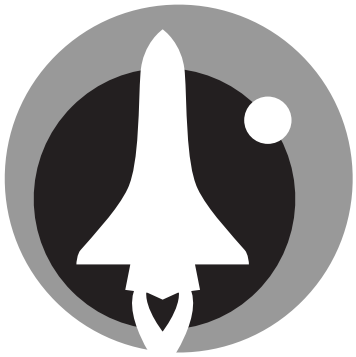


SPACE COMMAND

THE FUTURE HAS LANDED

Teacher's Guide

DEAR TEACHER,

Welcome to Space Command! Our low earth-orbiting space research station awaits you and your students. Because of the increase in space tourism, the station has opened a portion of its facility to the public to help visitors understand the purpose, experience the excitement, and appreciate the importance of space exploration. Space research missions are launched from our shuttle bays daily—even minute by minute—and you can participate in these explorations of deep space! Just come aboard.

The idea of visiting a space command center will add fun and excitement to your students' tour of space concepts. The exhibit is divided into four sections and has more than thirty interactive stations. As students walk through the entry and orientation portal, they will pass through a scanner that will help them make the transition from Earth to space. The Main Promenade of the Space Command Visitor Center provides a chronology of milestones in space flight and offers a view of the galaxy, just outside the window and visitors can choose to travel deeper through a star-filled skylight.

Students will then move into the Outer Space Outfitters area where they will learn about the planets in our solar system. The content emphasis is on what conditions are like on each planet—terrain, atmosphere, and gravitational pull. Travel posters and equipment advertisements as well as real artifacts from space travel are on display. Visitors can choose a planet to visit and find out what they would need in order to survive there. Students will see a shovel that the astronauts used during lunar training, a geology hammer they used to break off rock samples, and a penetrometer, a stick with lines on it for measuring the depth of the lunar soil.

As visitors leave the Outer Space Outfitters, they enter Remote Command. In this area, scientists manipulate exploration devices on planets with conditions that are inhospitable to humans. Visitors will participate in a three-person mission that requires each person to perform a critical task to make the mission a success. As visitors work through the simulation, they have to figure out and correct a problem, land on Mars, and collect samples to complete the mission. Another station allows visitors to track earth-orbiting satellite positions in real time. They will be able to track the International Space Station, the Hubble Space Telescope, a Tracking Data Relay Satellite (TDRS), and the space shuttle, if it is aloft. Visitors can also use satellite imagery to find their own houses from space.

A video in the entrance to the Space Academy asks for recruits with good observation skills. In this section of the exhibit, visitors use interactives to learn how other cultures have explored the sky for millennia and how the "sky-reading" skills those people developed are still used. Visitors can also test their observational skills through a computer-based activity. At the end of the challenge, the computer prints out a sky observation activity for the visitor to take home and do that night. When the task is completed, the visitor may email the results to the Space Command Academy, and receive a new activity to conduct. There are 52 sky-related observation activities in all, so visitors can do a new activity every week of the year.

If you time your visit to *Space Command* just right, you might be able to enroll in Space Command Boot Camp. In this live program, our drill sergeant will teach recruits some of the basics of space travel.

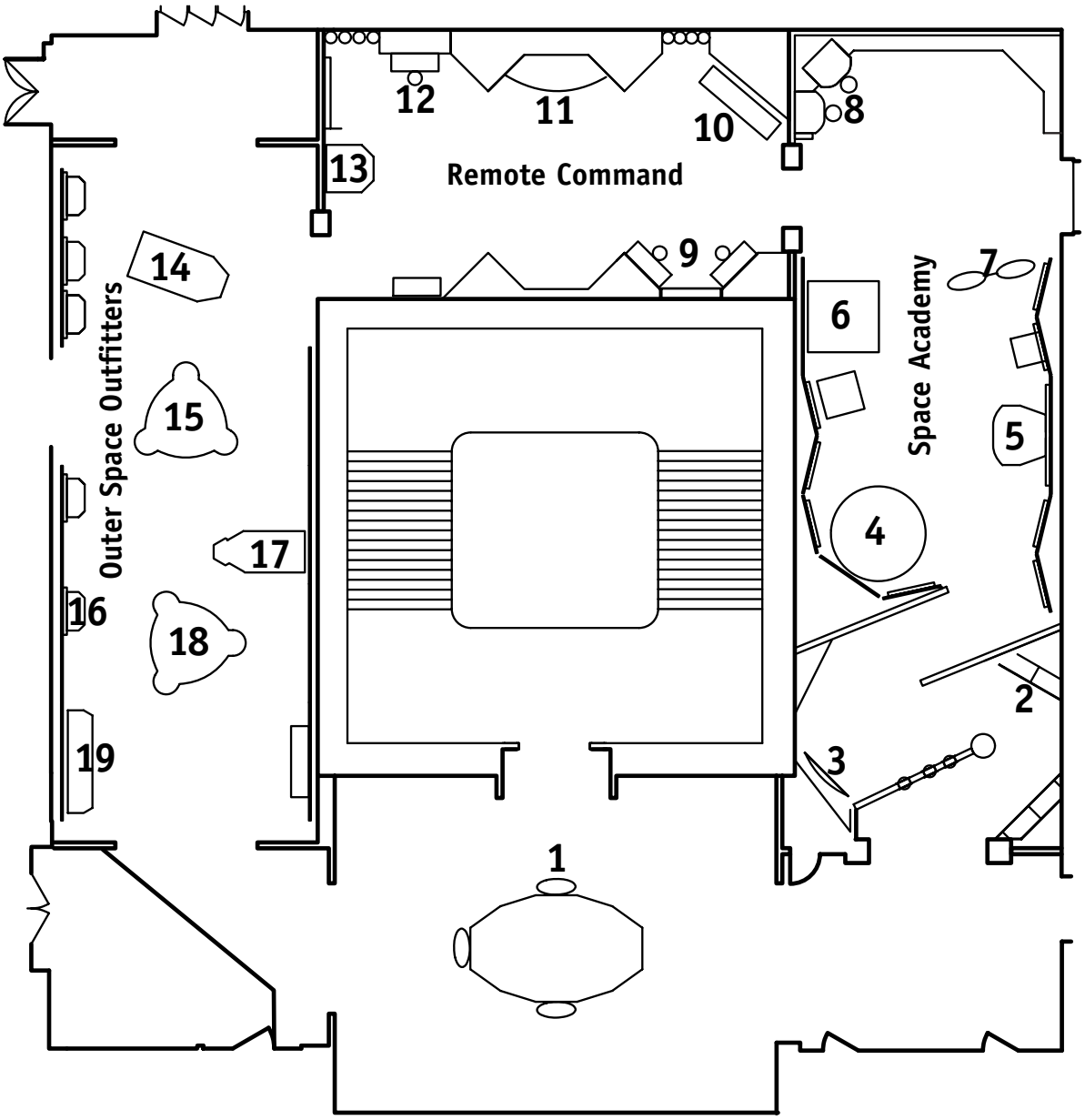
TEACHER SUPPORT

To help your students get the most from their visit to *Space Command*, this Teacher's Guide offers Previsit Activities to set the stage, In-Exhibit Activity Sheets to guide your students through the exhibit, and Post-Visit Activities to debrief students and extend and apply what they have learned in the exhibit. Helpful background information, cues, and suggested student responses are given throughout to provide solid science support for you.

