in 20"x24" sheets. Cut into a square big enough to cover the top of a flashlight.
- At least one day in advance, freeze the containers of ice as follows:
    - Stations 1 and 2: Fill containers half-way with water. When nearly frozen, add ice cubes so that the ice cubes are sticking up above the water. Continue to freeze. Keep the containers in the freezer until ready for the activity.
    - Stations 3 and 4: Create 6 colored ice cubes (three per station). Fill half of the ice cube tray with water. Add red coloring to compartments, blue coloring to compartments, and green coloring to compartments. Make sure the colors are very intense. Mix the water (taking care not to combine the colors) and freeze them.

- Stations 5 and 6: Fill containers with water and freeze. Fill the other containers with tonic water and freeze. If tonic water is unavailable, fill the containers ¼ full with water, and place a sheet of white copier paper on top and freeze. After the water and paper is frozen, add more water on top and freeze.

- Prepare an area large enough for six ice stations, allowing enough room for groups of children to gather around each. Prepare the room so it can be made very dark.
- For each station, tape a cardstock sign to the table so that the children will clearly see "Station 1", "Station 2", etc.
- At each of Stations 1 and 2 place a pan of disrupted ice, one flashlight, and copies of Shine a Light on Iceinvestigation sheets so that each child has a copy.
- For Stations 3 and 4, cover six flashlights with different color gels (two with red, two with blue, and two with green). Place one color of flashlight at each station, along with an additional flashlight, one pan of each color of ice, and copies of Color Coded Iceinvestigation sheets so that each child has a copy. Put a sign next to each block of ice, to label them "Ice #1", "Ice #2," "Ice #3".
- At each of Stations 5 and 6, place a container of ice and tonic water ice (or ice with paper), one flashlight, one UV light, and copies of Visible or Invisible?investigation sheets so that each child has a copy. Put a sign next to each block of ice, to label them "Ice A" and "Ice B".

Activity

1. Introduce the activity by asking the children to share what they know about light.

- Where does our light come from? Lamps, flashlights, the Sun.
- Do planets make their own light? No! Planets, moons, asteroids, and other objects in our solar system reflect light. They reflect the light from the Sun. We see these planets in the colors of light they reflect.
- Is there light we cannot see?

Share with the children that there are many different kinds of light. Some we can see. Some we cannot see; it is invisible to us. All of these different types of light or electromagnetic radiation make up the electromagnetic spectrum.

2. Divide the children into groups of two to three and provide each group with the Amazing Electromagnetic Spectrum cartoon.

- What does the image show? It shows different parts of the electromagnetic spectrum, or different types of light.
- Which can we see? We see the visible parts of the spectrum — red, orange, yellow, green, blue, and purple. Each of these colors that we see is a different type of light.
- What are some other types of light that we cannot see? X-rays, ultraviolet rays, microwaves, and others.
- Have they had any experience with any of these types of light? Have they ever had an x-ray of their bones? What type of light does the x-ray machine use? Do they use a radio to listen to music? What type of light does their radio "see"? Do they use microwaves to heat their food? Have they seen a blacklight before? What types of light does a blacklight emit? (ultraviolet and some visible).

3. Share with the children that scientists use different types of light that are reflected off distant planets and moons to study the ice on those planets and moons. Explain that they will be investigating three different ice stations using different types of light.

4. Invite the children to investigate the ice! Arrange the children to work in groups. Explain that Ice Investigation Station sheets are located at each station to assist them in their investigations. Review with the children what they will be doing at the stations; let them know that the room will be dark during their investigations.

- At Ice Investigation Stations 1 or 2 the children will first examine the ice with their eyes only and draw and record what they see. They will then examine the ice using a flashlight, shone at different angles and in different areas of the ice sheet, then draw and record what they observe with the flashlight. At these stations, the children will observe such characteristics as bubbles, fractures, internal features, and spikes in the ice, and a white or clear color. They will observe finer details, and different details at different angles, with the flashlight. The point is that different amounts and angles of light can reveal different features.
- At Ice Investigation Station 3 or 4 the children will observe the ice using different colored flashlights. At these stations, when the children look at the different colored ices using flashlights covered with colored films, the ice that is the same color as the flashlight will appear bright and those with

different colors will appear dark or even disappear. For example, red ice appears red because it is reflecting red light. When a blue light shines on red ice, the ice absorbs the blue light and there is no red light to reflect, so the ice appears dark. The point is that different colors or types (or wavelengths) of light can tell us about different types of ice.

- At Ice Investigation Station 5 or 6 the children will view and compare two pans of ice first with their eyes only.Next, they will shine an ultraviolet light — or "blacklight" —on both pans and record any differences they observe. At these stations, the children will not see much difference between the two pans of ice with their eyes, but will see that one pan "glows" with the blacklight. The point is that different types of light can reveal different information about ice's features and characteristics.

5. Instruct half of the teams to visit the even numbered stations and the other half of the teams to visit the odd numbered stations. Each team will visit three stations. Dim the lighting in the room and invite them to begin their explorations! Allow approximately 10 minutes for each station and let the teams know when it is time to rotate.

6. After all the children have had a chance to visit each station, invite them to share their discoveries. Prompt them with questions.

- Before they used the different lights or films, what did they observe about the ice with just their eyes?
- Was the ice the same everywhere — was it uniform? Or were there differences that their eyes could see?

The variations that occur in the icy surfaces of planets and moons — seen in visible or invisible light — are very important. They can hold clues to how the ice formed and what might be under the surface.

- What did they see that was different when they used the flashlights to illuminate the surface? Did different features "pop out?"

Remind the children that scientists are not shining big bright flashlights on the surfaces of planets. This would be very expensive (and also quite a challenge to the engineers!) Instead, scientists let the Sun's light help them. The Sun's light contains the visible colors that we see everyday, but also ultraviolet or infrared light. Scientists use special telescopes on Earth and instruments aboard spacecraft that are orbiting different planets and moons to study the different types of sunlight reflecting from the surface.

- Why might scientists want to study a planet when the Sun's rays are striking the surface at different angles? What did they see when they used the flashlights at different angles? Different angles of light caused different things to be revealed. When the light is shining directly on a surface, the surface can look flat. When the light is shining on a surface at an angle, you can see that the surface has lots of different features. These features cast shadows at low angles of light.
- What did the children observe about the different ices using the colored flashlights? What happened to the ices — did they look the same? Do the children think there was something different about the different ice pans? Some ice was bright under the red light and dark under the blue light, other ice was bright under the blue light but dark under the red light. Different colors of light made it easier to see the different types of ice.
- What did the children observe happening when they looked at the ultraviolet light reflected off the ice trays? Do the children think the ices were the same, or were they different? When the ultraviolet light shined on one of the ices, it appeared very bright revealing it had a different composition.

Ultraviolet light is invisible to the human eye, and yet some substances that we cannot see — or cannot see well — reflect ultraviolet light that can be detected by special telescopes and instruments aboard spacecraft.

- Why might scientists look at a planet's surface using different parts of the electromagnetic spectrum? Because some colors or features or materials show up more in one part of the spectrum than in another part. Every substance reflects the different parts of the electromagnetic spectrum in a unique way. Different types of ices reflect different amounts of visible and infrared light. Scientists can look at the amount of infrared, red, orange, yellow, green, blue, purple, ultraviolet light that a place on a planet's surface reflects, and they can use that information to help determine the composition of the material at that location.

Conclusion

Prompt the children to consider how scientists use light to study the surfaces of other planets and moons and how light can help them to determine if ice is present on the surfaces. Review with the children what they have learned.

- Materials of different compositions reflect different types of light, some visible and some — like ultraviolet and infrared light —invisible.

- Scientists use different types of reflected light to investigate the presence and properties of ice on planetary bodies in the solar system.

Ice Investigation Station #1 or #2

Shine a Light on Ice!

