IMAX®

TOM HANKS
PRESENTS

MAGNIFICENT DESOLATION
WALKING ON THE MOON

EDUCATOR'S RESOURCE GUIDE

TAKE YOUR STUDENTS FOR A WALK ON THE MOON.

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DEAR EDUCATOR,

Thank you for choosing to enrich your students' learning experiences by supplementing your science, math, history and language arts curriculums with an IMAX® film. Since inception, The IMAX Corporation has shown its commitment to education by producing learning-based films and providing complementary resources for teachers, such as this Educator's Resource Guide.

For many, the dream of flying to the Moon begins at a young age, and continues far into adulthood. Although space travel is not possible for most people, IMAX provides viewers their own unique opportunity to journey to the Moon through the film, ***Magnificent Desolation: Walking on the Moon***.

This thrilling IMAX film puts the audience right alongside the astronauts of the Apollo space missions and transports them to the Moon to experience the first steps on the lunar surface and the continued adventure throughout the Moon missions. Audiences will be able to leap and bound beside the astronauts and join the race against the clock to pack as much science and sample collection as possible into the limited stay time on the Moon's surface. Movie-goers will share in the courage, the excitement and the joy that accompanied these missions and cemented the Apollo program as a crowning achievement in NASA history.

Turn your local IMAX theatre into an extension of your classroom as your students discover the Moon and learn more about NASA's lunar exploration endeavors. This Educator's Resource Guide, created by Weekly Reader and IMAX, extends the ***Magnificent Desolation: Walking on the Moon*** film experience into classroom activities that will continue to pique your students' interests and help them learn long after the film has ended.

This 24-page Educator's Resource Guide is designed for students in grades 3 through 9, with activities that are appropriate for the varying learning levels in this grade span. The Educator's Resource Guide offers reproducible student activities for each grade level that meet national standards. All of the activities can be adapted to meet the needs of your students. Hands-on lessons, experiments and observation activities will educate students about lunar exploration and the Moon. The Educator's Resource Guide also includes ideas for implementing the lessons, extension activities, resources, Web sites and a quick-fact reference sheet. Photocopy and share the reference sheets with students in order to build background for the film.

Enjoy taking your students on a journey to the Moon and thank you for using IMAX films to challenge your students' knowledge of space exploration. Although these materials are copyrighted, they may be reproduced for educational purposes. Please feel free to share this guide with your colleagues and encourage them to book their field trip to see ***Magnificent Desolation: Walking on the Moon***.

We look forward to seeing you and your students again at your local IMAX theatre.

Sincerely,

Your Friends at IMAX

USING THIS GUIDE

This Comprehensive Educator's Resource Guide includes an Educator's Guide to Student Activities (beginning on Page 5) to help you use the contents fully. The Educator's Guide to Student Activities is comprised of hands-on lessons and experiments to complete in the classroom or outdoors, before or after film viewing. The guide also includes:

- **10 reproducible, corresponding student activities (beginning on Page 10)**
- **learning objectives and summaries for each student activity**
- **ideas for implementing the student activities**
- **subject areas and recommended grade ranges for each lesson**
- **page numbers of corresponding student activities**
- **follow-up activities for each lesson**
- **recommended Web sites for expanding the topics covered in lessons**
- **answers, diagrams, and procedures for student activities**
- **additional extension activities**
- **a quick-fact reference sheet for students (Page 21)**
- **Moon and Apollo mission trivia (Page 22)**

THE IMAX EXPERIENCE®

ABOUT THE FILM

The twelve Apollo astronauts who walked the lunar surface between the years 1969 and 1972 lived for a brief time in spaces only imagined. The Apollo project was a stunning demonstration of technological virtuosity, and many consider that was all it needed to be. The astronauts who made the million-mile journey to the Moon didn't just bring back rocks and pictures; they brought home the Moon as an extension of human territory. No longer just a bright circle in the night sky, people recognized the Moon as a place with mountains, valleys, canyons, and vast plains. The Apollo astronauts were true explorers, and only through the magic of The IMAX Experience can audiences go back to the Moon with them to see and hear their stories in a way never before possible.

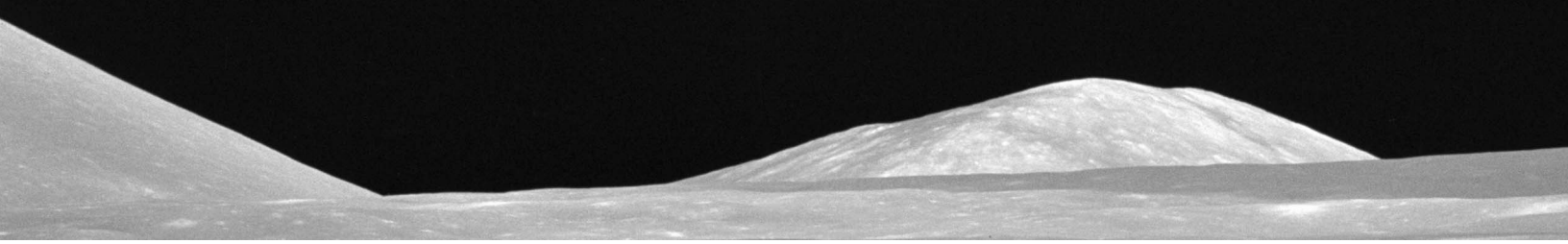
EDUCATION AND THE IMAX EXPERIENCE

IMAX® films are designed to educate and enlighten as much as they are to entertain. They offer educators a powerful teaching tool that extends learning beyond the classroom and integrates easily into existing curriculums. IMAX films provide students with unique and exciting opportunities to explore new worlds and new ideas.

With breathtaking, crystal-clear images up to eight stories high and state-of-the-art surround sound, The IMAX Experience® takes viewers to places only imagined. The highly-specialized and precise projectors employ a unique system that ensures outstanding clarity and brightness. The IMAX Experience is completed by a specially-designed sound system, ensuring that each viewer receives the same sound quality. Only IMAX technology lets you feel as if you're really there.

More than 700 million people around the world have been mesmerized and educated by The IMAX Experience. Technically advanced and visually stunning, The IMAX Experience continues to be the world's most immersive theatre entertainment.

IMAX invites your students to think big®.



EDUCATOR'S GUIDE TO STUDENT ACTIVITIES

MOON MYTHS VS. REALITIES (Page 10)

(Language Arts and Critical Thinking – All Grades)

Objective: *To strengthen students' critical thinking and comprehension skills*

Have students write the myth and reality statements into the chart independently before reading. Have groups read the upside down passage so they can check their work. Then provide the additional myth and reality statements below and have students predict where they belong in the chart. Read aloud the explanations provided so students can check their predictions.

The Moon "rises" and "sets"—just like the Sun. (Myth) The moon doesn't rise and set—and neither does the Sun. It seems like the Moon rises and sets, but that's just a trick of the eye. That's because the Earth is spinning around and around at the same time the Moon is going around it.

The entire Moon has very cold temperatures. (Myth) Brr! On the "dark side" of the Moon, the average temperature is a chilly -279˚F (-173˚C). But it isn't cold everywhere on the Moon. On the sunlit side, the average temperature is around 212˚F (100˚ C). (The average temperature on Earth is 60˚F, or 15.5˚C.)

The Moon doesn't have weather. (Reality) The Moon doesn't have weather because it doesn't have an atmosphere. That means there's no rain, wind, or snow to disturb the surface of the Moon. (Even footsteps left by astronauts!)

A lunar eclipse happens within a few minutes. (Myth) A lunar eclipse occurs when the Earth is directly between the Sun and the Moon. The Earth will block the Sun's light from reaching the moon. A lunar eclipse can occur for about 1 to 4 hours.

Extension Activity

The Moon has played a major role in stories, myths, plays, music and art. It has inspired many tales in almost every culture, including Roman and Greek mythology and Native American and African legends. Have students write their own myths or legends about the Moon. Since most traditional literature was shared through oral retellings, encourage students to read the stories aloud or ask a group to act out a scene as a play.

EXPAND THE IDEA!

