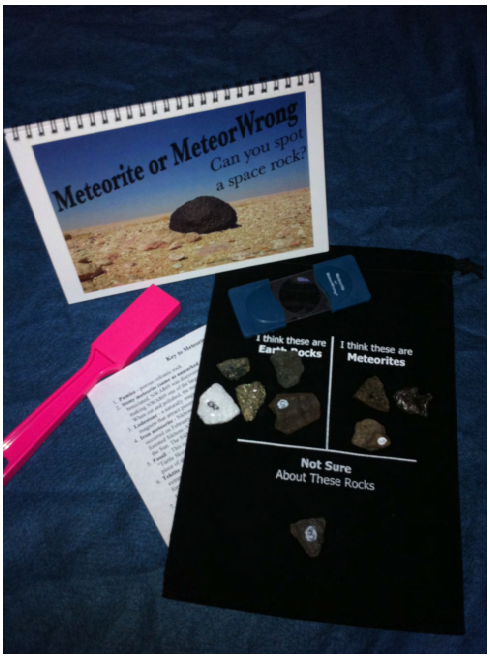
Meteorite or MeteorWrong



What's this activity about?

Learn all about meteorites with this hands-on activity: where they come from, how they got here, and what they are made of. Compare the characteristics of meteorites and Earth rocks.

Big Questions:

- What are the physical characteristics of meteorites?
- How can they be distinguished among a group of Earth rocks?

Big Activities:

Use various tests to pick meteorites from among a group of Earth rocks.

Participants:

From the club: One presenter

Visitors: Appropriate for families, the general public, and school groups in grade 5 and up. Up to 5 visitors at a time may comfortably participate.

Duration:

About 15 minutes. Additional time can be used for discussion and extensions.

Topics Covered:

- Where meteorites originate and how they end up on Earth
- Types of meteorites and what they are made of
- Characteristics of meteorites

Where could I use this activity?

ACTIVITY	Star Party	Pre-Star Party – Outdoors	Pre-Star Party – Indoors	Girl Scouts / Youth Group Meeting	Classroom			Club Mtg	Gen Public Presentation (Seated)	Gen Public Presentation (Interactive)
					K-4	5-8	9-12			
Meteorite/MeteorWrong		√	√	√		√	√	√		√

What do I need to do before I use this activity?

What materials from the ToolKit are needed for this activity?	What do I need to supply to run this activity that is not included in the kit?	Preparation and Set Up
• Set of rocks and meteorites • Flipbook • Magnet • Magnifying Glass • Bag that is used for sorting	It is helpful to have a table or flat surface to spread the rocks on.	• Remove the sliced meteorite (with no dot) from the set of rocks. • Place the rest on a flat surface or on the bag for your visitors to see. • Keep the sliced specimen and the magnet out of view until needed. • Begin the flipbook with the title page facing your audience and the words "Start Here" facing the presenter (page 1).

Helpful Hints

Common misconceptions addressed by these resources:

- Meteors are thought to be actual falling stars
- Many people think that meteorites are easy to find
- Meteorites are assumed to be very valuable and expensive.
- Meteorites are hot when they land on the Earth.
- Contrary to what most people have learned, meteors are not caused by friction.

Background Information

A well-annotated and timeless article about meteorites by Dr. David Kring:
http://www.lpi.usra.edu/science/kring/epo_web/meteorites/toc.html

For a good animation of the difference between a meteoroid, meteor, and meteorite, try here:
http://upload.wikimedia.org/wikipedia/commons/6/63/Meteoroid_meteor_meteorite.gif

Many metals are mistaken as meteorites, including:
Lodestone, or magnetite, is a naturally occurring iron-rich stone found here on Earth in veins like gold. It responds strongly to a magnet. However, it does not have the high nickel content of an iron meteorite.
Slag refers to impure pieces of metal left over from the ore refining process or other melting of metal. These pieces may look like meteorites at first glance and may also respond to a magnet.

