

**FOSS ® PLANETARY SCIENCE
TEACHER PREPARATION VIDEO TRANSCRIPT**

<An Introduction to FOSS Middle School>

Larry Malone: Hi I'm Larry Malone.

Linda De Lucchi: And I'm Linda De Lucchi.

Larry: We're the co-directors of the Full Option Science System or simply FOSS.

Linda: The FOSS Middle School Program developed at the Lawrence Hall of Science with funding from the National Science Foundation includes 9 courses for grades 6 through 8. The courses are organized into 3 strands: Earth and Space Science, Life Science, and Physical Science and Technology.

Larry: Each course includes 8 to 10 sequential investigations and lasts 9 to 12 weeks. The 9 courses can form a complete 3 year science curriculum. Three topics to a year or individual 9 to 12 week courses can be integrated into an existing program.

Linda: With FOSS, students learn science by doing science. They develop deep durable understanding of science concepts and principles through authentic investigations, analysis, and reflection.

Larry: The FOSS middle school activities are informed by cognitive research about how adolescents think and learn and field tested in middle school classes around the country. The result is a program that reliably teaches important science content and critical scientific thinking processes such as logical analysis and database decision making.

Linda: Students engage the FOSS course content in 4 ways: active investigation, reading, multimedia, and assessment. These 4 learning modalities are seamlessly integrated to maximize every student's opportunity to learn. Experiences in the 4 learning modalities build on and reinforce one another resulting in comprehensive understanding of science concepts.

Larry: Students in FOSS middle school classrooms are engaged and thoughtful. They love to study science in collaborative learning groups with their peers using real scientific equipment. And FOSS makes science fun for you too. It's easy to maintain interest and motivate learning with FOSS. Welcome to the FOSS family. You and your students are about to embark on a wonderful science learning adventure.

<Assessment>

Linda: The FOSS Middle School Assessment materials are designed to be used throughout the course. They can be used to monitor progress during the investigations and as evaluation tools at the end of the course. There are three overarching goals for the program: Science Content, Conducting Investigations, and Building Explanations.

On the first page of each investigation, these goals are listed with the objectives for each. Science Content is the facts and concepts of science that students learn throughout the course. Conducting Investigations includes designing experiments and the skills needed for successfully engaging in scientific inquiry. Building Explanations includes the discussion students have, their ability to articulate

concepts developed during the investigations, and to use evidence to support ideas and conclusions.

Unlike many curriculums that treat assessment as a separate component only related to giving grades, FOSS Assessments are integrated into the instruction throughout the course. Assessment activities in FOSS provide teachers with immediate feedback about student understanding and give students the opportunity to reflect on their own learning.

In each investigation you'll find suggestions for Embedded Assessments in the Getting Ready section as well as in the Conducting the Investigation section.

There are two kinds of Assessments in the FOSS curriculum: Formative and Summative Assessment. Read through the Overview and Assessment chapters of your teacher guide for complete information about the two types of FOSS Assessment. There are scoring guides for both Formative and Summative Assessments in the Teacher Answer Masters and Assessment chapters of your teacher guide.

Formative Assessments are embedded throughout the course to provide diagnostic information. This information will help you make decisions about instruction for individual students and for the class. In general, FOSS suggests that these Formative Assessments not be graded. Although you might score them with a check, plus, or minus to keep a record of student's progress.

Formative Assessment Strategies include: informal notes, teacher observation, student sheets, quick writes, response sheets, self assessments, and group projects. Additional information about using each of the Formative Assessment Strategies can be found in the Assessment chapter of your Teacher Guide.

It's important to remember that all Formative Assessments are intended to give you greater insight into student's thinking and guide your instructional decisions. Formative Assessment is an important part of each day's lesson. It may be a look at a notebook sheet or a response sheet to look for content understanding, or an observation in which you look over student's shoulder to see if they're developing inquiry skills. In any case, Embedded Assessment is integrated into instruction so your students may not even realize that assessment is part of the activity.

FOSS provides a Mid-Summative Exam for most investigations and a Final Exam for the course. The Mid-summative exams are short tests presented in a number of formats including: multiple choice, short answer, and narrative questions. The Mid-summative Exams serve as checkpoints for student learning. Even though these are considered Summative Assessments they can be used formatively.

If you notice particular areas where students seem to have developed a misunderstanding you can make a note to yourself and come back to that idea during the next investigation. Remember to give students an opportunity to gather and process the information from the course before you have them take the Mid-summative Exams.

Understanding the big ideas of science requires that students construct relationships among many different pieces of evidence. It's important that students have time to build these higher levels of understanding before they are assessed. A final exam for the course is included it can also be used as a pretest or survey before students begin the course.

<Course Introduction>

Narrator/Teri Dannenberg: Hi, my name is Teri Dannenberg. In this video I will lead you through the investigations of the FOSS Planetary Science middle school course. This video is not intended to be a replacement for the teacher guide, so please plan on spending time reading the teacher guide to make sure you get step-by-step instructions for each of the investigations.

This course explores the vastness of our Solar System and outer space, how we have studied it, and what we've learned. Students will investigate how ancient observers studied the sky and how they began making sense of our place in the Universe.

Students will take a look at our closest neighbor, the Moon, and conduct investigations to explain its possible origin and surface features. Students are introduced to manned and unmanned mission in our Solar System. They analyze data and conduct research before planning their own exploration of the planets.

The materials for this course come in three boxes, with enough consumable equipment for five classes of 32 students each. In addition to the boxes of equipment, the course comes with a detailed Teacher Guide, a lab notebook containing the student sheets and organizers for the students to use while they engage in the investigations, 32 Resources books containing data, images, and readings that are used throughout the course, and five CD ROMS for use as a whole-class demonstration as well as an individual or small-group interactions.

Both the lab notebook masters and multimedia are also available online at FOSSweb.com. Before you start, check with your district regarding safety contracts, goggles, and other safety guidelines that may already be in place. For more information check the Overview chapter of the teacher guide.

<Teacher Guide Overview>

Narrator: The teacher guide is the heart and soul of our program, so let's spend a little bit of time and look through it. The guide is subdivided into 19 tabbed chapters: Overview, Materials, the 10 Investigation Chapters, Transparency Masters, Special Teacher Masters, Teacher Answer Masters, Assessment, Assessment Masters, Multimedia User Guide, and References.

Be sure to read the Overview chapter before you begin teaching the module. It contains many helpful suggestions for getting started. In it you will find:

- The National Science Education Standards that are addressed in this course
- A complete description of the program components
- Planetary Science in context.
- Why Study our Solar System?
- Can I teach this? I'm not an astronomer.
- Instructional methods for all students.
- Assessing progress
- Reading and Writing in Science
- Encouraging Discourse
- Management Strategies
- Using FOSS Technology, and

- Safety in the Classroom

Notice the safety symbol in the margin. Notice the other symbols in the margin. You'll see these icons throughout the investigation chapters.

The Course Matrix gives a quick overview of the course, including a synopsis of each investigation, how many class sessions it will take to complete the investigation, the science concepts, thinking processes, the media used in that investigation, readings from the Student Resources book, and extensions.

In the Materials chapter there's an inventory of the equipment provided in the kit and the directions for its preparation and maintenance. An inventory sheet is also enclosed in drawer one of the kit and each drawer has an inventory list on the outside of the drawer, listing the equipment contained in it. Starred items indicate consumable items.

You can order replacement parts for all FOSS modules and courses at the Delta Education website, or by calling this number. Some items for this course need to be supplied by the teacher. Most of these are common items found in science classrooms. You should look over this list before beginning to teach the course to identify items that might need to be collected or ordered.

The Preparation section provides guidance for preparing a new kit, which is done once by the first user, and how best to organize the materials for sequential classes. Next comes the Investigation chapters that are the heart of the course. There are ten investigations in Planetary Science. These will be described in detail in this video.

The first page of each chapter lists the Goals and Objectives for the Investigation. The At a Glance chart summarizes the Investigation and helps you plan for assessing, preparing, and executing each part of the investigation.

Next you'll find background information specific to the investigation, including a section explaining why this investigation is important for middle school students. Common student misconceptions are listed in this section. Each investigation has several parts. For each part you'll find a Materials List, a Getting Ready section, and step-by-step directions for conducting the activity with your students including when to assess their progress.

After the investigation chapters, you will find the Transparency Masters. The actual transparencies are in drawer one of the kit, but the masters are provided in case you need to replace them.

The Special Teacher Masters chapter contains masters you will need to copy at different points throughout the course. The Teacher Answer Masters chapter has answers for most of the student lab notebook sheets.

There are many ways to assess your students' learning as they progress through the course. Read through the Assessment chapter for more information about formative and summative assessment. This chapter contains the scoring rubrics for formative assessments, and scoring guides for the summative assessments. These will assist you in evaluating student progress throughout the course.

After the assessment chapter, you'll find the Assessment Masters. Assessment charts can be used to record individual student progress. These are followed by masters of the summative exams for each Investigation and a final exam for the whole course.

Another helpful chapter is the multimedia User Guide. Multimedia is an integral part of the course. Students can use it to interact with simulations, images, and text that will help them with their understanding of concepts. This chapter also includes System Requirements, Program Basics, and Specific Navigation tips. The Reference chapter has an annotated list of print and web-based materials for both the teacher and student.

<Multimedia Overview>

Narrator: The multimedia is an essential part of every FOSS middle school course. It is not optional.

Give students time to interact with the various simulations, images, and text. This gives them the opportunity to further develop their understanding of the concepts in each course. Five identical CD ROMs come with the kit.

You can also access the multimedia online at www.fossweb.com. To use the multimedia online you need to register to get a username and password you can share with your students. The username and password will work for all of the FOSS multimedia. Go to the multimedia chapter of the teacher guide to view the system requirements for Macs and PCs. The browsers that are compatible with the FOSS multimedia are listed in this chapter.

In the same spot you can find which plug-ins are needed to run the simulations, troubleshooting suggestions, and ideas for getting the best view of the multimedia in a classroom setting.

Before using the multimedia with your students, make sure that you have prepared your computers and dedicate some time to cruising around the different components so that you are comfortable. The multimedia in each course has a unique welcome screen. Follow the basic instructions in the multimedia chapter of the teacher guide to access the program.

A few hints follow: If you click on the button, "Enter the Program" you have access to all of the simulations and activities through the main resource room. Click on a title to go to a specific activity.

From here you can also access the multimedia teacher guide resources by clicking the title. From the welcome screen you could also choose to "Enter the Teacher Guide". Here you will find a convenient way to access the multimedia in each investigation. Click on an investigation title.

Once you are in an investigation, you can access the PDFs of the lab notebook sheets and transparencies. If an investigation part has any simulations or activities, they will be listed and you can click on them to go directly there. You can click the link on the bottom of the screen to return you to the list of investigations.

The last choice from the Welcome Screen is a link to check your browser. This makes sure that your web browser is properly configured to run the program. Here is how you access the multimedia through FOSSweb.com.

From the front page, click the middle school button, then choose your course. Click on it and you are given several options. In the top left, click on the Multimedia button, and go to the Welcome Screen described earlier.

Let's look at some of the options for students: Updated websites, books, and a glossary. For teachers and parents, you will find a summary of the course, information on plant and animal care, when appropriate, a link to the PDF duplication masters for the lab notebook, a list of references, and course notes.

This section includes important information about corrections, ordering, and tips for teaching the course. Accessing the lab notebook file take a separate password from the one you give the students to access the multimedia. This user name and password should not be given to students.

In the teacher guide, more details about each multimedia option are given in the investigation chapters. Look for the CD ROM icon in the margin.

