

**FOSS® WEATHER AND WATER  
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/David Lippman: Hi, my name is David Lippman. Welcome to the FOSS Weather and Water middle school course. This video is not intended as a replacement for the teacher guide, so please do make sure that you read through the guide for all the details and specifics contained in the guide.

This course focuses on Earth's atmosphere, weather, and water. Understanding weather is more than reading a thermometer and recording air-pressure. Students delve into topics that may seem unrelated to weather, including physics and chemistry. The conceptual understanding of weather depends on the study of Earth sciences.

This 12-week course comes 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 for students to use while they engage in the investigations, Resources books containing data and readings that are used throughout the course, and 5 CD ROMs for use as a whole-class demonstration tool as well as an individual or small-group interactive instructional tool.

Both the lab notebook masters and the multimedia are also available online at FOSSweb.com. Before you begin teaching, check with your district regarding safety contracts, goggles, and any other safety guidelines that may already be in place. For more information, check the Overview chapter of the teacher guide. Be sure to put the FOSS Safety Poster up where students can see it easily.

### **<Teacher Guide Overview>**

Narrator: The teacher guide is the heart and soul of the curriculum, so you want to make sure that you really sit down and take a look through it before you start teaching. Really read the investigations beforehand. We'll take a little bit of time right now to look through the different components of the guide.

You'll notice that the guide is subdivided into 18 tabbed chapters: Overview, Materials, 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 this course. 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
- Weather and Water in Context
- 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. As we discuss each investigation, we'll point out specific safety issues you should consider.

You can download the Materials Safety Data Sheets by looking under the Course Notes section of the Weather and Water course at FOSSweb.com.

Note the other symbols in the margins. You'll see these same symbols in 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, science concepts, thinking processes, media used in that investigation, and readings from the student resources book.

In the Materials chapter there's an inventory of the equipment provided in the kit and 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 courses at the Delta Education website, or by calling this number (800-258-1302).

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, and how to best organize the materials for sequential classes.

The next section addresses safety issues. Be sure to read through this section carefully. Next come the Investigation chapters that are the heart of the course. 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 the 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.

After the investigation chapters, you'll 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 any. The Special Teacher Masters chapter contains masters you'll need to copy at different points throughout the course.

The Teacher Answer Sheets 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. The assessment charts are followed by masters for the summative exams for each Investigation and a final exam for the whole course.

Another helpful chapter is the multimedia User Guide. The multimedia is an integral part of the course. Students can use it to interact with simulations, images, and text that can enhance their understanding of concepts. This chapter includes system requirements, program basics, and specific navigation tips.

The References 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 your students time to work 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 FOSSweb.com. To use the multimedia online, you'll need to get a username and password which you can share with your students. Go to the multimedia chapter of the teacher guide to view the necessary 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 are included.

Before using the multimedia with your students, make sure that you prepare 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. Click on a title to go to a specific activity. From here you can also access the teacher guide resources by clicking on the teacher guide. 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 the 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. On the bottom of the screen you can return to the investigation list. Your 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's how you access the multimedia via FOSSweb.com. From the front page, click on the Middle School button and then choose your course. Click on your course and you are given several options. On the top left, you can click on the Multimedia button and go to the Welcome Screen as described earlier.

Let's look at some of the options available to students. Students can access a list of updated websites, books, and a glossary. For parents and teachers, you'll 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 sheets, a list of references, and course notes with important information about corrections, ordering, and the links to any material safety data sheets.

Accessing the lab notebook file takes a separate password from the one you gave 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 provided in the Investigation chapters. Look for the CD ROM icon in the margin.

### **<Investigation 1, Introduction>**

Narrator: This investigation introduces weather and the tools that meteorologists use to measure and study weather factors.

Look over the At a Glance chart paying close attention to the objectives, assessment opportunities, preparation, outline for conducting the investigation, and when to use the video, student resources book, and multimedia.

Be sure to read through the Scientific and Historical background pages for information about the study of weather and the factors that contribute to Earth's weather and the tools used to collect weather data. You'll also read about some of the more extreme weather such as tornadoes and hurricanes and where to find weather data.

The Why Do I Have to Learn This? section examines students' beliefs about weather. It explores how to help students understand how weather and climate affect their daily lives.

Familiarize yourself with the multimedia before beginning to teach this course. Look through the multimedia teacher guide, and familiarize yourself with the control room, and how to access the activities and simulations.

### **<Investigation 1, Part 1>**

Narrator: In this part, students grapple with the question, "What is weather?" They view segments of a video about severe weather and generate a list of inquiry questions.