In order to determine whether or not a piece of metal is a meteorite, it is necessary to do further testing. This includes testing for nickel, a metal that is present in high concentration in meteorites. This test is not recommended for use with a general audience or with children because of the chemicals involved. More information is found here:
http://meteorites.wustl.edu/id/metal.htm

Meteorite Treatment
Thanks to Dr. Mike Reynolds for preparing the meteorites and providing us with this description of the process:
Most meteorites – about 99% -- contain iron and nickel. Depending on the iron to nickel ratio, these can oxidize or rust. To prevent or inhibit rusting, several steps are taken with the meteorites in this set.

- Meteorites and slices are thoroughly cleaned with Ethyl Alcohol (EtOH) and a nylon brush. This does two things: loosens/removes surface rust and dehydrates the meteorite samples. The meteorites are left to “soak” in EtOH for about 30 minutes and then set to the side to dry. Meteorites that are found

to be extremely oxidized are further treated to remove rust and hopefully prevent future oxidation.

- The meteorite samples are next baked in an oven to dry and further dehydrate the samples. One does not want too high a temperature; around 175^{o}F is about right. The baking process takes between 30 and 60 minutes depending on the size of the meteorite(s).
- Finally, each sample is lightly coated with a spray that was specifically formulated for meteorites.
- There is no need to treat tektites in this manner since they are dry, glassy materials. However, each tektite was cleaned and rinsed in EtOH.

Key to Meteorite or MeteorWrong Rocks

1. **Pumice** - porous volcanic rock
2. **Stony meteorite (same as unmarked slice)** - Northwest Africa 869 Ordinary Chondrite (L5); brecciated, NWA869 was discovered in 1999. It is estimated that 1,500 kg have been recovered, making NWA869 one of the largest total known weight meteorites to come out of Northwest Africa. When cut and polished, the matrix is full of color and chondrules.
3. **Lodestone** - a naturally magnetized piece of the mineral magnetite. They are naturally occurring magnets that attract pieces of iron. They are often mistaken for meteorites.
4. **Iron meteorite** - Sikhote-Alin Found in Russia. Coarsest Octahedrite (IIAB) This well–observed fall occurred on February 12, 1947 over the Maritime Territory. A shower of fireballs fell in the thick-forested Sikhote–Alin Mountains. According to eyewitnesses, the fireball's brightness exceeded that of the Sun. The Sikhote–Alin fall produced 106 impact holes and over 27,000 kilograms of meteorites.
5. **Fossil** – This is a piece of a turtle shell that has been fossilized in the creeks of Florida. They are called "Turtle Skutes" and naturally fall off of turtles as they grow. On most fossils, you can see where the piece of shell was once fused to the vertebrae. They are between 10,000 and 4 million years old.
6. **Tektite** - Chinese Tektite Found in the Australasian Strewn Field, Composition-wise, tektites are extremely dry fused glasses–that is, they contain very little water. They are silica-rich (SiO_2) with a form that indicates aerodynamic flight, including spheres, ellipsoids and spheroids, dumbbells, and teardrops, with spheres being the most-common form.
7. **Pyrite** – a naturally occurring Earth mineral. It is an iron sulfide with the formula FeS_2. It is also called "fool's gold" because of its appearance.
8. **Marble** – a metamorphic rock (made from calcite or dolomite) commonly used in sculpture and building materials.