<Investigation 1, Introduction>

Narrator: In Investigation 1 students are introduced to maps and images of the Earth in a variety of scales and formats. They develop a sense of place on the Earth and where they fit into it. The Earth will serve as our launch pad for our exploration into the Solar System.

Look over the At a Glance chart on pages 30 and 31 for a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book, multimedia, and videos. Be sure to read through the Scientific and Historical Background pages for information on maps and images used in this course.

The Why Do I Have to Learn This? section describes how to help students put themselves into the picture as they begin to grapple with the vastness of the Universe.

<Investigation 1, Part 1>

Narrator: In this part, students begin by describing their location in the classroom and then venture outside to draw a map of their school. They consider their point of view and establish a frame of reference for their location throughout the day.

This is what you will need to provide for each group of four students: four pieces of paper to draw a map of the school. You may also want to provide colored pencils. Make a copy of the Assessment Chart for Investigations 1 and 2 for each class. See the assessment chapter in the teacher guide for more information on using these charts in your classroom.

In Part 1 students will be walking around the outside of the school to draw maps of the building. Plan how you will guide them around the building to limit the number of stops they need to complete the map.

If you are using the assessment charts, have them ready on a clipboard. The charts might be easier to use if you list students' names by group rather than in alphabetical order.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions.

Introduce students to the course and tell them that over the next few weeks they will planetary scientists studying our planetary system.

Students begin their study by describing their location and establishing a frame of reference. Propose to students that they make a map that a visitor could use to locate them through out the day. Plan the map making trip around the school with your students. They will need to work quickly since time outside will be limited.

As they are drawing encourage them to include sidewalks, trees, and other features around the school. Students will mark their maps with their locations throughout the school day. Discuss point-of-view and that the point-of-view for this map is the bird's-eye view. Assess student maps to see if they have drawn them from a bird's-eye view and are fairly accurate. Also assess to see if they have marked their locations throughout the day.

<Investigation 1, Part 2>

Narrator: In Part 2 students will use aerial photographs to study their local area and record human-made and natural structures that can be identified at different elevations. At each elevation they are challenged to locate their school.

This is what you will need to provide for each group of four students: four pieces of paper, four Planetary Science Resources books, and four copies of Lab Notebook page 3.

This is what you will need from the kit for the class: Transparencies no. 1, Bird's-Eye Views, no. 2, Bret Harte Neighborhood, no. 3, Bret Harte Community, and no. 4, Overlay grid.

You may want to provide aerial photographs of our school community if they are available. You will need to provide an overhead projector, and a multimedia set up, and the Planetary Science CD-ROM or access to the internet. For assessment you will need assessment chart for Investigations 1 and 2 and a copy of the Response Sheet—Where Am I? for each student.

In Part 2 students will be looking at Earth from different elevations. The kit includes a series of images above Bret Hart Middle School in Oakland, CA. This part will have more personal relevance if students study images of their own school and community. Aerial photographs can be ordered from the USGS. Instructions for ordering and sizing the photos are described in the teacher guide.

There are also several online resources for obtaining aerial images of your community. Suggestions for alternative sources are described in the course notes for Planetary Science at FOSSweb.com. The overlay grid can be used with the Bret Harte images in the kit or with images of your school to help students describe locations.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions.

Introduce students to the term elevation and ask them: How would the view of their school be different if you looked down from ten times higher than their drawings, such as from 100 meters?

Project the image of your school or Bret Harte Middle School and allow students a few minutes to study it. Then ask them to identify objects or features they can see. The overlay grid will help them pinpoint locations.

The Bret Harte Neighborhood image is also found on page 4 of the Student Resources book. Students can record their observations in their lab notebooks or on the student sheet, Bird's-Eye Views. Then they continue recording their observations at the community elevation. With each increase in elevation, remind students to keep up with where they are in each of these images.

Ask for volunteers to share their observations and compare the number of human-made structures with natural features. Monitor students as they work and note on the assessment chart any students who are struggling. Use the Response Sheet—Where Am I? to assess student progress. You won't grade it until students have had the opportunity to revise it after the next part.

<Investigation 1, Part 3>

Narrator: In Part 3, the student's point of view moves from a few meters above the school out into space until the entire disk of Earth can be seen. They continue to record human-made and natural structures as the elevation increases.

This is what you will need from the kit for each group of four students: four copies of the Planetary Science Resources book and the Bird's-Eye View observations the students began in the previous part.

And you will need to provide the aerial images of your school if you were able to get them. For the class you will need the Planetary Science CD-ROM or access to the internet and a multimedia set up. For assessment students will use the Response Sheet—Where Am I? from the previous part. You will need to make copies of Mid-summative Exam 1 and a map of your school for each student.

Students will be using images from the Student Resources book, the CD-ROM, and images from your school if you have obtained copies.

Practice using the multimedia so you can show the images in quick succession. Enter through the teacher guide to get direct access to the simulation needed for each part. Click on Investigation 1, then Part 3, and the Bret Harte Flyaway in the multimedia box. This opens the simulation for the Flyaway and the Bret Harte images. Use the arrows in the lower right corner to flip through the pictures.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions.

Ask students to review the photos of the school and ask how they think the photos were taken. Explain that these two photos were taken from airplanes flying over the area and are often used for surveying.

Introduce the next four images, either from the Student Resources book or the images you obtained of your school. After studying the photos, students will continue to fill out the Bird's-Eye View sheet from the previous part. Review student observations and ask them to compare the number of human-made structures with the number of natural features they can resolve as the elevation increases.

Project the Bret Harte Fly Away from the CD-ROM and click through the six images quickly or project images of your own school moving from a lower elevation to the whole Earth view. In either instance, challenge students to keep track of their location in each image.

Introduce the concept of the powers of ten. Each image represents an increase in elevation ten times higher than the previous one: one hundred meters, one thousand meters or one kilometer, ten thousand meters or ten kilometers, one hundred thousand meters or one hundred kilometers, one million meters or one thousand kilometers, and ten million meters or ten thousand kilometers.

Return the Response Sheet—Where Am I? and allow students time to make any additions or corrections. You'll find a rubric for scoring in the assessment chapter of the teacher guide. When you think students are ready, have them take Mid-summative Exam 1. You'll find the answers for the Mid-summative in the assessment chapter of the teacher guide.

<Investigation 2, Introduction>

Narrator: In this investigation students review information gathered by ancient astronomers that lead to the conclusion that the Earth is round. They also use models and computer simulations to gather additional information.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book and the multimedia. Be sure to read through the Scientific and Historic Background pages for information on the evidence used by ancient astronomers to prove the Earth was round.

The Why Do I Have to Learn This? section explores the questions of "What do you know?" and "How do you know it?"

<Investigation 2, Part 1>

Narrator: In this part students use models of a round Earth and flat Earth to investigate how ancient sailors knew the Earth was a sphere. This evidence is reinforced with the multimedia.

This is what you will need from the kit for each group of four students: one piece of cardboard, one map of the flat Earth, a 4-liter zip bag, one Earth globe, four slim straws, four copies of Lab Notebook sheet, Shape of Earth, and four Planetary Science Resources books.

You will need to provide two pairs of scissors for each group. You will need transparency no. 5, Shape of Earth from the kit for the class. You will need to provide: masking tape, transparent tape, an overhead projector, and a multimedia set up with the Planetary Science CD-ROM or access to the internet.

For assessment you will need: the assessment charts for Investigations 1 and 2 and copies of Response Sheet—Round Earth/Flat Earth for each student.

Attach the laminated Flat Earth maps to the cardboard sheets using transparent tape. Remove the Earth globes and bases from their boxes and put them in 4-liter zip-bags. Preview the multimedia so you will be able to switch between the round Earth and flat Earth simulations. This button changes between the round Earth and flat Earth.

You can also change the observer's point of view. It opens on the deck of the ship. Other views are, from the crow's nest, from the lighthouse, or from the dock. Let's leave it here for now.

The telescope gives students a close up view as you watch the ship sail away or they can look at the geometry from the side and compare it to the flat Earth. There is also video footage of the tall sailing ship, the Libertad as it sailed out of San Francisco Bay.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions.

Students know the Earth is round, but in this part, they will think about how they know the Earth is round. Introduce the two models of Earth, the flat Earth and the round Earth. Challenge the students to work with the models and gather evidence to support the idea that Earth is either round or flat. Suggest using a sailing ship model with the map and the globe.

Demonstrate how they can make a small ship model with a straw and piece of masking tape. Place a slim straw in the middle of a 6 cm strip of masking tape and fold it around the straw to create a small flag. It may help students to draw the ship on the tape before they begin cutting. Use scissors to cut out the small ship. Students use the flat map and observe the ship as it sails away from the observer.

One student can hold it for another so they can make their observations at eye-level. Then they repeat the process with the globe.

Student record their observations and drawings on the student sheet, Shape of Earth. Provide students with the historical perspective of centuries of observing sailing ships. This information is found in Step 11 in the teacher guide.

Introduce the Round Earth/Flat Earth simulation on the multimedia. Use the multimedia set up to project the simulation, so the whole class can see. Demonstrate the flat Earth and the round Earth views. Call on students to select different parameters for their point of view and to make observations as you run the simulation. Finish the demonstrations by showing the video of the Libertad tall ship as it sailed out of San Francisco Bay.

Use Response Sheet—Round Earth/Flat Earth to assess student's progress. Collect the sheets but don't grade them at this time. Students will use them for self-assessment in the next part. Quickly scan their responses and note their ideas and any misconceptions.

Use the assessment chart to give student's a check, plus, or minus. Assign the reading in the resources book, *The Accidental Discovery of America: The First Voyage of Columbus*.

<Investigation 2, Part 2>

Narrator: In Part 2 students will continue their inquiry into the round Earth question by investigating shadows cast by poles at intervals from the North Pole to the Equator.

This is what you will need from the kit for each group of four students: one Earth globe and base, one flat Earth map on cardboard, two strips of index card, ten thumbtacks, four copies of the student sheet, Shadow Evidence, and four copies of the Planetary Science Resources book.

You will also need to provide a metric ruler for each group. For the class you will need: transparency no. 6, Shadow Evidence from the kit. You will need to provide: 1 pair of scissors, a metric ruler, masking tape, a lamp with a bare 75–100 watt light bulb or another strong light source, and an overhead projector.

You may also need the multimedia set up and the Planetary Science CD-ROM or access to the internet if you need to review latitude and longitude. For Assessment you will need: the assessment charts for Investigation 1 and 2, the response sheets students began in Part 1, and copies Mid-summative Exam 2 for each student.

Cut several 3x5 index cards lengthwise into 1/2-inch strips. In this part students will measure shadows on their globes and maps. This can be done outside, but if that is not possible, use a bare light bulb in the center of a darkened room.

If your students are not familiar with longitude and latitude, plan on using the multimedia review. From the multimedia teacher guide for Investigation 2, click on Part 2. There you will find a brief explanation of latitude and longitude and how they are measured.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review the evidence students gathered for a round Earth by observing the sailing ships. Then introduce the observations made by the Greek mathematician, Eratosthenes.

A short description of this is included in Step 2 in the teacher guide. Introduce the shadow investigation and distribute maps and globes to the students. You may want to project the longitude and latitude review from the CD-ROM.

The students mark latitude lines for 0°, 15°N, 30°N, 45°N, and 60°N on the strips of index card on the globe and on the map. Then they carefully push thumbtacks up through the card on the lines. They can add a small strip of transparent tape to the back to secure the tacks. Students can then add latitude

numbers to the front. Students collect their shadow data by positioning the globe and map with the tacks at the Equator pointed directly at the light source.

There should be no visible shadow from the Equator tack. As one student holds the globe, another student traces the shadow of each tack. The other members of the group will repeat this process with the map. After they have marked the shadows, they carefully remove the strips and measure the length of each shadow.