This is what you'll need from the kit. For the class, the video called Wonders of Weather. You'll need to provide a way to view the video. You'll need the assessment chart for Investigations 1 and 2. The assessment chart can be found in the assessment master chapter of the teacher guide.

You'll also need a Weather and Water Student Resources book for each student. You'll need to provide 4 sheets of notebook paper, colored marking pens, and a sheet of chart paper for each group of students. You may also want to have an overhead projector, overhead transparency pens, and blank transparencies.

Before starting this part with your students, take some time to preview the Wonders of Weather video.

The video has four parts. You'll show Part 4 first, called "Things That Fall from the Sky." You'll then show Part 2, "Hurricanes." The other two parts can be used as extension activities at any time in the Weather and Water Course. Make sure you have the video cued to Part 4 before each class.

Note that the Wonders of Weather video is also available in DVD format. Contact Delta Education for more information.

You will also need to plan space for students to display their weather questions at the end of this part. You can take each class's questions down at the end of each period, but plan to keep them on file for future reference.

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

Begin by telling students that they will be investigating weather and its causes and effects over the next several weeks.

Students do a quick write to begin this part. Ask, What is weather? and What would you need to consider if you were going to describe or forecast weather?

Write the quick write question on the board or project in on the overhead projector. Have students work alone on a clean sheet of paper or in their notebooks to answer the questions. Allow about 5 minutes and then collect the papers. You'll use the students' responses as an assessment.

Next, ask students to describe today's weather. You can use these questions to guide the discussion. Then show Part 4 of the Wonders of Weather video, "Things That Fall from the Sky." Discuss the video using these questions in the teacher guide. Now show Part 2 of the video, "Hurricane." Discuss the video using these questions from your teacher guide.

Students may have some additional questions about weather in general and the weather where they live. Have each student write their questions on a sheet of paper or in their science notebooks. These are examples of questions asked by a group of middle school students from Oklahoma.

Then have students share and discuss their questions with other students in their groups. They should select four questions to share with the rest of the class.

Students will refer to these questions as they continue their studies in the Weather and Water course. Ask students how they might sort the questions into categories. Here are some categories students have suggested.

Before completing Part 1, introduce the word meteorology. Meteorology is the study of Earth's weather. The person who studies the causes and effects of weather is called a meteorologist. You can find more information about meteorology in the teacher guide. Have students consider how they might use weather forecasts. Here's some things they might suggest.

To finish Part 1, ask students to bring in a copy of a local weather report as homework. The report can either be from the newspaper or notes taken from a radio or TV report. You should also allow time, either in class or as homework, to read the article in the Resources book called Naming Hurricanes.

Look through students Quick Writes to get an idea of students' understandings about weather. You might want to mark the assessment chart to provide baseline data about students' ideas.

### **<Investigation 1, Part 2>**

Narrator: In this part, students review local weather reports and determine the factors that combine to produce weather. They learn to use a variety of weather tools and begin collecting weather data.

Here's what you will need from the kit: For each group of four students, four copies of lab notebook page one, Class Weather Chart. You'll also need 4 Weather and Water Resources books.

For the class, you'll need the two sets of the weather tools, the Worldwide Weather poster; a hole punch; the special teacher master called Class Weather Chart, and the assessment chart for Investigations 1 and 2. You'll need to provide notebook paper, a sheet of chart paper, and colored marking pens.

You may also want to have an overhead projector, overhead transparency pens, and blank transparencies. Make a copy of a local weather report, which you may need to enlarge and then make a transparency for the class.

You'll also need to make one paper copy and one transparency for each class of Special Teacher Masters Class Weather Chart. Each day one group will take the paper copy outside to record class data using the weather instruments. They come inside and transfer the information to the class transparency, using a permanent marker.

Take some time to review the various weather-data resources that are available online. Pick two or three to share with your students.

To access the resources, enter the teacher guide section of the multimedia, click on Investigation 1, Part 2, and Links to Online Resources. Get out the weather tools and familiarize yourself with them. There's a barometer, thermometer, a hygrometer, a compass, an anemometer, and a screwdriver for calibrating the barometer. There are specific instructions that come packaged with the tools in the kit that update any information in the materials section of the teacher guide. Your tools may look like this or your barometer may be a bit larger, or your thermometer may have changed shape. The thermometer and hygrometer may also be in one digital instrument, like this one.

You can read through the section about the tools in the Materials section of the teacher guide, and the article called Weather Tools in the Resources book. The tools in your kit may look a little different from the ones illustrated in the article, but they all function in the same way.

