FIELD TRIP TO THE MOON

COMPANION GUIDE

You'll find:

- More about the show
- Classroom Activities

AMERICAN MUSEUM OF NATURAL HISTORY

Get ready to experience Field Trip to the Moon!

"Mission Control … we're ready for lift-off"

Field Trip to the Moon is a virtual journey that was created using NASA engineering models and scientific data. Like NASA's astronauts, you and your students will come face-to-face with the challenges and excitement of launching from Earth's surface and journeying through space to land on the Moon. Along the way, you'll discover some of the differences between the Earth and the Moon and what makes our planet unique and habitable.

Fasten your virtual seatbelts and enjoy the journey!

Introduction: 3 minutes

Feature Presentation: 21 minutes (available with and without narration)

Extras: 7 minutes

amnh.org/education/ftm
www.nasa.gov

IMAGE CREDITS:
Earth, Moon, and illustrations of lunar base and spacecraft landing, © NASA; solar wind, © NASA, ESA, SOHO; illustration of magnetic field, © AMNH

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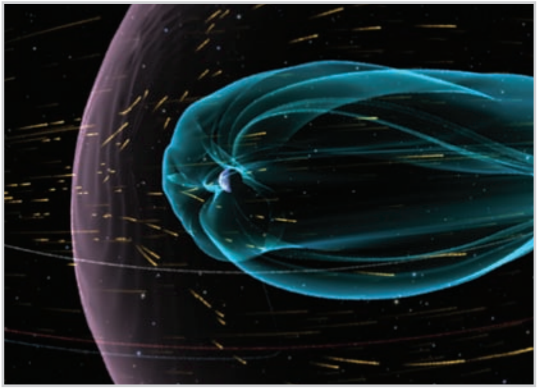
Field Trip to the Moon explores the following key concepts:

The Earth System Has Natural Defenses

Harmful radiation, fast-moving meteoroids … outer space can be a dangerous place. Luckily, our planet is protected by its natural defenses.



Earth is protected by an invisible magnetic field, visualized here in blue.

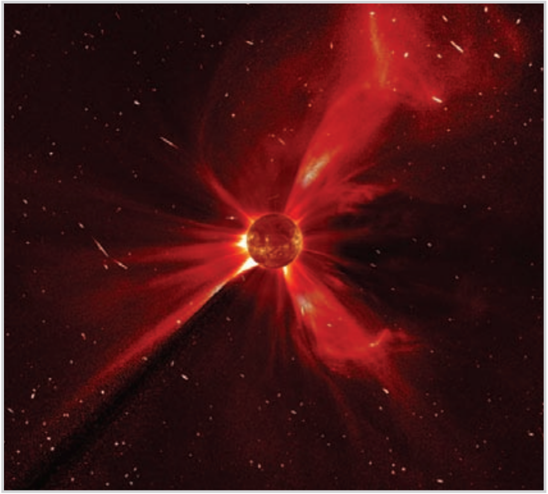
Produced by the rotation of Earth's liquid outer core, Earth's **magnetic field** shields us from energetic particles in the solar wind. These particles stream off the Sun's surface at more than a million miles an hour, and can damage the DNA in living organisms.

The **atmosphere** also protects us. Most of the tons of rock and dust from space that collide with Earth's atmosphere every day burn up through friction before they hit the ground.

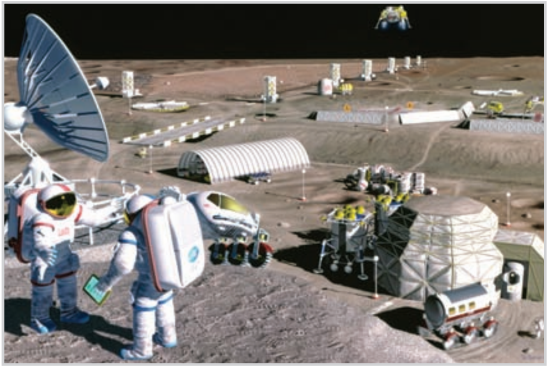
The Lunar Environment Is Unprotected

Without a magnetic field or an atmosphere, the Moon is exposed to the Sun's **radiation** and potential **impacts**.

Moon explorers also face many other challenges. There is electrically charged soil that makes **moondust** cling to everything. And without an atmosphere to moderate the Moon's **temperatures**, it gets as cold as -250°F and as hot as 250°F!



Solar wind blasts from the Sun's surface.



Artist's rendition of future commercial lunar base.