They record the data on the lab notebook page, Shadow Evidence and complete the graphs. Ask students to share their groups' ideas about what their data shows.

Tell the Eratosthenes story and how he was able to use this data to calculate the circumference of Earth. Have students carefully remove the tacks from the paper strips and return them to the materials table for the next class.

Make sure students account for all their tacks. Return the response sheet from the first part and allow students time to reflect on their answers. They should make corrections and additions based on today's investigation.

Use the rubric in the assessment chapter to score the response sheets. When you think the students are ready, have them take Mid-summative Exam 2. Find the answers in the assessment chapter of the teacher guide.

<Investigation 3, Introduction>

Narrator: In this investigation students study the geometry and motions that produces day and night. They use models, 3-D models and even their own bodies to further explore these motions.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find out when to use the Student Resources book and the multimedia. Be sure to read through the Scientific and Historical Background pages for information day and night, timekeeping, and seasons.

The Why Do I Have to Learn This? section explains how developing a model for something observable, like day and night, will help students to grapple with more abstract concepts of motions in the Solar System and the Universe.

<Investigation 3, Part 1>

Narrator: In this part, students will begin thinking about day and night. They will use their bodies to model Earth's rotation and determine how much of Earth is in daylight at any one time.

This is what you will need for each group of four students: four pieces of paper or student lab notebooks if you're using them and four copies of the student sheet Day/Night Think Questions.

This is what you will need to provide for the class: a light source, the Planetary Science CD-ROM from the kit or access to the internet, and a multimedia set up. You may also want to have some blank overhead transparencies and pens, and an overhead projector. For assessment you will need assessment chart for Investigations 3 and 4 and notebook paper or index cards for the Quick Write.

You will need to have a darkened room with a light source in the middle for the first two parts of this investigation. Check to see that the room can be darkened enough to show shadows cast by the light source.

Become familiar with the Day/Night Simulation in the multimedia. From the teacher guide, select Investigation 3, then Part 1, Introducing Day and Night, and the Day and Night simulation. This simulation may take a minute or two to load the first time. In the upper left corner, select the Earth/Moon simulation mode.

Practice using the simulation. The red X's on Earth and the Moon are used as reference points. You can choose to follow the Moon's motion hourly, daily or weekly. To change the observer's point of view, stop the simulation and select a different point of view and rerun the simulation. The 90° view places the observer directly over the North Pole.

Plan on how you will use the Day/Night Think Questions. They can be used for small group discussions or as homework before discussing them with the whole class.

This is only brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Students begin this investigation with a quick write. This will reveal student's ideas and misconceptions before they begin the investigation. Ask student to write down everything they know about how day and night occurs. Collect the quick writes but don't grade them. Read through them to get a sense of their preconceptions.

Students will revisit them at the end of the investigation and make corrections or additions before you grade them. Ask students to share their ideas about night and what causes it. Write their ideas on the board or an overhead. Ask them about their explanations of day. Introduce the lamp as the Sun and get ideas for how they can use it to demonstrate day and night. They will probably suggest putting it in the middle of the room to be the Sun.

After they have had time to discuss how they will conduct this activity refine the simulation by suggesting they use their heads as Earth and one of their eyes as an observer on Earth. Then ask them to stand as if it were noon for the observer. Next ask them to stand as if it were midnight for the observer.

These two positions are usually easy for them. Now ask students to demonstrate how Earth's motion can produce day and night. If their left eye is the observer, stand so that it is sunrise. This may cause a bit more thought and usually a variety of positions.

Then reinforce the orientation of Earth to the Sun by giving them a series of challenges. There is a list of suggested challenges in the teacher guide in Step 10. After students have grappled with day and night

the class needs to come to an agreement about the direction of rotation. Ask them to return to the position for sunrise. If students are facing in different directions, let them work in pairs to sort out the correct direction of rotation.

When students have come to an agreement that Earth rotates to the left, introduce the multimedia simulation. You may want to allow one student to control the simulation and another to explain what is happening. More information for using the simulation can be found in the teacher guide in Step 13.

Use the Day/Night Think Questions for small-group discussions. These questions should not be used as an assessment or be graded. Use them to encourage class discussions. Answers can be found in the Teacher Answer Sheet chapter.

<Investigation 3, Part 2>

Narrator: In this part students will take what they've discovered about Earth's rotation using their own bodies and transfer it onto an Earth globe.

This is what you will need from the kit for each group of four students: one Earth globe and one jumbo straw. For the class you will need transparency no. 7, Day/Night Focus Questions from the kit.

You will need to provide: one light source, transparent tape, a small knife or nail file, scissors, and an overhead projector. You may also want to provide a large Earth globe. For assessment you will need the assessment chart for Investigations 3 and 4.

If you didn't use the light source for Part 1 make sure you can darken the room enough for students to see shadows on the globes. Use a nail file or knife blade to remove the plastic buttons from the globes. Insert a straw so students have a handle to hold. Cut the tip off at an angle if the straws are difficult to get through the holes.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions. Each group will use one of the globes to confirm Earth's counterclockwise rotation.

Ask students to imagine there is an observer on the globe. Challenge them to orient the globes so the observer sees day, night, noon, midnight, sunrise, and sunset. Set up the large globe in the center of the room and ask students to demonstrate day and night.

Review the Day/Night Think Questions and after students discuss them in their groups, have them write answers in their lab notebooks.

Let the students use the multimedia if they need more practice. Before going on, summarize day and night covering the points outlined in Step 8 of the teacher guide. Use the assessment chart and give students a check, plus, or minus for completing and discussing the Day/Night Think Questions.

<Investigation 3, Part 3>

Narrator: In this part students will investigate time and calculate local noon. They'll make the distinction between clock noon and local noon.

This is what you will need for each group of four students: four copies of the student sheets How Many Hours Have you Worked? and Local Noon.

This is what you will need from the kit for the class: transparencies no. 8, How Many Hours Have You Worked? and no. 9, Local Noon. You will need to provide an overhead projector. For assessment you will need the assessment chart for Investigations 3 and 4.

Before you begin this part you will need to gather information about the precise local times for sunrise and sunset. This information can be found in most newspapers on the weather page. You can also find this information at the U.S. Naval Observatory website. After entering the date and your location, you can print out the information for class.

Consider your students' math skills. If you feel they need practice plan on using the student sheet, How Many Hours Have You Worked? Review the Local Noon student sheet to become familiar with calculating local noon. Use the data you will be giving students to make your answer key.

This is a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review day and night with students and remind them that half of Earth is in daylight and half in darkness.

Refer to Step 1 in the teacher guide to review questions to lead a discussion about local time and noon. Begin the discussion about local noon and present the sunrise and sunset data.

If students are struggling with the procedure, refer to Step 11 in the teacher guide to help them through the process. Give students a check mark on the assessment chart if they can successfully calculate local noon.

<Investigation 3, Part 4>

Narrator: In this part students will be introduced to time zones and the historical rationale for them.

This is what you will need for each group of four students: one Earth globe and base from the kit, four Planetary Science Resources Books, four copies of the student sheet, Thinking in Time, and four copies of Time-Zone Homework if you decide to use it.

This is what you will need for the class from the kit: one thumbtack, transparency no. 10, Global Time Finder, and transparency no. 11, Earth Polar View. You will also need to provide: a large Earth globe, a pair of needle nose pliers, a pair of scissors, and an overhead projector.

For assessment you will need: the assessment chart for Investigations 3 and 4, student sheet, Thinking in Time, and the students' Quick Writes from Part 1. Make copies of Mid-summative Exam 3 for each student.

You need to assemble the Global Time Finder the first time you use it. Cut out Earth's Polar View from transparency no. 11. Poke the thumbtack up through the center of the Global Time Finder. Then press the polar map onto the tack. Use the needle nose pliers to curl the point of the thumbtack. If you don't have pliers, you can press a small piece of an eraser onto the point to hold the time finder together.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions.

Review local noon and read the story about Richard Feynman in Step 2 of the teacher guide.

Pass out the globes to each group. Ask them to imagine they are in Miami, Florida at noon and to figure out where on Earth it would be midnight, 6 am, and 6 pm. Allow time for students to grapple with this before introducing the Global Time Finder.

Put it on the overhead projector and set the 12 noon line on Miami. Ask student to help determine the locations for: midnight, 6 am, and 6 pm. Introduce time zones and time maps found in the Student Resources books on page 36 and 37.

Allow time for students to explore the two maps. Give them the challenges listed in Step 7 of the teacher guide. Finish this part by resolving the Feynman time question and assigning the challenges on the Thinking in Time student sheet.

Assign one set of questions to each group for them to discuss and answer. Return the quick writes from Part 1 and ask students to reflect on what they wrote. They should be able to add more information and make corrections.

Use the scoring rubric in the assessment chapter to score the corrected quick writes. When you feel students are ready, have them take Mid-summative Exam 3. Answers for the Mid-summative are found in the assessment chapter of the teacher guide.

<Investigation 4, Introduction>

Narrator: In this investigation students will begin an exploration of the Moon. They'll start a month-long observation, study images, and come up with their own questions about the Moon.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book. Be sure to read through the Scientific and Historical Background pages for information on helping students get the most out of their Moon observations. You will also find suggestions to guide students in generating their questions about the Moon.

The Why Do I Have to Learn This? section explains how something as familiar as the Moon has intrigued astronomers and the casual observer for centuries.

<Investigation 4, Part 1>

Narrator: In this part students will begin a month-long observation of the Moon during a Moon-watching field trip to the school grounds.

This is what you will need from the kit for each group of four students: four copies of the student sheet Moon Log. This is what you will need from the kit for the class: one Planetary Science Resources book, the Moon Log classroom poster, and transparency no. 12, Moon Log.

You will also need to provide: A piece of white paper, scissors, a ruler or meter stick, masking tape, blank overhead transparencies and pens, and an overhead projector. You may also want to provide a pair of binoculars or a spotting scope for looking at the Moon.

For assessment you will need the Assessment Chart for Investigations 3 and 4 for informal notes.

Students will begin this investigation by looking for the Moon during the day. Instructions for selecting the best time for your class to make their observations can be found in Step 1 of the teacher guide. Return to the U.S. Naval Observatory website to get moonrise and moonset times for the day you plan to observe the Moon with students.

Find a location on the school grounds that will provide an unobstructed view of the Moon. Round up as many pairs of binoculars and spotting scopes for students to use as you can find. Cut a large crescent Moon from a piece of white paper for the demonstration in Step 9. Find a convenient place in the classroom to hang the Moon Log poster. Different students will be updating it throughout the month.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Start a discussion by asking students to identify objects in the Solar System and ask what is our closest neighbor. They should identify the Moon as our closest neighbor.

Ask them what they know about the Moon. If they have trouble with this, there are several questions in Step 2 of the teacher guide to get them started. Continue the discussion by pointing out that people have been always looked at the Moon and read the first Moon myth: Father Moon. It can be found in the teacher guide and in the Student Resources book.

After reading the myth, suggest going outside to see if they can find the Moon in the daytime sky. Some students may be very surprised to see the Moon during the daytime. Once they have found the Moon, ask questions to help them make careful observations. Back in the classroom, students report their observations and continue asking questions.

Challenge them to come up with a way to record this information. When they decide to keep a record of how the Moon looks each day, introduce a method of record keeping.

Tape a paper moon onto the wall and draw a circle next to it. Hold a straight edge at the horns and notice that it is at about a 30° angle. Carry that angle to the circle and draw a line. And then draw the Moon. Then fill in the dark portion of the Moon.

Distribute the Moon logs and assist them with filling in the first observation they just did outside. Each student will be responsible for an observation and log entry every day. Use the assessment chart to make note of students with insightful comments or who are struggling. Point out the classroom Moon Log that students will keep for all your classes.

