Splat!

The original version of this activity comes from “Explore! Marvel Moon,” a group of activities intended for libraries and other informal education environments. It can be found on the Lunar and Planetary Institute website:
http://www.lpi.usra.edu/education/explore/marvelMoon/activities/familyNight/splat/index.shtml

Overview

Students model ancient lunar impacts using water balloons. By measuring the diameter of the crater area, students discover that the Moon’s largest impact basins were created by huge asteroids! Like these huge asteroids, the water balloons are destroyed on impact and leave a splash (i.e. a “crater”) that is 10 to 20 times wider than the impactor. The largest basins formed on the young Moon, when it was 400 million to 800 million years old. Students find the impact basins — the Moon’s largest features — on a map and consider how they have changed since they first formed to become the dark patches (“maria”) on the Moon’s face. Students may examine a type of Earth rock (named breccia) that is also found on the Moon and that would have been shaped by the processes explored here.

What’s the Point?

- Scientists study the Moon’s rocks and surface features to learn how it formed and changed over its long “lifetime.”
- Impact craters and basins are caused when an impactor, such as an asteroid or comet, collides with a planet or moon.
- The Moon’s largest impact basins — those we can see with our eyes (without the aid of instruments) — were formed by very large asteroids or comets striking the surface early in the Moon’s history.
- The Moon endured a violent period in solar system formation when large impacts were much more common than they are today; based on the ages of the Apollo samples, scientists theorize that this period ended by 3.8 billion years ago. Lunar researchers are trying to determine how long this period of intense bombardment occurred, and what caused it.
- The size of an impact crater or basin depends on the speed and size of the asteroid or comet before the collision and the material it impacts. Most impact craters will be 10 to 20 times the size of the impacting asteroid.
- The Moon has some of the same types of rocks that are found on Earth. The rocks have certain properties, such as color.
- Models — such as those the students are using here — can be tools for understanding the natural world.

Materials

Facility needs:

- An outdoor area, such as a concrete patio or parking lot

The following materials are for one *Splat!* activity set and will serve approximately 10 students working in teams of 2-3 each.

- 5 water balloons
- Optional: 1 bucket
- 5 rulers or tape measurers
- 5 clipboards
- Towel for cleaning up spills
- Optional: 1 sample of Earth breccia, ordered from a natural science catalog; a volcanic breccia hand specimen (item #47 V 1324) is available from WARD'S Natural Science (http://wardsci.com/product.asp_Q_pn_E_IG0004671_A_name_E_Breccia+%28Volcanic%29+Sedimentary+Rock+Specimen)
- Illustrations and images of basin-forming impacts, basins, and asteroids, printed in color or displayed on a computer (and projector, if desired)
- *Moon Map: Lunar Impact Basins*
- *Splat!* student guide
- Art materials, such as colored pencils, crayons, and markers

For each student:

- *Kid Moon: Splat!* comic panel
- His/her *Marvel Moon* comic book and binder clip
- 1 pencil or pen

For the facilitator:

- Access to water
- Background information
- Shopping list

Preparation

- This is a fun, but messy activity! If possible, tell the students ahead of time to wear an old shirt or apron, or you may wish to provide trash bags for them to wear. Have a towel handy for cleaning spills.
- Prepare enough water balloons for each team to have one and identify a safe location for dropping them. (Prepare additional balloons if you would like each student to drop one.)
- Provide the balloons — contained in the bucket, if desired — at that location with clipboards and rulers or tape measurers.
- Place the Earth rock sample, art materials, Moon map, and student's guide on a table nearby.

Activity

Described in the student guide.

Facilitator's Note: The students will measure the width of their balloons and the splashes they create. They will do a simple calculation in their comic books. For example:

Balloon Size:
3 inches
(7.6 cm)

Splash Width:
54 inches
(137.2 cm)

54 inches (137.2 cm) Crater width (splash width)	÷	3 inches (7.6 cm) Impactor (balloon) size	= 18

Most impact craters are 10 to 20 times the size of the asteroid.

Conclusion

Once they have completed the experiment, the students should understand that the large circular features they observe on the Moon are impact basins. They were formed by large impactors (asteroids or comets) striking its surface. Craters and basins on the Moon are larger than the asteroids and comets that created them — 10 to 20 times larger!