Students will begin collecting weather data. Plan to take a mini-field trip outside with the students to introduce how to use the weather tools and allow them time to practice reading the tools. Choose a site where direct sunlight won't fall on the thermometer and that is exposed to the prevailing winds. This

teacher chose a site just outside of her classroom where she could keep an eye on the students as they made their observations.

You need to plan for daily weather recordings for each of your classes. One way is to divide the class into groups of four students and have each student in a group be responsible for a particular tool. Assign each group a day to collect weather data. Students record their weather data on the Class Weather Chart and also on their individual copies of the Class Weather Chart. A spreadsheet is available that can be used to compile weather data for all of your classes.

You can find it by going to the teacher guide section of the multimedia and clicking on Investigation 1, Part 2. The Weather Data Collection spreadsheet will appear under the Multimedia heading. More information about using the spreadsheet can be found in the multimedia section of the teacher guide. If you use other spreadsheet software with your students, you can use this section as a guide for creating a sheet to use with your software.

Assessment for Part 2 involves teacher observation. As students collect and record data, consider whether their results are reasonable and keep track of their progress on the Assessment Chart for Parts 1 and 2.

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

Begin this part by asking student to write a brief description of the current weather. Have students share their weather reports, as you keep track of the words they use on the board or on a transparency. Add a checkmark each time a student uses the same word to describe weather.

Now ask students to look at the weather reports they collected as homework. Discuss the sources of the weather reports, the types of information that is included in the weather reports and how these reports compare with the ones they just wrote.

They should note that depending on the source the professional reports usually include temperature, humidity, pressure, cloud conditions, wind speed and direction, visibility, and a forecast. Show students the copy of the local weather report you have printed on a transparency. Review the conditions on the report and what each means. Temperature: how hot or cold the air is; Humidity: the amount of water vapor in the air; Wind direction: the compass direction from which the wind is coming; Wind speed: how fast the air is moving past a measuring point; Pressure: the force of the air pushing in all directions; Visibility: how far one can see through the air.

Students will become more familiar with these terms as they progress through the course. Now it's time to introduce the weather tools. Show students the tools and tell them what each tool measures. A barometer measures air pressure. A thermometer measures temperature. A hygrometer measures humidity. An anemometer or wind gauge measures wind speed. And a compass measures direction. You can use it to figure out from which direction the wind is blowing.

Tell students that they'll use these tools to collect weather data outdoors over the next 8 days. Students can review how to use each tool by reading the article in the Resources book called *Weather Tools*. Introduce the Class Weather Chart to the students, using the transparency from the kit. Review the categories of the data to be collected. You might need to spend a little extra time discussing what is

meant by “Visibility” and “Other Observations.” See your teacher guide for more information about these factors.

Now it’s time to head outside. Assign one group to carry both sets of weather tools. Remind students that they are going outside to practice using the tools and include any other directions you feel are necessary to provide a successful mini-field trip.

Once outside, describe the area where students should work and distribute one tool to each group. After a few minutes, have the groups switch tools and continue in this way until every group has had a chance to use each of the tools.

Back in the classroom, review the weather factors students measured with the tools and introduce the units used to quantify and describe the various factors.

Describe the observation schedule you’ve set up for each group’s weather observations. Distribute copies of the Class Weather Chart, one to each student. Explain that each day after a group has completed and recorded their weather observations, each student will copy the data on their own Class Weather Chart.

Call students’ attention to the *Worldwide Weather* poster you have displayed in the classroom. Encourage them to read over the poster as they progress through the course. Remember to assess student progress using the weather tools over the next few weeks.

Take a moment to review the Extending the Experience section at the end of this investigation. If you have time, choose one or more of the extensions to assign your students.

### **<Investigation 2, Introduction>**

Narrator: In Investigation 2, *Where’s the Air?*, students learn that weather happens in the atmosphere and that the atmosphere is composed of air. They find out that air has mass and can be compressed.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and outline for conducting the investigation. You’ll 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 gases that make up the atmosphere, a discussion of matter, mass and energy, as information about how the three states of matter are related to the atmosphere. You’ll also find information about Earth’s early atmosphere.

The Why Do I Have to Learn This? section focuses on why students should pay attention to Earth’s atmosphere and the properties of air and the atmosphere.

### **<Investigation 2, Part 1>**

Narrator: In this part, students work with syringes and plastic tubing to discover that air takes up space and is compressible.

This is what you will need from the kit for each group of 4 students: 4 syringes, 4 pieces of flexible tubing, and 4 small binder clips. You'll also need 4 Weather and Water Student Resources books, 4 copies of lab notebook page 3, Air Investigations, and the assessment chart for Investigations 1 and 2.