<Investigation 4, Part 2>

Narrator: In this part students will study photographs of the Moon to become familiar with its prominent features. They will write questions to focus their study of the Moon.

This is what you will need for each group of four students: the student Moon Log sheets from Part 1, four copies of the student sheet Moon-Picture observations, and 4 copies of Group Questions about the Moon.

You will also need four copies of the Student Resources book. This is what you will need for the class: the Moon Log poster with student observations, the Moon Photo poster, transparencies no. 13, Moon Photo, no. 14, Rona: The Maori Water Carrier, and no. 15, Group Questions About the Moon. You will also need to provide an overhead projector and have some blank transparencies and pens handy.

For Assessment you will need the Assessment Chart for Investigations 3 and 4 and some extra paper for students to submit their group questions.

Practice using the Moon Photo and the Rona transparencies. First you will project the Moon photo, then line up Rona with the large areas of mare. You will see that she lines up with several large basins. See, here's her calabash and here's her hair. The Rona image will help students to identify landmarks when they look at the Moon photos or in the sky.

Hang the Moon Photo poster in a spot where it can remain in for the duration of the course.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Ask students to report what they see when they make their Moon observations. Talk about photographing the Moon. Details about how the Moon photos are taken is discussed in Step 2 of the teacher guide.

Ask student to look at the Moon photo in the Resources book. Allow time for them to make some close observations. Point out the Moon Photo poster and tell students they can use it for their observations.

Students use the student sheet Moon-Picture observations for recording. Discuss their observations and develop the definitions for the features: craters, maria or mare, highlands, and rays.

During the discussion, students will begin asking questions. Instruct them to talk in their groups to come up with five questions they have about the Moon. They can record their group questions on the student sheet, Group Questions About the Moon.

One student from each group transcribes the questions to turn in. Give groups a check on the assessment chart if their group comes up with five Moon questions. After students have formulated their questions, read the second lunar myth, Rona in the Moon. Use the overhead to demonstrate the Rona in the Moon image to help students become more familiar with the face of the Moon.

<Investigation 4, Part 3>

Narrator: In this part students will organize questions generated by all the students.

This is what you will need to provide for each group of four students: Copies of questions from Part 2, a large piece of paper, scissors, and transparent tape or glue sticks. If you think students will need help with sorting items into categories, you can supply a typical grocery shopping list. Each group will also need the four copies of the Student Resources book.

For the class you will need blank overhead transparencies and pens and an overhead projector. For assessment you will need Assessment Chart for Investigations 3 and 4.

Students will begin by sorting the questions posed by all of your students. There are a couple of ways to compile the questions and they are described in Step 1 of the teacher guide. Plan on the type of paper students will use to attach the questions to. You can use chart paper, 11x17 paper, construction paper, or any large format paper.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions. Begin this part by reading the third lunar myth, Moon and His Sister in the Resources book

Pass out the sets of questions and tell students that they should cut the questions apart and put them into groups of similar questions. Ask them to share their categories and write them on the board or overhead. Allow time for students to make their final sort and attach them to the paper. Give students, as they complete the sorting a check mark on the assessment chart.

<Investigation 4, Part 4>

Narrator: In this part students will read two more myths and write a myth of their own to explain the Moon's appearance or behavior.

You will need four copies of the Student Resources books for each group of four students. For the class you will need: a summary of the Moon questions, the class Moon log poster, the Planetary Science CD-ROM or access to the internet, and the multimedia setup.

For assessment you will need: the assessment chart for Investigations 3 and 4, paper for the students to write their Moon myths, and copies of Mid-summative Exam 4 for each student.

Compile the questions from the previous part into a list that is displayed for the remainder of the course. There are several ways to summarize the list explained in Step 1 of the teacher guide. If students have missed days recording on their Moon Log, plan on using the Lunar Calendar in the multimedia to fill in the gaps.

The calendar is found in the upper left corner of the resources room. Practice using the calendar. Enter any date and then click "Show Phase", and it will display the Moon's phase for that day. Then students can fill in their logs with days they missed. Plan for the students to write their Moon myths. There's a suggested scoring rubric in the teachers guide.

This is only a brief outline of this part. Make sure you read and follow the teacher guide to get step-by-step directions.

Review the Moon logs and make sure students have them up to date. Use the Lunar calendar if students need to fill in any missing Moon observations. Read the remaining two Moon Myths, Tale of the Rabbit and Bahloo, Moon Man.

Discuss the meanings of the myths with students to set the stage for writing their own myths. Pointers to help students get started can be found in the teachers guide. Call on students to share their myths with the class and discuss the explanations for the Moon's appearance or behavior that the myths address.

Use the rubric in the assessment chapter to score the student's myths and explanations. When you feel students are ready have them take Mid-summative Exam 4. Answers for the Mid-summative are found in the Assessment chapter of the teacher guide.

<Investigation 5, Introduction>

Narrator: In this investigation, students will study craters and simulate their formation.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book and multimedia. Be sure to read through the Scientific and Historical Background pages for information on the formation of craters.

The Why Do I Have to Learn This? section explains how students will begin inquiry investigations in to the formation of Moon craters and compare them to impact craters on Earth.

<Investigation 5, Part 1>

Narrator: In Part 1 students use an historical controversy about the origin of Moon craters to begin their investigation of craters and the Moon.

This is what you will need from the kit for each group of four students: one basin, four marbles, and a plastic cup. You will need to provide a piece of cardboard, 10 cm x 20 cm copies of the student sheet Lunar Crater Formation and four copies of the Student Resources book.

This is what you will need for the class from the kit: 2 half-liter containers, four cocoa shakers, and transparency no. 16, Lunar Crater Formation. You will need to provide: cocoa, about 20 pounds of flour, newspaper, an overhead projector, the multimedia set up, and the Planetary Science CD-ROM or access to the internet.

For assessment you will need the Assessment Chart for Investigation 5 and 6. If you have not done so, make copies of the Moon questions for the students or prepare them to be posted in the room. Read the script for the Moon crater controversy in the Student Resources book to become familiar with the views of Dr.'s Shoemaker and Green.

Collect enough newspapers for students to use under the flour basins to catch the flour spray. You will need about 20 pounds of flour, put about 1½ liters of flour in each basin. After students have worked with the flour and cocoa, you can reuse the flour by mixing the cocoa in for the next class. Between classes, basins can be stacked to save space. Fill the cocoa shakers. You will only need a few that will be shared by groups.

If you don't have cocoa, you can use any dark-powdered substance that shows up on the flour, such as cinnamon, dry tempera paints, or even ground up charcoal. Cut a piece of cardboard for each group. They it to level the surface of the flour between trials. Plan a materials station for students to pick up materials and for them to have access to the cocoa powder.

This is only a brief outline of this part of this investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review the students' questions by either passing out copies of the question summary or pointing out where the questions are posted in the room. Point out that most groups had at least on question about craters and introduce the dialog between Dr.'s Shoemaker and Green. Ask two students to read the parts of Dr. Shoemaker and Green to the class.

Afterwards lead a discussion about how the controversy could be resolved. This discussion will lead them to the crater formation investigation. Show students the simulated lunar surface and the flour basin.

Introduce the term meteoroid and the marbles that will they will use. The first introduction to this activity is open-ended, but you need to establish some ground rules. Groups will share the cocoa shakers. They lightly cover the surface of the flour with the cocoa. Distribute the materials and allow students to make informal observations and comparisons of their craters.

This first part is unstructured to give students experience with the materials before designing their own investigations. Use the assessment chart to make notes on student and group cooperation.

<Investigation 5, Part 2>

Narrator: In this part students will conduct a controlled experiment to discover the relationship between meteoroid speed and crater diameter and ray length.

This is what you will need for each group of four students: one basin of flour, four marbles in a plastic cup, one piece of cardboard, a pair of scissors, a millimeter ruler, pencil compass or a tagboard divider, which we'll tell you how to make in a bit, and a meter stick or meter tape. If you decide to make the tagboard dividers you will need to provide: tagboard or old file folders and brass fasteners.

You will need to make copies of the student sheets, Model Impact Craters, Crater-Diameter and Ray-Length Graphs, and Tagboard Divider, if students are going to construct their own tagboard dividers.

For the class you will need: four cocoa shakers and one small zip bag. You'll provide extra cocoa and newspapers. You'll need to make one copy of Teacher Special Master, Millimeter Rulers on tagboard and you'll need from the kit transparency no. 17, Tagboard Divider, no. 18, Model Impact Craters, and no. 19, Crater-Diameter and Ray-Length Graphs. You'll also need blank overhead transparencies and markers, and an overhead projector. For assessment you will need the assessment chart for Investigations 5 and 6.

Check your supply of flour to make sure there is plenty in the basins. Check your shakers and refill with cocoa if necessary. Make copies of the Millimeter Rulers found in the Teacher Special Masters chapter. Rough cut the millimeter rulers to give to students. They will complete the trimming as part of the investigation. Students will need to measure the diameter of the flour craters.

Line up the points of the pencil compass with the edges of the craters and then compare the diameter to the millimeter ruler. If you don't have pencil compasses students can use the tagboard dividers. To make the tagboard dividers cut a 1 cm strip of tagboard about 20 to 25 cm long. Cut the strip in half at an angle. Poke a small hole near the end and insert a brass fastener. Then bend back the ends.

You can make these ahead of time or have your students make them in class. Students use the dividers the same as the compasses to get the diameter of their craters.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions.

Review the students' crater experiments from the previous part. Reinforce the vocabulary and clarify the definitions. Ask students to share the ways that their craters were different in the first part and list them on the board. Challenge them to think about what caused these variations. Propose a new experiment but this time with controls.

As a class, ask students to design this experiment. Once students have decided on their procedure, describe the measuring tools you have for them and distribute the materials and let them begin. Monitor groups as they conduct their investigations, and take their measurements for crater diameter, and crater depth.

When they have collected and recorded their data on the student sheet Model Impact Craters, instruct them to graph their results. They can use the graphs from the student sheet Crater-Diameter and Ray-Length Graphs or they can make their own graphs in their notebooks. Continue making informal notes as students work.

<Investigation 5, Part 3>

Narrator: In Part 3 students will continue their investigation of impact craters. They will discover the relationship between meteoroid size and different crater characteristics.

This is what you will need for each group of 4 students: 1 basin of flour, rocks of five sizes in a cup, a piece of cardboard, one pair of scissors, a millimeter ruler, a pencil compass or a tagboard divider, and

one meter stick or meter tape. Each group will need four copies of student sheet Investigating Meteoroid Size.

For the class you will need: four cocoa shakers and one small zip bag. You'll provide extra cocoa and newspaper, electronic balances accurate to 1 gram, transparency no. 20, Investigating Meteoroid Size from the kit, and an overhead projector. For assessment students will need notebook paper and you will need the assessment chart for Investigations 5 and 6.

Check your supply of flour and cocoa to make sure there is plenty in the basins. Check your shakers and refill with cocoa if necessary. Replace any damaged or lost millimeter rulers or tagboard dividers. Set up a weighing station for the rocks that students will use in this part. Two electronic balances will be enough for a class of 32 students. If you are using triple-beam balances or pan balances you will need more.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Ask student to review the data from Part 2 and ask them to compare the crater they made to those found on the Moon. When they are comparing the different sizes, ask them if this is only the result of speed or could there be another reason. Propose they conduct a similar investigation but with different sizes of meteoroids.

Allow time for students to rewrite the investigation to include different sizes of rocks. Distribute the materials and let students begin their investigation. This time they will be dropping rocks of different sizes, all from the same height.