This Teacher's Guide is divided into two sections, one for grades 1 through 3 and one for grades 4 through 6. A mini-table of contents at the beginning of each section lists the activities in that part. There is also a Further Resources section listing appropriate publications and Web sites to use in setting the stage for visiting *Space Command* and to provide follow-up materials. Relevant science standards based on the National Science Education Content Standards are referenced in each lesson.

We hope you and your students enjoy *Space Command*.

SPACE COMMAND FLOOR PLAN



1 Galact-O-Scope
2 Moon Rock
3 Parabolic Mirror
4 Moon Phases
5 The Sun's Path
6 Gravity Well
7 What Do You See
8 Academy Challenge
9 Find Your House from Space
10 Resolution
11 Remote Command
12 Satellite Tracking
13 Probe Rescue
14 Build a Rover
15 Space Suits
16 Interplanetary Travel Agency
17 Cooling Arm
18 Air Pressure in Action
Working in Space
Space Walk Gloves
19 Astronaut Lunch Boxes

SPACE COMMAND

GUIDE FOR GRADES 1-3

CONTENTS

GENERAL ORIENTATION

When your students visit Space Command, they will imagine that they are tourists visiting a low-orbiting space station where scientists carry out explorations of space. To help students get in the spirit of the visit, explain to them ahead of time the four areas they will see as described in the letter at the beginning of this guide: Main Promenade of the Space Command Visitor Center (the entrance), Outer Space Outfitters, Remote Command, and Space Academy.

Younger children may understand and get more from some stations than others in the exhibit. For example, although the astronaut gloves at the Working in Space station may be too large for small hands to use, children will enjoy trying them on. The lunch box gravity experiments and the cooling suit will intrigue them. They will have fun designing their own planetary rover and seeing how well it works. The Remote Mission Control computer simulation may be too complex for younger students, but they will be able to use the pin box experiment to see that the more pins there are, the clearer their hand appears (the greater the number of pixels in a picture, the sharper the definition of the picture). In the Space Academy section, children will be able to follow the phases of the moon, detect constellations, laugh at their funny reflections in the parabolic mirror, and be fascinated by the moon rock.

PREVISIT EXPLORATION: SOME GENERAL ACTIVITIES

At the entrance to Space Command, your students will be asked to become tourists visiting Space Command. So they get the most out of the learning opportunities that the exhibit offers, consider doing some of the following activities beforehand.

- Read aloud to the class some of the grade-level appropriate books on the Further Resources list and make as many as possible available to children for reading on their own in order to become familiar with astronomy and space.

- Some of your students may already know something about space and the sun, moon, and stars from picture books they have at home. Invite them to bring in their books to share with the rest of the class.

- To help build interest immediately before the visit, tell children stories of the Big Dipper and the Little Dipper from different cultures. Show a picture of the two constellations or draw them on the board. After you have finished the stories, draw a series of ten dots on the board and ask children what they think the dots represent. The dots should be placed randomly, but with enough definition so that children could discern several different objects, for example, a car, a wagon, a house, or even a flower. Students will work with this idea again at the Constellation Finder station in the exhibit.

- On the bus, give each child two pieces of paper folded in half so that they have eight surfaces on which to draw. Children should already have a sharpened pencil in order to fill out their In-Exhibit Guides. Ask children to think of an object that could become the name of a constellation and then draw ten dots on a sheet of paper to represent it. Seatmates could exchange their sheets and try to figure out what the name is of each other's new constellation. Continue until children's interest flags.

GRADES 1-3 PREVISIT ACTIVITY

Sizing Up the Planets

SCIENCE CONCEPTS

- The planets have properties, locations, and movements that can be observed and recorded.
- The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets, and numerous smaller objects.
- The sun is the central and largest body in the solar system.

SKILLS

Observing, distinguishing differences, taking measurements, working cooperatively

SUGGESTED TIME

1 or 2 class periods

MATERIALS

- Copy of Solar System graphic on next page to help students visualize the planets and to aid them in creating their mural
- 1 grapefruit or small cantaloupe
- 1 large orange, apple, or peach
- 2 plums or apricots
- 2 peas
- 3 peppercorns
- 1 basketball
- newsprint
- markers or water-based paints

Optional: substitute sports balls for the larger pieces of fruit and use pebbles of two sizes instead of the peas and peppercorns; the sports balls must be in the same size ratio as the fruit listed above

PROCEDURE

1. Explain that the solar system has nine planets of which Earth is the third planet from the sun. All the planets are different and one of the most noticeable differences is their size. Use the fruit to explore the different sizes of the planets. The pieces of fruit represent the following planets:
    - grapefruit or small cantaloupe: Jupiter
    - large orange, apple, or peach: Saturn
    - plums or apricots: Uranus and Neptune
    - peas: Venus and Earth
    - peppercorns: Mars, Mercury, and Pluto

2. Use a basketball to represent the sun. Then have children place the planets in their correct order from closest to the sun to farthest away: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

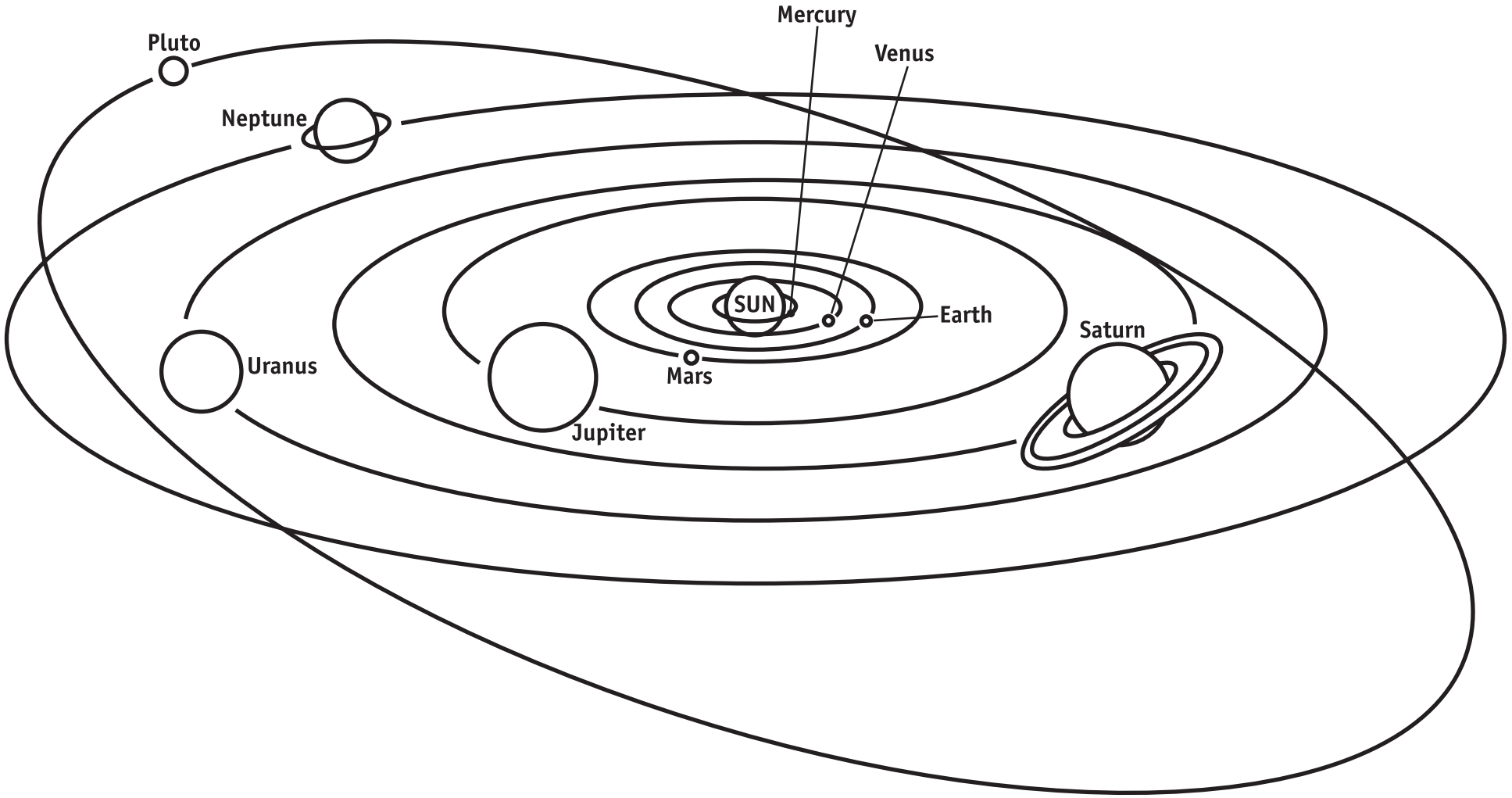
3. Ask children to make comparisons such as how many times larger or smaller one planet is than another, how many Jupiters it would take to make the sun, and so on. The sun is actually a little more than 8 times the size of Jupiter, the largest planet. For example, if Jupiter (the grapefruit) is 6 inches in circumference, the sun would be 48 inches or 4 feet around. (Students should be able to compare relative sizes easily and to make accurate estimates about how many of one planet would be needed to make another.)