1. Examine the ice with the flashlight shining **straight down** at the ice. Draw and label a picture of what you see.

2. Now examine the ice, shining the light at **different angles** to the ice sheet. Draw and label a picture of what you see.

Observations with direct light

Observations with light at different angles

Ice Investigation Station #3 or #4
Color Coded Ice

1. Turn on a flashlight—what color is the light coming out of the flashlight? ________. Use your flashlight to examine the three blocks of ice on your table. Note the color and brightness of each block in the spaces below.

Brightness/Color of Block #1	Brightness/Color of Block #2	Brightness/Color of Block #3

2. Turn on another flashlight—what color is the light coming out of the flashlight? ________. Use this flashlight to examine the three blocks of ice and note the color and brightness of each block in the spaces below.

Brightness/Color of Block #1	Brightness/Color of Block #2	Brightness/Color of Block #3

3. Turn on the last flashlight—what color is the light coming out of the flashlight? ________. Use this flashlight to examine the three blocks of ice and note the color and brightness of each block in the spaces below.

Brightness/Color of Block #1	Brightness/Color of Block #2	Brightness/Color of Block #3

Why might scientists want to look at a planet's surface using different colors of light?

3. Ice Investigation Station – Visible or Invisible?

1. **Compare the two blocks of ice using *a regular flashlight*.** Circle the words you would use to describe each block. Are there differences in the ice blocks?

Block 1

bright shiny dull glowing bubbly bumpy

rough slushy brown yellow green

red sparkly clear milky smooth dark

Block 2

bright shiny dull glowing bubbly bumpy

rough slushy brown yellow green

red sparkly clear milky smooth dark

2. Now turn on the ultraviolet light - or "black light" and shine it on both blocks of ice.
Circle the words you would use to describe each block. Are there differences in the ice blocks?

Block 1

bright shiny dull glowing bubbly bumpy

rough slushy brown yellow green

red sparkly clear milky smooth dark

Block 2

bright shiny dull glowing bubbly bumpy

rough slushy brown yellow green

red sparkly clear milky smooth dark

Why might scientists want to look at a planet's surface using different types of light?

See the Light

This exploration of light and color in Earth's atmosphere combines a simple hands-on investigation using a prism, glue stick, and pen light with an (optional and free) video clip and online book. The optional video clip, *Our World: Sunsets and Atmospheres*, provides a kid-friendly explanation about how NASA uses sunrises and sunsets to measure the health of our atmosphere from aboard the International Space Station. The video clip can be viewed or downloaded for free at: https://goo.gl/2jsemq

Related storybook & observation sheets: https://goo.gl/DtWfms

Credit: Pixabay

Content Area:
- Earth Science
- Physics

Age Group:
- Family
- Early Elementary
- Upper Elementary

Time to Complete Activity:
40 minutes to 1 hour

Time Needed to Prep Activity:
5-10 minutes

Difficulty Level:
Easy

Mess Level:
Low

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- There's more to the universe than meets the human eye.

Build a Program with Related Resources

Explore the idea that human eyes aren't able to see everything with the activities Make a *UV Detector* and *Reflections on Ice*.

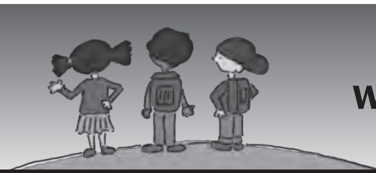
Combine this activity with the *Taking Earth's Temperature* activity from Kit A: Sun-Earth-Moon Connections. Both activities are part of the Global Learning and Observations to Benefit the Environment (GLOBE) Program, an international science and education program that provides youth in citizen science and hands-on learning.

Need more ideas? Browse activities in the "Earth Science" content area on the STEM Activity Clearinghouse (http://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), or mess level. Or, view featured collections of activities.

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:
See the Light was developed by the NASA Langley Research Center and is part of the NASA portfolio of educational resources available on NASAWavelength.org.



See the Light

Purpose

- To introduce students to properties of light.
- To demonstrate that white light is made up of seven colors that represent different wavelengths.
- To illustrate why the sky is blue during the day and red at sunset.

Overview

Students will use prisms and glue sticks to explore the properties of light. The activities demonstrate how white light is made up of a series of colors across the visible spectrum, and how these colors can be scattered. Students will observe how light exiting different mediums, such as prisms and glue sticks, changes the color of the light they see. Students will compare their observations in the classroom with their knowledge of sky color and rainbows in the natural environment.

Student Outcomes

Students will learn how light can be affected when it passes through a medium, and will directly observe that white light is made up of many colors across the visible spectrum. Students will learn that blue wavelengths are the shortest of the visible spectrum and red are longest. They will be able to construct an explanation of how rainbows form and why the sky color appears blue during the day and red or orange at sunset.

Time

- One 45 minute class period

Level

Primary (most appropriate for grades K-5)

Materials

Part 1:

- Optional video *Our World: Sunsets and Atmospheres* can be viewed online: http://science-edu.larc.nasa.gov/skycolor/video

Part 2:

Per Group

- 1 Copy *See the Light Student Activity Sheet 1*
- 1 Prism
- Colored pencils

Part 3:

Per Group

- 1 Copy *See the Light Student Activity Sheet 2*
- 1 Hot glue stick
- 1 Penlight
- White paper
- Colored pencils

Activity Updated July 13, 2015

Preparation

- Gather materials for the prism and glue stick activities. You'll need enough materials so that students can work together in small groups.
- *Optional:* Access the short video online and have it loaded on a shared screen, so the class can watch it together. The video is just under five minutes long. The first two minutes describes how light is made up of seven colors of different wavelengths.

Teacher's Notes

The light from the Sun is made up of all of the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet (the popular mnemonic "ROY G BIV"). When viewed together the color that we see is white, but when viewed through a prism the colors are separated out into the different colors of the visible spectrum. The prism slows down light and causes it to change directions, or bend. This property is called refraction. When white sunlight enters a prism, the various colors slow down to different speeds and are bent at different angles. This process spreads out white light into a rainbow.

A rainbow occurs in the sky as light passes through rain droplets, mist or water particles in the sky after a storm. The light is scattered through the water droplet in the same way it is separated when viewed through a prism.

Light will travel in a straight line unless something gets in its way to: reflect it (like a mirror), bend it (like a prism), or scatter it (like molecules of the gases in the atmosphere). Sunlight reaches Earth's atmosphere and is scattered in all directions by all the gases and particles in the air. Blue light is scattered in all directions by the tiny molecules of air in Earth's atmosphere. Blue is scattered more than other colors because it travels as shorter, smaller waves. This is why we see a blue sky most of the time. (Just as blue light is most readily scattered from white light in the glue sticks.) As the Sun gets lower in the sky, its light is passing through more of the atmosphere to reach you. Even more of the blue light is scattered, allowing the reds and yellows to pass straight through to your eyes. Just as the light traveling along the glue stick gets more red as the length of the glue stick path got longer, so the sunset is red when the atmospheric path through which the sunlight travels gets longer. Particles (aerosols) in our atmosphere can scatter certain wavelengths of light causing the sky color to look different.

Safety Considerations

- Make sure to warn students against shining the penlight in anyone's eyes.

What To Do and How To Do It

Part 1: Discuss Light

1. Ask students to describe the color of light.
2. Ask students how many light sources they can think of (for example: sun, star, flashlight, fireflies, light bulb)?
3. *Optional:* Show students the short video, *Our World: Sunsets and Atmospheres.*
4. Tell students that during this activity they are going to explore properties of light.

Part 2: Bending Light with Prisms

1. Before you pass out materials for the activity warn students about the danger of shining the penlight into their eyes or someone else's eyes.
2. Place the students in groups based on the number of materials you have. Tell students that they are going to use the prisms to bend light.
3. Give students at least five minutes to engage with the prisms and penlight.
4. Instruct the students to draw what they see, particularly the layers of color.

