## 11. Earth in Space

While we usually keep our eyes on the ground when rockhounding, geology isn't only underfoot. The earth is like a little blue marble floating among other marbles and big gassy balls, accompanied by metallic BBs and splinters of ice in the form of meteors and comets. On a clear night, look to the sky, and you'll occasionally see streaks left by meteors burning up in our atmosphere. Sometimes, though, they make it to the earth's surface, where we can collect them and hold a piece of space in our hands. This unit will teach you about such visitors from space.

Activity 11.1: Modeling the solar system.
Check out a book or explore websites to learn about the earth and its fellow planets. Then use materials like marbles, balls, and similar round items to make a model of our solar system. You can also make paper or cardstock cut-and-fold models of the Earth and other planets. Or draw a colorful poster of our solar system on long paper or a big sheet of poster board.

Activity 11.2: Learning about visitors from space.
In addition to planets, our solar system is filled with "cosmic debris" in the form of meteors, an asteroid belt between Mars and Jupiter, and the Oort cloud of comets. Read about our solar system and learn the definitions of a.) meteorite, b.) tektite, c.) asteroid, and d.) comet. If someone in your club has a collection of meteorites or tektites, invite them to show-and-tell so that you can hold a space rock in your hand.

Activity 11.3: Effects of meteorites and famous craters.
Most meteors are tiny and burn up in our atmosphere, creating bright streaks in the night sky that we often call "shooting stars." But some bigger meteors make it to the earth's surface. If they're big enough, they can create craters and shoot out glassy fragments called tektites when they melt rock from our earth's crust on impact. Make a crater by dropping or tossing marbles or ball bearings into flour, wet sand, or mud. Find pictures of meteor craters in a book or on a web site. Then pick one crater and learn everything you can about it and write a report on it for your club newsletter.

Activity 11.4: Collecting meteorites and tektites.
If you happen to be lucky enough to live near a known "strewn field" where a meteor exploded and left fragments over a wide area and you have club members with metal detectors, organize a field trip to search for a meteorite. However, meteorites are very rare and hard to identify in the field. So if you want to add a meteorite or tektite to your rock collection, your best bet will be to purchase one at a rock shop, gem show, museum gift shop, or through a meteorite dealer on the web.

Activity 11.5: Collecting meteorite dust.
While large meteorites are rare and hard to find, a constant "rain" of meteorite dust falls through our atmosphere. By some estimates, 30,000 to 90,000 tons of such dust falls every year! Work with your youth leader to develop a way to collect such dust to examine under a hand lens or a microscope.

Activity 11.6: More fun measuring impact cratering.

Activity 11.6 is an extension of 11.3, where you were able to learn the effects of meteorites via impact craters. This new activity provides a more detailed exercise by which you can see and measure the effects of multiple impacts and how they might be used to date the surfaces of planets and moons.

**11. Earth in Space**

□ 11.1 Modeling the solar system

□ 11.2 Learning about visitors from space

□ 11.3 Effects of meteorites and famous craters

□ 11.4 Collecting meteorites and tektites

□ 11.5 Collecting meteorite dust

□ 11.6 More fun measuring impact cratering.

To earn your Earth in Space badge, you need to complete at least 3 of the 6 activities. Check off all the activities you've completed. When you have earned your badge, sign below and have your FRA leader sign and forward this sheet to the AFMS Juniors Program chair.

Date completed

My signature

Youth leader's signature

Name of my club

Leader's preferred mailing address for receiving badge:

Back-up page 11.1: Modeling the solar system.

When I was a kid, modeling our solar system was easy. We just memorized this little ditty: "My very earnest mother just served us nine pizzas." The first letter of each word represents the first letter of each planet in order from the sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.

Since that simple time, we've filled our solar system with an asteroid belt between Mars and Jupiter, an Ort cloud of comets surrounding our solar system along with a Kuiper belt and Centaurs, and a host of interesting moons we've begun exploring via spacecraft. Plus, most scientists have kicked poor Pluto out of the family of planets, demoting it to a mere "dwarf planet"! Others have added a planet or two in the form of icy bodies like Xena, larger than Pluto, that have been found in the outer reaches of our solar system.