EXTENDING THE ACTIVITY

Have children work in pairs to paint a mural of the solar system showing the planets in their correct order.

IN THE EXHIBIT

In Outer Space Outfitters, students will be learning about the planets of the solar system and the conditions that exist on each planet.



GRADES 1-3 PREVISIT ACTIVITY

Sizing Up the Planets

Distances not to scale

STUDENT IN-EXHIBIT EXPLORATION GUIDE

Grade 1

NAME _____

WELCOME ABOARD THE SPACE COMMAND VISITOR CENTER!

Look around you. What do you see? Draw a picture.

OUTER SPACE OUTFITTERS

A. Some lunch boxes are heavier than others. On what planet was the lunch box the heaviest?

_____

B. On what planet was the lunch box the lightest?

_____

C. Did you design a rover? Draw a picture of it here.

Grade 1 *continued*

REMOTE COMMAND

See your house from space. Type in your address. Draw what your house looks like.

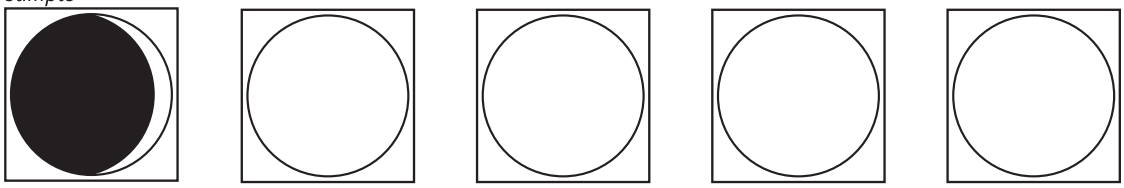
Try out the pin boxes. Start with the box with fewest pins. Try all the boxes.
Which box made the best picture of your hand?

Box _____

SPACE ACADEMY

Draw the different shapes of the moon.

sample



Find the moon rock. What is it like?

What is the oldest thing in the exhibit that you can touch?

TEACHER INFORMATION

Answers for In-Exhibit Exploration: Grade 1

SPACE COMMAND VISITOR CENTER

Reading all the plaques to the children may not be feasible, but point out the most important ideas:

- The Chinese began the concept of rockets with their gunpowder-filled bamboo tubes that they fired at enemies.
- The Russians put the first person in space in the last century—when your students' grandparents were probably children or teenagers.
- The first person landed on the moon a few years later. Only 12 people have ever walked on the moon.
- The next important step was sending up space stations that go around the Earth where scientists can live and work for months at a time.
- People can also explore space without ever leaving Earth. We use cameras, satellites, landers that send out rovers, and telescopes of many different kinds.
- This large telescope is from The Franklin Institute's own astronomical observatory.

Encourage children to draw the telescope in their In-Exhibit Guides.

OUTER SPACE OUTFITTERS

The humor in the travel posters may be too sophisticated for your students, but as you move through the exhibit, note the differences among the planets.

Point out the major features on the spacesuit display:

FRONT VIEW

- the helmet for protection and visibility
- temperature control valve to make sure the suit is neither too hot nor too cool
- tubes of running water that are close to the skin to keep the body cool
- lighting system

BACK VIEW

- two oxygen tanks
- water tank that holds the cooling system water

LAYERS DIAGRAM

- pressure bladder that keeps the suit airtight
- thermal management cover to protect against tiny meteoroids
- cooling layer—tubes of running water

There are several interactive activities in this section of the exhibit:

- a space glove children can try on and manipulate to see how difficult it is working in space
- a hand pump to observe the effects of air pressure or lack of it
- a cooling system similar to the layers of water tubes in a spacesuit
- the planetary rover design project

As children manipulate the interactives, encourage them to state what they did and what they felt or saw as a result of their actions. They will need to answer questions in their In-Exhibit Guide about the lunch box gravity exhibit. Have them also draw their rovers in their In-Exhibit Guides.

REMOTE COMMAND

While children may have fun working with the pin boxes, the science behind it may be too sophisticated, but they should be able to recognize that the box with the greatest number of pins makes the best impression of their hand. The pins represent pixels, the tiny dots that make up pictures. The more dots—the more pins—the greater the clarity, or resolution, of a picture.

To see their houses from space, children must type in their street address and zip code. The image on the screen will zoom down to the roof of their homes. The children will be able to zoom in and out and scroll around their houses.

At Traffic Control: Crash Warnings, children can check on the International Space Station, the Hubble Space Telescope, a Tracking and Data Relay Satellite, and the space shuttle, if it is aloft. The main screen will trace the satellite's path across the Earth and the two inset screens will show the path from the satellite's viewpoint and the view from the satellite forward along its orbit. Have children note in their In-Exhibit Guides what they see from space.

Stop at Stellar Cartography and talk about how stars are all around, not above us. Point out the different phenomena in space as described in the plaques.

SPACE ACADEMY

Because of the reading ability needed for the recruitment activity at the end of the section, focus in this part of the exhibit on the different types of observations peoples have made about the sun, moon, and stars since early times. Children will be able to see a replica of a stone calendar from the Mayans of Central America and pictures of a giant sundial from 18th-century India.

At Solar Path, children will be able to follow the sun through the seasons of a year to see that the sun's path is higher in summer, so days are hotter and the hours of sunlight are greater. In winter the path of the sun is lower, so the days are colder and the hours of sunlight are fewer.

At Constellation Finder, children will recognize the connection to the activity about finding the story in the stars that they did in class.