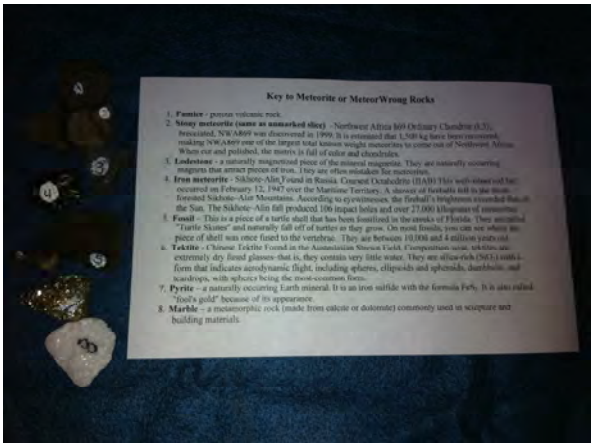
Detailed Activity Description

Meteorite or MeteorWrong

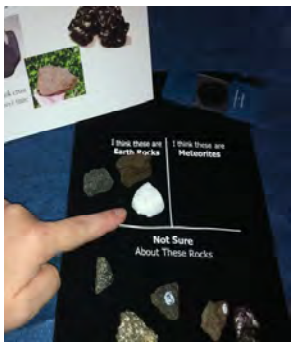
Presentation Tips:
The flipbook is a useful tool to use with this activity. It gives the audience visual reinforcement of the concepts. And it doubles as a reminder of points to cover in the activity for the presenter. In the "Activity Description" below, the column on the left indicates when to turn to the next page in the flipbook and what image the visitors will be seeing. (Only the presenter pages are numbered.)

Included in the black bag is a key to the rocks and meteorites. To help you remember what you are looking for, the meteorites and tektite are labeled 2, 4, and 6.

The rocks and meteorites are numbered to ensure you pick the correct meteorites. You will also find the key to the numbers on page 13 of the flipbook.



Page	Leader's Role	Participants' Role (Anticipated)
1 Intro/ Start Here	<u>*To say:*</u> Hey, I have some cool rocks from outer space here. Can you figure out which of these rocks are meteorites? It's impossible to tell just by looking. Would you like to become a meteorite detective and see if you can find one? Are you ready for some clues? Our first clue comes from how they got here. Between outer space and the ground here on Earth, what do they have to travel through?	Yes! Yeah Atmosphere

Page	Leader's Role	Participants' Role (Anticipated)
2 Rocks	*To say:* Right. And they're traveling really fast when they slam into Earth's atmosphere. To make it through our atmosphere and onto the ground, a space rock has to be strong and solid. If they're not strong, the only thing we'll see is a streak of light as the small rocks vaporize in our atmosphere. What do we call that streak of light?	Shooting stars/ falling stars
3 Meteors Porous Rocks	Right. Or **meteors**! Space rocks that are porous or with lots of holes wouldn't have made it through the atmosphere. That means that any of the rocks that are full of holes are probably Earth rocks, not meteorites. Do any of these rocks have holes? If so, you can be pretty sure they're not meteorites. Put those in the Earth Rocks category.	Put porous rocks in the Earth Rocks pile
4 Fusion Crust	Another thing their trip through the atmosphere does is to heat the outside layer of the rock until it melts. This gives some meteorites what we call a dark fusion crust, like in this picture. *To do:* Point to pictures of stony meteorite with fusion crust, then to iron meteorite next. *To say:* Other types of meteorites look like a splash of dark metal instead. You may be able to see tiny dents that look almost like thumbprints. These are called regmaglypts. (Pronounced *reg* mag lips) No matter what type they are, the outsides will be dark in color. So light colored rocks are not meteorites, unless you can see that thin, dark fusion crust on them somewhere. Put any light colored rocks into the Earth Rocks section too. Those aren't likely to be meteorites.	  Put rocks light in color in the Earth Rocks pile

Page	Leader's Role	Participants' Role (Anticipated)
Misconception Tips: Many people think that meteorites are hot when they land on the Earth. For small meteorites, that is not the case. Only the very outer layer of the rock has time to heat up. Most of the mass of a meteorite is lost as the outside layer vaporizes in the atmosphere, leaving only a thin fusion crust by the time it hits the ground. Heating of the surface of the rock (the meteor phase) only lasts a few seconds upon entering the atmosphere and normally stops between 15 to 20 km (9-12 miles) altitudes. After this point, they are moving at only about 0.2 km/sec and there is minimal heating from friction. They are free falling through the atmosphere for a minute or two and it is very cold that far up. So meteorites are most likely to arrive on the ground about room temperature. Imagine holding a piece of metal over a flame for a few seconds then putting it in the freezer for a minute. The interior never heats up and the heat on the top layer dissipates quickly. Contrary to what most people have learned, the glow of meteors is not caused by friction. The great speed of a meteoroid entering the atmosphere (average 30 km/sec or 20 miles/sec) compresses the air in front of it, causing the outer layer of the rock to heat so that it glows and vaporizes.		
5 Asteroid Belt	*<u>To say:</u>* Okay, so now we're down to strong, dark rocks without holes. We'll get the next clue when we figure out where space rocks come from. Does anyone know where meteorites come from originally? Right. More specifically, almost all meteorites found on Earth originally come from the Asteroid Belt. They are pieces of an asteroid. Way out past the orbit of Mars, asteroids collided and pieces of them were scattered. Just a few end up here on Earth as meteorites. So when you hold a meteorite, you're actually holding a piece of an asteroid.	Space.