Even as I type this 2016 update to our Badge Manual, the newspaper has announced a potential ninth planet to replace Pluto, a hypothetical planet 5,000 times bigger than Pluto (or nearly as large as Neptune) that is so far out in the solar system, it would take 10,000-20,000 years to circle the sun! So far, it's just being called "Planet 9" but stay tuned! We'll see if this "predicted" planet proves real. Meanwhile, use this as an example of how science is always changing and incorporating new theories, data, and information.

Work with kids to **create a model of our solar system** or to draw and color it on a long sheet of paper or poster board. The easiest is a model of the planets. You might choose marbles and balls of varying sizes to show how big different planets are relative to one another (from tiny, pea-sized Pluto to giant basket-ball sized Jupiter), and you might include a lamp to represent the sun. If you spread planets across a room, the heat emitted by a light bulb can illustrate how the sun's warmth that nurtures us on Earth makes for broiling conditions on Mercury yet barely reaches poor, maligned Pluto. You can also purchase models or posters of the solar system.

The California Department of Conservation provides a page on their website with links to a number of really neat masters you can download and print for free to then copy on paper or cardstock for kids to craft cut-and-fold 3D models of the Earth and other planets: http://www.conservation.ca.gov/cgs/information/Pages/3d_papermodels.aspx.

To vividly illustrate the long distances between planets and the length of the solar system as a whole, one club has taken their kids outside and has used a roll of toilet paper for measuring out distances from the sun to Pluto. Yet another club uses a very long roll of brown wrapping paper and marking each planet's position using a scale of one inch for every 10 million miles. They then made a model of each planet's relative size using a 6-foot beach umbrella for the sun and scaling down from that.

Before setting kids loose to make models or posters of the solar system, a fun activity to teach the names of our planets is via **flashcards**. You can make your own set by cutting planet photos from old astronomy or *National Geographic* magazines and pasting them to cardboard. Or you can go to web sites to download and print images of each planet onto cardstock and print or write the name of the planet on the back. See http://pds.jpl.nasa.gov/planets/ for terrific NASA photos.

To return to the fate of Pluto, the International Astronomical Union's 2006 revised definition of a planet demoted Pluto with this resolution: "(1) A 'planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighborhood around its orbit. (2) A 'dwarf planet' is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighborhood around its orbit, and (d) is not a satellite. (3) All other objects, except satellites, orbiting the Sun shall be referred to collectively as 'Small Solar System Bodies.'"

Use Pluto as an example for talking about how we define a planet versus a moon, a dwarf planet, and small solar system bodies such as asteroids, comets, or mere celestial debris. Kids should learn that science isn't always fixed or definitive. Definitions change, and scientists often debate and challenge one another and don't always come to a consensus as new discoveries come to light.

Back-up page 11.2: Learning about visitors from space.

Here are some basic definitions for four visitors from space:

**meteorite:** a particle from space (rocky or metallic in composition, or both) that reaches the surface earth without totally burning up in the atmosphere. (While still in space, it's referred to as a **meteor**.) Cordelia Tomasino (Michigan) points to the NASA web site http://www.nasa.gov/centers/jpl/education/ediblerocks.html where you enter "Edible Rocks" to get a ready-made activity teaching kids about the characteristics of different sorts of meteorites using common candy bars.

**tektite:** a glassy body that forms when a meteor or asteroid crashes into earth, melting rocks below it during an explosive impact and blasting them into the atmosphere or even outer space. On their return to earth, they cool and harden during their fall through the air into round, oblong, or pear-shaped glassy rocks often pock-marked with tiny pits.

**asteroid:** celestial bodies larger than meteors but smaller than planets, most often found in our solar system between the orbits of Mars and Jupiter. It's believed they represent debris formed from colliding planets or material that failed to form into planets during the creation of our solar system. They sometimes cross earth's orbit, and some are believed to have caused spectacular explosions, such as the one that may have exterminated the dinosaurs 65 million years ago.