At Moon Phases, children will see why the moon's shape seems to change during a month. The moon orbits the Earth about every 28 days or four weeks, so it takes the moon about a week, or a quarter of the full 28-day cycle, to go from one phase to the next. For example, seven days after the new moon (when we cannot see the moon at all), the moon has traveled through the first quarter of its trip around the earth, and we can see only half of the side of the moon (one quarter) illuminated by the sun. Seven days later, when the moon is halfway through its trip about the earth, we see a full moon, all of the half of the moon illuminated by the sun. Seven days later, the moon starts the last quarter of its journey around the earth, and we see only half of the side of the moon(one quarter) illuminated by the sun. Seven more days pass and the moon reaches a point in its orbit where it is between the earth and the sun, and we can't see any of the moon's face illuminated by the sun. This is the new moon again.

Like the stars, different cultures have different stories to explain the changes in the moon. Summarize the plaques for the children. Have children view the moon rock and describe in their In-Exhibit Guides what they see.

The meteorite is the oldest thing in the exhibit and the only thing that children can touch from outer space.

STUDENT IN-EXHIBIT EXPLORATION GUIDE

Grades 2-3

NAME _____

WELCOME ABOARD THE SPACE COMMAND VISITOR CENTER!

This first section of the visitor's center describes milestones in the study of astronomy. Find the answers to these questions.

A. Who made the first rockets? _____

B. What did Yuri Gagarin prove? _____

C. Find a picture of the Sojourner rover. Describe what it looks like.

D. Why is Galileo important? _____

E. What does the Hubble Space Telescope do? _____

OUTER SPACE OUTFITTERS

A. Imagine you are going on a space flight to visit the other planets in the solar system. What will you need? What are the other planets like? At Outer Space Outfitters, you will find the answers to all your questions about interplanetary travel.

Choose your favorite planet—other than Earth—and describe what it's like on that planet.

My favorite planet is _____ because:

B. Some lunch boxes are heavier than others.
On which planet was the lunch box the heaviest? Write its name here. _____

On which planet was the lunch box the lightest? Write its name here. _____

C. Did you design a rover for Mars? Draw a picture of it here.

Grades 2-3 *continued*

REMOTE COMMAND

A. Try out the pin boxes.
Which pin box gave you the best impression of your hand? _____

Which picture is the sharpest? _____

B. See what you can do at the Search and Rescue Simulator.
What problems did you have? How did you correct for them?

C. Did you see your house from space? What did it look like?

D. Check out the satellite tracking station. What satellites did you track?

SPACE ACADEMY

A. Follow the sun. What did you learn about the path of the sun?

B. Now follow the moon. Why does the moon change shape through a month?

C. Draw a picture of the Mayan calendar or the Indian sundial.

D. Try out the Academy Challenge. Have fun and receive a project to do at home!

TEACHER INFORMATION

Answers for In-Exhibit Exploration: Grades 2-3

SPACE COMMAND VISITOR CENTER

This section has a more traditional museum look to it than the other sections in this exhibit. Children will hit the high points by answering these questions:

A. Chinese

B. People could live in weightlessness.

C. Children should describe the shape of the rover and its outstanding features.

D. That Galileo was the first to study the sky through a telescope is his major contribution; by doing this, he discovered Jupiter's moons in 1610 and confirmed that the sun was the center of the solar system.

E. The Hubble Space Telescope is a space-based telescope that sends back to Earth information about the stars and the evidence that the universe is ever expanding.

OUTER SPACE OUTFITTERS

A. Answers should reflect the information provided about the planets.

B. Gravity is a function of the size of planets. The bigger a planet the stronger its gravity, and the more able it is to hold down an atmosphere.

- Jupiter, as the largest planet, generates the most gravity and, therefore, things are heaviest.
- Mars and Mercury, as the smallest planets, have the least gravity, and, therefore, the lunch boxes would feel the lightest on either.

C. Children should draw a picture of the rover they designed. Engage them in discussion of whether their rover navigated the course or whether they had to redesign it to overcome obstacles like rocks.

REMOTE COMMAND

A. The pin box with the most pins gives the best impression. The pictures with 300 pixels per inch give the sharpest (best resolution) picture.

B. The simulation will create problems that the participants need to over come in order to collect sufficient data. The probe's thrusters are misfiring and the team has to adjust course and manually steer the Franklin in order to compensate for the randomly firing thrusters. Once the Franklin lands on Mars, the students have to drive the Liberty, a rover, and find samples according to a map they are shown.

C. After students type in their address including zip code, the screen image will zoom down to their house. They will be able to zoom in and out and scroll around the image.

D. International Space Station, Tracking and Data Relay Satellite, Hubble Space Telescope, space shuttle, if aloft

SPACE ACADEMY

A. The sun's path is higher in summer, so days are hotter and the hours of sunlight are greater. In winter the path of the sun is lower, so the days are colder and the hours of sunlight are fewer.

B. At Moon Phases, children will see why the moon's shape seems to change during a month. The moon orbits the Earth about every 28 days or four weeks, so it takes the moon about a week, or a quarter of the full 28-day cycle, to go from one phase to the next. For example, seven days after the new moon (when we cannot see the moon at all), the moon has traveled through the first quarter of its trip around the earth, and we can see only half of the side of the moon (one quarter) illuminated by the sun. Seven days later, when the moon is halfway through its trip about the earth, we see a full moon, all of the half of the moon illuminated by the sun. Seven days later, the moon starts the last quarter of its journey around the earth, and we see only half of the side of the moon (one quarter) illuminated by the sun. Seven more days pass and the moon reaches a point in its orbit where it is between the earth and the sun, and we can't see any of the moon's face illuminated by the sun. This is the new moon again. The moon's true synodic period is 29.5 days, however 28 days is more easily compared to a weekly calendar.

Like the stars, different cultures have different stories to explain the changes in the moon.

C. In describing their drawings of the Mayan calendar or Indian sundial, children should demonstrate an awareness that people in other cultures and at other times have explored astronomical phenomena and come up with their own understandings. In the discussion, loop children back to the opening of the exhibit and what they learned there about other cultures and other times and their study of the heavens.

D. Children's ranking of their skills should not become competitive. Discuss instead what the computer station asked them to do and what they had learned. Go over the project that each student received who did the computer assessment. Encourage them to work with their parents to complete the project and email the results back to The Franklin Institute to receive another project. (There are 52 projects in all.)

GRADES 1-3 POST-VISIT ACTIVITY

Hotter or Cooler?

SCIENCE CONCEPTS

- The sun provides the light and the heat necessary to maintain the temperature of the earth (and other planets in the solar system).
- Light travels in a straight line.

SKILLS

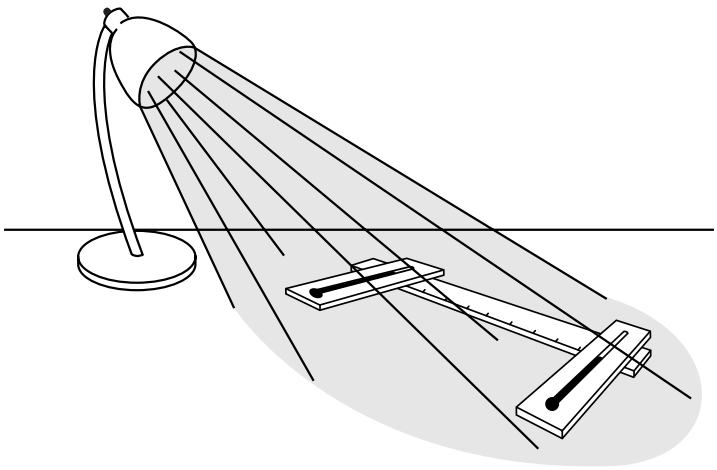
observing, recording, recognizing cause and effect, drawing conclusions

SUGGESTED TIME

1 class period

MATERIALS

- 1 desk lamp or goose neck lamp
- 2 identical room thermometers
- timer
- globe
- flashlight (lamp may also work)



PROCEDURE

1. Remind children that the sun is the center of our solar system. The sun provides the light and heat that warms Earth. It also provides light and heat to the other eight planets in the solar system. Ask children if they think that the other planets all have the same atmospheric temperature that Earth experiences. To answer this question, have them participate in the following experiment. *(Density and pressure also influence atmospheric temperature, but this experiment deals only with distance from the sun—a manageable concept at this level.)*

2. Position the lamp on one side of a desk or table. It should be placed on the width of the table with the light bulb facing the length of the desk or table top. Place the two room ther mometers on the desk or table top so that one is 6 inches from the lamp and the other thermometer is 36 inches from the lamp.