Impactors are like water balloons because they are destroyed upon impact, and very little of the asteroid or comet remains. (Remnants of asteroids found on a planetary surface are called meteorites.) Asteroids are much more rocky and moving faster than the balloons in this model; they are far more damaging.

Scientists experiment with physical models — like the students did — to determine the size of an impactor. Their models use projectiles that can move at high speeds and impact different types of materials. Videos of these impacts help scientists model how the materials behave. Scientists also use computer models to understand what happens during an impact. They also study impact craters on Earth, like Barringer Crater (Meteor Crater) in Arizona to understand impact processes. The meteorites and altered rocks and minerals in these craters contain clues as to the type, size, and speed of the impactor.

A Little Background for the Facilitator

A storm of impacts occurred shortly after the Moon and planets formed. The impactors left their mark: Huge impact basins such as Imbrium, Crisium, and Serenitatis, which are hundreds of miles across, mark where the impactors struck the Moon.

The impacts broke apart the rocks at the surface of the Moon and fused them into impact melt breccias — rocks made of angular, broken fragments, finer matrix between the fragments, and melted rock. These rocks, collected by Apollo astronauts, provide scientists with the timing of basin formation.

The largest impacts appear to have occurred when the Moon was relatively young – about 400 million and 800 million years old (or, between 4.1 and 3.7 billion years ago). This is a remarkably narrow window of geologic time.

This period of impacts is one of the mysteries scientists are working to solve. The timing continues to be a puzzle: Were these impacts just part of the gradual “clean up” of debris left over after solar system formation? Or were they part of a distinct period of asteroid bombardment? Scientists wonder how an event of this magnitude could have happened: Where in the solar system could so many asteroids have come from? What caused this to happen? Recent research suggests that asteroids from the asteroid belt between Mars and Jupiter may have been pushed out of their relatively stable orbits by the gravitational interactions of the largest planets. Scientists also find evidence for large impacts from this time period on Earth as well as the other planets.

When the Moon was about 800 million years old, the period of intense bombardment came to a close; impact events, while ongoing, became less frequent and were generally smaller. Small, infrequent impacts still occur on the Moon, Earth, and all other planetary bodies today. Scientists distinguish between “impact craters” and “impact basins.” Basins are 190 miles (300 kilometers) across, or larger. When you look at the Moon, you can easily see the large, circular basins.

The size of an impact crater depends on the speed and size of the asteroid or comet before the collision, and the material it is impacting. A faster impact will create a larger crater. Typically, asteroids hit Earth at about 20 kilometers (slightly more than 12 miles) per second. Such a fast impact produces a crater that is approximately **20 times larger in diameter** than the asteroid. Most impacts will be 10 to 20 times the size of the asteroid. Smaller planets have less gravitational “pull” than large planets; asteroids and comets will strike at lower speeds.

Scientists have observed small asteroids and comets hitting the Moon and Earth, and these formed small craters. NASA’s Lunar CRater Observation and Sensing Satellite (LCROSS) mission intentionally impacted the Moon’s south pole with a used rocket and the spacecraft itself on October 9, 2009. The crater left by the LCROSS impacts were about a third of a football field across and less than 10 feet (about 3 meters) deep.

Splat!

Correlations to National Science Standards

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

- The sun, moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.

Changes in the Earth and Sky

- The surface of Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes — and impacts!

Grades 5-8
Science as Inquiry — Content Standard A
Abilities Necessary to Do Scientific Inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, and some involve making models.

Earth and Space Science — Content Standard D
Structure of the Earth System

- Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

Earth in the Solar System

- The earth is the third planet from the sun in a system that includes the moon.

Earth's History

- The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.

National Geography Standards
Grades K-12
NSS-G.K-12.1 THE WORLD IN SPATIAL TERMS

- Understand how to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Splat!

Correlations to Next Generation Science Standards

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.

Disciplinary Core Ideas ESS1.C: The History of Planet Earth

- Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.