Check out this Web site to learn more about Moon myths: **http://amazing-space.stsci.edu/eds/tools/type/myths.php**

PHASES OF THE MOON (Page 11)

(Science – Grades 3-6)

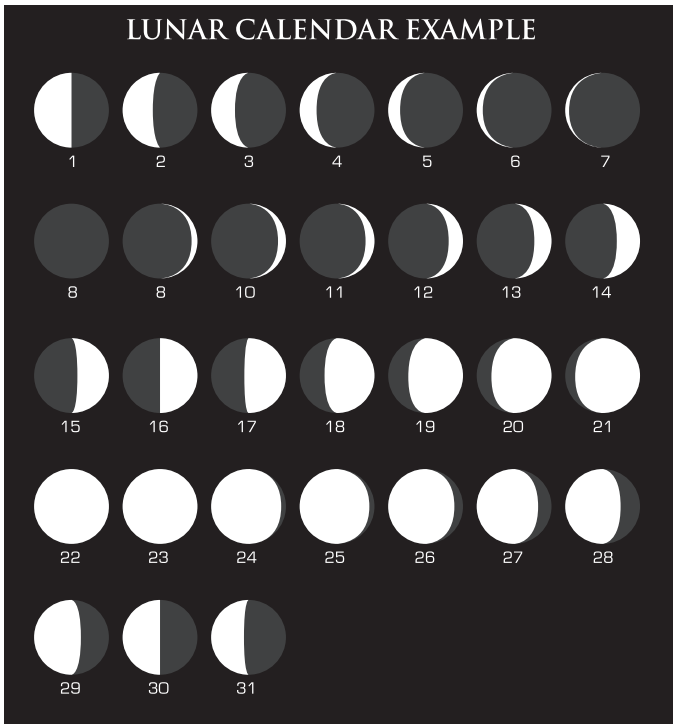
Objective: *To strengthen observation skills and teach students about the phases of the Moon.*

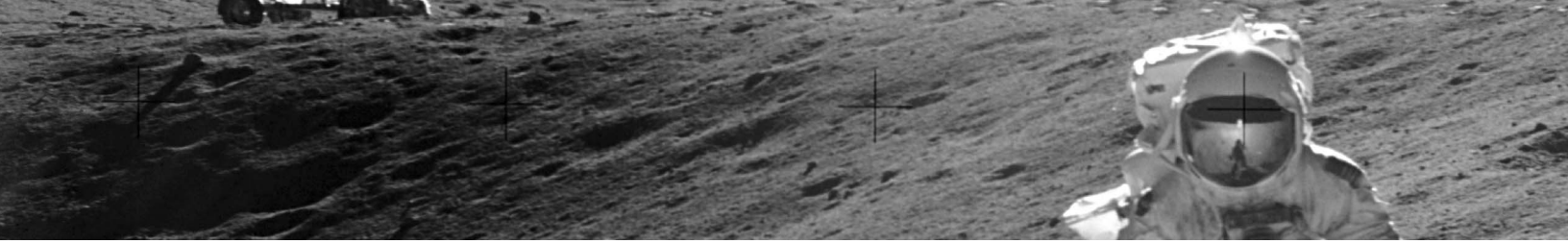
For thousands of years, people have been watching and tracking the phases of the Moon. The Moon's 29½-day calendar was the basis for one of the earliest calendars on Earth. As students chart the Moon's phases, ask what geographic features are visible and why only one side of the Moon is visible to people on Earth at all times.

If the Moon is not visible to students in your area (due to weather or an increased amount of light), direct students to visit **www.nasa.gov/audience/forkids/home/CS_What_Will_Moon_Look_Like.html** to view NASA's daily online photos of the Moon.

Extension Activity

After students have charted the Moon's phases, ask them to predict the future dates for the next month's full Moon, new Moon, waxing gibbous and waning crescent. As an extra challenge, have the class predict the dates of the Moon's phases for an entire year and then track the Moon's calendar using your local newspaper or the Internet.





CRATERS AND CANYONS (Page 12)

(Math and Science – Grades 6 and up)

Objective: *To have students test and measure the sizes of model asteroids and the "craters" they leave on the lunar surface*

The Moon does not have an atmosphere to slow down objects coming towards it. For that reason, asteroids are able to hit the Moon's surface at high impacts, leaving many scars, or craters, on the lunar surface. In this activity, students will measure and chart the size of the craters left by asteroids on a model lunar surface.

Extension Activity

As students are performing the "Craters and Canyons" activity, ask them to observe the ejecta—the debris or dust that is thrown off during an impact and formation of a crater. Try measuring the distance of the model ejecta (the dirt or flour that flies outwards upon impact). You can also ask students to repeat the experiment from a distance above the pan or bowl. As an extra challenge, ask students to predict the differences in the width and depth of the craters from the higher distances and then confirm their predictions after performing the activity. Students can also convert all weights and measurements to the metric system.

MOON MASS (Page 13)

(Math – Grades 6 and up)

Objective: *To develop students' computation skills as they compare gravity on the Earth and the Moon*

This activity will complement your existing science curriculum on gravity, forces, and types of energy. The force of gravity on the Moon is about ⅙ as strong as it is on the Earth. To help students understand this fractional comparison, use a simpler example, such as ½, to explain why the weight of objects on Earth are divided by 6. (If the pull of gravity on another celestial body is ½ the pull of gravity on Earth, you would divide by 2—the denominator.)

Older students can try using 0.165 in place of ⅙. (To explain why it can be used, tell students that there is a mathematical formula for comparing the forces of gravity on the Earth and Moon. The formula involves finding the ratio between the force of gravity on the Moon and the force of gravity on the Earth. The force of gravity is calculated using the masses and radiuses of each. It is determined the same way for planets and other celestial bodes.)

Extension Activity

The "giant leap" Neil Armstrong took while on the Moon demonstrates the effect a weaker gravitational pull would have on objects. Explain that gravity holds an object down on Earth. On the Moon, objects seem to float or remain suspended longer than on Earth. To demonstrate this concept, ask students to take a "giant step." Compare the amount of time that lapses during a step each student takes to that of the "giant leap" made by Neil Armstrong while on the Moon.

Extension Activity

Ask students to name people that experience microgravity, other than astronauts. Sky divers and trampoline acrobats experience weightlessness for up to a few seconds when they "free fall." So do people that ride roller coasters. Trained pilots can also experience the effects of low gravity when they fly a parabolic, or bell-shaped, maneuver at altitudes between 24,000 and 32,000 feet. The plane is pulled up "nose high" at a 45 degree angle. When the plane makes it over the top of the maneuver, the pilots experience weightlessness for about 25-30 seconds. Draw a parabola on the chalkboard or chart paper and point out the top area where weightlessness will occur.

WORKING FOR NASA (Pages 14-15)

(Language Arts and Math – All Grades)

Objective: *To have students answer an interest inventory to discover NASA careers that might be right for them*

NASA employs over 400,000 people in a variety of positions, including researchers, scientists, engineers, computer programmers, technicians, personnel specialists and media executives. But the most popular and well-known of all of NASA's employees are the astronauts.

Many people dream about becoming an astronaut. This activity allows students to see if they have what it takes to journey into space, or work as another important member of the NASA team. Here are some specific requirements for becoming a NASA astronaut.

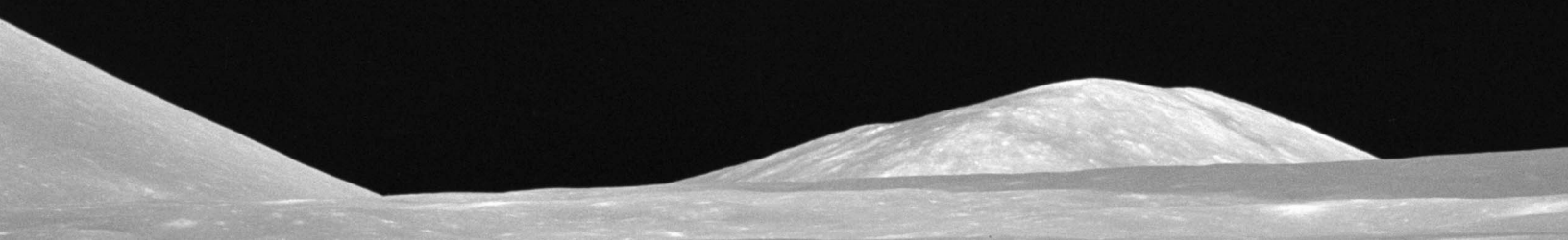
NASA requirements for mission specialist astronauts:

- A four-year Bachelor's degree in engineering, biological science, physical science or mathematics; a Masters or Doctorate (Ph.D.) is desirable
- At least three years of professional experience related to your college degree
- Ability to pass a NASA space physical, including:

  Eyesight: 20/20 or better uncorrected, 20/20 corrected (with glasses or contacts)

  Blood pressure: no higher than 140/90 (measured in a sitting position)

  Height: between 58.5 and 76 inches



To be a pilot astronaut, you also need:

- At least 1,000 hours of pilot-in-command flying time in a jet aircraft
- Height between 64 and 76 inches

Extension Activity

Make a class list of occupations at NASA, from the astronauts and engineers to the maintenance crew and security staff. Point out that students who are not inclined to fields in math or science can still work at a space agency in various positions.

EXPAND THE IDEA!

Check out this Web site to learn more about NASA careers: **http://edspace.nasa.gov/careers**

LIVING IN SPACE Q&A

(Page 16)

(Language Arts and Math – All Grades)

Objective: *To have students examine how everyday tasks are done in space and compare them to analogous situations*

Living in orbit or on a space station is a lot like living on Earth—astronauts eat, sleep, work, exercise, and play. Astronauts eat three planned meals a day, plus snacks. They also spend a lot of time just preparing the meals.