The Moon Is Vital to Human Space Exploration

Did you know that humans plan to once again land on and explore the Moon?

In decades ahead, NASA plans to build a new **outpost** on the Moon. This site, along with the International Space Station, will be a place for astronauts to prepare for **missions** to Mars and beyond. They will be testing new approaches, systems, and operations for sustainable human and robotic missions.

AFTER THE SHOW

The journey has just begun!

Now that you've landed on the Moon, it's time to take a closer look.

MOON ACTIVITIES

You can continue your investigation of the Moon and human space exploration in the classroom, after-school settings, or museum programs, using the activities to the right.

MORE ONLINE

Visit the Field Trip to the Moon website at amnh.org/education/ftm to access an **Educator's Guide** with more in-depth investigations.

Continue your students' investigation of the Moon and human space exploration with these three activities.

You may choose to do one or more of these activities with your students.

OBSERVE THE MOON

Students will make observations and collect data about the Moon. They will analyze how the Moon changes as it moves through the night sky.

Time Frame: One class period plus five minutes each day for 10 days

INVESTIGATE CRATERS

In this hands-on classroom lab, students will create and examine models of impact craters to investigate how craters are formed.

Time Frame: One class period

EXAMINE HUMAN EXPLORATION

Students will read a supplemental article about plans for future lunar exploration and discuss its purpose and implications.

Time Frame: One class period

INVESTIGATE CRATERS

Objective

Students will create and examine models of impact craters to investigate how craters are formed.

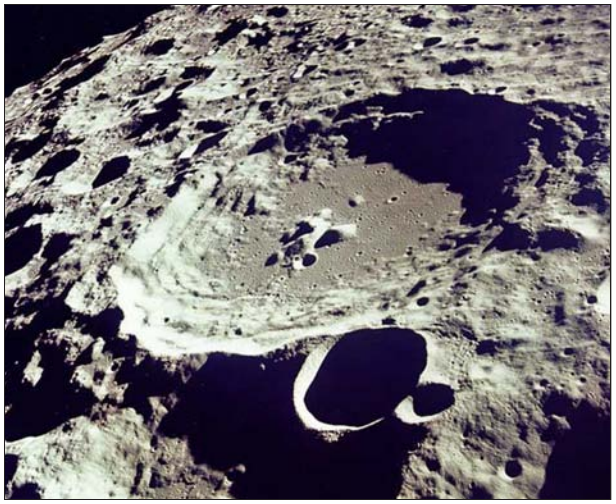
Time Frame: One class period

Prior Knowledge

Discuss with students what they learned about the Moon's surface from the show. Ask:

- What does the lunar surface look like?
- How is the Moon's surface different from Earth's surface?
- Why do you think this is so?

The far side of the Moon is rough and filled with craters.



Exploration

Explain to students that they will investigate impact craters by varying the speed and mass of impacting objects, and observing and measuring the craters they create. During the investigation, have students record: (1) the relative size and mass of the object making the crater, (2) height from which it was dropped, and (3) the size of the crater made.

- Place a large shallow baking pan or box on the floor. Fill it with two inches of flour and sprinkle a thin layer of cocoa powder over the surface.

Variation in Size and Mass

- Obtain a number of small balls that vary in size and mass, from the size of a marble to a golf ball.
- Call on a volunteer to drop the first ball straight into the center of the pan. Remove it and have students examine the crater that was formed.
- Continue in the same manner by dropping different sized second and third balls in different parts of the pan from the same height as the first ball. Have students compare the difference in craters created by each ball's mass.

Variation in Speed

- Fill the craters and sprinkle more cocoa if needed. Continue with the experiment by having students vary the height of the balls. Have students compare the results of varying the size, mass, and speed of the balls.

Students may compare the craters they made with those on the Moon at moon.google.com/

EXAMINE HUMAN EXPLORATION

Objective
Students will read about plans for future lunar exploration and discuss its purpose and implication.

Time Frame: One class period

Prior Knowledge
Discuss human exploration with students. Use the following questions to generate a discussion:

- Think about the early explorers. What were some of the challenges they faced?
- If you could explore a remote place on Earth, where would you go? How would you plan for your journey and what would you need to take with you?
- Think about the astronauts traveling to space. What challenges do they face?

Exploration
Have students read the article on page 7. It's an excerpt from the NASA article "The Moon is a School for Exploration."

As they read, have them think about what exploration of the Moon could teach us.