Disciplinary Core Ideas: PS3.A: Definitions of Energy

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)

Nature of Science: Scientific Investigations Use a Variety of Methods

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

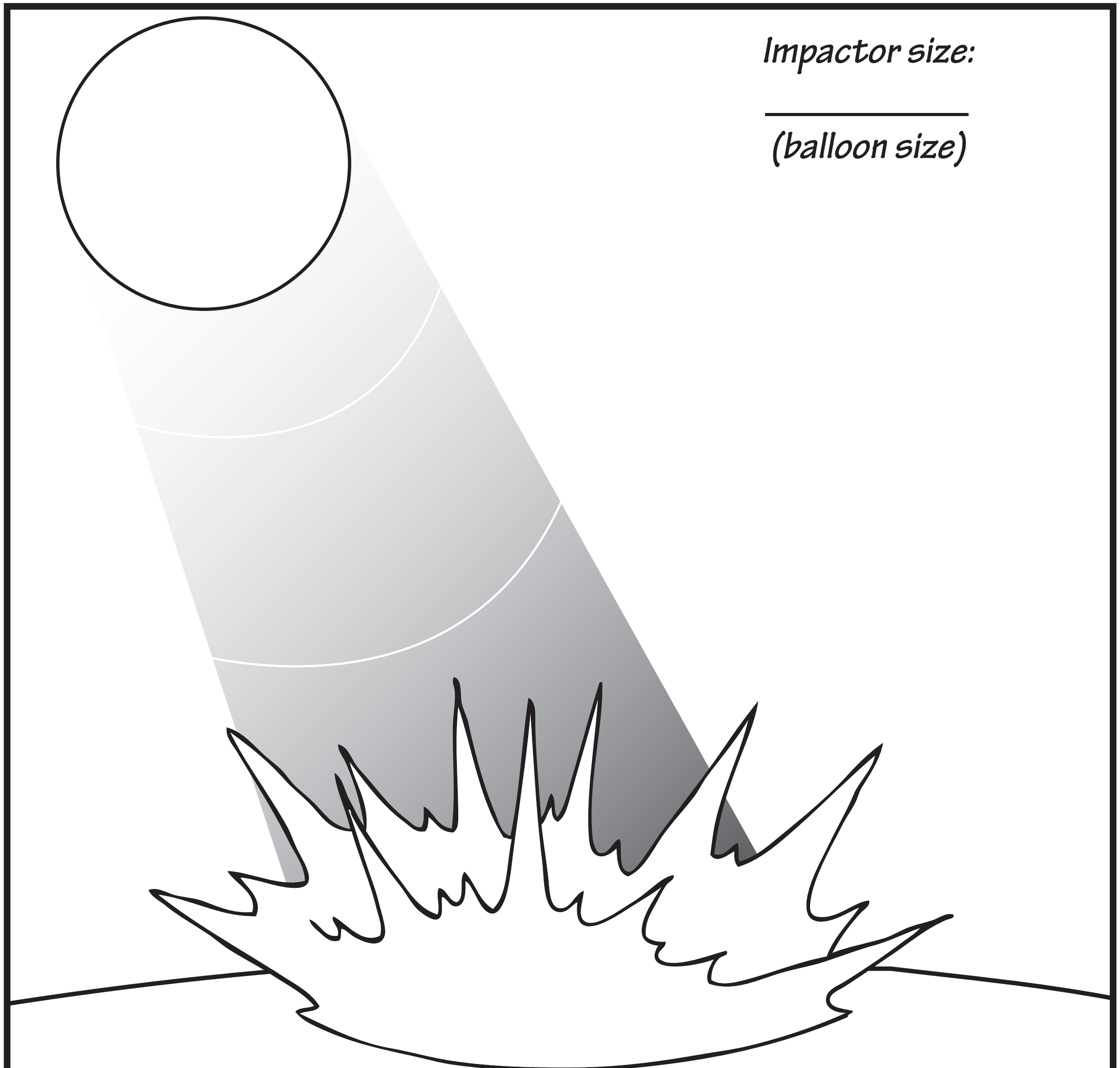
Science and Engineering Practices: Developing and Using Models