Mix-up a space meal to eat here on Earth just like an astronaut would do! Here's how:

Ingredients:

1 box of instant pudding (2.5oz.)
¼ cup of dry milk
2 cups of water (warm or cold)
a sandwich-sized zipper bag

Method:

1. Empty the box of instant pudding into the zipper bag.
2. Add the dry milk.
3. Zipper and shake the sandwich bag to blend the contents.
4. Open the bag and add the two cups of water.
5. Zipper the bag again. (Be sure that it isn't filled with air.)
6. Knead the bag gently until all the ingredients have combined.
7. Eat the pudding using a spoon or punch a small hole into one corner and squeeze it into your mouth!

EXPAND THE IDEA!

Log on to **http://spaceflight.nasa.gov/living** to learn more about this topic. Have students visit **www.ag.iastate.edu/centers/ftcsc/pages/meal.htm#** to see a photo of a real space food tray.

Extension Activity

Have students check refrigerators and cupboards at home and then list five things that astronauts could eat in space and five things they could not. (Hint: No crumbs allowed in space!)

Extension Activity

Astronauts need a break from their busy daily schedules. Days or even months of straight work is certain to cause stress among crew members. That's why flight planners on Earth schedule time during each day for astronauts to relax, exercise and have fun. Astronauts talk to friends and family using special phones that call directly home! They also listen to musical wake up calls. Log on to **http://spaceflight.nasa.gov/living/spacesleep/index.html** to have students hear a few.

MOONOLOGY: THE GEOLOGY OF THE MOON

(Pages 17-18)

(Science and Math – Grades 3-5)

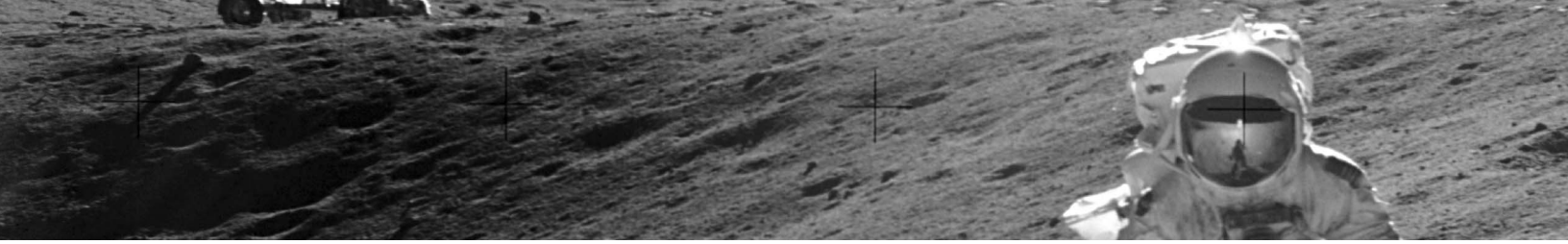
Objective: *To strengthen students' scientific inquiry abilities by collecting, observing, and analyzing data*

In this two-part activity, students will collect rock and soil samples as the astronauts did during the Apollo missions. Students will use the samples to learn more about the geology where they live—just like scientists and geologists learned about the Moon from the Apollo samples.

ROCKS

The Apollo Moon missions succeeded in bringing 843 pounds of rocks and soil samples from the Moon for scientists and geologists to study here on Earth. From these samples, it has been learned that:

- The Moon was once active with volcanoes and had a magma core.
- The lack of wind and water on the Moon means there is no erosion to wear away the lunar surface. This has allowed the Moon's surface to remain virtually unchanged for thousands of years.
- Because the Moon does not have an atmosphere, its dust-covered regolith (or surface) becomes embedded with particles from solar winds. Solar winds leave deposits on the Moon that may hold clues to the formation of the universe.
- Footprints left behind by astronauts more than 30 years ago will remain on the Moon's surface for thousands of years.
- The Moon scientists are studying today, through rocks and dust collected during missions, is pretty close to the same Moon that existed thousands of years ago.



Extension Activity

Have students sort all of the rocks collected according to these categories: size, color, shape, hardness. Encourage students to point out similarities and differences among the rocks. Pick up the *National Audubon Society Field Guide to North American Rocks and Minerals (Audubon Society Field Guide)* by Charles Wesley Chesterman to help you identify the rocks. Then weigh all the rocks students collected and compare the total weight to that of the 843 pounds of Moon rocks collected by Apollo astronauts.

SOIL

You'll need:

- two (2) plastic zipper bags
- gardening shovel
- measuring cups and spoons
- distilled water
- pH strips
- magnifier

What to do:

1. Find a location site (backyard, street corner, under a tree or flowering plant).
2. Label two plastic zipper bags with the location site.
3. Use a gardening shovel to dig into the soil (about 6 inches deep).
4. Scoop one tablespoon of soil and place it into a plastic zipper bag. Scoop a second tablespoon into the other bag.
5. Add ¼ cup of distilled water into the first bag.
6. Zipper the bag closed, and then shake!
7. Dip a pH strip into the soil-water mixture.
8. Match the color change on the pH strip with the key on the container. (7=Neutral; Less than 7=acidic; Greater than 7=basic)
9. Empty the soil from the second bag onto a white piece of paper.
10. Observe the soil using a magnifier. (Notice the color and shape of the grains.)

Extension Activity

The tines on the rakes used by astronauts were only one centimeter apart. Draw lines one centimeter apart at the bottom of a piece of construction paper. Cut along each of the lines and then cut out every other flap. Have students look closely at the small space between each. *Ask: What objects on Earth do you think you could gather using a rake like this?*

EXPAND THE IDEA!

Check out this Web site to learn more about this topic:
http://teachspacescience.org/cgi-bin/search.plex?keywords=craters

MOON MAP

(Page 19)

(Math – Grades 5 and up)

Objective: *To have students use charts to learn more about the lunar landing sites.*

In 1961, President John F. Kennedy challenged the nation to send a man to the Moon before the end of the decade.

I believe that this nation should commit itself to achieving the goal, before the decade is out, of landing a man on the Moon and returning him safely to Earth.
— President Kennedy's State of the Union Speech, May 25, 1961

That goal was achieved with the Apollo 11 mission on July 20, 1969, when Neil Armstrong took the first step on the lunar surface. Six more Apollo missions to explore and study the Moon followed. In 1972, Apollo 17 was the last crew to visit the Moon.

This activity provides a brief introduction to the Apollo missions and the areas of the Moon that were explored during the years NASA astronauts walked on the lunar surface. Students will read about the landing sites and then plot their positions using a grid. Once the activity is completed, discuss the various landing sites with your students. Ask the class why those sites might have been chosen.

IMAX® Extra! Answer: 93 kilometers is almost 58 miles

THE FUTURE OF LUNAR EXPLORATION

(Page 20)

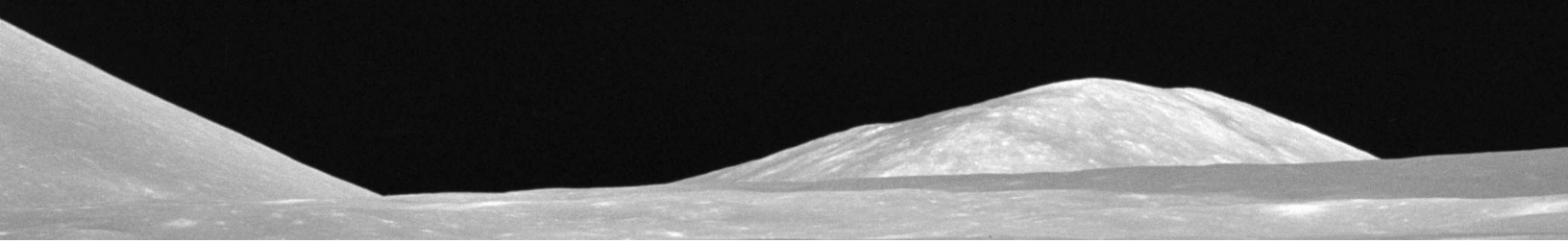
(Language Arts – Grades 7 and up)

Objective: *To strengthen students' debate and persuasive writing skills as they argue their position on the future of lunar exploration*

Should the Moon be colonized? NASA plans to return lunar rovers and astronauts to the Moon by the year 2020. There is also a mission to Mars underway, as scientists prepare for landing an astronaut safely on the Red Planet. Students will use this activity to put their persuasive writing skills to the test to acquire funding for future space missions, and debate whether or not the Moon should be colonized, or developed for civilization.

Extension Activity

Take a class poll to learn the number of students willing to live on the Moon. Ask students to poll adults and then compare the results.



ADDITIONAL EXTENSION ACTIVITIES

THE MOON'S ORBIT

To help students understand the rotation and orbit of the Moon, try the demonstration below. (You can modify the activity to demonstrate how the nine planets orbit around the Sun.) You will need a flashlight, aluminum foil, ruler, a ball about the size of a baseball, and a ball about the size of a golf ball.