When students have finished reading the article, discuss it with them. Ask:

- What are the plans to explore the Moon in the future?
- What techniques can astronauts develop and test on the Moon?
- Why can't the Moon's environment be duplicated on Earth?
- How might robots be used in exploration of the Moon?
- Why is extracting oxygen and hydrogen from the Moon's dirt an important goal?
- How will learning to live on the Moon prepare astronauts for exploring Mars?
- Do you think humans will set up bases on the Moon and on Mars during your lifetime? Support your answer.

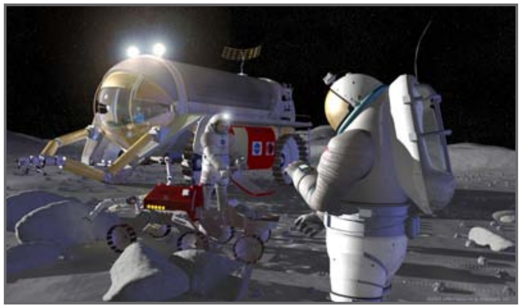
Artist's rendition of a roving vehicle and lunar base.

THE MOON IS A SCHOOL FOR EXPLORATION

February 14, 2007: NASA has been exploring space for nearly half a century, often with stupendous success. Yet "there's one thing we really don't know: what is the best way to explore a planet?" says Paul D. Spudis, a senior planetary scientist at Johns Hopkins University's Applied Physics Laboratory in Laurel, Maryland.

Discovering the most effective techniques for exploring a planet is itself cutting-edge research. It can be compared to discovering the most effective mining technologies or the best ways of surviving and making machinery work in Antarctica.

On the Moon, astronauts can develop and test techniques. They'll build habitats, harvest resources, and operate machinery. They'll do it all in an environment with low gravity, high vacuum, harsh radiation, pervasive dust, and extreme temperatures—an environment that is simply impossible to duplicate on Earth. What the astronauts learn will be useful on the Moon. It is also essential for preparing missions that will go to Mars.



Artist's rendition of astronauts and robots working together on a lunar geology study.

One research project topping the curriculum: What is the best combination of humans and robots? Unmanned orbiting spacecraft and rovers have returned high-quality data from the Moon and planets. The data has helped revolutionize our understanding of the solar system. But for geological field work, says Spudis, nothing can replace a trained geologist with a rock hammer. They have experienced eyes and the knowledge to "understand rocks in the context of their environment."

For that reason, NASA wants to explore how best to use humans along with machines. One promising technology is telepresence. It is similar to what's now used in hospital operating rooms for certain types of surgery. From the safety of a radiation-shielded underground lunar habitat, a geologist's movements could be instantly mirrored by a robot on the surface, complete with instant sensory feed-back. Is that the best way, though? In some cases, a robot making lightning-fast decisions with artificial intelligence might do a better job. But this is a question best answered by on-site research.

Other things humans could learn from lunar experience is how to "make useful things from dirt," Spudis says. On the Moon and Mars, local resources are going to be crucial to astronauts. They cannot remain wholly dependent on Earth for supplies. "Aside from solar power, we've never used space resources," Spudis says, "so we need to figure out how to do it."

The official NASA acronym for living off the land is ISRU, for In-Situ Resource Utilization. ISRU is basically figuring out how to dig into the surface of another planet, how to get the alien dirt to funnel down a hopper in low gravity (a surprisingly tricky problem), and how to crack and heat the soil to extract valuable liquids and gases. And this all must be done with high reliability and few mechanical problems.

What's on or beneath the rocky lunar surface that astronauts might need or want to mine? Most immediately useful are oxygen and hydrogen. "From those two elements, we can generate electricity using fuel cells, which makes drinkable water as a by-product," Spudis explains. "Hydrogen and oxygen are also rocket propellant. The oxygen astronauts can breathe."

Good news: Oxygen on the Moon is abundant. The lunar crust is 40 percent oxygen by mass. NASA scientists have lots of ideas for how to extract it. Simply heating lunar soil to very high temperature causes gaseous oxygen to emerge. More efficient techniques remain to be discovered.

Not-so-good news: Hydrogen on the Moon is relatively rare. That's one reason NASA is keen to explore the lunar poles. There some 10 billion metric tons of frozen water may exist in permanently shaded craters. "Ice is a concentrated form of hydrogen," Spudis notes. Experience gained at the Moon's poles may apply to Mars, where ice is also thought to be mixed with deep soil and rock.

"We need to set up shop on the Moon for one clear and understandable reason," Spudis concludes. "The Moon is a school for exploration."

Article excerpted from: science.nasa.gov/headlines/y2007/14feb_school.htm