3. Have two volunteers read aloud the temperatures on the thermometers. Have a recorder write the two temperatures on a chart on the board.

4. Turn the light on and set the timer for 5 minutes. When the timer rings, keep the light on and have the children cluster around the experiment. Have two volunteers read the two temperatures, while the recorder writes them on the chart. *(The thermometer closer to the lamp will have a higher reading.)* Ask students to speculate why this has occurred. *(The closer to the lamp, the hotter it is.)*

5. To be sure, repeat the experiment. Ask students whether their original conclusion seems still be true. *(Yes, the closer thermometer has an even higher reading. The thermometer farther away has a higher reading than it had, but it is not so high as the closer thermometer.)*

6. Ask what this tells students about the atmospheric temperature on planets closer and farther from the sun. *(Planets closer to the sun will have higher atmospheric temperatures. Because they receive more heat—energy—from the sun. Pluto as the farthest planet from the sun is cooler than Mercury, the closest planet to the sun.)*

EXTENDING THE ACTIVITY

Explain that the sun does not heat Earth evenly. Use a globe and a flashlight to illustrate this. Hold the flashlight about 4 inches from the equator so that children can see how the light strikes the globe. Extrapolate this to the seasons of the year and the area around the equator. *(The area on and closest to the equator will have warmer seasons all year round.)*

IN THE EXHIBIT

In Follow the Sun, students will be learning about the sun's effect on Earth's seasons.

GRADES 1-3 POST-VISIT ACTIVITY

Meteorites on the Moon

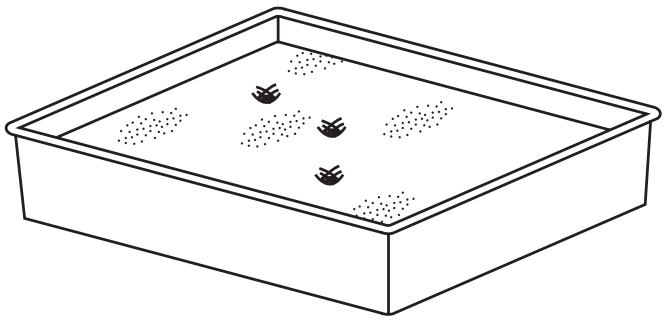
SCIENCE CONCEPT
The surface of the moon (and Earth) may change because of an outside body striking it.

SKILLS
observing, predicting, measuring, recording, recognizing cause and effect

SUGGESTED TIME
30 minutes

MATERIALS
- enough sand, moistened, to fill a shallow baking pan up to within 1/2 inch of the edge
- 3 marbles
- 3 golf balls

Optional: substitute 3 same-size pebbles and 3 same-size small rocks instead of the marbles and golf balls



PROCEDURE
1. Fill the pan with the sand up to within 1/2 inch of the top edge and smooth it out. Remind children of the moon rock that they saw in the exhibit and the pictures of the moon throughout the exhibit. Did they notice the big depressions on the moon? These depressions are called craters and were caused by meteorites. These rocks that hit the surface of the moon are left over from the formation of planets at the beginning of the solar system.

2. Hold a marble 2 inches above the surface of the sand and then drop it into the pan. Have a volunteer carefully remove the marble and measure the depth and width of the depression it made. Have a student record the information on a chart on the board.

3. Hold a marble 4 inches above the sand and drop it into the pan. Have the volunteer remove the marble and measure the depth and width of the depression. Ask the class to predict what happened to the size of the crater. *(The depth increased noticeably but the width only a little.)*

4. Repeat the activity but hold the marble 6 inches above the sand. *(Again, the crater is deeper but not significantly wider.)*

5. Try the experiment three times using the golf ball dropped from 2, 4, and 6 inches. *(The initial crater is wider and deeper than the one made by the marble the first time. Each time the crater is deeper and somewhat wider.)*

6. Have students summarize what this experiment has just shown. *(The larger the object the more force it has when it strikes. The higher the balls when they are released, the more force they accumulate and the harder they strike the surface. The greater the impact, the deeper and somewhat wider the depression.)*

EXTENDING THE ACTIVITY
When the meteors hit the surface of the moon, they actually explode. Meteors also hit the Earth but very rarely. Whereas the moon has no atmosphere to shield it from meteorites, the Earth does. Most meteors burn up as they enter the Earth's atmosphere, although some are large enough and travelling fast enough that they may survive to strike the Earth. The meteors that burn up are mistakenly called shooting stars or falling stars.

IN THE EXHIBIT
Pictures of the crater-marked moon are used in the Milestones section at the beginning of the exhibit and children will learn about what's in space besides the planets and orbiting satellites in Space Traffic Alert.

SPACE COMMAND

GUIDE FOR GRADES 4-8

CONTENTS

GENERAL ORIENTATION

When your students visit Space Command, they will imagine that they are tourists visiting a Space Research Station, a place where scientists carry out explorations of space. To help students get in the spirit of the visit, explain to them ahead of time the four areas that they will see, as described in the letter at the beginning of this guide: Main Promenade of the Space Command Visitor Center (the entrance), Outer Space Outfitters, Remote Command, and Space Academy.

Children in grades 4 through 8 should enjoy and be able to understand and manipulate all the stations in the exhibit. They may particularly enjoy the rover design activity in Outer Space Outfitters, the satellite tracking station and the search and rescue simulation in Remote Command, and the computer-assisted skills assessment station in the Space Academy.

Previsit Exploration: Some General Activities

- As part of the two Previsit Activities, encourage children to begin to think about space. What's out there? Why does the sun rise in the east and set in the west? Why does the moon change shapes through the month? Do children even notice that the moon changes shape? Are there the same number of stars across the whole sky? Are there clusters in some parts of the sky and not in others?

- Encourage children to begin generating questions about space, the sun, moon, stars, and planets.

- As one quick activity to build interest, talk about how difficult it must be to work in space wearing a spacesuit. Provide rubber kitchen gloves and have children try to pick up small objects like coins, screws, nuts, and bolts. Provide a block of wood with several screw holes and have students attempt to tighten screws wearing the rubber gloves.

- As a spelling challenge the week before the trip to the exhibit, have children learn to spell the names of the nine planets.

- To help build interest immediately before the visit, tell children stories of the Big Dipper and the Little Dipper from different cultures. Show a picture of the two constellations or draw them on the board. After you have finished the stories, draw a series of ten dots on the board and ask children what they think the dots represent. The dots should be placed randomly, but with enough definition so that children could discern several different objects, for example, a car, a wagon, a house, or even a flower. Students will work with this idea again at the Constellation Finder station in the exhibit.