Page	Leader's Role	Participants' Role (Anticipated)
6 Planets Asteroids	*To say:* All of the rocky planets and asteroids formed from the same space stuff- mostly dust, rock, and metal. But here's the thing that makes asteroids different from planets like Earth. Most never got very big. And this gives us a clue. Let me explain. When Earth and the other rocky planets formed from space dust, they got big enough and hot enough that most of the metal liquefied and sank to the core. Does anyone know what the Earth's core is made of? Right, well, most asteroids never got very big so all of these little bits of material are still stuck together just the way they arrived. And the metal never heated up or sank to the core. So in most asteroids, there's metal all mixed in with the rock. Meteorites from these asteroids are called stony meteorites. Now, there are some exceptions. Some asteroids did get big enough to have a core. And these also get smashed apart sometimes. When they do, the bits of metal from the core can land on Earth too. We call these iron meteorites.	Iron
Tip: An astute audience member may ask why we don't see many meteorites from the crust/mantle part of these large asteroids. This question is as yet unanswered by scientists as well.		
7 Scale	*To say:* But **either way**, it turns out that 99% of meteorites found on Earth have a good amount of iron in them. And iron is heavy. That makes a meteorite heavier than an average Earth rock of the same size. Go ahead; pick up some of the rocks. If any of them weigh considerably less than another of the same size, it's probably not a meteorite. Make sure to compare rocks of about the same size for this test.	

Page	Leader's Role	Participants' Role (Anticipated)
8 Stony vs. Iron	*To say:* Now we can put aside not just the rocks that are light in color but also those that are light by weight. Now there's one last test that's a really important one. Can you think of another way to test for iron? Good guess. How about a magnet? Rocks with iron in them should stick to a strong magnet. I just happen to have this one here. *To do:* Bring out the magnet. *To say:* Remember that some meteorites come from the cores of asteroids. These are called **iron meteorites** and they will stick to a magnet very strongly. When you find rocks that stick to the magnet, let's put those in the Meteorite pile. The other type of meteorite we talked about is a mixture of metal and stone. These are called **stony meteorites** and you have to watch carefully for these. Try dragging the magnet slowly across the surface of the rocks to see if any stick even just a little bit. Great. Let's see what you found. *To do:* Pick up the lodestone (#3). *To say:* Now, a few types of Earth rocks also have iron in them, so this isn't definitive. If we did more extensive tests, we'd find that this rock doesn't have nickel in it, like meteorites do. That's because it's a lodestone- an Earth rock with lots of iron in it that is often mistaken for a meteorite! It's hard to tell unless you slice it or do more thorough tests.	Put rocks that are not heavy for their size in the Earth Rocks section. Metal detector! Make a pile of rocks that stick to the magnet  Visitors usually identify the lodestone and the iron meteorite (#4). Some careful observers find the stony meteorite (#2).