5. Have a class discussion about the following ideas:

- What happened to light as it passed through a prism?
- What colors did you see? In what order did the colors occur?
- Did everyone have the same order of colors?
- How did your observation resemble a rainbow like the ones that we see in the sky?
- Based on what you learned through this activity, describe how a rainbow is made.
- What colors were you surprised to see?

Part 3: Atmosphere as a Glue Stick

1. Pass out materials for the glue stick activity.
2. Have each group tape a sheet of white paper to the wall in the classroom.
3. Instruct the groups to point one end of the glue stick toward the white paper about 1 cm away, then shine the penlight through the opposite end of the glue stick.
4. Instruct the students to observe the colors at each end of the glue stick, and have each student draw what they see.
5. Have a class discussion about the following ideas:

- What colors did you see at each end of the glue stick?
- Which color in the visible spectrum (ROY G BIV) is the shortest wavelength?
- Which is the longest?
- How does the glue stick represent the atmosphere?
- Based on what you learned about different wavelengths of light, describe why the sky often looks blue during the day and red or orange at sunset?

Adaptations for Younger and Older Students

Depending on the age of the students these activities could also be done as a teacher demonstration. Older students can be asked to label the colors identifying the smallest and largest wavelengths.

Further Investigations

- **Electromagnetic Spectrum:** Visible light is a relatively small section of the electromagnetic spectrum. Have the students conduct research about the electromagnetic spectrum. Additional NASA resources include: *Why Wavelength Goes with a Color* http://science-edu.larc.nasa.gov/EDDOCS/Wavelengths_for_Colors.html and *Tour of Electromagnetic Spectrum* http://missionscience.nasa.gov/ems/.
- **Our World from Space:** In the video *Our World: Sunsets and Atmospheres,* students learned about an instrument onboard the International Space Station that measures ozone and aerosols. NASA's SAGE instruments have been collecting data on our planet since the 1970's. Have students learn more about the instrument online at: http://sage.nasa.gov/. Ask students why long term data records are important to understanding our atmosphere?

See the Light Student Activity Sheet 1

Name: ____________________

When I shine a penlight through a prism I see:

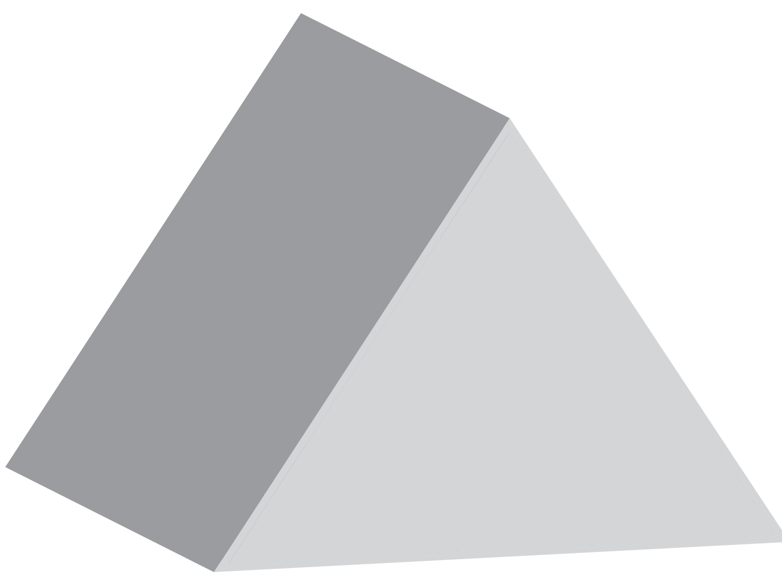
____

____

____

____

Draw your observation here:



See the Light Student Activity Sheet 2

Name: ____________________

When I shine a penlight through a glue stick I see:

____

____

____

____

Draw your observation here:

Art and the Cosmic Connection

This activity appeals to learners of all ages, including adults, and participants get to take their artwork home with them. View facilitation tips and art techniques from educator/artist, Monica Aiello, at goo.gl/kMNtgk and goo.gl/p51T2D

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- Models help us understand things we can't directly observe.

Build a Program with Related Resources

Explore additional aspects of NASA planetary science through the activities *Space Rock Sherlock* and *Investigating the Insides*. Or, use *Art and the Cosmic Connection* to explore NASA images of Earth. Encourage teens and adults to be citizen scientists using the GLOBE Observer app (https://observer.globe.gov/about/get-the-app).

Combine this activity with other activities from Kit A: Sun-Earth-Moon Connections that introduce learners to our Solar System, such as *Sorting Games: How Big? How Far? How Hot?* and *Jump to Jupiter*.

Or, combine this activity in learning stations with other hands-on activities relating to the Moon or Mars. Have the Green Screen and tablet available for participants to make *Moon Skits* or *Mars Skits* (How's the Weather? and Space Adventure Travel Corporation Commercials). Use the Kit A tips, Tour the Moon and Mars Using Google Earth, to explore digital imagery.

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.

Need more ideas? Browse activities in the "Astronomy and Space" and "Earth Science" content areas on the STEM Activity Clearinghouse (http://clearinghouse.starnetlibraries.org)

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!

Credit: Space Science Institute/NCIL

Content Area:
- Astronomy and Space
- Earth Science

Age Group:
- Family
- Early Elementary
- Upper Elementary
- Tweens
- Teens
- Adults

Time to Complete Activity:
1-2 hours

Time Needed to Prep Activity:
20-40 minutes

Difficulty Level:
Medium

Mess Level:
Medium

Originating Source:
Art and the Cosmic Connection was developed artists and educators Monica and Tyler Aiello in partnership with the Mid-continent Research for Education and Learning (McREL) and NASA Jet Propulsion Laboratory and is part of the NASA portfolio of educational resources available on NASAWavelength.org.

National Aeronautics and
Space Administration

ART & THE COSMIC CONNECTION

Elements of Art Inspire Planetary Image Analysis

Created by Monica & Tyler Aiello, Artists & Educators
for NASA's Discovery and New Frontiers Programs

Cool new images arrive from NASA missions to planets, asteroids, comets, moons. What do they tell us? Using the elements of art—shape, line, color, texture, value—make sense of what you see, honing observation skills and inspiring questions. Learners of all ages create a beautiful piece of art while learning to recognize the geology on planetary surfaces. We start with what we know here on Earth and use that awareness to help us interpret features on distant objects in the solar system. *Art & the Comic Connection* offers a terrific bridge between Earth and Space Science, as well as a wonderful dive into the potential of science to inspire art—and art to empower science!

PROGRAM OVERVIEW

For the past three decades, NASA has sent many space missions to the planets, moons and small bodies of our solar system. Spacecraft have acted as robotic explorers, capturing images of mysterious alien landscapes using a range of instruments: spectrometers, gamma ray neutron detectors, cameras. These pictures are studied using a variety of techniques including visual analysis, or "looking to understand." Similarly, visual artists depend on their sense of sight to guide their creativity. Both artists and scientists are keen observers of the natural world and engage in creative problem solving.

Artists utilize a system of concepts to make sense of visual information called the elements of art—line, shape, color, value, and texture. Planetary scientists utilize analogous concepts, and the elements of art can be a valuable tool in planetary image analysis. Fusing art and science education proves an exciting and effective method for inspiring students to explore both disciplines.

PROGRAM FEATURES:

Flexible, can be scaled for K-12 students and informal education settings of all kinds.