**comet:** a celestial body of ice, dust, and other compounds that circles the sun in a looping, eccentric orbit (as opposed to the more uniform circular orbits of planets). As its orbit nears the sun, particles burn off and form a long tail pointing away from the sun.

To help your kids learn more about these visitors from space, you might direct them to books and websites like these and others:

- Carman, *Collecting Meteorites: Starting in Your Own Back Yard* (1995), 78 pages. Although focused on Australia, this is a great, handy introduction for the beginner anywhere on earth.

- McSween, *Meteorites and Their Parent Planets, Second Edition* (1999), 310 pages. Written by a past-president of the Meteoritical Society, this is a somewhat more technical book describing the nature of meteorites, where they come from, and how they get to Earth.

- Norton, *Rocks From Space: Meteorites and Meteorite Hunters, Second Edition* (1998), 447 pages. This is considered one of the best all-round meteorite books for a general audience. It is a must on the shelf of anyone who gets seriously interested.

- Smith, *The Meteor Crater Story* (1996), 79 pages. The story of one meteor crater near Winslow, Arizona, this book ends with a handy appendix listing known impact sites throughout the world.

- Notkin, *Meteorite Hunting: How to Find Treasures from Space* (2011), 84 pages. Written by the host of the TV series *Meteorite Men*, this brief guide is filled with color photos and info written in accessible language.

- *Meteorite Times* (www.meteorite-times.com). A free monthly online magazine.

- The UCLA Meteorite Gallery. http://meteorites.ucla.edu. UCLA is home to one of the largest meteorite collections in the U.S., and they've set up a website to showcase a gallery they've opened to the public. The website includes a wonderful pamphlet all about meteorites that you can download and print for free.

Back-up page 11.3: Effects of meteorites and famous craters.

While most meteors simply burn up on hitting the atmosphere, some meteorite, asteroid, and comet impacts have had profound effects on our earth. For instance, it is now generally accepted that an immense impact off Mexico's Yucatan Peninsula 65 million years ago was responsible for the extinction of the dinosaurs and many other creatures. It has recently been postulated that a comet exploding over North America did in large Ice Age mammals like woolly mammoths, giant ground sloths, and saber-toothed cats as recently as 10,000 years ago. In 1908, in a remote spot of Siberia, an enormous explosion known as "the Tunguska event" flattened trees in every direction over 770 square miles and could be heard over a 500 mile radius. (That's 800,000 square miles!) On a smaller scale of destruction, a couple of cars and a mailbox have been hit by small meteorites, and one even crashed through an Alabama woman's home to bounce off her hip, leaving a nasty bruise and a very surprised woman. (That meteorite is now in the Smithsonian.)

The most visible and obvious effect of a large meteorite strike is a scar or crater on the ground. **As an activity to show kids how craters form, have them create small craters by dropping or tossing marbles, ball bearings, golf balls, rocks, or other objects into wet sand or mud or a tub of dry white flour whose surface has been dusted with dry powdered paint or a similar powder like cocoa.** See if it makes a difference in crater size and shape by how hard the object impacts, whether it drops straight or from an angle, or whether you use a large, small, heavy, or light object.

As a follow up to this activity, particularly with older kids in your group, the web site www.lpl.arizona.edu/impacteffects lets you calculate the destructive power of meteorites of different sizes and trajectories.