- On the bus, give each student two pieces of paper folded in half to give students eight sides to draw on. Children should already have a sharpened pencil in order to fill out their in-exhibit guides. Have students think of an object that could become the name of a constellation and then draw eight dots on a sheet of paper to represent it. Seatmates could exchange their sheets and try to figure out what the name is of each other's new constellation. Continue until students' interest flags.

GRADES 4-8 PREVISIT ACTIVITY

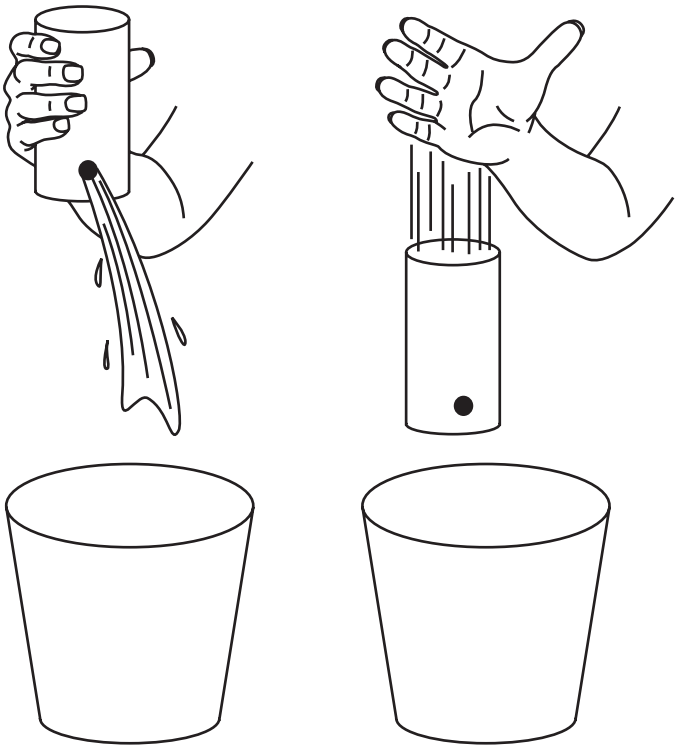
Gravity's Pull

SCIENCE CONCEPT
Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion of the solar system. Gravity alone holds us to the earth's surface.

SKILLS
observing, recognizing cause and effect

SUGGESTED TIME
1 class period

MATERIALS
- soda can
- awl
- pitcher of water
- plastic bucket
- paper towels



PROCEDURE
1. Explain that without gravity, things are weightless. Ask if students have ever taken a ride on a roller coaster. The feeling they experienced as the roller coaster went down the steep inclines is similar to what astronauts feel in space. The following experiment illustrates this.

2. Ahead of time, punch a small hole in the soda can about a _ inch from the bottom of the can.

3. Have a volunteer hold the can high enough for everyone to see. Be sure that the can is positioned over the bucket. Pour water into the soda can to fill it about 2 inches from the bottom. Before the water level is lower than the hole, have the volunteer drop the can into the bucket. Ask children what they see. You may need to repeat the experiment several times for students to discern that no water falls from the can as it descends. *(When the can is held still, gravity is pulling down on both the water and the can. But the can is stopped from falling by the person holding it. The water, on the other hand, has a path that it can take to fall out of the can. When the can is dropped, the water and the can fall together. The central points are that the water and the can are falling together and that the water stays in the can as long as the can is falling.)*

EXTENDING THE ACTIVITY
As another way to demonstrate gravity, have students place a sheet of paper on top of one of their textbooks. Tell them to hold the book about waist high and let it go. Ask what they see. *(The book drops quickly and the paper descends more slowly. The Earth's gravity pulls the two objects toward the ground. As they fall, air molecules bump against the book and the paper. Air resistance pushes equally on the book and the paper but it is harder for the air to stop the more massive book. If you drop the book with the paper laying on top of the book, they will fall together because the paper is no longer encountering the air resistance that the book is.)*

IN THE EXHIBIT
Children will see a display of astronauts working in space and read a chart about gravity on other planets. In Try Our Weight Change Program, children will lift lunch boxes to experience how gravity on different planets would feel.

GRADES 4-8 PREVISIT ACTIVITY

The Man or the Men in the Moon?

SCIENCE CONCEPTS

- Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.
- The sun is the central body in the solar system.
- Seasons on Earth result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the Earth's rotation on its axis and the length of the day.

SKILLS

observing, making distinctions, predicting, working cooperatively

SUGGESTED TIME

1 class period

MATERIALS

- "Lunar Calendar" photocopies, one for each student
- 2 sports balls of different sizes
- world globe
- 2 sheets of paper
- marker
- tape

PROCEDURE

1. The distinction between the terms rotation and revolution is an important one that students need to understand in order to understand why it appears that the sun moves around the Earth and why the moon has phases.

2. Use the smaller sports ball to show how Earth turns on its axis, a hypothetical line that runs from top to bottom through the center of the globe. This turning is known as rotation. The Earth completes one rotation in one 24-hour period—one day.

3. In showing what a revolution is, use both balls. The smaller one is Earth and call the other, the sun. Explain that Earth, while spinning (rotating) on its axis, also moves, or revolves, around the sun. One complete revolution of the sun by Earth takes one year, 365 days.

4. Ask students whether the moon also rotates on its axis as it revolves around the Earth. To determine the answer, place the globe on the floor and around it draw a circle with a four-foot diameter. Mark a sheet of paper with an "X" and tape it to the wall behind the "Earth."

5. Instruct other students to watch while a volunteer acting as the moon moves around the circle facing the Earth. Then have the volunteer walk around the circle facing the "X." Students should see that when the moon faces the Earth, the volunteer has to turn his or her body slightly in order to always face it. When the volunteer faces the "X" as he or she walks, different parts of the volunteer's body faces Earth. Since the same side of the moon always faces Earth, the moon must rotate on its axis.

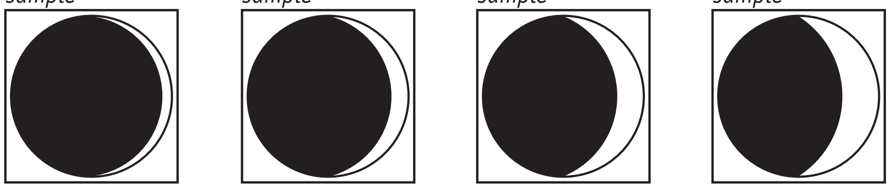
EXTENDING THE ACTIVITY

Reproduce and distribute the "Lunar Calendar," one for each child. You will need to explain that lunar is a word used to mean the moon. One can say "moon's surface," for example, or "lunar surface." Explain that the moon orbits the Earth about every 28 days, or a week to pass through each phase of the cycle. Have children check the sky every day for 28 days to see if they can detect the changes in the shape of the moon. Each day, they should write in the date and draw what they see of the moon.

IN THE EXHIBIT

Students will learn about the nine planets in Outer Space Outfitters. In Space Academy, they will be able to Follow the Sun to discover why summer is hotter and winter is colder. In Why Does the Moon Change?, they will learn how the Earth's and moon's positions affect how we see the moon.