***Art & the Cosmic Connection* PowerPoint Presentation**

- Easy to follow presentation notes and science notes for expanded content

- Pastel Art Activity to engage students and reinforce concepts

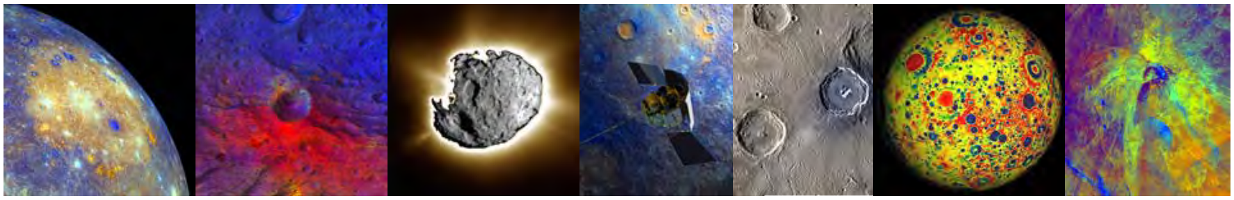
- Beautiful and inspiring NASA images you can print

- **NASA images correlate with current and recent missions to highlight space exploration**
- **Downloadable from the NASA Discovery Program website**

- Program can be a one day or two day activity

-Works with both science and art curricula, providing opportunities for cross-curricular collaboration

-Curriculum has proven success with both youth and adults via schools, universities and museums



Courtesy NASA/JPL

PRESENTATION + ART ACTIVITY

Art & the Cosmic Connection is a 2-part interdisciplinary program developed by artists and educators Monica & Tyler Aiello. Learn more about their work at http://www.studioaiello.net. Designed to engage students in space science education by becoming artist explorers, the project incorporates the use of the elements of art as a tool to investigate and interpret the mysterious surfaces of our celestial neighbors. Students learn to analyze images of planets and smaller bodies such as moons, comets and asteroids with basic art concepts which parallel scientific practice. The project includes a PowerPoint presentation and pastel art activity which teachers can incorporate into their classroom curriculum or out-of-school time program. The project is scalable for different grade levels and blends artistic concepts with the investigation of planetary studies and storytelling. Utilizing art-making as a vehicle for scientific inquiry both inspires and engages students—preparing them for a more rigorous exploration of space science and art theory, while gaining a broader perspective of their own planet, Earth.

MATERIALS & SUPPLIES

- **PowerPoint presentation**
- **NASA image prints**
- **Artist drawing paper**
- **Soft pastels or other drawing media**
- **Gummy erasers**
- **Hand wipes**
- **Q tips**
- **Fixative, either artists' or hair spray (prone to wrinkling the paper) (optional but very helpful)**

LEARNING OBJECTIVES

Space Science

- Explore the basic structure of the solar system
- Appreciate the diverse planets and small bodies within the solar system, including moons, dwarf planets, asteroids, comets, and Kuiper Belt Objects (KBOs are similar to main asteroid belt objects, beyond the orbit of Neptune)
- Introduce current and recent NASA space missions
- Appreciate the concept of remote sensing and how it is used in scientific research
- Apply the Elements of Art (shape, line, color, value, texture) to planetary image analysis and learn how they can be used to recognize geologic processes in Earth science
- Learn about basic geologic processes including impact cratering, volcanism, erosion, and tectonic activity
- Begin to interpret more complex geologic stories
- Create a beautiful piece of artwork inspired by planetary images!

BACKGROUND INFORMATION

CORE CURRICULM CONCEPT: Art Elements Correspond to Geological Features

The elements of art—shape, line, color, value, texture—offer an amazing way to make sense of the geology of planetary surfaces. The core curriculum connects the elements of art to planetary image analysis. This simple concept shows how basic art forms can be sign posts for specific geologic processes – art depicts geology. The Elements of Art can provide a road map for students to interpret planetary images. When there are exceptions to these rules, or if these rules have multiple interpretations, students can learn to use other factors to infer results, just like scientists. As these concepts build, students can combine these elements to understand more complex images, thus discovering geologic narratives and engaging in storytelling.

SLIDE/PRESENTATION RECOMMENDATIONS

GRADES 3-5
Break the presentation into several lessons.

Lesson 1 60 120 min
Introduction to the Solar System: Slides 1-13
- **Have student teams create a KWL chart, and then build one for the entire class.**
- **Explore books to help students develop understanding of celestial bodies**

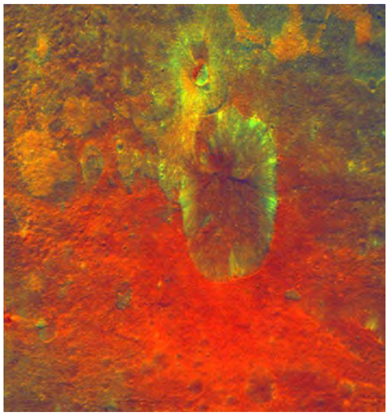
Lesson 2 60 120 min
- **Have each child choose a favorite image. Introduce the elements of art**
- **Choose 2-3 examples of each element of art from Slides 14-58 to illustrate concepts, hiding the rest.**

Pastel Art Activity
- **Suggest a focus on just shape, color, and line to start.**
- **Children are able to appreciate value and texture, too, but try it in context of kids' art creation to keep from overwhelming them with content/talk.**

GRADES 6-10
90-120 min
- **Encourage students to engage actively in the PowerPoint; noting features and writing down ideas are ways to keep participation lively.**
- **Use the PwPt notes to familiarize yourself with the content ahead of the presentation.**
- **Encourage interested students to use the many PwPt links to investigate further.**
- **It is also effective to have small discussions with students about art elements in their particular images in lieu of an extended presentation – the art making leads to rich scientific discourse!**

Elements of Art and their Geology Matches

- **Circle:** When circles are viewed on a planetary image, it often indicates an impact feature, a crater. The size, shape, ejecta blanket (stuff thrown away or ejected from the impact site, material from both the impactor and the area impacted) and number of craters give important clues as to the history of a planetary body. Sometimes circular features are volcanic or tectonic in origin, such as volcanic pancake domes found on Venus, for example.
- **Blobs:** Organic shapes, or blobs, can often be interpreted in two ways. Blobs frequently mean that one is viewing volcanic processes and lava flows. Blobby shapes can also indicate existing bodies of surface liquid (rivers and seas) or ancient bodies of liquid that left remnants of dried beds.
- **Straight Lines:** The presence of straight lines on a planetary body is often indicative of tectonic activity, including faults, ridges, cracks and mountains. On Earth tectonic activity is thought of as a land phenomenon; it can also be present in icy worlds.
- **Squiggly Lines:** The presence of squiggly lines on the surface often tells us forces of erosion are at work, including that of liquid and wind.
- **Color:** In addition to visible light, scientists image planetary bodies in many different frequencies of the electromagnetic spectrum (infrared, radio waves, X-ray, ultraviolet, etc.) They also create colorized images, adding and often exaggerating color differences to show subtle differences that the eye cannot detect otherwise, highlighting distinct aspects of a planet: topography, mineral composition, even gravity! Light and color are critical tools in interpreting and understanding planetary surfaces.
- **Value:** Value is the contrast of light and dark. Its scientific counterpart is called *albedo* - the measure of the reflectivity of a surface (think of snow vs. charcoal—which reflects more light?). Value/Albedo is a critical tool for understanding a planetary body.
- **Texture:** Implied texture is the tactile quality of a two-dimensional surface which we can see with our eyes, yet not touch. Images of planetary bodies are replete with various textures corresponding to eons of geologic history. Geologic processes build over time to create complex textures which can be deciphered with the aid of the other art elements.



TEACHING PART 1: Art & the Cosmic Connection PowerPoint Presentation

The presentation uses many beautiful NASA planetary images to illustrate concepts. It is flexible and scalable for various ages, experience levels, and time requirements. To prepare, teachers are encouraged to review the PowerPoint and make appropriate revisions for their particular students (see sidebar page 3), depending on the curriculum you would like to cover. The PowerPoint includes extensive ***Presentation Notes*** to guide teachers through the curriculum. The notes serve as a basic script and also include question prompts to encourage class discussion. There is also a ***Science Notes*** section with links to NASA web resources for educators who wish to expand their lesson plans.

Courtesy McREL

Show the PowerPoint

After reviewing the PowerPoint and the *Presentation Notes*, show the PowerPoint presentation to your students. The PowerPoint has an introduction to the solar system, an overview of remote sensing and space exploration, and the core concept that describes planetary image analysis using the elements of art.