- Cover the smaller ball with aluminum foil. This will represent the Moon. The larger ball will represent the Earth.
- Place the Earth and Moon models on a table, about 8 inches apart.
- Turn the flashlight on and lay it three feet from Earth and Moon models (you may need to place the flashlight on top of a few math and science books for the best exposure). The flashlight will represent the Sun.
- Use your finger to slowly move the Moon around the Earth. Be sure to keep the Moon at the same 8-inch distance from the Earth as you move it through its orbit.
- Have students notice the way the flashlight reflects light on the model Moon. This is the way the Moon appears to be illuminated from the perspective of the Earth. Compare this demonstration to the Moon's phases for a complete lunar calendar (29½ days).

SPACESUITS

The spacesuits worn by the astronauts on the Apollo 11 mission were self-contained life support systems that weighed 180-pounds. The NASA spacesuit has not changed drastically over the past three decades—it still has a large "bubble" helmet that attaches to the suit. Astronauts still wear caps with radios and microphones and a bodysuit with special tubing to keep cool in extreme heat.

Have students research the NASA spacesuits and those of other space agencies. Then get students to design their own version of spacesuits that meet all of the astronauts' needs, including extreme temperatures, movement, safety, communication and durability.

As a follow-up, compare the NASA spacesuit to a firefighter's safety equipment and early diving gear. Similarities: *self-contained breathing apparatus, protection from the elements and they permit people to move and do their jobs.*

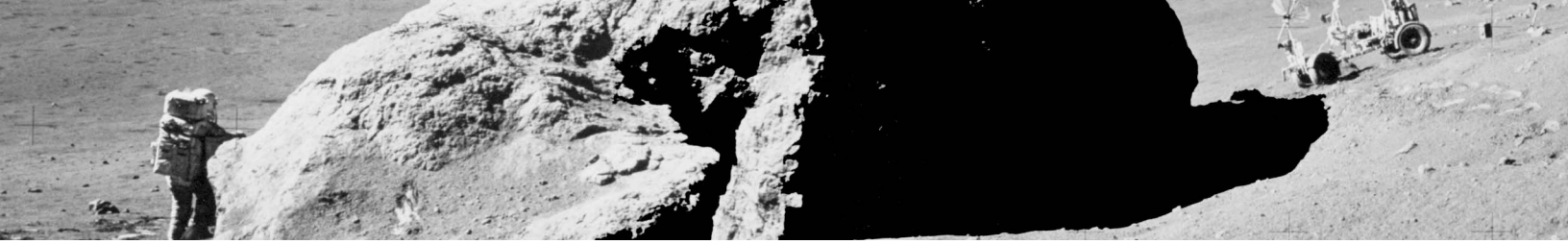
SPACE INVENTIONS

During NASA's four decades of space travel and exploration, many inventions and tools that have been designed for astronauts have made their way into the mainstream in order to make people's everyday lives easier. For instance, the cordless drill was first developed for astronauts who didn't have an outlet on board their spacecraft. Have students research other NASA inventions that have improved life for those of us on Earth.

EXPAND THE EXPERIENCE!

Space Camp and **Aviation Challenge**, located in Huntsville, AL, use space and aviation as a platform to excite and educate children ages 9-18 in the fields of math, science and technology. Programs run from 3-13 days, during which teamwork, self-confidence and communication are achieved through state-of-the-art simulations, missions and training.
Visit **www.spacecamp.com** or call (800) 63-SPACE for more information.

Challenger Learning Centers offer realistic mock-ups of Mission Control and an orbiting space station. Students "rev up" their imaginations and work together toward the mission's goal, whether it is the launching of a probe or the interception of a comet. E-mail **ns@challenger.org** or log on to **www.challenger.org** for more information on student programs.



Name _____

MOON MYTHS VS. REALITIES

Is the Moon made of cheese? Is there really a man in the Moon? No! These are just Moon myths, or imaginary stories and beliefs about the Moon. Reality is something that is an actual fact, such as: *The Moon orbits the Earth* and *The Moon is the Earth's nearest neighbor in space*. Some facts about the Moon sound like myths but they're really true. Other ideas about the Moon are not at all true, but it is difficult to convince people to think differently. In this activity you will decide if a Moon statement is true (reality) or false (myth).

HERE'S YOUR MISSION:

See if you can tell the difference between a Moon myth and reality. Read each statement below and decide if it is true or false. Write the statements in the chart under the headings you decide. Then turn the page upside down and read the short passage to check your work.

- The Moon is made of cheese.
- There is no water on the Moon.
- The Moon is located millions of miles from the Earth.
- The Moon is the Earth's nearest neighbor in space.
- Australia is wider than the Moon.
- The Moon has a dark side.
- It takes the Moon 29 days to complete its orbit.
- People don't feel a gravitational pull when on the Moon.
- The Moon has a tail.
- The Moon turns blue during the Blue Moon phase.

MYTH	REALITY

Put down the crackers because the Moon isn't made of cheese! It's made of dust and many types of rocks, especially those that formed after volcanoes erupted on the Moon. It's also a fact that there isn't any water on the Moon.

If you dream of becoming an astronaut but don't like long rides, don't worry, a trip to the Moon is not that far—between 227,000 and 254,000 miles away. (A road trip from New York to California is only about 3,000 miles!) The Moon is our closest neighbor. It's also about 2,161 miles wide—almost as wide as Australia at it widest points.

The Moon doesn't really have a "dark side" but one side of the Moon is never seen from Earth. That's because the Moon takes about 27 days to orbit the Earth, and about the same amount of time to spin once on its axis. The side of the Moon we do not see gets just as much sunlight on it as the side we do see.

The Moon does exert gravity on people and things, just not as much as the Earth does. On the Moon, people and things weigh about one-sixth of their weight on Earth. (One-sixth is much less than one-half.) That's why astronauts seem to "float" on the surface of the Moon.

Astronomers have seen a "tail" that streams from the Moon, although it can't be seen without a telescope. It is actually a 15,000-mile, glowing trail of sodium gases that is orange in color. Speaking of color, when two full moons occur in a single month, the second full moon is called a "Blue Moon." The Moon doesn't turn blue during the Blue Moon phase. However, "once in a blue Moon" (every two or three years) the Moon will have a bluish color during this phase.

Name _____

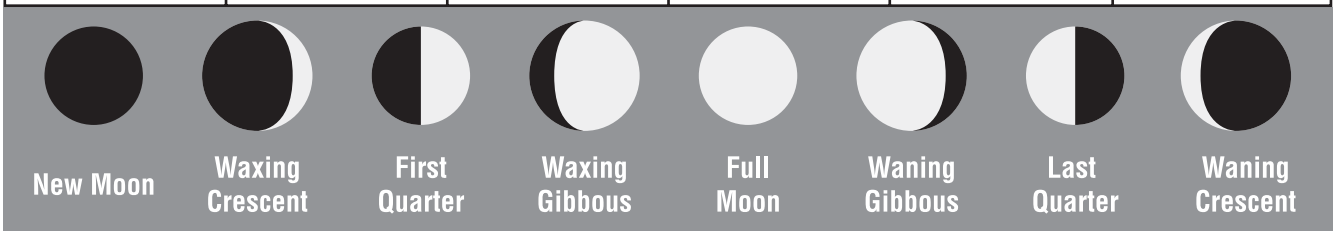
PHASES OF THE MOON

The Moon takes about 29½ days to complete its phases. The Moon doesn't actually change shape during each phase, we just see different amounts of sunlight reflected off of the Moon's surface. The phases are the changes in the different amounts of lighted surface of the Moon that we can see from Earth. During the New Moon phase, the Moon is between the Earth and the Sun. The side of the Moon that is not lit is facing the Earth, so we don't see the Moon during that phase.

HERE'S YOUR MISSION:

Observe the Moon every night for 30 days. Draw what you see each night in the correct box. After a month, you will have witnessed a complete Moon cycle!

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30

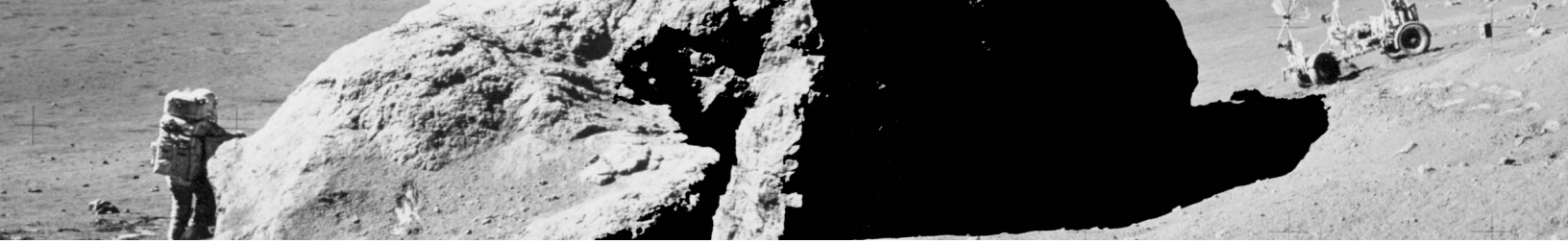


The New Moon could be seen on this date: _____

The Waxing Gibbous occurred on these dates: _____

The Full Moon occurred on these dates: _____

The Waning Crescent occurred on these dates: _____



Name _____

CRATERS AND CANYONS

The Moon's surface is covered with canyons, mountains, and craters. Craters are indentations, or "pot holes," that form when asteroids slam into the Moon.