When students have completed their investigations they will organize the results and write a position paper discussing whether or not they think the craters on the Moon were created by impacts. Use the rubric in the assessment chapter to score the students' position papers.

<Investigation 5, Part 4>

Narrator: In this part of the investigation students will use the multimedia to classify Moon craters based on how they were formed.

This is what you will need for each group of four students: the Investigating Meteoroid Size student sheet from the previous part, four Resources books, and four copies of the student sheet, Organizing Lunar Craters.

This is what you will need for the class from the kit, the Official Map of the Moon, transparency no. 20, Investigating Meteoroid Size, transparency no. 21, Organizing Lunar Craters, and the Planetary Science CD-ROM or access to the internet. You will need to provide an overhead projector and a multimedia set up. For assessment you will need the Assessment Chart for Investigations 5 and 6.

Check your students' graphing skills. If they are having trouble setting up their graphs you may need to spend some time helping them with graphing conventions. Check Step 1 of the teacher guide for some suggestions. Preview the crater and mare formation animations on the CD-ROM. Enter through

Investigation 5 in the multimedia teacher guide and Part 4. The first set of animations is under Crater formation. Here you will find simple and complex crater formation. Find a place in the room to post the Moon Map so that students can get close to study it.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review the crater experiments and classification activities. Discuss crater formation and the students' position papers. Have a group transfer their graphs to an overhead and project them ask the questions in Step 4 of the teacher guide.

Introduce the multimedia and ask a student to operate the simulations with the help of the class to demonstrate and explain crater formation. Ask students to study the eight pages of Moon photos in the Student Resources books. Each pair of students will pick one photo and find different crater features. Point out the location of the Moon Map for students to study. When students have located examples of simple, complex, and terraced craters, introduce other crater features and ask the students to find examples of them. Return to the multimedia and show the maria formation animation.

Return to the photos to investigate areas saturated with craters and superposed craters. Students will now be able to organize and describe craters on the student sheet. When students have completed their analysis and organization of craters, assign the reading from the Resources book, Craters: Real and Simulated.

<Investigation 5, Part 5>

Narrator: In this part students will take a summative exam, analyzing the face of the Moon.

Each group of four students will need: four copies of the Student Resources book and for assessment you will need a copy of Mid-summative Exam 5 for each student.

Plan for students to spend an entire class period completing this Mid-summative. This will be an important check point for you see how students have progressed in their analysis of evidence and ability to draw conclusions.

At the beginning of the next part, students will read The Crater That Ended the Reign of the Dinosaurs in the Resources book. You may want to assign it as homework at the end of this part.

This is only brief outline of this part of the investigation. Make sure your read and follow the teacher guide to get step-by-step directions.

Introduce Mid-summative Exam 5 to students and explain that they will need to use the photo on page 26 of the Student Resources book to answer the questions. Allow a full class period for students to work on the assessment. The answers for Mid-summative Exam 5 are found in the assessment chapter of the teacher guide. Assign the reading, The Crater That Ended the Reign of the Dinosaurs when students have completed the assessment.

<Investigation 5, Part 6>

Narrator: In this part of the investigation students will use what they have learned about craters and turn to look at evidence of craters on Earth.

For each group of four students you will need: four copies of the Student Resources books.

For the class you will from the kit: the Planetary Science CD-ROM or access to the internet, and the video, Asteroids—Deadly Impact. You'll need to provide a way to view the video.

You'll also need to provide a copy of your state map and a multimedia set up. For assessment, students will need notebook paper for a short essay and the Assessment Chart for Investigations 5 and 6. If students did not read the article, The Crater That Ended the Reign of the Dinosaurs, plan for them to read it during class.

Get a copy of a map of your state. The class will compare the Chicxulub crater with their state. Preview the multimedia so you will be comfortable with the images. Plan for showing the video, Asteroids—Deadly Impact, the video is 60 minutes long so you should plan for two class periods to show it. The second half can be shown during Part 7.

This is only a brief outline for this part. Make sure you read and follow the teacher guide for step-by-step directions.

Lead a class discussion of the article, The Crater That Ended the Reign of the Dinosaurs. Focus on the questions at the end of the article.

Work with students to draw a circle to represent the Chicxulub crater and center it over your town. Discuss the possibility of other craters on Earth. Refer to Step 4 in the teacher guide to help guide the discussion. Use the multimedia to explore other Earth craters and craters on Mars.

Enter through the Crater binder in the resource room. Navigate to the Earth Crater Locator Map and then investigate Earth craters. Repeat this for the Mars craters. Begin showing the video, Asteroids—Deadly Impact. You can finish the video during Part 7. Assign an essay on the possibility of future Earth impacts for homework. Use the Assessment Chart for Investigations 5 and 6 to record grades for the student essays.

<Investigation 5, Part 7>

Narrator: In Part 7 students will investigate several theories for the origin of the Moon.

Each group of four students will need: four copies of the Student Resources Book. For the class you will need: the Planetary Science CD-ROM or access to the internet and a multimedia set up. For assessment you will need: the Assessment Chart for Investigations 5 and 6 and notebook paper for student position papers.

Before you begin this part, preview the multimedia and the four theories presented. From the multimedia teacher guide, select Part 7 and Origin of the Moon. Preview each of the four theories presented.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher

guide to get step-by-step directions. Start a discussion about observing the Moon and pose the question, Where did the Moon come from?

Introduce the four theories of the Moon's origin with the mini-lecture in Step 4 of the teacher guide. Show the multimedia animations of the four theories of the Moon's origin: the capture theory, the daughter theory, the sisters theory, and the big impact theory. Finish this investigation by reading the two articles in the Student Resources book: How to Get and Hold Onto a Moon and Gene Shoemaker: The First Man on the Moon?

Use the assessment chart to score the student's explanation for one of the Moon theories.

<Investigation 6, Introduction>

Narrator: In this Investigation students will identify prominent craters on the moon and compare their size to places on Earth.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation. You will also find when to use the Student Resources book and multimedia.

Be sure to read through the Scientific and Historical Background pages for information on mapping and naming features on the Moon. The Why Do I Have to Learn This? section explains how mapping and scaling craters will help students develop proportional reasoning.

<Investigation 6, Part 1>

Narrator: In this part students study the face of the Moon more closely and identify prominent features

This is what you will need for each group of four students: two hand lenses from the kit, four copies of the student sheet, Map of the Moon, and four Student Resources books.

This is what you will need from the kit for the class: The Earth's Moon Map, The official map of the Moon, one copy of student sheet Major Surface Features of the Moon for you to use, and transparencies no. 13, Moon Photo, and no. 22, Map of the Moon. You will also need to provide an overhead projector.

For assessment you will need the Assessment Chart for Investigations 5 and 6. Become familiar with the names of the major craters on the Moon, especially those listed on the student sheet Major Surface Features of the Moon. Post the National Geographic poster, Earth's Moon so that it is accessible to the students.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review the crater questions from the student questions and describe the Moon-Crater Survey. Refer to the teacher guide for suggestions to help student's record descriptions in their notebooks.

Introduce using the Map of the Moon student sheet to make a permanent record of craters. Use the transparencies to demonstrate how to transfer information to their sheets. Point out that shaded areas

coincide with the dark areas of the Moon.

Ask students if they can identify any. They will probably recognize this one as Rona's basket. This is the Sea of Crisis. Once they have identified it they can label it. Using the Moon photo work with students to identify major landmarks on the Moon listed on student sheet, Major Surface Features of the Moon.

You can copy this list onto the edge of the transparency or on to another blank transparency taped to the edge. Tape it down, so it doesn't move around. Then draw lines to each of the landmarks while students transfer the names to their maps. Slide it over to the other side and continue with landmarks on this side of the photo.

Monitor students as they locate the craters listed on the student sheet and record informal notes on the assessment chart as necessary.

<Investigation 6, Part 2>

Narrator: In this part students will calculate the actual size of craters they have identified.

This is what you will need to provide for each group of four students: four metric rulers, four calculators, four copies of the student sheets, Scaling Moon Features and Major Surface Features of the Moon, and four copies of the Student Resources book.

If you decide your students need scaling practice you will also need copies of the student sheets Scaling Introduction and Scaling with Photos.

For the class you will need: transparencies no. 13, Moon Photo, no. 23, Earth/Moon Comparison, no. 24, Scaling Moon Features, and no. 25, Major Surface Features of the Moon. You will also need overhead transparency markers and an overhead projector.

For assessment you will need the Assessment Chart for Investigations 5 and 6, and paper for students to use for a quick write.

Based on your students experience with scaling you may decide to spend more time with the math and scaling activities. The student sheets, Scaling Introduction can be used as homework to help make this evaluation. If more help is needed you may also want to use the student sheet Scaling with Photos.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step instructions.

Project the Moon Photo transparency and lead a discussion with students to focus on areas saturated with craters and speculate how big they are. Step 3 in the teacher guide has suggested questions to move the conversation along.

When students notice there is no scale on the Moon photo, point out that we do know the diameter of the Moon, almost 3500 kilometers. Use the overhead transparencies and the Resources books to illustrate the size of the Moon compared to Earth.

Challenge students to find the size of Copernicus Crater and the distance between Plato and Theophilus craters. They should use the student sheet, Major Surface Features of the Moon for their calculations and answers. Allow time for students to work through the calculations.

Monitor student's progress and review scaling if necessary and then instruct them to continue finding the sizes of the features listed on the student sheet. Use the assessment chart to assess student's ability to calculate dimensions of craters and maria. Give them a check mark if they are able to do this with little assistance. Ask students to write their ideas about where this maria came from.

Collect these papers but do not grade them now. You will return them at the end of the next part of the investigation. Give students a check mark on the assessment chart for their ideas on maria formation.

<Investigation 6, Part 3>

Narrator: In this part students will compare the size of a lunar crater to their hometown and state.

This is what you will need for each group of four students: four pairs of scissors and four pieces of paper. You may want to use colored paper. For the class from the kit you will need, transparency no. 13, Moon Photo.

You will need to provide: several maps of your state, region, or the United States, pencil compasses, transparent tape, blank overhead transparencies, and overhead transparency markers, an overhead projector, a multimedia setup, and the Planetary Science CD-ROM or access to the internet.

For assessment you will need the Assessment Chart for Investigations 5 and 6, the Quick Writes from Part 2, and a copy of Mid-summative Exam 6 for each student.

Get enough maps so that each group will have a map to work with. They don't all have to have the same map, some state maps, some regional maps, and some of the whole United States will work. Since most craters are 70–100 km in diameter a city map won't work. Check the maps to make sure they have a metric scale. It is easier for students to work with metric units rather than English units. Students will need to convert miles to kilometers if the scale is in miles. They will need pencil compasses to draw circles. If you don't have enough of them for each group set up a materials station so they can share them.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Ask students to think about the craters they investigated in the previous part. Ask them which one was the largest and which was the smallest they found. Pose the question: What would happen if a meteoroid that formed one of these craters were to hit on our hometown or state? Bring out the maps and give one to each group.

Decide on a crater that all groups will use and describe the challenge. Guidelines for the challenge can be found in Step 7 of the teacher guide. Students will make a scale model for the crater using the scale from their map.

Depending on the map scale they may need to tape several pieces of paper together or use larger paper. When groups have finished, give students time to compare the size of the crater to their hometown or state.

Let students compare the same crater on maps at different scales. Here you see Copernicus crater compared to New York state map and here is Copernicus on a US map. Other features such as Ptolemaeus crater, and the Sea of Serenity can be shown for comparison.

Revisit the maria formation on the multimedia. Information about how to lead this simulation is found in Step 11 of the teacher guide. Return the quick write to students and allow time for them to make corrections and additions before they return them to you for grading.