Getting Started: What Do You Know About the Solar System?

Begin by making a KWL (Know, Wonder, Learn) table on the board or chart paper. Take notes (or invite students to) on the chart paper as students answer the following about the solar system:

- What do we ***know***?
- What do we ***wonder*** about?
- What have we ***learned***?

This forms a baseline of classroom knowledge, helps you be aware of your students' prior knowledge, and promotes inquiry. The KWL can be done in pairs or small groups initially to engage participants actively.

- ➢ If a student states something others are uncertain about, or you believe is inaccurate, post it in the Wonder section to return to for verification later.

> Avoid major discussion of the structure of the solar system (including the inner terrestrial planets, outer gas giants, and small bodies including moons, asteroids, comets, dwarf planets, and Kuiper Belt Objects [or KBOs]) until after the main presentation. Images there will help support your discussion.
>
> - Make special note that our activity focuses on worlds with visible geology. Thus, the presentation does not focus on the gas giants themselves, but does appreciate their marvelous moons!

Introduction: Science Inspires Art

The beginning of the presentation briefly introduces students to the painting and sculpture of project authors, Monica and Tyler Aiello. The husband and wife artist team collaborate with NASA and the scientific community in the development of their artwork and educational programs. Students are intrigued to view professional artists inspired by science, and are encouraged to become "artist explorers."

Remote Sensing & Space Exploration

A brief discussion of remote sensing incorporated in the PowerPoint explains how NASA sends robotic explorers to planetary bodies and takes pictures of their surfaces. The images used are shown from the aerial or "birds-eye" view. The planetary images provided correlate to recent and current NASA missions to provide an opportunity to build student interest and excitement in space exploration. The beautiful and often unfamiliar images keep students engaged with the content.

Elements of Art & Planetary Image Analysis

The core concept section relates how the Elements of Arts can be used to interpret planetary images. It is useful to have students define (or for the educator to review) the definitions of the Elements of Art. The remainder of the presentation includes sections for each of the Elements of Art and illustrates the how these relate to specific geological processes using examples of gorgeous NASA images.

- Circle – Crater
- Blobs – Volcanoes or Lakes
- Straight Lines – Tectonic Activity
- Squiggly Lines – Erosion
- Color, Value, Texture – Critical Scientific Tools

TEACHING PART 2: Art Activity

The *Pastel Art Activity* is designed to be a simple, yet fun and engaging way for students to explore the concepts they've learned from the PowerPoint presentation. Students enjoy making art in science class or exploring science in art class, depending upon how the project is taught. This reinforces the connections between the arts and the sciences and engages the students in an interdisciplinary learning environment. The art project can be taught during the same session as the presentation or in subsequent sessions.

Time Recommendations

Grades K-5: two or three 45-minute periods
Grades 6-12: one or two 45-60 minute periods

Supplies

- **Drawing paper –** A larger-sized, fine artist drawing paper is recommended, budgets allowing (22"x28" is great, at least 9"x12"). Students enjoy working with fine art materials and tend to take their projects more seriously. The drawing paper should be appropriate for the drawing media.
- **Drawing media –** Soft pastels are recommended for their ease of use and blend-ability. However, they should not be ingested. Water colors, crayons, markers and pencils are more appropriate for K-2 students.
- **NASA Planetary Prints –** Download from the NASA Discovery Program website, http://discovery.nasa.gov. The prints inspire the students' artworks.
    - Images are both in black and white and in color. Slipping them into sheet protectors is essential for future use; laminating them is more costly but more durable.
- **Gummy erasers –** Can be used effectively with soft pastels to lift pigment and create highlights
- **Q-tips –** Are a great blending tool
- **Cleaning or Hand Wipes –** Pastels are messy but easy to clean up, especially with cleaning wipes
- **Fixative (optional)** - A pastel spray fix can be used; however, it is toxic and should only be used by a teacher or with older or experienced students, and by all in a ventilated area. For other students, aerosol hairspray can be used. A light coating will help fix the pastel pigment to the drawing paper.
    - Drawings can also be spray-fixed between layers if they get too heavily loaded with pigment or muddy so that students may work on top of the drawing. This process should be completed or supervised by the educator. A fixative is not necessary.

Implementing the Art Activity

- Have all students select a NASA planetary image to work from; pass out paper.
- Ask students to make pastel drawings inspired by their image.
- Discuss or share images prior to the project, if desired.
- Ask students to pay special attention to the Elements of Art and how they relate to interpreting the geologic history of their image. They may choose to focus on one or two images.
- Explain that students do not have to make their artwork exactly like their image. They are making "art" and should feel free to interpret their image by altering their composition, cropping, color, orientation, etc. This is effectively done using question prompts, such as, *"Do you have to make your artwork black and white like your image? No, feel free to explore color!"* or, *"Focus on the details that intrigue you."*
- Encourage artists to explain their interpretation. For example, a student may have noticed especially bright areas and picked them out in a certain color.

TIP: Distribute drawing supplies AFTER you explain the assignment above so that students do not work ahead or get distracted. ☺

Artists and activity authors at work, Monica & Tyler Aiello

Wrap Up and Formative Assessment

- At the conclusion of the art activity, display artwork and discuss the project. Here are two possible approaches.
    - a) Conduct a **gallery walk**, where student art is hung up, with its inspiring image beside it, and students spend time viewing all. Ask all present, kids and adults, to offer observations about what strikes them about the drawing on sticky notes to leave for the artist.
        - Examples: "Really nice example of texture!" "What is your interpretation of that feature?" "Your blending really made those colors pop out!"
    - b) Break students into small groups (mix up the class so kids see others' work). Ask students to do a **think-pair-share**, where they write about their experience for a couple of minutes on a sticky note, share their ideas with a partner, and then with a small group.
        - Reflect on the selected planetary image: interpret the geology of their image, and discuss how they used that image to inspire their artwork.
- Ask students to share something new they have learned from the activity with the entire group.
- Conclude by returning to the KWL chart to record:
    - ➢ What have we ***learned***?
    - ➢ What do we ***wonder*** – what **new** questions do we have?
- Clean up studio or classroom.

Storytelling & Geologic History

- Interspersed within the Elements of Art sections are images with multiple art elements/geologic features. These examples provide students with the opportunity to combine what they have learned to decipher more complex geologic history *(i.e., circles and blobs might be interpreted as craters and volcanoes)*.

NATIONAL EDUCATION STANDARDS
ART & THE COSMIC CONNECTION
Elements of Art Inspire Planetary Image Analysis

SCIENCE
Source:
http://www.nap.edu/openbook.php?record_id=4962

K-4
Earth and Space Science
- Objects in the Sky
- Changes in the Earth and Sky

History and Nature of Science
- Science as Human Endeavor

5-8
Unifying Concepts and Processes
- Evidence, models and explanation
- Form and Function

Earth and Space Science
- Structure of the Earth System
- Earth in the Solar System

ART
Visual Arts

K-4 **Source:** http://artsedge.kennedy-center.org/teach/standards/standards_k4.cfm
- Content Standard #1: Understanding and applying media, techniques, and processes
- Content Standard #2: Using knowledge of structures and functions
- Content Standard #5: Reflecting upon and assessing the characteristics and merits of their work and the work of others
- Content Standard #6: Making connections between visual arts and other disciplines

5-8 **Source:** http://artsedge.kennedy-center.org/teach/standards/standards_58.cfm#04
- Content Standard #1: Understanding and applying media, techniques, and processes
- Content Standard #3: Choosing and evaluating a range of subject matter, symbols, and ideas
- Content Standard #5: Reflecting upon and assessing the characteristics and merits of their work and the work of others
- Content Standard #6: Making connections between visual arts and other disciplines

Section 3:

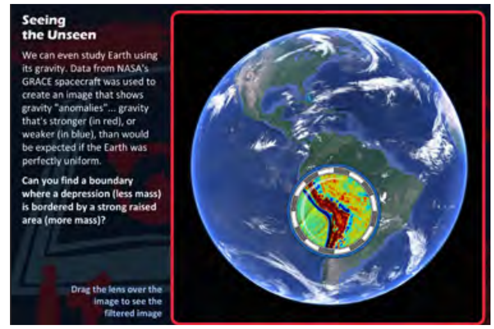
Quick Facilitation Guides

Quick Facilitation Guide

Seeing the Unseen App

This app lets you explore how scientists use instruments to see things that aren't visible to the human eye. Users are asked to find a feature in an image by using a special "lens" that lets them see in a different way (infrared, ultraviolet, gravity maps, etc.)