HERE'S YOUR MISSION:

Does the size of the crater depend on the size of the object hitting the surface? Follow these steps to find out:

Step 1 Choose five round objects to be your "rocks." Try to keep your objects smaller than a golf ball.

Step 2 Measure the diameter of each object (the distance from one end of the object to the other). Write the results in the chart below.

Step 3 Find the mass of each object and write the results in the chart under "mass (kg.)."

Step 4 Cover an area of the floor with waxed paper (or try this experiment outside). Then, fill a large bowl or pan with sand or flour and place it on the waxed paper. Smooth out the surface of the sand or flour. This will be your "Moon surface."

Step 5 Hold each object five feet above the bowl or pan (or above your head) and drop them one at a time onto the surface. Try not to drop them all in the same place.

Step 6 Observe the size of the "crater" each object leaves on your Moon surface. Measure the distance across each crater and record the results in the chart below under "crater." If possible, also measure and chart the depth of each crater.

OBJECT	DIAMETER (cm.)	MASS (kg.)	WIDTH OF CRATER	DEPTH OF CRATER

After you have completed your chart, use the information to answer the following questions.

1. Which object left the largest crater? Give reasons:

2. What is the difference in diameter and mass between the largest object and the smallest object?

3. What is the difference in the size of the craters made by your largest and smallest objects?

4. How do you think the mass of an object affects the size of the crater it makes?

IMAX® Extra! Drop the objects onto the surface from various heights and angles. Then record your results. How did changes in height and angle affect the sizes of the craters?

Name _____

MOON MASS

Mass is the measure of how much matter an object contains or is made of. ***Weight*** is the force of gravity affecting an object. The mass of an object is measured in kilograms, and it will never change—no matter where in the universe the object is. However, the weight of an object can change. But that depends upon where the object is in the universe and the force of gravity at that location.

Gravity is the attraction between any two masses, or objects, in the universe. The strength of the pull depends upon the mass of the objects and the distance between them. Bodies that are close together, such as the Earth and Moon, have a strong attraction. Larger and heavier celestial bodies have stronger gravitational pull than smaller ones. The Earth's gravity pulls on everything on or near its surface, such as animals, people, and cars. Gravity is a good thing because it keeps people from falling off the planet. It also holds air in the atmosphere and keeps the water put!

The pull of gravity on the Moon is only about one sixth as strong as the pull of gravity on Earth. That's because the Moon's mass is less than the Earth's. Because the Moon's mass is less, you wouldn't be held down on the Moon's surface as you are on Earth—and you'd weigh less. (Even though you're made of the same amount of stuff.)

HERE'S YOUR MISSION:

Can you calculate how much objects would weigh on the Moon? Use the example below to help you.

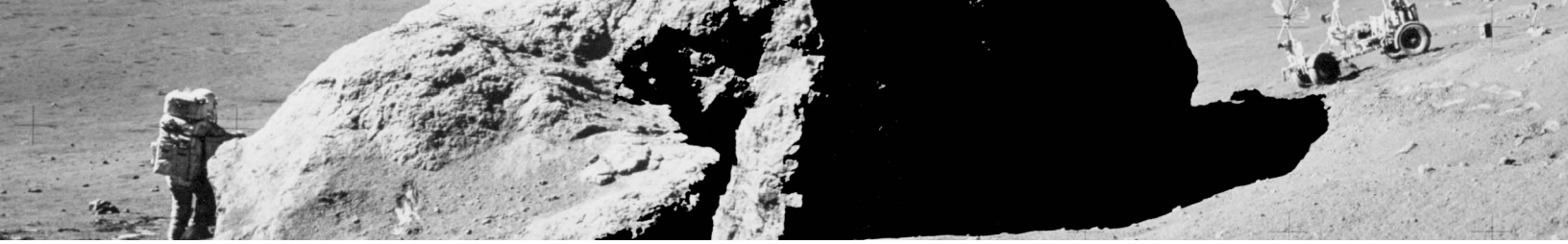
The average car weighs 3,000 pounds on Earth. Here's how to figure out the car's weight on the Moon:

WEIGHT OF CAR (LBS.) ÷ 6 = WEIGHT OF CAR ON THE MOON (LBS.)

3,000 lbs. ÷ 6 = 500 lbs.

OBJECT	WEIGHT ON EARTH (POUNDS)	÷ 6 (DIVIDED BY SIX)	APPROXIMATE WEIGHT ON MOON (POUNDS)
Five school books			
Backpack (full)			
Computer monitor (average weight: 46 lbs.)			
Globe			
Your choice:			
Your choice:			

IMAX® Extra! The pull of gravity on Mars is ⅓ that on Earth. Figure the approximate weight of the objects in the chart above on Mars. (Hint: Divide by 3).



Name _____

WORKING FOR NASA

NASA employs over 400,000 people in a variety of positions, including researchers, scientists, engineers, computer programmers, technicians, personnel specialists, and spokespersons. But the most popular and well-known of all of NASA's employees are the astronauts. NASA's latest group of astronaut candidates includes schoolteachers, doctors, scientists, and engineers.

HERE'S YOUR MISSION:

Take this quiz to see if you could make the cut to be an astronaut, or if your skills and interests could lead to another important job at NASA or another space center around the world. Read each question and write the point (0-5) to your response on the side. Find the total scores where indicated. When finished, read the job categories below to learn more about a NASA job that might be right for you.

1. Would you swim 75 meters wearing a flight suit and tennis shoes? Yes (5) No (0) **1.** ____

2. Can you tread water for 10 minutes without stopping? Yes (5) No (0) **2.** ____

3. Do you enjoy flying? Yes (5) No (0) **3.** ____

4. Are you able to read in a moving vehicle? Yes (5) No (0) **4.** ____

5. Would you ride NASA's "Vomit Comet" to train for weightlessness? Yes (5) No (0) **5.** ____

6. Would you eat dehydrated food for weeks at a time? Yes (5) No (0) **6.** ____

7. Can you live and work closely with several other people in small, confined spaces? Yes (5) No (0) **7.** ____

#1-7 Total ____

8. Do you feel comfortable speaking in front of groups? Yes (4) No (0) **8.** ____

9. Do you love to travel? Yes (4) No (0) **9.** ____

10. Are you comfortable working independently? Yes (4) No (0) **10.** ____

11. Would you enjoy working with educators, students, and the public? Yes (4) No (0) **11.** ____

#8-11 Total ____

12. Do you enjoy making things and testing how well they work? Yes (3) No (0) **12.** ____

13. Are you interested in how machines work? Yes (3) No (0) **13.** ____

14. Do you learn new technology easily? Yes (3) No (0) **14.** ____

15. Do you like to take things apart and then put them back together? Yes (3) No (0) **15.** ____

16. Do you have an interest in science, technology, space, chemistry, physics and/or math? Yes (3) No (0) **16.** ____

17. Are you interested in robotics and artificial intelligence? Yes (3) No (0) **17.** ____

18. Do you enjoy making things and testing how well they work? Yes (3) No (0) **18.** ____

19. Would you like to work in a lab performing experiments? Yes (3) No (0) **19.** ____

 # 12-19 Total ____

20. Are you good at reading maps and diagrams? Yes (2) No (0) **20.** ____

21. Can you follow oral directions? Yes (2) No (0) **21.** ____

22. Can you manage many tasks at once? Yes (2) No (0) **22.** ____

 # 20-22 Total ____

(continued)

Name _____

23. Do people call you a nature lover? Yes (1) No (0) **23.** ____

24. Do you like to explore outdoors? Yes (1) No (0) **24.** ____

25. Are you interested in biology? Yes (1) No (0) **25.** ____

#23-25 Total ____

Questions 1-7: If your total score for these questions is between 30 and 35, then you might have what it takes to be an astronaut! U.S. astronauts train for up to two years at the Johnson Space Center in Houston, Texas. They come from many different backgrounds, all of them scientific or technical. You may want to get your start as a jet pilot, which could lead to a career as an astronaut pilot.

Questions 8-11: If your total score for these questions is between 12 and 16, then you might make a great NASA Spokesperson, NASA Outreach Coordinator, or Aerospace Educator. These people speak on behalf of NASA and educate students, teachers, and the public about what NASA does, including important missions and initiatives.