**Assign craters to kids in your group to research all they can about them.** Have them report back to the group and/or write articles for the club newsletter. Some include:

- Campo del Cielo (Argentina)
- Chicxulub (Yucatan, Mexico)
- Henbury Craters (Australia)
- Manicouagan Crater (Canada)
- Meteor Crater (Arizona, USA)
- Monturaqui Crater (Chile)
- Odessa Crater (Texas, USA)
- Sikhote-Alin strewnfield (Siberia)
- Whitecourt Crater (Canada)
- Wolf Creek Crater (Australia)

Have kids pick a crater from this list, or let them read books or surf web sites to find craters of their own to explore. For instance, they may want to find out about a crater closest to their own homes. Dean Smith's brief book *The Meteor Crater Story* ends with a handy appendix listing known impact sites throughout the world and O. Richard Norton's *Rocks From Space* has a similar list in an appendix. In addition to books like these, here's a web site you might direct kids toward to find more famous meteor craters: http://geology.com/meteor-impact-craters.shtml. Using satellite images, this site includes a Meteor Crater Map of the world that allows you to click on a highlighted spot and zoom in with the "+" button for close-up views of 50 selected craters. The Planetary and Space

Science Centre of the University of New Brunswick (Canada) manages the Earth Impact Database listing all known craters and crater fields.  Finally, Wikipedia has an article all about impact craters, as well as a table of known craters on Earth.  You can access these at the following web addresses:

- http://en.wikipedia.org/wiki/Impact_crater
- http://en.wikipedia.org/wiki/List_of_impact_craters_on_Earth

***Note:*** *Kids who write a report about a famous meteor crater can use this toward satisfying requirement toward earning their Communication badge simultaneously (Activity 7.2).*

Back-up page 11.4: Collecting meteorites and tektites.

Given their extraterrestrial origins and rarity, meteorites have a lot of appeal. Once bitten by the meteorite bug, it's easy to get hooked into seeking a specimen of your own. However, this is no easy task, both because of the rarity of meteorites (for those seeking to collect one in the field) and their price (for those seeking to purchase one). If you're fortunate to live near a "strewn field" where a meteorite is known to have exploded into hundreds or thousands of fragments (as near Odessa, Texas), your chances of collecting one on your own are greatly increased. O.R. Norton's book *Rocks from Space* includes lists of strewn fields, and the Meteoritical Bulletin Database is an online resource listing all known and classified meteorite falls. But getting to a strewn field is the easy part. You then have to be able to pick out a rock that may look like every other rock on the ground. Because some meteorites have a high nickel-iron content, collectors use metal detectors or magnets attached to strings or a walking stick. One famed meteorite hunter, H. H. Nininger, used to drive through the desert towing a magnetic rake!

Still, even experienced meteorite hunters consider it a lucky day when they make a find. Thus, your most effective way of digging up a meteorite for your collection is with the "silver pick," or reaching for your wallet to buy one from a dealer. The most reasonably priced pieces for a child's budget are Nantan meteorites from China and small, black, pear-shaped tektites from Southeast Asia. I've seen these at almost every show I've attended. (Caution, though! I've heard that artificial tektites are now being produced in China from black glass and entered into the gem and mineral market as the real deal.) Encourage kids to check with dealers at rock and gem shows, rock shops, and museum gift stores, or to write or email for catalogs from such companies as:

- *The Universe Collection* (www.universecollection.com, Bethany Sciences, P.O. Box 3726-T, New Haven, CT 06525-0726, phone 203-393-3395). Write or call for their annual catalog, but be warned: this is a high-end enterprise, with prices to match. Most specimens are priced by the gram, and meteorites tend to be very, very heavy!
- *Meteorite Central* (www.meteoritecentral.com). Log onto this web site and get a password to join "The Meteorite Mailing List" and join over 1,300 members with an interest in collecting meteorites who exchange information to learn about, discuss, and purchase meteorites.
- *The Meteorite Exchange Network* (www.meteorite.com). This site has info about meteorites and the community of meteorite enthusiasts and dealers. In fact, it links to dozens of dealers, web sites, and eBay auctions and eBay stores.
- *Aerolite Meteorites, LLC* (www.aerolite.org). Geoffrey Notkin, host of the TV series *Meteorite Men*, started this company and website, which has meteorites, meteorite photos, expedition reports, science articles, and more.
- *Club Space Rock* (www.meteorites.ning.com). An online "meteorite community."