The app is available on the *NASA@ My Library* tablet. If it doesn't appear, ask for it to be pushed out to your tablet again.



Credit: Space Science Institute/NCIL

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

Materials List – Tablet loaded with Seeing The Unseen app

Activity Time – 5-10 minutes

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

Key Concepts

- There's more to the universe than meets the eye
  - Light comes in many different forms (e.g. radio, infrared, visible, ultraviolet, and X-ray). Most can only be viewed with special instruments
  - NASA missions observe various types of light (e.g., Kepler, James Webb Space Telescope, Hubble, Galex, Solar Dynamics Observatory)
  - NASA missions also measure other things which aren't light, but still tell us about how the Universe behaves (e.g., magnetism, gravity, charged particles).
  - The 5 human senses provide us with only a very limited view of our Universe
- These observational techniques help us in practical ways on Earth too

Walkthrough and Features

Each screen includes a picture, some introductory text, and a task. Find an object by dragging the "lens" around the image. The "lens" provides a window into a different view: this could be infrared, ultraviolet, or some type of data (such as gravity measurements). When the lens is over the object in question, the user can tap the button to confirm. The app will then give you a bit more information, then let you move on to the next image.

Connecting to Other Kit Materials

See *Investigating the Insides* and *Make a UV Detector.*

Connecting to Other *STAR Net* Activities

Please visit the *STEM Activity Clearinghouse* (www.clearinghouse.starnetlibraries.org) and view the "Expanding Your Senses" collection for more in-depth activities around seeing the unseen! We especially recommend the *Afterschool Universe Session 4* activities if you have a really curious group!

Magnet Table App

This app is a virtual "magnet table". You can see the magnetic field lines from different kinds of objects, and explore how charged particles interact with magnetic fields.

The app is available on the *NASA@ My Library* tablet. If it doesn't appear, ask for it to be pushed out to your tablet again.

Credit: Space Science Institute/NCIL

Key Concepts

Magnetism is all around us (see *Magnetism 101* for more info)

- Planets can be magnets; similar to household magnets
- Magnets generate fields that extend into space and can affect the motion of other objects

Ages – Families, Elementary-aged children, Tweens, Teens. (Note: schools typically cover magnetism in 2nd or 3rd grade, so students in these grades or higher will have an easier time, and are usually familiar with the vocabulary)

Materials List – Tablet running the Magnet Table app

Activity Time – 5-10 minutes

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

Walkthrough and Features

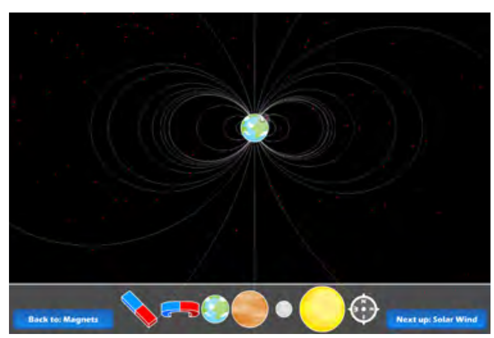
Screen 1: Magnets

On this screen you can drag various objects on to the center screen and see the field lines they produce. Things to note:

• The bar magnet has the standard "dipole" field generally shown in books (see Magnetism 101). Earth and Jupiter both have magnetic fields very similar to a dipole magnet. But that's not true of all planets: Some have no fields at all. And the Sun has a very complicated field.

• Note how fields combine: they don't overlay each other, instead they connect or repel, depending on the direction of the field lines (in other words, whether north or south poles are facing each other.

• There is a compass which can be dragged onto the screen that will show you the direction of the field lines.



Screen 1: Magents

Walkthrough and Features (continued)

Screen 2: Plasmas

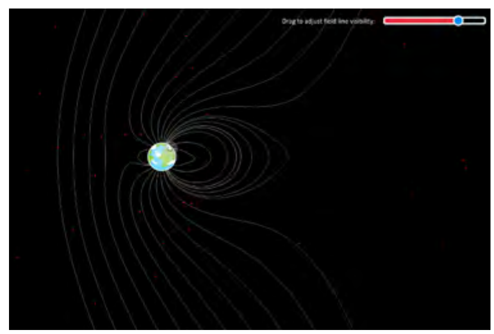
This screen is similar to the previous one, in that you can drag magnets onto it. But in addition, you can launch protons (a positively charged atomic particle) by dragging your finger across the screen.

Screen 2: Plasmas

- Start by just dragging your finger to launch protons. Note that they move in a straight line.
- Now put a magnet on the screen and launch a new proton. Electrically charged particles like this "stick" to field lines: either sliding along the lines or orbiting around them, like beads on a string. We don't normally notice this, because the atoms around us are electrically neutral (they have just enough electrons and protons to add up to zero charge). But space is full of electrons and protons moving around independently, which means they're guided by magnetic fields.
- Put the Earth model on the screen and launch some protons, trying to send them to "Earth". Note that the most likely place for them to end up is around the north and south poles, where the magnetic field lines enter the planet. That's why there are aurora near the poles: charged particles are guided toward the poles where they excite atmospheric atoms that emit various light.

Screen 3: The Solar Wind

This screen has just an Earth model on it (which you can move around), and a stream of protons. These (along with electrons) come from the Sun, which produce a constant stream of charged particles called the "solar wind". Watch how most are deflected by Earth's magnetic field. Some will move downstream and then reverse direction, moving back toward Earth until they get "stuck". These particles are trapped in Earth's magnetotail.



Screen 3: The Solar Wind

Connecting to Other Kit Materials

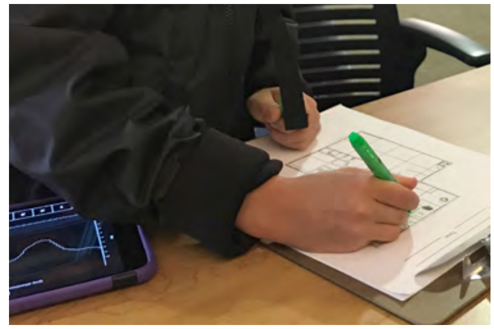
- This device works well in a station activity with other kit items or as a stand-alone exploration activity. Check out the *Magnetism Stations Facilitation Guide* to get started.
- Other activities to consider using with this one include *Neato Magneto Planet Quick Facilitation Guide*, *Space Rock Sherlock Facilitation Guide*, *Magnetic Science Kit Quick Facilitation Guide*, and the magnetometer app on the tablet.

Connecting to Other *STAR Net* Activities

Please visit the *STEM Activity Clearinghouse* (www.clearinghouse.starnetlibraries.org) and search "Magnet" for more in-depth activities around magnetism! We especially recommend the squishy circuits activity to increase the fun (and mess!) level.

Light Mapping

This activity uses the tablet's light sensor. Visitors can use it to map out an area of the library, then visualize that data.



Credit: Space Science Institute/NCIL

Key Concepts

- NASA scientists use tools to observe everything from Earth to the farthest reaches of the Universe.
- There's more to the Universe than meets the human eye

Ages – Families, middle school-aged children, Tweens, Teens.

Materials List – Tablet loaded with Light Sensor; floorplan of all or part of the library; colored pencils or crayons.