A rubric for scoring the revised quick write is found in the Assessment chapter of the teacher guide. When you think students are ready have them take Mid-summative Exam 6. Answers for the Mid-summative Exam are found in the Assessment chapter of the teacher guide.

<Investigation 7, Introduction>

Narrator: In this investigation, students study the history and technology involved in the exploration of the Moon.

Look over the At a Glance chart for: a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book, video, and multimedia. Be sure to read through the Scientific and Historical Background pages for information about our first missions to space culminating with Apollo 8's Moon landing.

The Why Do I Have to Learn This? section challenges students to think of space exploration as recent history being made and how everyone has the potential to be part of it.

<Investigation 7, Part 1>

Narrator: In Part 1 students are introduced to the history of space exploration and begin asking questions.

This is what you will need for the class: From the kit, the video, For All Mankind, you'll need to provide a way to view the video. You need to provide blank overhead transparencies, overhead transparency markers, an overhead projector, the multimedia setup, and the Planetary Science CD-ROM or access to the internet. For assessment you will need the Assessment Chart for Investigations 7 and 8.

Plan how you will show the video, For All Mankind. It is 80 minutes long, but you should only show about 20 minutes at the end of each part of this investigation. Preview the John F. Kennedy speech clip in the space exploration binder in the multimedia. Select the Moon folder and the speech by John F. Kennedy.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Introduce the history of space exploration. There is a mini lecture in Step 1 of the teacher guide. You may want to read parts of this to students. After the mini lecture show the short clip from President John F. Kennedy's speech, challenging the space community to land humans on the Moon.

Lead a class discussion about early reconnaissance missions and instruct students to come up with several questions that must be answered before a manned mission to the Moon leaves Earth. Observe students as they work and give them a check mark if they write relevant and productive questions. End this part by showing the first 20 minutes of For All Mankind. End with the space walk scene and before they go to the Moon. If you are using the DVD version, this is Chapters 1 through 4.

<Investigation 7, Part 2>

Narrator: In this part students will make a scale model of the Moon and calculate its distance from Earth.

This is what you need from the kit for each group of four students: one Earth globe and base with a straw and a piece of aluminum foil. You will need to provide four calculators, and a meter stick or meter tape, four copies of student sheet Earth/Moon Model, if you plan to use it, and four copies of the Student Resources books.

For the class you will need: transparency no. 26, Earth/Moon Model, the video, For All Mankind and a way for students to view it, and an overhead projector. For Assessment you will need the Assessment Chart for Investigations 7 and 8.

Each group will need a square of aluminum foil about 30 cm x 30 cm. This can be torn directly off a standard roll of aluminum foil. If students get a little more or less it will be ok.

Assess your students' proportional reasoning skills. If they are struggling with scaling, you may want to consider using the student sheet and transparency, Earth/Moon Model.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions. Ask students to recall the questions they had yesterday about lunar missions.

When the question of how long would it take to get there comes up, propose they construct a model that represents the size of the Moon and its distance from Earth to figure that out. To assess student ideas about the size of the Moon and the distance to it, call on two students to model where they think the Moon would be if this globe was the size of the Earth. Tell students to remember this when they construct their models.

Direct students to the resources book to find the sizes of the Earth and Moon and the distance between them. They will also need to find the diameter of the Earth globe. There are several ways to do this. In one method, students stack books, place a straight edge across the top and measure the height.

Another method is to use the straw like a dipstick, mark the diameter, and measure directly from the straw.

Monitor students as they make their calculations. Step 7 in the teacher guide has measurement results to help you evaluate and guide students as they work. If your students struggle with the proportional math you may decide to use transparency no. 26, and lead them step-by-step through the process. Monitor students as they work to get their Moon the correct size to fit with their Earth globe.

Review the finished models with the class and have students demonstrate the correct distance between Earth and the Moon. Have them compare this to what they thought the distance would be. A shortcut to finding the diameter and distance can be found in Step 11 in the teacher guide, and more Earth/Moon relationship puzzles can be found in Step 12.

Now ask students how long they think it took the Apollo mission to get to the Moon. Lead a discussion with students to calculate the time. They can begin by dividing the trip into different blocks of time. Allow time for students to make these calculations and record them in their notebooks.

End this part of the investigation by showing the second 20 minutes of *For All Mankind* ending just before they get to the Moon. If you have the DVD this is Chapters 5 through 8.

Give students a check mark on the assessment chart if they were able explain the Earth Moon relationship as they were building their model.

<Investigation 7, Part 3>

Narrator: In this part students will investigate the lunar surface and select a landing site.

This is what you will need for each group of 4 students: the Map of the Moon student sheets from Investigation 6 and four copies of the Student Resources book. For the class you will need: the video, *For All Mankind* and a way for students to view it, an overhead projector, the multimedia set up, and the Planetary Science CD-ROM or access to the internet. For Assessment you will need the Assessment Chart for Investigations 7 and 8.

Review the reading on lunar probes so you will be prepared for class discussion. Preview the Lunar probes from the multimedia in the Space Exploration binder. Enter through the Space Exploration binder, select the Moon, then the thumbnails for Moon Exploration.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions. Ask students to consider the Moon's surface. There were probably some questions about what the Moon is made of.

A short mini-lecture about the Moon's surface is included in Step 2 of the teacher guide. Introduce the Ranger and Surveyor probes and have students read the article *Lunar Probes: Paving the Way for Apollo* in the Student Resources book.

Discuss the lunar surface data and ask students to look at the Moon photos on pages 18 through 25 and then should decide what they think would be a good landing spot. Have students add their suggested

landing sites to their Map of the Moon they completed in Investigation 6. Now have students can add the landing site for Apollo 11.

Plan on having the Assessment Chart for Investigations 7 and 8 handy so that you can jot down notes as students discuss landing on the Moon. End this part of the investigation by showing the third 20 minutes of For All Mankind ending just before they start using the lunar rover. If you have the DVD this is Chapters 9 through 14.

<Investigation 7, Part 4>

Narrator: Part 4, Lunar Day and Night is an optional activity. In this part students apply their knowledge of day and night to plan the time of day for the lunar landing.

For each group of four students you will need four copies of the Student Resources Book For the class you will need: the video, For All Mankind and a way for students to view it, a multimedia set up, and the Planetary Science CD-ROM or access to the internet. For assessment you will need the Response Sheet—Landing on the Moon, and the Assessment Chart for Investigations 7 and 8.

Review the multimedia for Day and Night. Plan on how you will make it available for students. You may want to have several computers for groups that need to verify that the Moon has day and night. Decide if you will show the last part of For All Mankind at the end of this part or at the end of Part 5. Provide access to the current Moon phase. You can use the student's class Moon Log or the Moon Calendar from the multimedia.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Pose a problem to students. NASA wants the astronauts to photograph a sunset on the Moon. Review day and night and call on students to explain day and night. Ask students if they think there is day and night on the Moon and allow time for them to discuss it in their groups.

Lead a class discussion and use the multimedia to help illustrate day and night on the Moon. Students should come to the conclusion that it takes a month for the Moon to go through a full day/night cycle Set a scenario for students that the mission must take off in 30 days and will only be on the surface for 4 days.

Tips for helping students analyze this problem are found in Step 6 of the teacher guide. Show the last 20 minutes of For All Mankind if you have decided to show it here.

After the video, present the Response Sheet—Landing on the Moon, to students. Let them discuss it in their groups before answering on their own. Give students a check mark on the assessment chart if they have an understanding of day and night on the Moon.

<Investigation 7, Part 5>

Narrator: In this part students will write a summary report of a fictitious Moon mission. This part of the investigation can be used as a homework.

For each group of four students you will need four copies of the Student Resources book. For the class you will need: a multimedia setup, and the Planetary Science CD-ROM or access to the internet. For Assessment you will need Assessment Chart for Investigations 7 and 8, paper for students to write their mission summaries, and copies of Mid-summative Exam 7 for each student. If you didn't show the last part of For All Mankind, plan on showing it before the Mid-summative Exam.

This is only brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Ask students to imagine that they have returned from a trip to the Moon and they must now submit their mission report.

Describe what students need to include in their mission report and brainstorm ideas of topics to include. Steps 2 and 3 on in the teacher guide will give you hints for leading this discussion. Give students a check mark on the assessment chart if they have included information from several sources to complete their mission report.

Show the last portion of For All Mankind if you haven't already done so. When you think your students are ready, have them take Mid-summative Exam 7. Answers for the Mid-summative Exam are found in the Assessment chapter of the teacher guide.

<Investigation 8, Introduction>

Narrator: In this investigation students collect and analyze simulated Moon rocks. They compare their results to information about the origin of the Moon.

Look over the At a Glance chart for: a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book and multimedia. Be sure to read through the Scientific and Historical Background pages for information about the geologic studies conducted by Apollo astronauts.

The Why Do I Have to Learn This? section explains how studying Moon rocks helps us to understand the Moon's origin and relationship to Earth.

<Investigation 8, Part 1>

Narrator: In Part 1, students make observations of simulated Moon rocks and develop a plan for collecting rock samples during a lunar mission.

This is what you will need from the kit for each group of four students: two canisters of Moon rock chips, which I'll tell you how to assemble, two hand lenses, a 1-liter zip bag, and the Lunar Landing Site Chart.

For students you will need to provide: two sheets of white paper or paper plates, and four copies of the student sheet, EVA-1: Moon Rock Survey. This is what you will need from the kit for the class: the

white measuring spoon, eight large zip bags, and the rock chip samples. You'll need one copy of labels for Lunar Sampling Missions from the Special Teacher Masters chapter, eight copies of the Moon rock and mineral key (make these copies on card stock if possible), transparencies no. 27, EVA-1: Moon Rock Survey and no. 28, Moon with Landing Sites.

You will need to provide: a permanent marking pen, transparent tape, white glue, and an overhead projector. For assessment you will need the Assessment Chart for Investigations 7 and 8.

To assemble the canisters of Moon rock chips you will need the bags of small rock chips for: feldspar, ilmenite, olivine, pyroxene, orange glass beads, anorthosite, fine-grained basalt, vesicular basalt, breccia, and norite, the blue canisters, and the long-handled white spoon.

If this is the first time the kit has been used you will have to prepare the lunar rock samples. These will not have to be prepared again next year.

For Part 2 of this investigation each group will need a Moon Rock and Mineral Key. Prepare them now when you have the rock samples out. Lay out all eight sheets, side by side. Put a small drop of white glue in the first blank space. Place a few rock chips on each drop. When they're dry, put them the large zip bags from the kit for protection.

Each group will have two canisters of rocks. One representing the mare rocks, which will look like this and one representing the highland rocks, which will look like this. To prepare the canisters make a copy of the label sheet from the Special Teacher Master chapter. There are two sets of labels on the sheet, so cut the sheet in half, save those in case you need a replacement.

The bottom eight labels are the highland labels, the top 8 labels are the mare labels. Cut the labels apart. There are two labels for each landing site. It doesn't matter which label you choose, all of the mare canisters will be alike and all the highlands canisters will be alike. Use transparent tape to attach a label to each of the mare canisters.

The table in Step 2 of the teacher guide lists how many spoons of each rock or mineral sample to add to the canisters. Use the long-handled white spoon to measure the rock chips into the canisters. This is easier to do one rock type at a time. The table showing the number of spoons for each highland sample is found at the top of the next page.

Use the same procedure for filling the highland canisters. Use a permanent marker to put the group numbers on the 1-liter zip bags so students can get the same pair of canisters each day. Put one canister from the mare and one from the highland into the zip bag and seal.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Use the mini-lecture in Step 2 in the teacher guide to describe the Apollo program and set the stage for this part.