For the class, from the kit, you'll need 20 large round balloons; 24 clear jumbo straws; string, paper clips, blue foam cubes, 1 or 2 vials, and 1-liter zip bags. You'll need to provide masking or transparent tape and 2 metal forks for the class.

Note that you will also need small-cell bubble wrap for this part. The bubble wrap may or may not be in your kit. If you don't find it in your kit, you can order it from Delta Education or provide your own. Here's the ordering information if you want to get the bubble wrap from Delta Education. The "bubbles" from the wrap should be small enough when they're cut apart that they can fit in the syringe barrel, like this.

You'll need access to the multimedia, using either the CD-ROM provided in the kit, or internet access. You can learn more about using the Weather and Water multimedia in the multimedia chapter in the Teacher Guide.

So, to get ready for this part, take some time to practice with the syringe and the plastic tubing. Take the plastic tubing and attach it to the end of the syringe. Just move the plunger in and out.

Then, pull the plunger out and bend the end of the tubing. Pinch the tube together like this; you can attach a small binder clip to pinch it close. Notice when you do this you can push on the plunger and the trapped air is compressed inside. It can take a bit of practice to remove the plastic tubing from the end of the syringe and you don't want to put too much pressure on the tip because you can break it off. So one way to do it is take a regular fork and take the tubing off just like that.

So, if this hasn't been done already, you'll need to cut out bubbles for each student. So cut down the middle of a row, sacrificing that row of bubbles. Then cut out bubbles for each student, trimming around the bubbles, just a little of the extra off making sure that you don't pop the bubble. You can then store the bubbles in the vials or in any other large empty plastic container.

You have just a few safety concerns for this part. Before beginning, establish ground rules for the use of the syringes. Students should not use the syringes to annoy each other. If students use the fork to remove tubing, be sure they aren't standing close to another student while they work. And be sure to check for any latex allergies before passing out the balloons.

Take a moment to preview the Gas in a Syringe simulation on the multimedia. Read over the article, What's in the Air? in the Weather and Water Resources book.

For assessment, plan to use the lab notebook sheet called Air Investigation to take a closer look at students' abilities to conduct an investigation.

This is only a outline of this part. Make sure you read and follow the teacher guide. Begin this part by asking students to answer this question: Where does weather happen? Students should agree that weather happens in the air that surrounds Earth.

Tell them that over the next few days they are going to learn more about air and its properties. Show students the syringes and explain how they will use it to investigate air. Each student will also get some plastic tubing, so they can either work alone or together in pairs. You'll want to establish ground rules before students use the syringes. Students should not point the syringes at another person.

They should try to answer these questions while working with the syringes. What happens to the air in the syringe when you push and pull on the plunger? What can air do?

Pass out the materials and let the inquiry begin. Be sure to visit the groups as they work. Make the small binder clips available in case students want to use them to crimp the tubing. After 5 minutes or so, pass out copies of the Air Investigations lab notebook sheet. Draw students' attention to Part 1 of the sheet and encourage them to record their observations and questions.

After 15 to 20 minutes, call for attention and have students share their observations. Students may report a number of different things: When you push the plunger down, the air in the syringe is pushed out through the tip of the tube. When the tubing is crimped, trapped air can be pushed into a smaller space. When two syringes are connected, one plunger can make the other plunger go out and in. When two syringes are connected, air can push one plunger all of the way out. Continue with a discussion about students' observations, using the questions in Step 7 of this part. Introduce the terms Compressed and Pressure. When you push air into a smaller place, it is compressed. The same amount of air occupies a smaller volume when it is compressed. Compressed air pushes back with a force equal to the force compressing it. That push is called pressure.

Distribute blue foam cubes and bubbles from the bubble wrap, one for each student. Have them place the foam cubes in the syringe barrels, make sure the plastic tube is crimped close with the binder clip, insert the plunger, and compress. Ask them to describe what happens to the foam. They should observe that it gets smaller. Ask them why they think this happens. They'll probably say that the air is squeezed out of the foam. Explain that the foam has closed cells. That means there are lots of little spaces, or cells, in the foam that are not connected. That means there is no way for the air to get out.

To illustrate what happens inside a closed cell, have students remove the foam cube and place a single bubble in the syringe barrel. Have them observe what happens to the bubble when they push the plunger in. They should notice that the bubble gets smaller.

Collect the syringes and tubing. Have a couple of students help you pry the tubing loose from the syringes. Use the fork as we talked about earlier. Be sure to remind students to be careful with the fork. They shouldn't stand next to another student when using a fork to remove tubing from a syringe.

Show students the Gas in the Syringe simulation to help them visualize what happens to air in a syringe under pressure.