***Note:*** *Kids can use this activity toward satisfying requirements for the Collecting badge simultaneously (Activity 5.1). Those who seek meteorites in the field can apply this toward earning the Field Trips badge (Activity 8.3). Kids who join "Club Space Rock" can use that toward earning the Rocking on the Computer badge (Activity 15.6).*

Back-up page 11.5: Collecting meteorite dust.

Kids who really get into meteorites will itch to collect their own. However, they run into two problems. First, even professional meteorite hunters have a hard time finding and collecting meteorites in the field. They are rare and elusive and hard to identify by scanning the ground. Second, although you can sometimes find small Nantan meteorites from China and little black tektites from Southeast Asia at reasonable prices at gem shows and rock shops, most meteorites are priced, well, out of this world.

What to do to get a meteorite into a kid's collection? *Think small!* A couple neat websites provide instructions on how to collect "micrometeorites" or meteorite dust:

- http://www.pbs.org/wgbh/nova/teachers/activities/3111_origins.html
- http://starryskies.com/Artshtml/dln/6-00/dust.html

Most meteors burn up in our atmosphere, but as they do, they leave a trail of dust. That dust, along with micrometeorites and other solar debris is constantly raining down. By some estimates, tens of thousands of tons of extraterrestrial material falls on earth each year! The web sites I've referenced give instructions on how to collect micrometeorites. Essentially, you need to create a "meteorite trap." Suggestions include: keeping a bucket under a down-spout during a rainstorm to collect dust in runoff water from a roof; placing a water-filled bucket on a rooftop or other elevated spot for 4 weeks (checking periodically to refill the water as it evaporates); and laying a large plastic sheet (like a shower curtain) in an open spot or at the bottom of a wading pool and collecting residue from the sheet every two days for a little over a week. Another technique involves placing a strong magnet in a paper cup and tapping the cup on the ground around downspouts. Black specks will attach themselves to the bottom of the cup until you remove the magnet and tap them loose over a sheet of white paper. Examine the flecks under a microscope, searching for ones that are spherical and pitted.

With all these techniques, most of what you'll collect will be ordinary earthbound dust and dirt. You'll need to collect, concentrate, and dry the residue, sort out the dead insects, leaves, and other big things, and then use magnets to separate potential meteorite dust from earth dust. Viewed under a microscope, meteorite dust is often rounded and may have small surface pits. Perhaps the most amusing or quirky incidence regarding meteorite dust comes from Norway, where Ragnar Martinsen, sitting in the outhouse of his cabin, heard an explosion and later found tiny grains of rock in aluminum pans he had left in his yard. Scientists reported these to be pieces of only the $14^{th}$ recorded meteorite landing in Norway.

At best, you're not likely to get more than a piece the size of a sand grain or smaller, but a meteorite is a meteorite, and how many people can claim to have collected one on their own? This fun activity also vividly illustrates how the earth we're on is part of the larger universe, floating through space with cosmic debris that sometimes pays a visit.

***Note:*** *Kids can use this activity toward satisfying requirements for the Collecting badge simultaneously (Activity 5.1).*

Back-up page 11.6: More fun measuring impact cratering.

Activity 11.3 explores effects of meteorites with craters made by dropping marbles or other objects into tubs of flour, sand, or mud. This new activity provides a more detailed exercise by which you can see and measure effects of multiple impacts and how they might be used as a relative means of dating surfaces of planets and moons.

Via plate tectonics, Earth continually recycles its crust. Plus, we have an atmosphere with dynamic weather that creates erosion and moves sediments around, and that atmosphere is relatively thick, causing smaller meteors to burn up before they might hit the surface. For all these reasons, we don't see as many craters on the surface of Earth as we see on other planets and moons within our solar system, such as Mercury, Mars, or our own moon. Basically, on planets and moons with little-to-no atmosphere and that are tectonically inactive, the older the planet, the more meteorite craters it will contain. And older craters will be degraded by subsequent crater formation. The number of craters might also tell us, on an otherwise heavily cratered planet, if an area experienced volcanic activity and flooding, creating one spot less heavily cratered than elsewhere.