Explain to students that they will be assuming the roles of astronauts and observing rocks at one of several landing sites. Each group of four students will have one set of canisters. One pair of the group will observe mare rocks and the other pair will observe the highland rocks. Directions for leading students through the observations can be found in the teacher guide.

First they will fill out the landing site information on the student sheet EVA-1: Moon Rock Survey. Distribute the canister sets and hand lenses. Students spread out the rocks onto paper and record everything they can in 10 minutes. After students have observed the rocks and returned them to the canisters, explain that during the next EVA you will pick up some of the rocks.

Have them to come up with three questions that can be answered by analyzing a collection of carefully selected rocks. Observe students as they examine the rock samples and make note of questions they may have.

<Investigation 8, Part 2>

Narrator: In this part, students will collect a small sample of rocks and determine the most common rock types for mare and highland landing sites.

This is what you will need from the kit for each group of four students: two vials with caps, two forceps, two magnets, two hand lenses, two canisters of rock samples in a zip bag, one Moon Rock and Mineral key, four copies of the student sheet, Collecting Samples and Moon Rock Conference Data, and four copies of the Student Resources book.

For the class you will need: transparencies no. 29, EVA-2: Collecting Samples, no. 30, Moon Rock and Mineral Key, and no. 31, Moon Rock Conference Data. You will also need an overhead projector. For assessment you will need the Assessment Chart for Investigations 7 and 8.

Think about timing for this part. Make sure you reach the breakpoint so that the rock samples can be returned to the canisters for the next class. For this part you will need to add two pairs of forceps and two small vials to each bag.

This is only a brief outline for this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review the sampling procedures used by the Apollo astronauts and describe how the students will have to limit the samples they collect to fit into the vial. Again they will only have 10 minutes to collect their samples. Pass out materials and give students 10 minutes to collect their samples. After they have collected their samples they will need to identify the rocks and minerals using the Rock and Mineral Key.

Students use the chart at the bottom of student sheet, EVA 2: Collecting Samples to list each kind of rock collected and identify the most common rock type for their location. Assess students as they work. Give them a check mark on the assessment chart if they are able to identify the rock types and determine the most common rocks. At this breakpoint, students will empty the vials back into the proper canister and they are now ready for the next class.

During the next class period students will share the information they found and fill out the Moon Rock Conference Data sheet. Discuss the results using the questions in Step 13 in the teacher guide to help students debrief.

<Investigation 8, Part 3>

Narrator: In Part 3, students will investigate the density of Moon rocks.

This is what you will need from the kit for each group of four students: 2 half-liter containers, four plastic cups, one pebble, one wood dowel, one iron bolt, two slim straws, two graduated cylinders, four copies of the student sheet, Exploring Density, and four copies of the Student Resources book.

You will also need to provide each group with a calculator and access to balances or scales. For the class you will need to provide: two apples, a knife, for teacher use only, a pitcher of water, paper towels, and an overhead projector.

From the kit you will need: 4 half-liter containers and transparency no.32, Exploring Density. For assessment you will need the Assessment Chart for Investigations 7 and 8.

Students will need small pieces of apple for this part. Cut pieces so that they will easily fit inside the graduated cylinders. Students can use the slim straws to hold the apple piece under water. Place the wood dowel pieces, iron bolts, pebbles, and apple pieces in separate half-liter containers. Place the density objects and water at a materials station for students to pick up.

This is only a brief outline of this part the investigation. Make sure you read and follow the teacher guide to get step-by-step directions. Introduce density as a property of Moon rocks that scientists were very interested in.

Use the student sheet, Exploring Density, to lead students through this activity. Let students talk in their groups to determine how they will find the mass and volume for each object. If students have not used water displacement to measure volume, you'll need to demonstrate the procedure for them.

First they will record the water level in the graduated cylinder, 40 mL in this example. Then drop the object in and record the new volume, now 45 mL. The volume of this rock is 5 mL or 5 cubic centimeters. You will need to tell them that 1 cubic centimeter equals 1 milliliter.

Students are now ready to begin measuring density. Monitor students as they work and make note of students who struggle with calculations. When they have completed their calculations, call on students to report their findings and rank the objects from densest to least dense.

Assign the reading in the Student Resources book, Top Ten Scientific Discoveries Made during Apollo Exploration of the Moon.

<Investigation 8, Part 4>

Narrator: In Part 4, students will investigate the density of the most common Moon rocks. They'll use this information to consider the origin of the Moon's crust.

This is what you will need from the kit for each group of four students: 2 half-liter containers, four plastic cups, two graduated cylinders, two slim straws, one large sample of each of these minerals: pyroxene, olivine, ilmenite, and feldspar. You will also need four copies of the student sheet, Lunar Density and four copies of the Student Resources book.

You will need to provide a calculator and access to balances. For the class you will need the following from the kit: 4 half-liter containers, five super jumbo straws, ten rubber bands, 25 gram pieces, some gravel, transparencies no. 33, Lunar Density, and no. 34, Moon Rock Formation.

You will also need to provide: A large graduated cylinder or jar, a pitcher and water, paper towels, and an overhead projector.

For assessment you will need the Assessment Chart for Investigations 7 and 8, the student sheet, Lunar Density, and copies of Mid-summative Exam 8 for each student.

Put the large mineral samples into half-liter containers. Set up a materials station like you did in Part 3, but with the large mineral samples. For the density demonstration you will need to four solids of different densities.

You'll need to prepare four or five super jumbo straws cut into pieces about this side, ten large rubber bands cut into pieces, about a 1/4 cup of gravel, and 25 of the gram pieces. You'll also need a large, slender jar or 1000 mL graduated cylinder with water.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Review density and introduce the Lunar-Density investigation. Students will find the density of four common Moon rocks and this will help them to understand more about the formation of the Moon's surface. Have students get the minerals and begin finding the densities of the Moon rocks. When students have completed their calculations, call on groups to share their information and rank the minerals from most to least dense.

Lead a discussion about lunar density and on the theory about how Moon rocks were formed. Questions to guide this discussion and information can be found in Steps 12 and 13 in the teacher guide.

Conduct the density demonstration for students. The water will represent the Moon's magma. Take all the materials, and pour them into a container, and mix them together. Then pour it into the water.

Ask students to speculate on which of the four Moon minerals they studied are represented by which pieces in the graduated cylinder. When you think students are ready, have them take Mid-summative Exam 8. Answers for the Mid-summative Exam are found in the Assessment chapter of the teacher guide.

<Investigation 9, Introduction>

Narrator: In this investigation students use the data they have been collecting about the Moon to describe the Moon's motion and the phases of the Moon.

Look over the At a Glance chart for: a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book and the multimedia. Be sure to read through the Scientific and Historical Background pages for information about the motion and geometry of the Moon's path around Earth.

The Why Do I Have to Learn This? section explains how students can take daily observations and use them to complete the picture of the motion of the Moon.

<Investigation 9, Part 1>

Narrator: In this part, students complete their Moon Logs, study the sequence, and explain the reasons for Moon phases.

This is what you will need for each group of four students: four pieces of paper or index cards, the student's Moon logs, and four copies of the Student Resources book.

This is what you will need for the class: the class Moon Log poster, transparencies no. 13, Moon Photo, and no. 35, Phases of the Moon, an overhead projector, the Planetary Science CD-ROM or access to the internet, and the multimedia setup. For assessment you will need Assessment Chart for Investigations 9 and 10.

Students will need their Moon Logs and the classroom Moon Log poster needs to be complete. Fill in any missing observations to the class log and plan time for students to get their Moon Logs brought up to date if they are missing days.

Students will begin this investigation with a quick write describing the causes of Moon phases. This should not be graded until the end of the investigation, when students have had the opportunity to make corrections and additions.

This is a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions.

Begin this part by projecting the Moon photo, but oriented so that North is not at the top. Wait for students to notice and direct you to fix it. Here I have it upside down. They're going to say oh, you have it upside down. So you can acknowledge this and flip it over, of course it is still wrong.

Let them direct you how to turn it. They should be able to recognize it when it's oriented correctly. Ask them why they knew it was wrong and have them explain what they looked for to correct it. They will probably talk about looking at it each night and recognizing the shapes from the Rona myth.

Assign the Quick Write. Ask students to write down everything they know about the phases of the Moon and why they look like that. After collecting the Quick Writes, ask students to describe the different Moon shapes they noticed during the month.

Allow time for students to update their Moon Logs. Lead a discussion with students about the shapes they observed. There are hints to help you move the discussion along in Steps 6 and 7 in the teacher guide.

When they have described the shapes, put names to each of the phases and add to their vocabulary lists. Continue the discussion by asking students to think about moonrise and compare it to sunrise. Ask students to open the Student Resources book and study the Moonrise/Sunrise Data.

Allow students a few minutes to discuss the data in their groups before reporting back to the class. They will determine that the Sun rises at about the same time everyday, but the Moon doesn't. Therefore the Moon must be moving also. Challenge them to figure out which direction it is moving.

Draw Earth and the Moon as shown in the teacher guide to help. Don't worry if they can't determine the Moon is in a counterclockwise orbit at this time. This is something for them to be thinking about in the rest of this investigation.

Read through the quick writes and make notes of student ideas and misconceptions. You may want to mark the Assessment Chart with a check, plus, or minus.

<Investigation 9, Part 2>

Narrator: In this part students will use a Moon model to simulate the phases of the Moon and explore the Sun/Earth/Moon relationship.

This is what you will need from the kit for each group of four students: one Earth globe, four Polystyrene spheres, four slim straws, and four copies of the Student Resources book.

For the class you will need to provide: a large globe, a light fixture with a bare bulb, masking tape, and an overhead projector. You may also want to have scissors and rulers available for students to use.

For the assessment you will need: the Assessment Chart for Investigations 9 and 10, and the quick writes from Part 1.

You will need to darken the room for this part. Set up a light bulb in the middle of the room. The slim straw is used as a handle to hold the small polystyrene Moon, but it is a little too slim to fit snugly.

Wrap a small piece of masking tape around the end of the straw and slide this end into the hole in the sphere. Now the Moon will fit securely.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions.

Introduce the small polystyrene sphere as a model for the Moon. The light in the middle of the room will be the Sun and the students' heads will be the Earth. Challenge students to use the Moon model to observe the Moon phases from new Moon to new Moon following the progression they recorded in their Moon log.

Tell students the polystyrene Moon needs a handle and describe how to add the tape to the end of the straw. Then insert the straw into the sphere. The straws will be left in the spheres so you only have to do this with the first class.

Darken the room and allow students time to make unguided observations. With the lights still off, ask students to focus on a series of observations prompted by your questions. Which way did your turn in order to simulate the revolution of the Moon around Earth? Where did you position the Moon model to observe the New Moon or the Full Moon? Where do you position the Moon model to show the first-quarter phase? How can you simulate the rising and setting of the Moon? When students are comfortable with the motion of the Moon around their heads, direct them to change their point of view to the Earth globe.

Give students a check mark on the Assessment Chart if they can demonstrate that they understand the points given in Step 7 of the teacher guide. Give students a new challenge after they have worked with the globes for a few minutes.

Demonstrate the relationship between Earth, Moon, and Sun at the New Moon, first quarter, full Moon, and third quarter. Reorganize the room with the overhead projector at the front pointing towards the room. Hold the globe or a ball in the center to represent the Moon.

Students will stand around the teacher and with their head representing Earth; describe what Moon phase they observe. Encourage students to rotate and observe sunrise and moonrise. Make sure students understand that it is the rotation of Earth that produces sunrise and moonrise. To finish this part, demonstrate a lunar eclipse.

Challenge students to demonstrate a lunar eclipse with their globes and the Moon model. Allow time for students to add information to their notebooks about Moon phases that they can later add to their quick writes.