As students view the multimedia, use the mini-lecture in Step 11 to introduce the molecular model of air. This is a possible place for a break.

Ask students to review the questions they had about air that they recorded on the Air Investigations sheet. Some students may have asked questions that considered whether air has weight. This is a good

time to have a discussion about the difference between weight and mass. You can use the explanation provided in Step 13. Students should understand these definitions of matter, mass, and weight.

- Matter is the stuff that everything is made of.
- The amount of matter in an object is its mass.
- Weight is the pull or force between Earth and the matter in an object or substance.
- Weight can vary slightly at different places on Earth and vary greatly on different planets.

Challenge students to think about an experiment to find out if air has mass. Give them some time in their groups to discuss how to do this. Show students the materials they can use in their experiments: round balloons, plastic zip bags, clear straws, string, paper clips, and tape.

Be sure to ask students if any of them have latex allergies before passing out the balloons. Visit students as they discuss their plans. They should record their plans in Part 2 of the Air Investigations sheet.

Many groups will construct some kind of balance system. Let's look at one plan that will produce evidence that air has mass. You're going to make a balance arm by taking three of the jumbo straws and inserting them together, like this. Then take a string and tie it around the middle of the arm, so you can hang it. Don't worry about balancing it right now. Take two balloons and blow them up to equal size and attach them to either side of your balance arm using tape or paper clips, and then balance the system.

Take a pair of scissors and cut a small hole in one of the balloons right near the top. As air leaves the balloon, the deflating balloon will go up, while the still-inflated balloon goes down. You can see it's not much of a difference here, but you can show your students that the balloon still full of air is a bit lower.

As students work on their experiments, encourage them to modify their plans and keep track of them in their lab notebooks. Help students summarize the results of their experiments and how they showed that air has mass. Make sure you touch on the ideas described in Step 21. By the end of this part, students should agree that air has mass. Have students read *What's in the Air?* in the Resources book and answer the questions at the end of the article.

The answers to the questions can be found in the Teacher Answer Masters section of the Teacher Guide. Collect the Air Investigations sheets to review as an assessment for Part 1. You can use the Teacher Answer Sheet as a scoring guide.

### **<Investigation 2, Part 2>**

Narrator: In this part, students use diagrams, photos from space, multimedia, and a reading to study Earth's atmosphere. They learn that the atmosphere is a mixture of gases with properties that change with altitude.

Here's what you will need from the kit for this part: For each group of four students, 4 Weather and Water Student Resources books, and 4 copies of lab notebook page 5, Earth's Atmosphere Questions.

For the class, from the kit, you'll need the Earth's Atmosphere and Troposphere posters, Transparency #1, Earth's Atmosphere Questions, the Assessment chart for Investigations One and Two, and copies of the Mid-summative Exam for Investigations 1 and 2.

You'll need access to the multimedia, using either the CD-ROM provided in the kit, or Internet access. For the class, you'll need to provide transparent tape, an overhead projector, and a multimedia setup.

To get ready for this part, check to see if the Troposphere and Atmosphere posters have been assembled. If they haven't been, you'll trim along the trim here line on two of the sections and then connect the three sections using the transparent tape. Notice that the Earth's Atmosphere poster represents the entire 600 km of the atmosphere. The Troposphere poster shows only the first 30 km of the atmosphere. This is the lowest layer where Earth's weather happens. The Troposphere poster also includes part of the stratosphere.

Plan for a location in your classroom where the two posters can be displayed for the remainder of the course.

Take a moment to preview the interactive tour of the atmosphere, called Elevator to Space. This animation allows you to sample and analyze air at different levels in Earth's atmosphere. Make sure you made arrangements for the class to use the multimedia before starting this part.

Read over Step 7 in Conducting for some suggestions on how to use the multimedia, either in a one-computer classroom or in a computer lab or room with more than one computer.

Look over the reading called A Thin Blue Veil in the Resources book. Decide whether you want to assign this as a reading during class or as homework.

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

To begin this part, have students turn to the article called A Thin Blue Veil in the Resources book. Describe the images to them. The lower image is a photo of Earth taken by Apollo 17 astronauts during their mission to the Moon in 1972. The upper image is a photo taken by space shuttle astronauts and shows only a small portion of Earth. The shuttle was orbiting in Earth's atmosphere at the time. Ask students these questions about the images:

- Where is the atmosphere? They should respond that the atmosphere is surrounding Earth.
- Can you see the atmosphere in the image of Earth taken from space? They should determine that you can't see the atmosphere in the lower image.
- Can you see the atmosphere in the image of Earth taken from the Shuttle? Students should notice they can see the atmosphere as the illuminated white and orange layer above Earth's surface.
- What structures can you see in the atmosphere? Students should mention the black shapes and possibly identify them as clouds.
- Why can't you see the atmosphere in the image taken from space? They should suggest that Earth's atmosphere is so thin it's not visible from far away.