To illustrate these points, fill two large petri dishes or similar containers with very fine-grained sand, much finer than typical beach sand (check at a pet shop with aquarium supplies). Place a dish on the floor on top of a drop cloth or newspaper. Fill an eyedropper with water from a small cup or bowl. Hold the eyedropper at chest level and hold a piece of fine mesh window screen about a foot beneath the eyedropper and above the dish of sand. Now, one drop at a time, drip just a couple drops from the eyedropper. The mesh screen will break the water drops into smaller droplets. Let these fall onto the surface of the sand. Move the screen around so that drops from the eyedropper keep hitting dry screen to break into droplets. You should see several craters formed atop your sand. Pick up and set your dish aside. Then repeat with a second dish of sand, but this time rain several drops.

Count the number of craters in each dish. Which has more? Look at the condition of the craters in each dish. You should notice in the dish that was rained on longer, not only are there more craters, there also are more craters that overlap and degrade one another. Similarly, one way scientists date surfaces of extraterrestrial bodies is by looking at the number of craters and the conditions of craters. Take your first dish and simulate an outpouring of volcanic lava by pouring a little sand to cover over the craters at the top of the dish. Return the dish to the floor and rain a couple drops, then compare the appearance of the top of the dish to the bottom. What was the effect of your simulated volcanic activity?

This exercise is derived from a 1998 NASA publication entitled *Planetary Geology: A Teacher's Guide with Activities in Physical and Earth Sciences.* For this and other helpful resources for exploring space, go to the following link on the NASA website: http://www.nasa.gov/audience/foreducators/index.html.

## 12. Gold Panning & Prospecting

Gold has been highly valued throughout human history as a precious metal. This unit will teach you why. You can learn about gold as a mineral, its uses and history, and even how to become a prospector to find a gold flake or nugget of your own. In addition to gold, modern-day prospectors use metal detectors to find not just gold but also coins, artifacts, and other metal objects.

<u>Activity 12.1: Gold as a mineral</u>.
Buy a book on minerals or pick one up at the library to learn about the properties of gold as a mineral: its color, streak, cleavage, fracture, luster, hardness, crystal shape, and weight or specific gravity. Compare all these to properties of pyrite, or "fool's gold."

<u>Activity 12.2: Uses of gold</u>.
Write a report about why gold is considered valuable and the many ways it's used. Publish your report in your club newsletter or present what you've learned at a club meeting.

<u>Activity 12.3: Gold throughout history</u>.
Gold has been valued, sought, and fought over throughout history. Learn about a historical event involving gold and either write a report about it for your club newsletter or prepare a presentation about it for your fellow club members.

<u>Activity 12.4: Gold resources in your own state or region</u>.
Where has gold been found near you? From your library, from adult members of your club or society, or from your state geological survey, learn and then report to your fellow club members about areas closest to you where gold has been found. Show locations on a map. Gold is rare, so the closest spot may be in a neighboring state or region.

<u>Activity 12.5: Field trip to a gold mine</u>.
If there are any active gold mines within a convenient drive of your hometown, work with your youth leader to see if they would allow a group visit. Then go and see for yourself how gold is mined.

<u>Activity 12.6: Panning for gold</u>.
If there are streams in your area that are known to hold gold, arrange a field trip and pan for some gold of your own. If the nearest gold streams are too far away, you can still pan for gold in your own backyard. Some companies sell bags of "gold concentrate," or gravel from gold-bearing streams that you can buy and pan through in a tub of water. See if you can add a gold flake—or even a nugget!—to your rock collection.

<u>Activity 12.7: Metal detecting for gold, coins, and other artifacts</u>.
Learn how to use a metal detector, then take one to a beach, park, playground or other area where many people have been to see if you can dig up any lost coins, jewelry or other objects. First, though, learn about the "Code of Ethics" for metal detecting and respect all laws and property rights whenever you go treasure hunting.