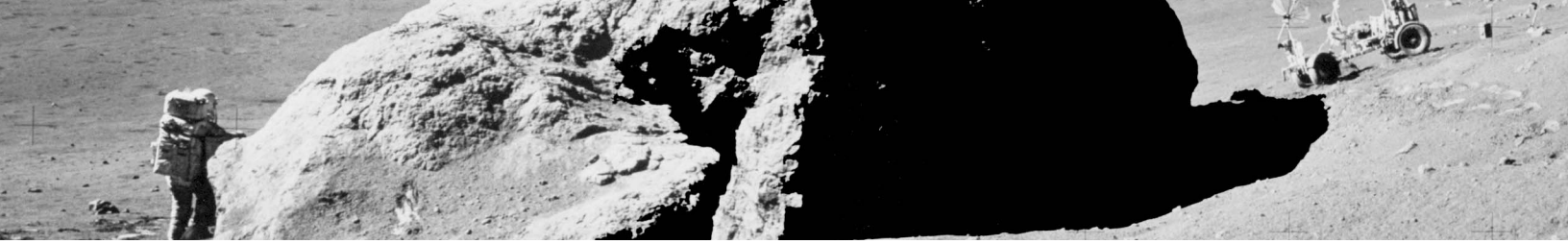
Questions 12-19: If your total score is between 18 and 24, then you might enjoy these NASA careers: Research Engineer, Research Model Technologist, Architect or Avionics Engineer. NASA employees in these positions create model spacecrafts, flight simulators, robotic parts, hardware, and spacesuits.

Questions 20-22: If you scored a total of 6 for all of these questions, then you might want to pursue a career as a Mission Manager, Mission Controller, or Systems Safety Engineer. Their job is to successfully navigate spacecrafts to destinations. They manage the mission way before liftoff by assuring all of the mission hardware, checking with engineers, and performing system safety activities.

Questions 23-25: If you scored a total of 3 for all of these questions, then you would be a great astrobiologist! Astrobiologists seek to understand the origin of cells, how parts of cells combine to create life, how the environment affects the way cells form and grow. Today, astrobiologists are working to learn whether life exists beyond our planet—and how it began!

Check out **http://education.nasa.gov** or **www.nasajobs.nasa.gov** for more information on NASA's student internship and employment programs.

IMAX® Extra! Research the education and career backgrounds of NASA astronauts and those from other space agencies. What are some of the career paths they took to become space explorers?



Name _____

LIVING IN SPACE Q&A

Living in orbit or on a space station is a lot like living on Earth—astronauts eat, sleep, work, exercise, and play. (Don't get too excited, astronauts also attend meetings and do chores, like taking out the trash!) Every activity that astronauts perform is scheduled—even free time. The schedule, called the Onboard Short-Term Plan (OSTP), is developed by operations managers on Earth. The graph below shows about how much time astronauts spend doing different tasks.

Q: *What do astronauts eat in space?*

A: The earliest space foods were freeze-dried, powdered, and bite-sized. Today's astronauts eat the same foods people eat on Earth. How? For one, scientists developed special packaging for a tortilla that will remain edible for about a year—and still taste good! But, the favorite space food among astronauts is still shrimp cocktail.

Q: *How do astronauts eat in space?*

A: Astronauts eat at tables using foot and leg holds. Knives, forks, spoons, and scissors are held to food trays using magnets. Beverage packets include special straws with clamps to prevent liquids from escaping into the cabin.

Q: *How do astronauts wash and keep clean?*

A: Each astronaut has a personal hygiene kit that can be stuck to a wall or locker. Besides brushing their teeth, astronauts mostly take care of personal hygiene without the use of water. For instance, they wash their hair with a rinse-free shampoo. Plus, the toilets don't use water to remove waste—it's all done with air!

Q: *How do astronauts sleep?*

A: Astronauts living on the space shuttle sleep inside sleeping bags in bunk beds, but they have to seat belt themselves in! There are only four bunk beds in the space shuttle, so some crewmembers have to sleep in their seats. Mission Control plays a wake-up song each morning, chosen by a different astronaut for each day.

HERE'S YOUR MISSION:

Read the graph to learn more about how astronauts spend their day. Then use the blank circle to make your own circle graph that shows how much time you spend performing tasks. (There are 24 sections for 24 hours.)

AN ASTRONAUT'S DAY

Morning Inspection: give blood for analysis later in the day

Pre- and Post-sleep: personal hygiene, cleaning, preparing for the day, and e-mails

Eating: three meals a day, plus snacks!

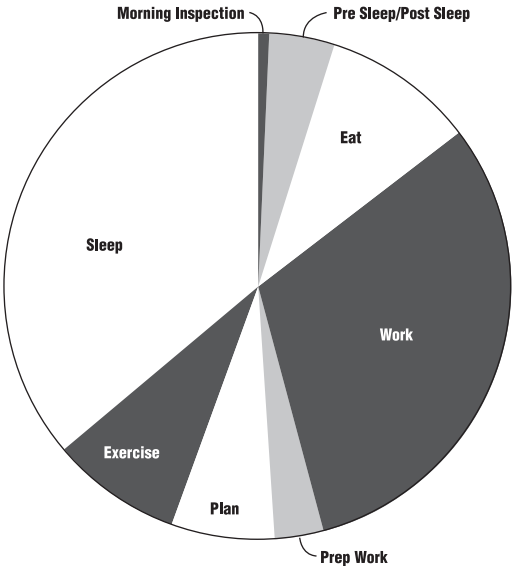
Working: performing experiments, space walks, blood analysis, and testing shuttle systems and oxygen levels

Prep Work: preparing for meals and experiments

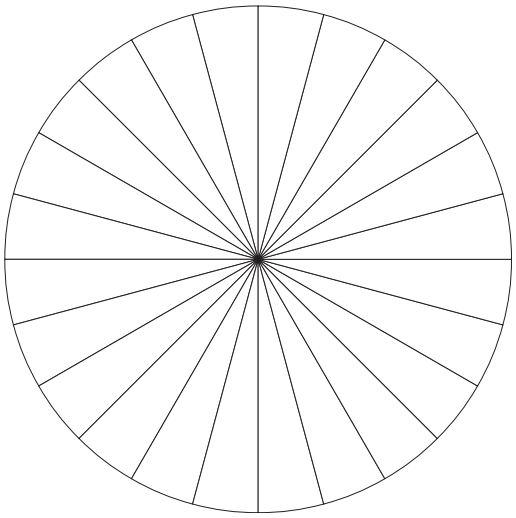
Planning: Daily Planning Conference (DPC)—meetings between the station crew and ground controllers to review and report daily activities

Exercising: about 2-2½ hours each day, but not just before or after mealtimes

Sleeping: crew usually sleeps between 8-9 hours



MY DAY



Name _____

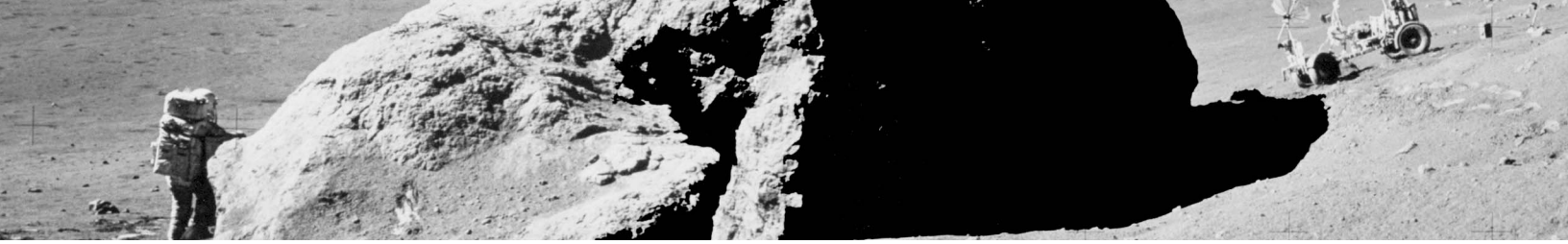
MOONOLOGY: THE GEOLOGY OF THE MOON (ROCKS)

The Apollo missions returned with a collection of over 2,000 soil and rock samples from the Moon. Altogether, these samples weighed 843 pounds! Astronauts used specially-designed rakes, shovels, and tongs to gather rocks and soil. Each sample was stored in a small bag labeled with an identification number matched to the collection site location. The rocks and dust the Apollo astronauts collected offer scientists clues to the history of the Moon, as well as our solar system. By studying the Moon, scientists learned that it had many volcanic eruptions. The rocks and soil in your neighborhood, school playground, and backyard provide clues about the Earth's history.

HERE'S YOUR MISSION:

Be a geologist! A geologist is a scientist who studies rocks and soil to learn about the Earth's history in a particular region. In this activity, you'll collect rocks and soil to discover clues about the topography of your neighborhood. Use this chart to help you collect and analyze your samples.