Now establish a definition for the word atmosphere. Show students the Earth's Atmosphere poster.

Explain that scientists have described Earth's atmosphere as different layers based on the properties at different altitudes. The lowest layer is called the troposphere. Most of Earth's air is found here. Earth's weather happens in the troposphere. The layer above the troposphere is called the stratosphere. This is where the ozone layer is found. The mesosphere is found above the stratosphere. It's the layer where meteors burn up to create shooting stars.

The thermosphere is next. The thermosphere is the least-understood layer of the atmosphere and contains very little air. A small amount of energy from the Sun can cause huge temperature changes in the thermosphere. The layer farthest away from Earth's surface is the exosphere. It's a thick layer that contains very little air. The exosphere is the transition layer between Earth's atmosphere and outer space.

Next, draw students' attention to the Troposphere Poster. Explain that this poster is an enlarged view of the layer called the troposphere that they saw on the Earth's Atmosphere poster. Explain that the troposphere extends from Earth's surface up to about 10–24 km. It represents only 2% of the atmosphere's height, but about 85% of Earth's air is found in the troposphere.

Tell students that people and other living organisms can be found at different levels in the atmosphere and that scientists send different devices into the atmosphere to study it. Point out some of these locations to students on the posters. The space shuttle in orbit; the International Space Station; the peak of Mt. Everest; a jetliner.

You will find a list of more locations to point out in Step 5. Distribute the Earth's Atmosphere Questions sheet and review the questions. Explain that students will be able to use the Weather and Water Multimedia and information in the Resources book to answer the questions.

Show students the interactive multimedia simulation called Elevator to Space and explain how the class will be using it with your particular computer set-up.

Have students read the article in the Resources book called A Thin Blue Veil, either in class or as homework. Answers to the questions at the end of the reading can be found in the Teacher Answer Masters section of the Teacher Guide.

When students have completed answering the questions on the Earth's Atmosphere Questions sheet, discuss the answers. You can find suggested responses in Step 10. You can use this Earth's Atmosphere Questions sheet to assess students' understanding of the atmosphere's composition. Use the Teacher Answer Masters to score students' efforts. When you think the students are ready, have them take the Mid-summative Exam. A scoring guide for the exam can be found in the Assessment chapter of the Teacher Guide.

### **<Investigation 3, Introduction>**

Narrator: In this investigation, students learn that seasons are affected by the amount of solar energy transferred to Earth. They learn that the amount of energy transferred is affected by latitude, the tilt of Earth's axis, revolution, and rotation.

Look over the At a Glance chart for a synopsis of 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 why Earth has seasons and what effect seasonal variations and sunlight have on Earth's weather and climate.

The Why Do I Have to Learn This? section discusses students' beliefs about why seasons happen and the misconceptions they will probably bring to this part of the Weather and Water Course.

### **<Investigation 3, Part 1>**

Narrator: In this part, students calculate the hours of sunlight for the 21<sup>st</sup> of each month, for one location on Earth using sunrise and sunset data.

This is what you will need from the kit for each group of 4 students: 4 Weather and Water Student Resources books, and 4 copies of lab notebook page 7 Sunrise and Sunset Times for 2000. For the class you'll need Transparency 2, Sunrise/Sunset Times for 2000, and the assessment chart for Investigations 3 and 4. You'll need to provide notebook paper for the class, and an overhead projector.

Before starting this part, you need to get sunrise and sunset times for the day you plan to teach this part. You can check your local newspaper, or the data-service section of the U.S. Naval Observatory website. Click on the link that says "Complete Sun and Moon Data for One Day." [aa.usno.navy.mil/data/](http://aa.usno.navy.mil/data/)

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

Begin this part by asking: What causes seasons? Students respond to this question notebook paper.

After about five minutes, collect the papers. These Quick Writes will be returned to the students to review at the end of Investigation 3. Tell students,

- I've heard it said that December 21 is the shortest day of the year. Why would someone say that?
- Do we have fewer than 24 hours on December 21?
- If it's true that there is a shortest day, is there also a longest day in the year?

They may respond that we get fewer hours of sunlight in winter and more in summer, but every day has a total of 24 hours. They may also know that June 21 is the day with most hours of sunlight. Ask students to consider how many hours of sunlight will happen today. Write the day's sunrise and sunset times on the board and then work through the procedure for calculating sunlight hours with them.