<Investigation 9, Part 3>

Narrator: In this part, students will complete a Moon-phase chart. Then construct a model of the Earth and the Moon to study the relationship of the Earth, Sun, and Moon.

This is what you will need from the kit for each group of four students: one Earth globe, super jumbo straw, one polystyrene Moon model with a slim straw, one flexible straw, and four copies of the student sheet, Looking at the Moon from Earth.

For the class you will need: transparency no. 36, Looking at the Moon from Earth, and the Planetary Science CD-ROM or access to the internet.

You will need to provide masking tape, the multimedia setup, and an overhead projector. For assessment you will need the Assessment Chart for Investigations 9 and 10, and the student sheet, Looking at the Moon from Earth. An Earth/Moon model may help some students to visualize how the motion of the moon produces phases of the Moon.

Practice putting this model together so that you can help students when they construct their models.

Insert the super jumbo straw through the globe. Insert the short end of the flexible straw into the straw at the North Pole end of the super jumbo straw. You may want to cut the end at a slight angle to make it easier to fit into the other straw. Wrap a strip of about 7–15 cm of masking tape around the end of the slim straw. You may need to adjust this length, depending on the thickness of your masking tape. Insert the end of the slim straw into the flexible straw. This completes your Earth/Moon model.

Practice using the Day/Night simulations and plan how you will have it available to student during the investigation.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions.

After a review of students' explanations about Moon phases, pass out the student sheet, Looking at the Moon from Earth. Use transparency no. 36, Looking at the Moon from Earth, to help student fill out the chart.

The Moons on the inner circle are seen from above the North Pole. The outer circles are the Moons as seen from Earth. First draw a line on the Moon showing which side of the Moon is lit and which is in shadow. Students will do this for each of the Moons.

Pick a point on Earth opposite one of the Moons to be your observation point. Draw two lines from this point on Earth to the edges of the Moon. Draw a third line from the Earth to the terminator, if possible. Transfer this point to the Moon. This is the Moon as you see it from Earth. Shade a portion of the Moon view that falls on the dark part of the Moon. Remember this is only a straight line at the first and third quarters.

In this example, only a small portion of the Moon, on the right side, is lit. This is a crescent Moon. Remind students that the inner Moons represent the position of the Moon in eight locations around Earth. The outer Moons represent what the Moon would look like from Earth. Propose an Earth/Moon model to help students visualize the Moon phases.

Explain how to construct the Earth/Moon Model. Let students use the Earth/Moon models to help them complete the student sheet, Looking at the Moon from Earth. Assess students' progress as they work through the sheets. Collect the sheets and if they have a good understanding of the Earth/Moon/Sun relationship, give them a check on the assessment chart.

<Investigation 9, Part 4>

Narrator: In this part students put nine Moon images in sequence and this is reinforced with a multimedia simulation.

This is what you will need from the kit for each group of four students: four Phase of the Moon Sequence Puzzles and four small zip bags. For the class you will need a pair of scissors, a multimedia set up, and the Planetary Science CD-ROM or access to the internet.

For assessment you will need the Assessment Chart for Investigations 9 and 10, the student's quick writes from Part 1, and copies of Mid-summative Exam 9 for each student.

If this is the first time the kit is used, cut the nine Moon images apart. Be careful to not cut the letters off of the bottom row. Store the puzzles in small zip bags. There are enough sets for each student to have a set to use. Decide how you will have students use the Moon phase simulation on the multimedia.

Groups can cycle through one computer in the classroom. Practice using the Moon-phase simulation so you will be able to help students. From the Investigation 9 multimedia teacher guide, select Part 4, and phases of the Moon. Then begin the simulation.

It opens in the practice mode. Practice using the hourly mode, and the daily mode to see how the Moon changes over time. In the daily mode the Moon appears to move from west to east. This apparent motion is the result of the Moon rising later each day and being farther from the Sun in the sky each day. It may take multiple viewings for students to understand this. In the hourly mode the Moon moves from east to west as the night progresses.

When you feel students understand the motions in the practice mode, have them switch to Game mode by clicking the Game button in the center. This can be done as a class demonstration with students answering or in small groups. Click on New Phase. They look at the phase shown in the sky and determine where the Moon is in relation to Earth and the Sun. If they select the correct position, they hear the wolf howl and the phase is shown in the window in the lower left. If they select the incorrect position, they get the sound of a sheep and a chance to select again. If you have a class set of computers, let each pair have access to a computer.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Present the two Moon-phase challenges to students. First, the Moon-phase puzzle. Each student will have a set to work with. Then introduce the Moon-phase simulation on the multimedia. Explain how students will rotate through the computer station if you are only using one.

They are only using the simulation in this step. You will use the game with the whole class as a review. Students will begin working on the two challenges. When all students have had time to work on the puzzle and the multimedia, give them a few minutes to let each group review each other's works and offer suggestions.

Assess students' progress sequencing the Moon-phase puzzle and if they can put the images in order give them a check on the assessment chart. When students have finished the Moon-phase puzzle, play the Moon-phase simulation game with the class. After the Moon-phase game, instruct each group to put one set of the puzzle pieces in order in the center of the table.

You may see a group do this with the Moons in order from smallest to largest without regard to waxing and waning phases. Discuss with the class and reach a class consensus. Here it is in correct configuration, beginning with the new Moon in this space passing through the phases to the full Moon and then back to the new Moon.

Return the quick writes and allow students time to make their final corrections, additions, and reflections about what they have learned about phases of the Moon. Let them know this time it will be graded. Use the rubric in the Assessment chapter to score the student's corrected quick writes. When you think students are ready, have the take Mid-summative Exam 9. Answers for the Mid-summative Exam are found in the Assessment chapter of the teacher guide.

<Investigation 10, Introduction>

Narrator: In Investigation 10 students locate possible planets, send probes to gather information, and prepare planet travel brochures.

Look over the At a Glance chart for: a synopsis of each part, the objectives, assessment opportunities, preparation, and an outline for conducting the investigation.

You will also find when to use the Student Resources book and multimedia. Be sure to read through the Scientific and Historical Background pages for information planets and how they are discovered.

The Why Do I Have to Learn This? section explains how immense the Universe is and how much there is for future generations to learn and discover.

<Investigation 10, Part 1>

Narrator: In Part 1, students are introduced to a photographic technique for locating planets and they use digital images for analysis.

This is what you will need from the kit for each group of four students: one set of planet-finding pictures, which come in an envelope in drawer one of the kit, and copies of the student sheet, Digital Data—DDC-1000 and Digital-Image Grid. Be sure to make extra copies of the Digital-Image Grid for students who need a replacement.

You will need to provide: one pair of scissors and black felt tip or ballpoint pens. For the class you will need the following from the kit: transparencies no. 37, Digital Data—DCC-100, and no. 38, Digital-Image Grid. You will also need the Planetary Science CD-ROM or access to the internet and the multimedia set up. For Assessment you will need the Assessment Chart for Investigations 9 and 10.

Become familiar with the planet-finding pictures. Each envelope contains a two-picture set. The codes to identify the planets are found in Step 1 of the teacher guide. Preview the Digital Data sheets. Each group will work on one set of data. Each student will have their own strip to code, then transfer the data to a group sheet.

Students will make mistakes when they begin filling in the grids, so make sure you have extra copies for each group. Students will need black pens to fill in the grids. It is easier if each student has a black felt-tip or ballpoint pen. Gather extras for students who don't have a black pen. Assess students by making notes on the assessment chart as they work through the activity.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide to get step-by-step directions.

Introduce the process of searching for planets using images of the sky on consecutive nights. Background information and a mini-lecture on the history of finding planets can be found in Steps 1 and 2 of the teacher guide. Introduce the two photographs and present the challenge of finding planets to the students. Distribute the envelopes and allow time for students to find the moving object.

After they have shared their discoveries, propose taking a closer look at the objects by sending a probe. Describe how digital technology sends information from probes in space to Earth. Introduce the digital data and tell students it is their job to convert the data to an image of the far side of the Moon.

Distribute the materials and when students have completed the images lead a class discussion about the disadvantage of manually creating digital images. Introduce the multimedia digitizer to students. To get to the digitizer, go to Investigation 10 of the multimedia teacher guide, select Part 1, and Creating Images. This opens the digitizer simulation.

Show students how they can change the parameters of threshold and grid size or pixels and change the quality of the image. When they think they have a clear image, click the "Peek" button to see an actual photo of the Moon feature. If time permits let students explore other images to digitize.

<Investigation 10, Part 2>

Narrator: In Part 2, students will begin researching the planet they discovered.

This is what you will need from the kit for each group of four students: four copies of the student sheets, Planet Data and Solar System Tours, and one copy each of the scientists' reports: Meteorologist, Astronomer, Geologist, and Historian and four copies of the Student Resources book.

This is what you will need from the kit for the class: one set of Solar System Lithographs, transparency no. 44, Planet Data, and the Planetary Science CD-ROM or access to the internet. You will also need to provide an overhead projector and a multimedia set up. For assessment you will need the Assessment Chart for Investigations 9 and 10.

In Part 1 of this investigation only four planets were used. For this part you will probably want to have each group research a different planet or Solar System object, such as Mercury, Neptune, Uranus, asteroids, comets, or Pluto. Gather as many other resources as you can to provide for students. If possible, provide internet access so students can explore the resources available online from NASA. Plan to assess students as they work by making informal notes on the Assessment Chart for Investigations 9 and 10.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions.

Use the multimedia set up to project images of Solar System objects that students will be researching. Access the images through the Solar System binder in the bookcase of the resource room. This opens that database of images for each planet and other Solar System objects. Describe the research elements for the students' Solar System project. A list of suggested guidelines is found in Step 3 of the teacher guide. Assign the article "Solar System in a Nutshell" in the Student Resources book to introduce students to each of the planets.

Tell students they will form an interdisciplinary team of an astronomer, meteorologist, geologist, and historian. Each member will focus on their area of research. Show students where the resource materials are located.

Include the article Space Probes in the Student Resources book as part of the resources they have available. Let students begin their research and provide access to the Planetary Science CD-ROM and the internet. After students have had time to do some research, introduce the Planet Data sheet. This may be on the second day.

The Earth column is optional, but it may help for students to compare their Solar System object with Earth. Use the Assessment Chart to comment on the students' research techniques.

<Investigation 10, Part 3>

Narrator: In Part 3, students will plan and present trips to their planet.

This is what you will need from the kit for each group of four students: the student's Solar System Tour sheets from Part 2 and four copies of the Student Resources book. For the class you will need the Planetary Science CD-ROM or access to the internet and the multimedia set up.

You will also need to provide for the class a variety of professional travel brochures and materials for students to construct their projects. For assessment you will need the Assessment Chart for Investigations 9 and 10, copies of Mid-summative Exam 10, and the Planetary Science Final Summative Exam for each student.

To help students complete their brochures and presentations gather materials that will help them such as poster boards, scissors, construction paper, and other presentation materials. Collect travel brochures to help students with ideas for their planetary travel brochures. If you have access to presentation software you may want students to make multimedia presentations incorporating the Planetary Science multimedia resources. Plan to assess students during the activity.

This is only a brief outline of this part of the investigation. Make sure you read and follow the teacher guide for step-by-step directions.

Give students the guidelines for their Planetary Tours and brochure presentations. Make sure they know the location of all the resources and allow time for them to complete their projects.

Be sure to set aside enough class time for student presentations. Assess the student presentations using the rubric in the Assessment chapter of the teacher guide. When you think students are ready have them take Mid-summative Exam 10.

On the following day, give students the Final Summative Exam and use the scoring guide in the teacher guide to grade students. And this concludes our trip through the FOSS Planetary Science middle school course. Have fun!