Activity Time – 20-30 minutes

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

Walkthrough and Features

- This activity can be done by a single patron, but teams of two allow one person to hold the tablet, and the other to record data.
- Provide the team with the tablet (running the "Light" app), a printed floorplan (sample provided), and a pen/pencil. Their goal is to create a "brightness map" of the area. They need to move methodically around the library, then note the brightness value on the tablet (from 0-10), and record that on the floorplan. Older children could use a grid pattern, with a goal of determining the best places to put plants in the library. Younger ones may be more interested in simply finding the brightest light sources.
- Remind the children to be careful not to cover the tablet's sensor with a finger (or their own shadow), and to orient the tablet in a consistent way as they move around the library (for instance, holding it flat and level to the floor). The sensor is located on the front of the tablet, at the top, just to the right of the word "Samsung" (try to confirm this by putting your finger over it while the Light app is running).
- Once they've covered the whole area, have them come back and color in the map, assigning a different color to each brightness level.
- This is the same type of process NASA uses to display many kinds of data. For instance, CO2 levels might be measured from orbit across the whole Earth, then an image made that uses different colors to represent different concentrations of CO2. The Space Science Institute also uses color maps of astronomical objects like nebula in various wavelengths. See 2 examples on the next page.

Connecting to Other Kit Materials

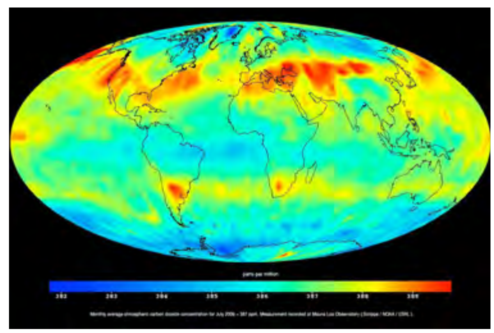
- This activity works well with other tool based activities (activities where patrons use tools to think like a scientist). These include *Investigating the Insides*, *Recipe for a Comet*, *Space Rock Sherlock* and others. They can also use different kit tools in combination with this activity. Does a spike in light intensity correlate with a warmer spot on the thermal camera? Or the infrared thermometer (from Kit A)?

Connecting to Other *STAR Net* Activities

- Check out the *Expanding Your Senses* collection on the *STEM Activity Clearinghouse* (www.clearinghouse.starnetlibraries.org)

Global CO2 Concentrations (PIA11194)

This image was created with data acquired by the Atmospheric Infrared Sounder, AIRS, during July 2008. The image shows large scale patterns of carbon dioxide concentrations that are transported around the Earth by the general circulation of the atmosphere.



Credit: NASA

A Giant Hubble Mosaic of the Crab Nebula

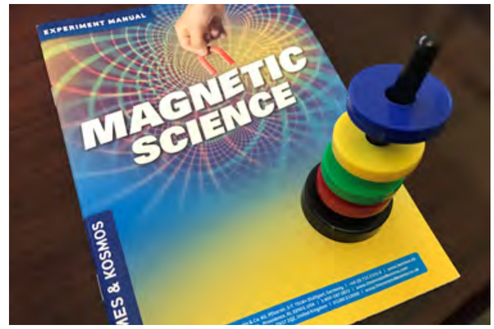
The orange filaments are the tattered remains of the star and consist mostly of hydrogen. The rapidly spinning neutron star embedded in the center of the nebula is the dynamo powering the nebula's eerie interior bluish glow. The blue light comes from electrons whirling at nearly the speed of light around magnetic field lines from the neutron star. The neutron star, like a lighthouse, ejects twin beams of radiation that appear to pulse 30 times a second due to the neutron star's rotation. A neutron star is the crushed ultra-dense core of the exploded star.

Credit: NASA/ESA/ASU/Hester

Sample Floorplan

Magnetic Science Kit

This *NASA@ My library* facilitation guide provides tips on using the *Magnetic Science Kit*, and provides suggestions for engaging activities. The suggested activities below are based on testing conducted at other public libraries. Please feel free to explore, and try other activities in the kit, based on the interest level of your patrons!



Credit: Space Science Institute/NCIL

Key Concepts

Magnetism is all around us (see *Magnetism 101* for more info)

- A magnet is an object that produces a magnetic field that is invisible, but we can feel its force when other magnets are placed close to it. Magnets and magnetism are very important in our everyday life. Examples include compasses, motors, and high-speed transportation systems.
- A magnet has a north and south pole that attracts and repels another magnet depending on the north/south orientation of each magnet.
- The magnetic force is much stronger than gravity.
- Electrically charged particles interact strongly with magnetic fields.

Ages – Families, Elementary-aged children, Tweens, Teens. (Note: schools typically cover magnetism in 2nd or 3rd grade, so students in these grades or higher will have an easier time, and are usually familiar with the vocabulary)

Materials List – Magnetic Science Kit, Magnetic Globe and unclamped staples (you will need to clamp them)

Activity Time – 5-30 minutes

Directions and Suggested Activities from Kit

- If you have a younger audience, or you are unsure about the comfort level of your group with concepts about magnets, consider doing a free-form exploration before encouraging more complicated activities. Take all of the non-magnet items out of the box and place on the table (you can add other objects too!) Have patrons use the bar magnet to determine which items respond to a magnet (you can let them know that they respond because they contain iron). Have them do the same test with the ball magnets, the horseshoe magnet, and the bar magnet.

- Once you do the above activity, have participants take turns choosing magnets and placing them at a distance from one another, then slowly move them closer until they interact. Do they come straight together? Do they flip or move to come together? That's because most magnets (like Earth!) have a north and south pole. Two similar poles will repel, and opposites will attract!

Directions and Suggested Activities from Kit

- For older groups, or once participants are comfortable with the above experiments, we recommend the following activities from the kit's instruction book (in testing, we framed them as "I need you to help me do this magic trick, can you….."
  - From Page 8 "Iron turns into a magnet": Lay out the block magnet, plastic chips and the iron rod, and ask participants to use the iron rod to pick up the plastic chips. They should deduce that if they attach the iron rod to the block magnet, it becomes magnetic and will pick up the chips.
  - From page 15 "Hovering Magnets". Lay out the ring magnets and the ring magnet stand. Ask participants to place all the rings on the stand not touching one another (floating).
  - From page 27 "Hidden Forces Made Visible". Lay out the bar magnet, block magnet, ball magnet, ring magnet, horseshoe magnet, and box with iron powder. Ask participants to create different patterns in the iron powder using the magnets. They can create a circle, an oval, or barbells of different sizes with the provided magnets.
  - Use the "Magnetic Globe" to see how these forces work on a model of Earth. Spread the clamped staples out (you will need to staple them before the activity so they are not sharp) and have patrons roll the globe over the staples. Magnetic field lines will start to form on the ball (patrons may need to adjust or un-bunch the staples).

Guiding Questions

- Ask participants what they use magnets for in daily life. What would their life be like without magnets?
- Ask participants what they already know about magnets. If they're not providing answers, lead them with words like "poles", "polarity", "north" and "south" to elicit a response. These responses will help you determine how much guidance is needed for the activities!
- Ask patrons if they are familiar with the Northern lights. Tell them to keep this phenomena in mind as they explore, as it's caused by magnetism!

Advanced Instructions

- Consider using this kit in conjunction with the *Magentic Table App* on the tablet to really dig into the concept of Earth as a giant magnet, and to see an interactive representation of Earth's magnetic field and how charged particles will interact with it.

Connecting to Other Kit Materials

- This kit works well in a station activity with other kit items or as a stand-alone exploration activity. Check out the *Magnetism Stations Facilitation Guide* to get started.
- Other activities to consider using with this kit include *Space Rock Sherlock Facilitation Guide*, and the magnetometer and *Magnetic Table App* on the tablet!

Connecting to Other *STAR Net* Activities

Please visit the *STEM Activity Clearinghouse* (www.clearinghouse.starnetlibraries.org) and search "Magnet" for additional activities around magnetism! We especially recommend the squishy circuits activity to increase the fun (and mess!) level.