Here is a sample calculation. First, calculate the hours and minutes between sunrise and noon. From 6:24 am to 11:24 am, there are 5 hours. Between 11:24 am and 12 noon, there are 36 minutes. Adding 5 hours to 26 minutes, you find there are 5 hours and 36 minutes of daylight between sunrise and noon. Now, calculate the hours and minutes of daylight between noon and sunset. This is a bit easier; the answer is 6 hours and 44 minutes. Now, add the two figures to get the total time of sunlight. You should get 11 hours and 80 minutes, which can be reduced to 12 hours and 20 minutes. On this particular day, there are 12 hours and 20 minutes of daylight.

Distribute copies of the lab notebook sheet called Sunrise/Sunset Times for 2000. Use transparency #2 which is a copy of the lab notebook sheet to explain to students what they should do. Tell them, the

sunrise and sunset in the table are for Berkeley, CA; the times were recorded on the 21st of each month. Ask students to calculate the hours and minutes of daylight on the 21st of each month.

Then they should complete the graph to show the amount of daylight month by month. Help them decide that a bar graph is right type of graph to use.

Remind students to write the months under the columns and to fill in the hours and minutes of daylight. As students work, circulate among the groups to observe how they are doing. Review and discuss the graphs when students have completed them. Use the questions in Step 7 of Conducting Part 1 to guide the discussion.

Collect the graphs for review. An answer sheet for the graph is available in the Teacher Answer Masters section of the teacher guide.

Have students think about what day-length might be like around the globe, using the questions in Step 8.

Students read *Wendy and Her Worldwide Weather Watchers* in the resources book. Discuss the questions at the end of the article when students have completed the reading. Answers to the questions are located in the Teacher Answers Section of the teacher guide.

### **<Investigation 3, Part 2>**

Narrator: In this part, students investigate the amount of sunshine on different parts of Earth throughout the year and explore the reasons for seasons.

This is what you'll need from the kit for each group of 4 students: 4 Weather and Water Student Resources books, and 4 copies of lab notebook page 9 Seasonal Changes, and Lab notebook page 11, Response sheet—Seasons and Sun. For the class you'll need the lamp with the bare bulb from the kit. You'll need Transparency number 3, Day-Length Questions, Transparency number 4, Sun-Earth System, and the assessment chart for Investigations 3 and 4.

You'll need access to the multimedia, using either the CD ROM provided in the kit, or Internet access.

For the class, you'll need to provide one to four tabletop globes, tilted at 23.5°, ten, ½" colorful sticky dots, an extension cord, an overhead projector, and a multimedia setup.

Before starting Part 2, you'll need at least one globe on a stand. If you can get more than one, students will have more opportunity to try out the Sun-Earth model. The globes should be tabletop versions that rotate and tilt at 23.5°.

The kit includes a lamp with a bare, 60-watt light bulb. You will use this as your model Sun. Plan to arrange your room so you and your students can orbit the Sun (that is, the light bulb) without obstacles, as shown in this illustration. You will also want to make the room as dark as possible. Have an extension cord available if you need it.

Make sure you take some time to explore the multimedia. The Seasons simulation is rich with opportunities to explore what happens as the Earth revolves around the Sun over a year. Make sure

students have ample opportunities to explore the multimedia, controlling variables and observing season changes. If possible, plan to work with multiple computers.

Students will use the lab notebook sheet called Seasonal Changes as they review the Seasons simulation. If you only have one computer, let individual students take turns at the controls. In this case, you may not want students to complete the last item on the lab notebook sheet.

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

To begin this part, have students review the questions from the end of the article called Wendy and Her Worldwide Weather Watchers. Use transparency no. 3 called Day-Length Questions to guide the discussion. Have students discuss these questions in their groups, using their graphs from Part 1 and what they learned from the reading to support their ideas.

To conclude this discussion, ask students: Why do daylight hours change over a year? Some students may have ideas or misconceptions about Earth traveling around the Sun. They may think that winter happens when Earth is farthest from the Sun, summer happens when Earth is closest to the Sun, and they may know that Earth's tilt has something to do with seasons. But it's not likely that anyone will have a complete explanation.

Show students the globe and lamp. Explain that you are going to use these items to set up a model of the Sun-Earth system. Ask students to help you figure out the best way to set up the model. Let them suggest where to place the Sun and Earth and how the Earth should move around the Sun. Here is one suggestion of how to set the model up. Introduce the term revolve as the movement of one object around another. Tell students that Earth revolves around the Sun.