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

Splat! Student Guide

Check It Out	What To Do	What To Ask
1. The young Moon was hit by large asteroids.	Each group will model their own impact with a water balloon. Using a ruler, measure the shortest width of the water balloon. Record your measurement on the Splat! comic panel.	How wide across is your water balloon?
2. These impacts left scars that we can see today: impact basins.	Break the balloon by throwing it onto an outdoor concrete patio or sidewalk. Measure the width of the continuous part of the splash. Record your measurements on the Splat! comic panel.	How big is the splash (the "crater")?
3. Craters on the Moon are larger than the asteroids that created them – 10 to 20 times larger! Like the water balloon, the impactors broke apart when they hit the Moon.	Calculate the ratio of the size of the impact to the size of the balloon. Record your measurements on the Splat! comic panel.	How much larger is your splash compared to the size of the balloon? Asteroids and comets travel much faster than you can throw a balloon. They are also rocky and hard. What do you think would happen if you threw the balloon faster? How would the "splash" caused by an impactor on the Moon look compared to the balloon's splash?
4. Rocks like this Earth rock were found on the Moon and brought back to study in laboratories. On Earth, these rocks, breccias, can form in many ways. ON the Moon breccias form when the heat and pressure of an impact breaks the rock. Some of the rock is melted and glues the pieces together into one bigger rock. Impacts eject the rocks far from the crater.	Feel and study the rock.	What do you notice about the color and texture of this rock?
5. Scientist record videos of projectiles impacting different types of materials. They study the videos to see how the materials behave. Scientists also use computer models to imagine and test their ideas about what happens during an impact. They also study impact craters on Earth, Like Barringer crater in Arizona.	Check out the Moon map and find the largest features. These impact basins were caused by large impacts long ago. These features changed since they first formed; they are not simple bowl-shaped features on the Moon's surface.	Go outside sometime and look at the Moon. Can you find the large circular features?

Kid Moon: Splat!

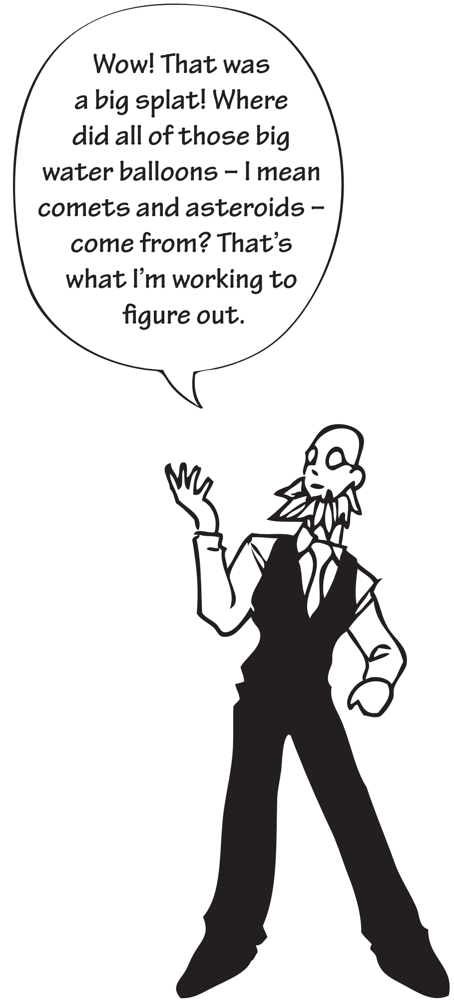


Impactor size:

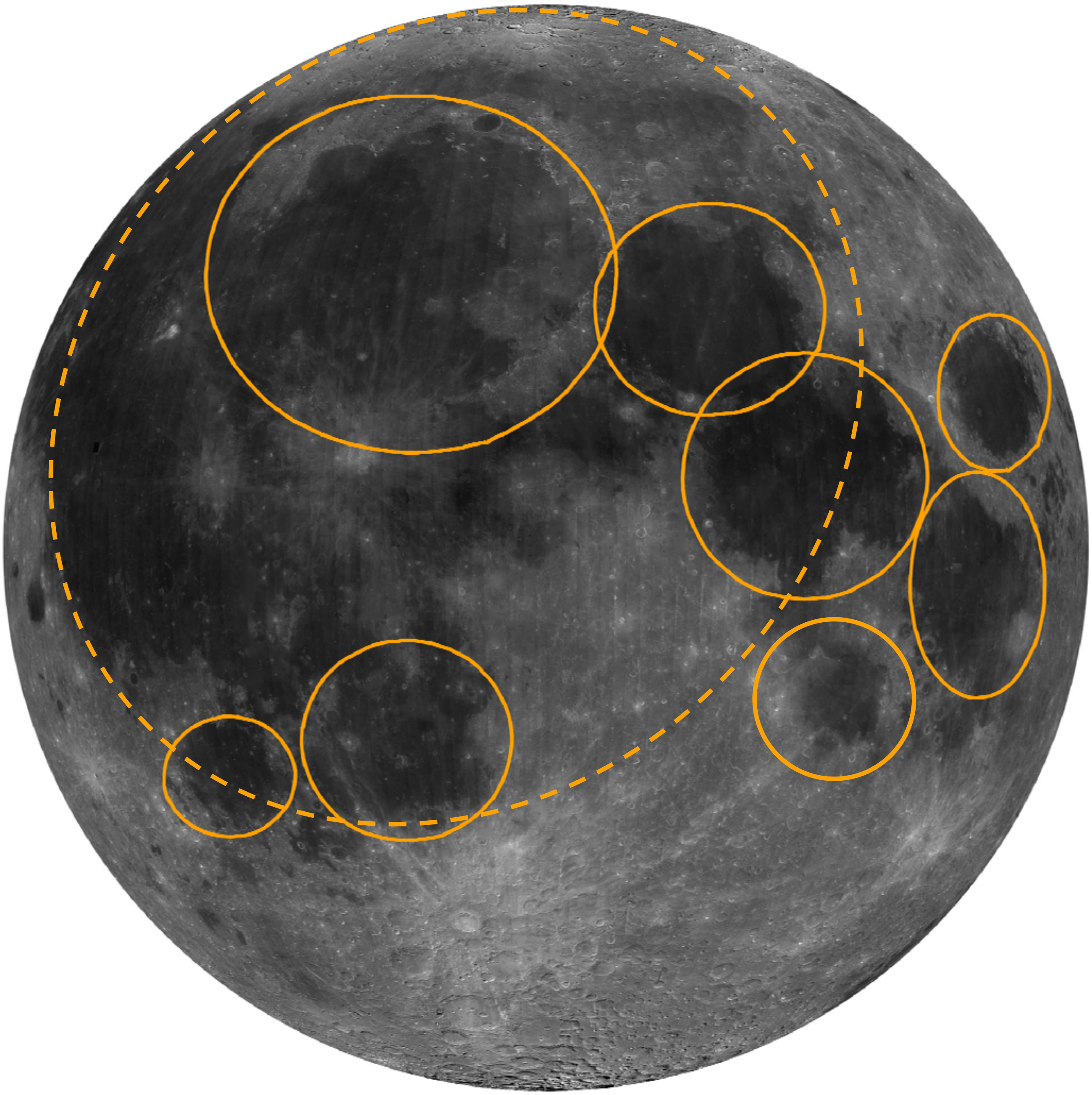
____
(balloon size)

Crater size: ____________ (splash width)

Crater size ÷ baloon size=___________



Moon Map: Lunar Impact Basins



Splat!

Each group will model the impact process using water balloons. Impacts will be modeled by breaking water balloons onto an outdoor concrete patio or sidewalk and measuring the resulting splash.

1. Each group of 2-4 students should have 3 water balloons.
2. Before beginning, measure the shorter diameter of the water balloon and record it below. This is the size of your impactor.
3. Drop or throw your water balloon on a flat, solid, dry area.
4. Measure the width of the continuous wet area (splash) and record it below. This is your crater.
5. Calculate the ratio of crater size to impactor size and record it.
   Hint: [crater width ÷ impactor width]
6. Repeat for all 3 balloons.
7. Calculate the average of your ratios and record it.
8. Be sure to pick up all of your leftover balloon pieces!

Impact #1

Impactor (balloon) width ____________

Crater (splash) width ______________

Ratio of crater size to impactor size: __________

Impact #2

Impactor (balloon) width ____________

Crater (splash) width ______________

Ratio of crater size to impactor size: __________

Impact #3

Impactor (balloon) width ____________

Crater (splash) width ______________

Ratio of crater size to impactor size: __________

Calculate the average of the three ratios. [(ratio 1 + ratio 2 + ratio 3) ÷ 3]

Average size ratio for three impacts: [ ]