Magnet Madness

This *NASA@ My library* facilitation guide provides tips on using the magnetism- based pieces in the kit in a free exploration station format. The suggested activities below are based on testing conducted at other public libraries. Feel free to explore, and add other activities from the kit (or even that you've tried before), based on the interest level of your patrons!

Credit: Space Science Institute/NCIL

Key Concepts

Magnetism is all around us (see *Magnetism 101* for more info)

- A magnet is an object that produces a magnetic field that is invisible, but we can feel its force when other magnets are placed close to it. Magnets and magnetism are very important in our everyday life. Examples include compasses, motors, and high-speed transportation systems.
- A magnet has a north and south pole that attracts and repels another magnet depending on the north/south orientation of each magnet.
- The magnetic force is much stronger than gravity.
- Electrically charged particles interact strongly with magnetic fields.

Ages – Families, Elementary-aged children, Tweens, Teens. (Note: schools typically cover magnetism in 2nd or 3rd grade, so students in these grades or higher will have an easier time, and are usually familiar with the vocabulary)

Materials List – Magnetic Science Kit, Magnetic Globe, Meteorite or Meteor-Wrong box, Magnetism 101 handout

Activity Time – 30+ minutes

Directions and Suggested Activities for Stations

- If you have a younger audience, or you are unsure about the comfort level of your group with concepts around magnets, consider doing a free-form exploration of the components with the group before beginning your stations. This will let you know if you may need to group participants in a certain way, or if everyone has the basic concepts down already.

- We recommend setting up 4 to 8 stations
  - A free exploration station where participants play with various types of magnets. These can be from the *Magnetic Science Kit* or your own collection. Just make sure you have enough magnets, depending on how many stations you'll be setting up!

Directions and Suggested Activities for Stations

- From Page 8 of the *Magnetic Science Kit: Iron turns into a Magnet*. Lay out the block magnet, plastic chips and the iron rod, and ask participants to use the iron rod to pick up the plastic chips. They should deduce that if they attach the iron rod to the block magnet, it becomes magnetic and will pick up the chips.
- From page 15 of the *Magnetic Science Kit: Hovering Magnets*. Lay out the ring magnets and the ring magnet stand. Ask participants to place all the rings on the stand not touching one another (floating).
- From page 27 of the *Magnetic Science Kit: Hidden Forces Made Visible*. Lay out the bar magnet, block magnet, ball magnet, ring magnet, horseshoe magnet, and box with iron powder. Ask participants to create different patterns in the iron powder using the magnets. They can create a circle, an oval, or barbells of different sizes with the provided magnets.
- Use the *Magnetic Globe* to see how these forces work on a global level! Spread the clamped staples out and have patrons roll the globe over the staples. Magnetic field lines will start to form on the ball (patrons may need to adjust or un-bunch the staples).
- Use the *Meteorite or Meteor-Wrong* box to discover the magnetic properties of meteorites. Letting participants see the "right answer" from the sheet in the kit will allow them to explore the differences between magnetic rocks from Earth, and those from space. You may consider having them use the magnetometer at this station (see the *Tablet Quick Facilitation Guide* for instructions).
- If the tablet isn't being used for the meteorite station, have the last station use the *Magnet Table* app on the tablet. This app provides a great interactive exploration of how magnets behave, and how they impact our daily lives.

Guiding Questions

- Before starting, ask participants what they already know about magnets. Ask them where they or their family use magnets in their daily life (like on their refrigerator door, pacemakers, or in motors).

- If they're old enough to have learned about magnets in school already, lead them with words like "poles", "polarity", "north" and "south" to elicit a response. These responses will help you determine how much guidance is needed for the activities! And don't worry if you don't know much about magnets yourself, check out the *Magnetism 101* handout provided in the kit to jog your own memory!

- Ask patrons if they think that magnetism exist in outer space? If so, where? Are they familiar with the Northern lights. Tell them to keep this phenomena in mind as they explore, as it's caused by magnetism and electrically charged atomic particles! Also refer to *Magnetism 101*.

Connecting to Other Kit Materials

- *Space Rock Sherlock* is a great follow up activity for patrons who were excited to use the *Meteorite or Meteor-Wrong* activity but didn't get a chance to explore as much as they wanted.

- *Investigating the Insides* focuses on observations scientists make from afar, and provides further discussion of magnetism.

Connecting to Other *STAR Net* Activities

Please visit the *STEM Activity Clearinghouse* (www.clearinghouse.starnetlibraries.org) and search "Magnet" for more in-depth activities around magnetism! We especially recommend the squishy circuits activity to increase the fun (and mess!) level.

Space Rock and Earth Rock Kit

The Space Rock and Earth Rock kit contains a mix of rocks formed on Earth and rocks formed in space. The kit also contains a magnet and a hand lens that can be used to make scientific observations about the rocks. This kit is best used in conjunction with the "Space Rock Sherlock" activity, but can also be used by itself for a quick, hands-on facilitation.

Credit: Space Science Institute/NCIL

Key Concepts

Space Rocks are clues to our origins

- Space Rocks provide us with information about the history and formation of our solar system
- Space Rocks can tell us about places humans haven't been yet (like Mars or the outer solar system)

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

Materials List – Space Rock and Earth Rock kit, which contains: magnified hand lens, small magnet, Earth rocks (pumice, river rock, idochinite, pyrite, lodestone, anorthosite), Space rocks (Campo del Cielo, NWA 869, NWA 869 slice, Zag)

Activity Time – 5-20 minutes

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

Usage and Features

- Each sample has unique physical properties that can be observed by patrons using their sense of touch and sight.
- The first step should involve patrons making observations with their naked eye and hands. When you hand them a mystery rock, ask "What's the first thing you notice?" There are no right or wrong answers to this question. It is meant to get patrons in the "observational" mindset.
- After patrons make their initial observations, ask them which rocks they think formed on Earth and which rocky formed in space. What is it about the rocks that makes them think that? (Possible answers include the sample's color, weight, or shape.)
- After patrons make observations with their sense of sight and touch, introduce the magnet. Place the magnet on a smooth surface and move the rock slowly towards it. Is the magnet drawn towards the rock? Most space rocks are attracted to a magnet, while only a small number of Earth rocks are attracted to a magnet.

Usage and Features (continued)

- The magnet is strong and small. **Please use caution when using the magnet with younger patrons.**
- Don't rub the magnet on the mystery rocks. This could change the mystery rock's magnetic properties!
- The hand lens allows patrons to get a magnified view of the mystery rocks. Patrons should hold the hand lens to their eye while moving the rock into focus. Good lighting is necessary.
- Don't be afraid to say, "I don't know!" It's one of the most commonly used phrases in science! Be honest if you don't know their answer. Brainstorm with patrons on ways that you could figure out the answer.

Connecting to Other Kit Materials

The Space Rock and Earth Rock kit is best used with the *Space Rock Sherlock* activity.

Connecting to Other *STAR Net* Activities

Check out the Expanding Your Senses collection on the *STEM Activity Clearinghouse* (www.clearinghouse.starnetlibraries.org) to find more uses for this cool science tool!

Section 4:

Science Books

1) Secrets of Our Earth (Carron Brown) –A Shine-A-Light Book

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

Reading and facilitating the use of this book provides a fun way to learn about many natural changes that take place on Earth. "Discover a world of amazing surprises" by shining the included flashlight behind the page in order to answer the questions posed in the book about our home planet.

Consider using this resource with the "Investigating the Insides" activity in Section 2.

2) Ludwig the Space Dog (Henning Lohlein)

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

Come and fly through space with Ludwig in this extraordinarily designed 3-D book and see how he learns about flying by reading books. Because Ludwig has read so much about flying, he is ready when a special situation presents itself…spaceflight! 3-D paper space goggles are provided, but the book is very readable without them too. A great way to talk to a younger audience about using tools to see things "in a different light!"

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

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

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