LUNAR CALENDAR



sample Date *3/05*	*sample* Date *3/06*	*sample* Date *3/07*	*sample* Date *3/08*	Date ________	Date ________	Date ________	Date ________
Date ________	Date ________	Date ________	Date ________	Date ________	Date ________	Date ________	Date ________
Date ________	Date ________	Date ________	Date ________	Date ________	Date ________	Date ________	Date ________
Date ________	Date ________	Date ________	Date ________	Date ________	Date ________	Date ________	Date ________

STUDENT IN-EXHIBIT EXPLORATION GUIDE

Grades 4-8

WELCOME ABOARD THE SPACE COMMAND VISITOR CENTER!

This first section of the visitor's center describes Milestones in the study of astronomy. See if you can figure out questions for these answers.

Who built the first rockets? _____

What was the name of the first ever artificial satellite? _____

Name the orbitting telescope that has changed our view of the universe. _____

OUTER SPACE OUTFITTERS

A. Imagine you are going on a space flight to visit the other planets in the solar system. What will you need for the journey? At Outer Space Outfitters, you will find the answers to all your questions about interplanetary travel. Choose your favorite planet—other than Earth—and describe what it's like on that planet.

   My favorite planet is _____ because:

B. Some lunch boxes are heavier than others.
   On which planet was the lunch box the heaviest?_____

   On which planet was the lunch box the lightest?_____

C. Describe trying to move the wand while wearing the space gloves.

D. What problems did you encounter with your rover?

   How did you fix the problems?

STUDENT IN-EXHIBIT EXPLORATION GUIDE

Grades 2-3

REMOTE MISSION CONTROL

A. Try out the pin boxes.
Which pin box made the best impression of your hand? _____

Which picture is the sharpest? _____

Why?

B. See what you can do at the Search and Rescue Simulator.
What problems did you have?

How did you correct for them?

C. Did you see your house from space? Describe what it looks like.

D. Check out the satellite tracking station. Which satellites did you track?

SPACE ACADEMY

A. Why is it warmer in summer than in winter?

B. Why does the moon change shape across 28 days?

C. Which story about the stars or the moon did you like best?

D. Try out the Academy Challenge. Have fun and receive a project to do at home!

TEACHER INFORMATION

Answers for In-Exhibit Exploration: Grades 4-8

SPACE COMMAND VISITOR CENTER

This section has the most traditional museum look about it than the other sections in this exhibit. While students may wish to hurry through it to the "fun stuff," having to write several questions about what they see will ensure that they look at the important background on space and astronomy.

- *Who made the first rockets?* The Chinese began the concept of rocketry with their gunpowerd-filled bamboo tubes that they fired at enemies.
- *What was the first satellite in space?* Sputnik, launched by the Russians on October 4, 1957, was the first artificial satellite.
- *What is the name of a space-based telescope?* The Hubble Space Telescope was put into orbit on April 25, 1990, to view space from outside the Earth's atmosphere.

OUTER SPACE OUTFITTERS

A. Answers should reflect the information provided about the planets.

B. Gravity is a function of the size of planets. The bigger a planet the stronger its gravity, and the more able it is to hold down an atmosphere.
- Jupiter, as the largest planet, experiences the most force gravity and, therefore, things are heaviest.
- Mars and Mercury, as the smallest planets, have the least gravity, and, therefore, the lunch boxes would feel the lightest on either.

C. Trying to move the wand while wearing real space gloves indicates how difficult it is to do intricate work while wearing a bulky spacesuit. (The high and low pressure aspects of the interactive indicate the differences in working in different atmospheric pressures.)

D. Anyone's rover may become stuck in a crater. The designer will need to figure out how to get around or through the crater.

REMOTE MISSION CONTROL

A. The box with the greatest number of pins makes the best impression of their hand. The picture with 300 pixels per inch gives the sharpest (best resolution) picture.

B. The simulation will create problems that the participants need to overcome in order to collect sufficient data. The probe's thrusters are misfiring and the team has to adjust course and manually steer the Franklin in order to compensate for the randomly firing thrusters. Once the Franklin lands on Mars, the students have to drive the Liberty, a rover, and find samples according to a map they are shown.

C. After students type in their address including zip code, the screen image will zoom down to their house. They will be able to zoom in and out and scroll around the image.

D. International Space Station, Tracking and Data Relay Satellite, Hubble Space Telescope, and the space shuttle, if aloft

SPACE ACADEMY

A. The sun's path is higher in summer, so days are hotter and the hours of sunlight are greater. In winter the path of the sun is lower, so the days are colder and the hours of sunlight are fewer.

B. At Moon Phases, children will see why the moon's shape seems to change during a month. The moon orbits the Earth about every 28 days or four weeks, so it takes the moon about a week, or a quarter of the full 28-day cycle, to go from one phase to the next. For example, seven days after the new moon (when we cannot see the moon at all), the moon has traveled through the first quarter of its trip around the earth, and we can see only half of the side of the moon (one quarter) illuminated by the sun. Seven days later, when the moon is halfway through its trip about the earth, we see a full moon, all of the half of the moon illuminated by the sun. Seven days later, the moon starts the last quarter of its journey around the earth, and we see only half of the side of the moon (one quarter) illuminated by the sun. Seven more days pass and the moon reaches a point in its orbit where it is between the earth and the sun, and we can't see any of the moon's face illuminated by the sun. This is the new moon again.

C. Children may choose from the explanations of constellations from the Greeks, Native Americans of North America, or the Aztecs. Stories about the moon are drawn from the Hindu of India, the people of Benin in West Africa, and the Haida of British Columbia in Canada.

D. Students' ranking of their skills should not become competitive. Discuss instead what the computer station asked them to do and what they had learned. Go over the project that each student received who did the computer assessment. Encourage students to work with their families to complete the project and email the results back to The Franklin Institute to receive another project. (There are 52 projects in all.)

GRADES 4-8 POST-VISIT ACTIVITY

Star Light, Star Bright

SCIENCE CONCEPTS

- Stars are part of the solar system and have properties, location, and movement.
- The sun is a medium size star.
- The measure of a star's brightness is its magnitude, which depends on size, distance from Earth, and temperature.

SKILLS

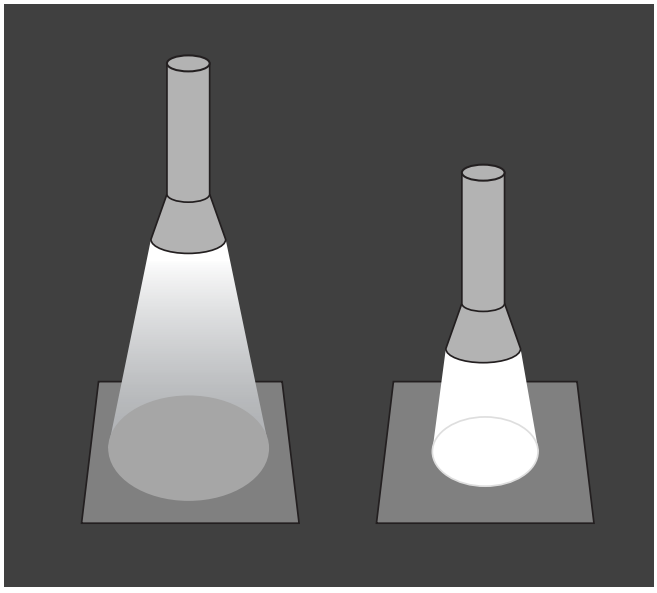
observing, recognizing cause and effect, drawing conclusions, constructing a scale, measuring,

SUGGESTED TIME

1 class period

MATERIALS

- 2 flashlights
- a piece of foil large enough to wrap over the end of a flashlight, 2 sheets of
- white paper
- large glass jar
- 1 sheet of colored paper
- paper punch
- stick or rod for stirring



PROCEDURE

Note: These activities work best in a dark room. If the classroom cannot be darkened adequately for good results, challenge students to replicate the activities at home. This activity will demonstrate how size and distance affect how bright a star appears from Earth.