ROCK COLLECTION	
Name of Geologist: *(Your Name)*	**Date:**
Draw a picture of your rock here:	**Describe your rock here:**
Test the hardness of your rock. "Hard" rock scratches glass; "soft" rock does not scratch glass but scratches other rocks; "very soft" rock can be scratched with a fingernail. Write about the hardness of your rock here:	



Name _____

MOONOLOGY: THE GEOLOGY OF THE MOON (SOIL)

The Moon's soil, called regolith (say: REH-go-lith), is made of very fine dust, tiny pebbles, and bits of glass. The Moon's soil doesn't have plant fossils. However, the Moon's soil has been put on plants growing on Earth and scientists noticed that they seemed to grow better than plants without the Moon's soil.

HERE'S YOUR MISSION:

Be a geologist! The soil collected by the first Apollo astronauts on the Moon was dark gray to brownish gray in color. In this activity, you'll collect soil samples to discover clues about the "dirt" where you live. Use the chart below to help you collect and analyze your rock and soil samples.

You'll need:

- two (2) plastic zipper bags
- gardening shovel
- measuring cups and spoons
- distilled water
- litmus strips (pH tester)
- magnifier

What to do:

1. Find a location site. **2.** Label two plastic zipper bags with the location site. **3.** Dig into the soil (about 6 inches deep). **4.** Scoop one tablespoon of soil into a plastic zipper bag and a second into the other bag. **5.** Add ¼ cup of distilled water into the first bag. **6.** Zipper the bag closed and then shake! **7.** Dip a pH strip into the soil-water mixture. **8.** Match the color change on the pH strip with the key on the container. **9.** Empty the soil from the second bag onto a white piece of paper. **10.** Observe the soil using a magnifier. (Notice the color and shape of the grains.)

SOIL SAMPLES

Name of Geologist: *(Your Name)*

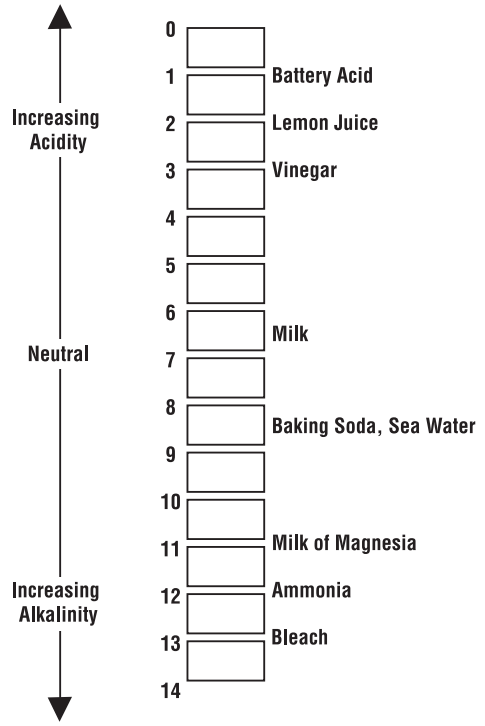
Date:

Write about your location site (including directions) here:

Gather a diverse mix of rocks from around your neighborhood.

When I observed my soil using a magnifier I noticed:
(Draw a picture)

Color in the pH scale and label the number of your soil sample:



IMAX® Extra! Special tools with tongs and shovels on the ends had to be designed to help the astronauts collect the rocks and soil samples because the pressure suits made it hard for them to bend over.

Name _____

MOON MAP

When the *Eagle* landing craft set down on the Moon on July 20, 1969 as part of the Apollo 11 space mission, it was the result of years of planning, designing, testing and hoping.

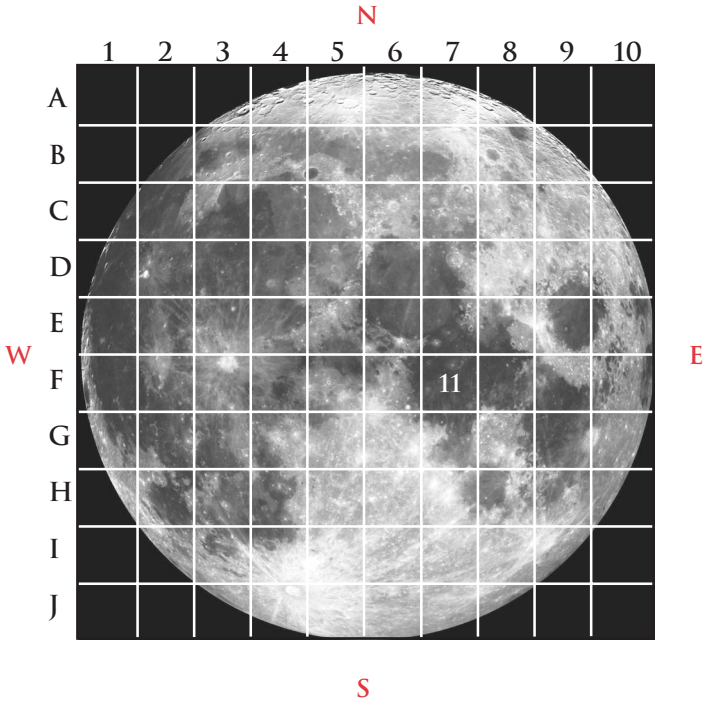
Six-hundred million people tuned in their television sets to watch astronauts Neil Armstrong and Edwin "Buzz" Aldrin become the first humans to set foot on the Moon, as Michael Collins piloted the *Columbia* spacecraft. Armstrong and Aldrin spent almost 22 hours on the Moon's lunar surface, called the regolith, collecting rocks and samples.

Six more missions and 12 more astronauts returned to the Moon to further study Earth's only natural satellite. The Apollo 17 mission in December 1972 was the last time anyone walked on the Moon. Since then, the Moon has been explored by lunar rovers—computerized or mechanically-operated vehicles—that collect samples and send pictures back to Earth.

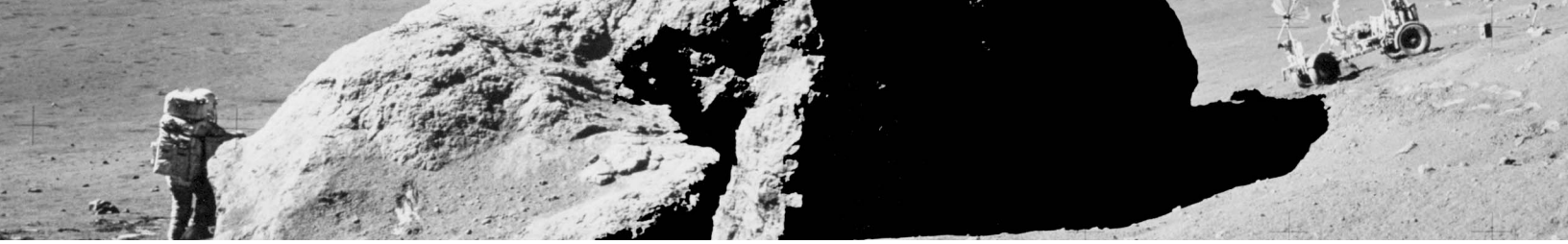
HERE'S YOUR MISSION

The Apollo missions landed on different areas of the Moon in order to study its vast landscape. To find where the NASA missions landed, find each location in the chart and then plot the coordinates on the map of the Moon. Write the Apollo mission number (11-17) in the correct square. (We did Apollo 11 to get you started.)

MISSION	LANDING SITE	LOCATION
Apollo 11	Sea of Tranquility	7F
Apollo 12	Ocean of Storms	3G
Apollo 13	Fra Mauro	4G (mission halted)
Apollo 14	Fra Mauro	4G
Apollo 15	Nothern extreme of Montes Appenninus (mountains)	5E
Apollo 16	between Craters Theophilius and Hipparchus	7H
Apollo 17	Montes Taurus (mountains)	7E



IMAX® Extra! Find Crater Copernicus on the Moon Map at 3F. The crater is 93 kilometers across. About how many miles wide is this crater?



Name _____

THE FUTURE OF LUNAR EXPLORATION

NASA plans to return to the Moon in the next decade. A mechanically-operated lunar rover is scheduled to visit first, followed by an astronaut mission by the year 2020. Scientists predict that the next crew to visit the Moon will establish a lunar station where astronauts can live and work.

HERE'S YOUR MISSION:

You and a classmate will debate the issue of colonizing the Moon. One person will argue in favor of establishing a community on the Moon, and the other will take the position of being against it. Before you begin debating, research and write down the main points of your argument in the chart below. (Record notes from your partner's arguments.)

Q: SHOULD THE MOON BE COLONIZED?