Page	Leader's Role	Participants' Role (Anticipated)
See Background Information for more details on slag and lodestone.		
9 Iron Meteorite	*<u>To say:</u>* Now *this* is an iron meteorite! The largest meteorites on Earth are iron meteorites. Can you guess why? They are really strong and more often make it to the ground in one piece. *<u>To do:</u>* Pick up iron meteorite (#4) and pass to a visitor. *<u>To say:</u>* Only the most careful meteorite detectives pick out this one. This is the stony meteorite (#2). *<u>To do:</u>* Also pick up the stony if you they haven't already picked it out. Now bring out the sliced chondrite to show the interior- the chondrules and metal flakes *<u>To say:</u>* Here you go. I have a stony meteorite that has been sliced open. With that magnifying glass, you can easily see the metal flakes and pieces of rock or chondrules. (Pronounced: *con*-drools) Congratulations! You are now holding pieces of the Asteroid Belt. These also happen to be **older than any Earth rock**. They are glimpses into what our Solar System looked like when it was first forming. Now there's one other thing in here that's not a meteorite but that *is* related to Earth impacts. *<u>To do:</u>* Pick up the tektite (#6) and point out features before passing it around.	They are bigger to start with?
10 Chondrules		
11 Tektites		

Page	Leader's Role	Participants' Role (Anticipated)
	To say: When very large asteroids or comets impact the Earth, they explode with so much energy that they heat up the rock or sand they hit and can leave a big crater. The energy from that impact heats the rock and sand up to such high temperatures that they can melt.	
	(For older visitors) Does anyone know what happens when sand gets super-heated?	Older students and adults may know it becomes glass.
	That's right, melted sand becomes a kind of glass. This is a piece of glass that splashed out of an impact site. It's called a **tektite**!	
12 Other Kinds	There are also types of rare meteorites, from the Moon, Mars, and very specific parts of an asteroids, like the boundary between the core and the mantle. It's hard to come up with characteristics that fit every meteorite, but the tests we just did will help identify over 90% of meteorites out there.	
13 Looking for Meteorites	Does anyone want to see if you can pick out the two meteorites in this picture?	Sure! (Try it)
	It's still not easy. Here are some tips if you want to be a meteorite hunter: • Look in a place without lots of other rocks to fool you. What kind of place might that be? ○ Right, or even a freshly plowed field. • Get a good book about meteorite hunting from the library or a bookstore. Good luck!	Desert?

Misconception Tips:
Many people think that meteorites are easy to find. Be careful to let them know that finding meteorites is not a simple exercise. It can take experts days, weeks, or longer between finds.

Also, most people think meteorites are very valuable and expensive. Indeed some are! Point out that the meteorites you are passing around are small, common and worth less than ten dollars each.

Materials

Where do I get additional materials?

1. Powerful magnets can be purchased at a toy store, hardware store, or online. The wand magnets are simple to use for all ages:
    - http://www.discountschoolsupply.com search for "mag wand"
2. Magnifying glasses can be found at a drugstore or dollar store.
3. To make a copy of the Flipbook, follow these instructions:
    - Print the flipbook pages double sided on cardstock (best left to a professional printer).
    - Cut the pages in half.
    - Stack them with the presenter-side in numerical order, with *page 1 on top*. If you have access to the tools, spiral-bind the top edge.
    - If you leave them loose, as you flip the pages, place them on the table in front of you.
4. Limited numbers of bags with the 3 meteorites, one tektite, and Earth rocks that match the flipbook are available, while supplies last.
    - Contact Dr. Mike Reynolds: fallingstars1@comcast.net
5. Small rocks can be collected from your neighborhood or purchased from landscape supply centers.
6. Lodestone can be found through many online suppliers, including here:
    - http://www.buylodestones.com/
7. Meteorites and tektites: The largest supplier is EBay. Most of the sellers are honest and a pleasure to deal with. However, use caution when buying meteorites on EBay. Although most ads for meteorites are real, sometimes less reputable sellers try to list tektites as meteorites. Read this very informative site for more information:
    - http://reviews.ebay.com/Buying-Meteorites-on-eBay-a-Beginner-apos-s-Guide_W0QQugidZ10000000004437563
    - You can also go to gem and mineral shows in your area. A current list is here: http://www.rockngem.com/showdates.asp
    - Members of your astronomy club may have small meteorites they are willing to share for this activity.