1. Make a dime-sized hole in the center of the piece of foil. Fold the foil over the face of one flashlight so that the hole is in the center of the flashlight. Place the two sheets of paper side by side on a table or desk.

2. Darken the room as much as possible. Have students stand around the desk or table to block out light as well. Have two volunteers shine the flashlights on the sheets of paper. They should hold the flashlights about 6 inches above the sheets of paper. Which flashlight makes the brighter light? *(The flashlight without the foil creates the brighter light. Larger stars shine more brightly than smaller stars.)*

3. Ask how students think the distance from Earth might affect how stars appear to us. Would closer stars be brighter or dimmer? To test the class's predictions, have the volunteer with the foil-covered flashlight, remove the foil. Have the two volunteers hold the flashlights as high above the desk or table as possible and slowly lower them, stopping about 4 inches from the desk or table top. Ask students what they observed. *(The closer the flashlights came to the table, the brighter the lights became. The closer stars are to Earth, the brighter they appear. This is true even if the two stars are of the same magnitude, or brightness. The closer one will appear brighter.)*

   You might also have one student stop the downward move ment about 8 inches above the table while the other continues to lower the flashlight to within 4 inches. This may make the difference easier to distinguish.

EXTENDING THE ACTIVITY

Our solar system is part of the Milky Way, which is a spiral galaxy. To demonstrate how the Milky Way moves, pour water into a clear glass container until it is about three quarters full. Use a paper punch to punch out 10 to 20 circles depending on the size of the container. Drop them on the surface of the water and then stir the water in a circular motion. Have students watch the paper dots and the water move in a spiral.

IN THE EXHIBIT

These activities extend what students learned about stars in You Are Here in Space Command, What Do You See?, and A Star Is Born.

GRADES 4-8 POST-VISIT ACTIVITY

Bring Space to Your Classroom

EXTENDING THE EXHIBIT

At Traffic Control: Crash Warnings, students will have had access to real-time space positioning data from the International Space Station, the Hubble Space Telescope, and the Global Positioning Satellite (GPS), as well as the space shuttle if it was aloft. You can bring space into the classroom through NASA TV. It is available on some cable systems and on the Web. Check the NASA home page at www.nasa.gov/ for information on how to access it.

Check other Web sites listed in Further Resources for links to astronomy and space.

At the Space Academy Challenge, students took a computer-assisted assessment of their astronomical observation skills. At the end of the assessment, they received a print-out of a sky observation activity to do at home. If students complete and return their results by email to The Franklin Institute, they will receive another activity for the following week. There are 52 activities in all.

To stimulate participation, set aside 10 minutes each week to have students discuss their observations for that week's activity. Email class results to The Franklin Institute and receive another activity. Encourage children to do the activity at home as a family project and email their family's observations to The Franklin Institute as well. Doing the activity in class will provide encouragement and also the opportunity for children to participate who do not have computers at home.

FURTHER RESOURCES

FURTHER RESOURCES: GRADES 1-3

- Branley, Franklyn Mansfield. *Floating in Space.* (HarperCollins Juvenile Books, 1998)
- Branley, Franklyn Mansfield. *The Moon Seems to Change.* (Harper Trophy Book, 1987)
- Branley, Franklyn Mansfield. *The Planets in Our Solar System.* (Harper Trophy Book, 1998)
- Branley, Franklyn Mansfield. *Sunshine Makes the Seasons.* (Harper Trophy Book, 1986)
- Branley, Franklyn Mansfield. *Weight and Weightlessness.* (HarperCollins Juvenile Books, 1972)
- Graham, Ian S. *The Best Book of Spaceships.* (Kingfisher Books, 1998)
- Leedy, Loreen. *Postcards from Pluto: A Tour of the Solar System.* (Holiday House, 1996)
- Simon, Seymour. *Stars*. (Mulberrry Books, 1989)
- Wilson, Lynn. *What's Out There? A Book About Space.* (Scott Foresman, Pearson K–12)

FURTHER RESOURCES: GRADES 4-8

- Becklake, Sue. *Space, Stars, Planets, and Spacecraft.* (DK Publishing, 1998)
- Burns, Khephra, and William Miles. *Black Stars in Orbit: NASA's African American Astronauts.* (Gulliver Books, 1995)
- *DK Space Encyclopedia.* (DK Publishing, 1999)
- Hawcock, David. *Amazing Pop-Up Space Shuttle.* (DK Publishing, 1998)
- Lippincott, Kristen. *Eyewitness: Astronomy.* (DK Publishing, 2000)
- O'Byrne, Dr. John. *Stars and Planets (National Geographic My First Pocket Guides)* (National Geographic, 2002)
- Rey, Hans Augusto. *Find the Constellations.* (Houghton Mifflin, 1976)
- Simon, Seymour. *Our Solar System.* (William Morrow & Company, 1992)

TEACHER REFERENCES

- Consolmagno, Guy, et al. *Turn Left at Orion: A Hundred Night Sky Objects to See in a Small Telescope—and How to Find Them.* (Cambridge University Press, 2000)
- Heifetz, Milton D. *A Walk Throuhg the Heavens: A Guide to Stars and Constellations and Their Legends.* (Cambridge University Press, 1998)
- Pasachoff, Jay M. *A Field Guide to the Stars and Planets.* (Houghton Mifflin, 1999)
- *Peterson First Guide to the Solar System.* (Houghton Mifflin, 1999)

WEB SITES

- http://www.astro.wisc.edu
  Good general site on astronomy.
- http://www.badastronomy.com
  Various misconceptions your students (and many adults) hold about astronomical phenomena.
- http://hou.lbl.gov
  Hands-On Universe site: curriculum support for teachers and activities for students in grades 6 through 12.
- http://observe.arc.nasa.gov/nansa/core.shtml.html
  NASA Observatorium site: Highlights aeronautics, astronomy, remote sensing, space flight; sections on space flight and planet Earth
- http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets.html
  A multimedia tour of the solar system.
- http://skyandtelescope.com/observing/skychart/
  Web site to accompany *Sky and Telescope* magazine. The Sky and Telescope Interactive Sky Chart allows you to look at the sky at any time day or night from 1600 to 2400.
- http://starchild.gsfc.nasa.gov/docs/starchild
  NASA site for children ages 4 to 14.
- For the national science standards, see:
  http://books.nap.edu/html/nses/html/index.html
  For a hard copy of National Science Education Standards, ontact the National Research Council.
- For state science standards, see the following Web sites:
  http://www.pde.psu.edu/standard/science.pdf
  http://www.state.nj.us/njded/cccs/10sciintro.html
  http://www.doe.state.de.us/Standards/Science/science_toc.html
- Also be sure to visit the Franklin Institute site for additional science activities:
  http://www.fi.edu/learning.html

MAGAZINES

- *Astronomy.* Monthly star charts and tips for stargazing as well as information on the planets and galaxies.
- *Sky and Telescope.* Accessible discussion of astronomy, celestial events, and space science.
- *Sky Watch.* Excellent source for those new to astronomy; highlights celestial and space events.