FOR	AGAINST
Name:	**Name:**
Argument 1: *(Main Idea)*	
Argument 2: *(Cause/Effect)*	
Argument 3: *(Similar Situation)*	
In Conclusion:	

APOLLO MISSIONS QUICK-FACTS REFERENCE SHEET

Apollo 11
Length of mission: July 16 – 24, 1969
Crew: Neil Armstrong, Michael Collins, Edwin "Buzz" Aldrin
Command Module: Columbia/*Lunar Module:* Eagle
Lunar landing: July 20, 1969 at the Sea of Tranquility
Moonwalk duration: 2 hours, 31 minutes
Weight of Moon samples collected (in pounds): 47.7

Apollo 12
Length of mission: November 14 – 24, 1969
Crew: Charles "Pete" Conrad, Richard Gordon, Alan Bean
Command Module: Yankee Clipper/*Lunar Module:* Intrepid
Lunar landing: November 19, 1969 at the Ocean of Storms
Moonwalk duration: 7 hours, 45 minutes (two moonwalks)
Weight of Moon samples collected (in pounds): 75.7

Apollo 13
Length of mission: April 11 – 17, 1970
Crew: James Lovell, John Swigert, Fred Haise
Command Module: Odyssey/*Lunar Module:* Aquarius
Lunar landing: Did not land; mission canceled following the explosion of an oxygen tank inside the service module
Moonwalk duration: Not applicable
Weight of Moon samples collected (in pounds): Not applicable

Apollo 14
Length of mission: January 31 – February 9, 1971
Crew: Alan Shepard, Stuart Roosa, Edgar Mitchell
Command Module: Kitty Hawk/*Lunar Module:* Antares
Lunar landing: February 5, 1971 at Fra Mauro
Moonwalk duration: 9 hours, 21 minutes (two moonwalks)
Weight of Moon samples collected (in pounds): 94.4

Apollo 15
Length of mission: July 26 – August 7, 1971
Crew: David Scott, Alfred Worden, James Irwin
Command Module: Endeavor/*Lunar Module:* Falcon
Lunar landing: July 30, 1971 at Montes Appenninus
Moonwalk duration: 18 hours, 33 minutes (three moonwalks)
Weight of Moon samples collected (in pounds): 169

Apollo 16
Length of mission: April 16 – 27, 1972
Crew: John Young, T. Kenneth Mattingly, Charles Duke
Command Module: Casper/*Lunar Module:* Orion
Lunar landing: April 20, 1972 between Craters Theophilius and Hipparchus
Moonwalk duration: 20 hours, 14 minutes (three moonwalks)
Weight of Moon samples collected (in pounds): 208.3

Apollo 17
Length of mission: December 7 – 19, 1972
Crew: Eugene Cernan, Ronald Evans, Harrison Schmitt
Command Module: America/*Lunar Module:* Challenger
Lunar landing: December 11, 1972 at Montes Taurus
Moonwalk duration: 22 hours, 2 minutes (three moonwalks)
Weight of Moon samples collected (in pounds): 243.1

MOON AND APOLLO MISSION TRIVIA

DID YOU KNOW...?

- The Moon is often called Luna, named for the Roman goddess.
- The Moon is about 238,860 miles (384,400 kilometers) from the Earth.
- The diameter of the Moon is about 2,160 miles (3476 kilometers).
- The mass of the moon is 7.35e22 kg, or 7.35 x 10^{22} kg. (That's about 74 quitillion metric tons.)
- The average temperature on the side of the Moon exposed to Sun can reach as high as 260˚F.
- The coldest nighttime temperature on the side not exposed to the Sun can reach as low as -280˚F.
- The force of gravity on the Moon is about one-sixth as strong as gravity on the Earth.
- Maria are "seas" that formed about 3.5 billion years ago when hardened lava flowed out from inside the Moon and into craters.
- Rocks from the Moon's surface are between 4.6 and 3 billion years old.
- The largest Moon crater is 2,250 km in diameter and 12 km deep but it is on the far side of the Moon, which means it cannot be seen from Earth.
- Bailly is the largest Moon crater that can be seen from Earth and measures about 183 miles (295 kilometers) across and 2.46 miles (3.96 km) deep.
- The Moon's orbit around the Earth takes 27 days, 7 hours, and 43 minutes.
- The period of lunar phases of the Moon takes 29 days, 12 hours, and 44 minutes.
- The theory that the Moon and the Earth were formed at the same time from the Solar Nebula is called "co-accretion."
- The theory that the Moon was a piece of Earth that separated is called "fission."
- The theory that the Moon formed in the galaxy on its own and was then "captured" by the Earth's gravitational pull is called "capture."
- The belief that that a very large object hit the Earth and sent debris flying into the sky which formed into the Moon is called "the giant impact theory."
- The Moon is slowly moving away from the Earth at the rate of an inch per year.
- It would take 81 Moons to equal the mass of the Earth.
- The nature of gravity was first described by Sir Isaac Newton more than 300 years ago.
- The Moon's gravitational pull causes the Earth's oceans to rise and fall with "high" and "low" tides.
- President John F. Kennedy challenged the United States to go to the Moon on May 25, 1961. NASA reached that goal on July 20, 1969.
- On July 20, 1969, Neil Armstrong was the first person to walk on the Moon. He stepped on to the Moon with his left foot.
- Each Apollo mission cost approximately $400 million.
- The footprints left on the Moon by the Apollo astronauts should last close to 10 million years, since there is no wind or water to erode the topsoil.
- Alan Shepard played golf on the Moon. Due to the low gravity environment, he was able to hit the ball almost one half of one mile.
- NASA employed 420,000 people to work towards putting a person on the Moon.
- At 6 feet tall, Gene Cernan was the tallest astronaut. He was also the last person to walk on the Moon.
- Approximately 600 million people watched the Apollo 11 lunar landing on television.
- At age 47, Alan Shepard was the oldest astronaut to walk on the Moon.
- There is approximately 20 tons of trash on the Moon, leftover from Russian and U.S. lunar missions.
- The largest rock collected from the Moon weighed almost 26.5 pounds. Its nickname is "Big Muley."
- After a $78,000 color television camera on board Apollo 12 failed to work, it was learned that the camera could have been fixed with a screwdriver. (Apollo 12 had a million dollars worth of tools on board—but no screwdriver!)
- Contrary to popular belief, freeze-dried ice cream was taken into space only once, during the Apollo 7 mission.

SPACE GLOSSARY

Aphelion: the point in its orbit when a planet is farthest from the Sun

Apogee: the farthest or highest point from a planet or satellite

Astronomical Unit (AU): the distance between the Earth and the Sun; standard measurement scientists use to measure distances between planets, stars, etc.

Craters: "potholes" in the Moon's surface formed by objects crashing into it

Full Moon: the point in the Moon's orbit when it is completely visible in the Earth's sky

Gravity: the attraction, or pull, celestial bodies have on one another

Maria: the dark, smooth areas of the Moon's surface, formed millions of years ago when lava flowed over its surface and hardened (singular form: mare)

New Moon: the point in the Moon's orbit when it is not visible in the Earth's sky

Orbit: the path of a planet or moon path around the solar system

Perigee: the closest point to a planet or satellite

Perihelion: the point in its orbit when a planet is closest to the Sun

Regolith: a mixture of fine dust and rocky debris produced by meteor impacts; regotlith makes up most of the Moon's surface

Rotation: one complete turn; the spin of a planet or moon

Satellite: an object that circles another object; the Moon is Earth's only natural satellite

Waxing Moon: phase where the Moon is growing from a crescent to a full moon

Waning Moon: the phase where the Moon is shrinking from a full moon to a new moon

RECOMMENDED WEB SITES

www.edspace.nasa.gov
NASA's Educator Astronaut Web site

www.nasa.gov/home/index.html
NASA's main Web page

www.nasakids.com
NASA's Web site for kids

www.science.nasa.gov
NASA's Web site that offers a picture of the day, weather information and science news

RECOMMENDED LITERATURE

Grades 3-5

Midnight on the Moon (Magic Tree House Series #8)
by Mary Pope Osborne

A magic tree house transports two children to a futuristic moon base

Moonwalk: The First Trip to the Moon (Step into Reading Books Series: A Step 4 Book)
by Judy Donnelly

A historical look at the first time a person walked on the Moon

Thirteen Moons on Turtle's Back: A Native American Year of Moons
by Joseph Bruchac

The different seasons are celebrated through Native American poems and legends

What the Moon Is Like
by Franklyn Mansfield

An imaginative journey to the lunar surface

Grades 5-8

Footprints on the Moon
by Alexandra Sly

A look at the history of lunar exploration and the astronauts who have walked on the Moon

The Man Who Went to the Far Side of the Moon: The Story of Apollo 11 Astronaut Michael Collins
by Bea Uusma Schyffert

A biography of Apollo astronaut Michael Collins

All Grades

The Moon
by Seymour Simon

An informational read about the Moon and its characteristics

RESOURCES USED TO DEVELOP THIS GUIDE

Print

10 Easy Steps to Teaching the Solar System (Learning Resources, 2002)

Soaring Through the Universe: Astronomy Through Children's Literature by Joanne C. Letwinch (Teacher Ideas Press, 1999)

Janice VanCleave's Teaching the Fun of Science by Janice VanCleave (John Wiley & Sons, Inc., 2001)

1000 Facts About Space by Pam Beasant (Kingfisher, 1992)

Internet

www.nasa.gov

http://lunar.arc.nasa.gov

www.space-explorers.com

www.space.com

www.nineplanets.org

http://spaceflight.nasa.gov/living

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