Ask them, How long does it take for Earth to make one revolution around the Sun? They should respond that it takes one year or 365 days for the Earth to revolve around the Sun. Use the globe to point out the North and South Poles. Explain that these are the north and south ends of an imaginary line passing through Earth, called its axis. The Earth rotates on this axle, like a top rotates around its center point. This turning motion is called rotation.

Point out that the Earth doesn't spin straight up and down on its axis. Instead it is tipped over at an angle of  $23.5^\circ$ . Ask students to consider how long it takes the Earth to rotate once on its axis and how we know where it is day and where it is night. Make sure they understand that the globe always has exactly one half illuminated and one half dark.

Have students visualize where the North Star is from your classroom and pick a spot in the room, like a clock or place on a bulletin board, to designate as the North Star. Challenge students to come up with a way to investigate this question, Why do hours of daylight differ depending on time of year and location on Earth? Place one of the colored dots on the globe at the location of your town.

Make sure you read through the teacher guide for suggestions for doing this simulation and for questions to help guide further discussion about the relationship between the Sun and Earth and hours of daylight at different times of the year.

At the end of this demonstration, students should infer that Earth's position where days are longest is summer for a particular location; when Earth's position produces fewer hours of daylight the season is winter. Give students plenty of time to think about this.

Move through the simulation one more time to review the relationship between the Earth and Sun at each of the solstices and equinoxes. Follow the instructions in Step 11. Remember to pause at the equinox and solstice stops to reinforce the relationship between light exposure and season. Place more sticky dots on the globe to show where Wendy's Worldwide Weather Watchers are located.

Introduce seasons by making a second trip around the Sun and use transparency no. 4, Sun-Earth System to continue reinforcing how the Sun-Earth relationship produces seasons over a year. Point out the changing portion of Earth's surface that is in light and dark as the year progresses.

You can now assign the article in the Resources book called Seasons for students to read in class or as homework. This is a good time for a break.

Distribute copies of the lab notebook sheet called Seasonal Changes. Go over the sheet briefly and then turn to the multimedia, using the setup you have available. It may be helpful to show students the various elements of the multimedia in class and then set them loose on the other computers you have in class or in the computer lab.

Note that students may struggle with the questions on the Seasonal Changes sheet. You may want to spend a couple of days with the simulation so that students have a lot of opportunity to observe what happens at different times of the year. Remind students to think about what they observed with the lamp and globe model as they move through the multimedia simulation.

You can find answers to these questions in the Teacher Answer Masters section. Distribute copies of the response sheet for students to complete individually, once they've had an opportunity to explore the multimedia.

You'll collect the Response Sheets and return them to the students at the end of Part 3 of this investigation. Students will have an opportunity to self-assess their responses.

### **<Investigation 3, Part 3>**

Narrator: In this part, light is introduced as a form of energy. Students observe a beam-spreading demonstration and consider how solar angle affects the intensity of solar radiation.

Here's what you'll need for this part: for each group of 4 students: you'll need 4 copies of Lab notebook page 13, Beam Spreading. For the class from the kit, you'll need the convection chamber cover, transparencies 5, Solar Angle, 6, Solar Angle on Earth, and 7, Sunlight on Earth's Surface, the assessment charts for Investigations 3 and 4, and the Mid-summative Exam for Investigation 3. You'll also need the quick writes from Part 1 and the response sheets from Part 2.

For the class, you'll need to provide a flashlight and 2 stout rubber bands or a roll of masking tape or duct tape, a meter stick, a 12" globe on a stand, chart paper or a larger piece of white paper, and some notebook paper. You'll also need an overhead projector.

To get ready for this part, you'll need to prepare the beam-spreading demonstration. You'll need a flashlight with a strong beam of light. This is how you set it up:

- Take your flashlight and attach it to your meter stick, using rubber bands or masking tape. Make sure that the beam of the light is aimed along the meter stick.
- Tape a piece of chart paper, tape it to the floor, and dim the lights in your classroom. We're using the table, but you'll want to make sure to use the floor so everyone can see.
- Take your flashlight system; put it at a right angle to the chart paper, so the beam points directly down the stick on to the paper. Then just practice changing the angle of the stick, so the shape of the light on the paper changes. You'll want to keep the stick in the same place on the paper.
- Students will be watching for how the size of the shape on the paper changes as you move the system to different angles.

You'll also do a second demonstration with a globe and an overhead projector. I've taken the convection cover lid and taped a piece of cardboard to the top, to block a little bit more of the light from the projector. In our demonstration here, the projector and the globe are pretty close together, but you'll want to have them further apart. You can see the teacher guide for more information about that. Dim the lights in the classroom and turn on the projector. Use the convection chamber cover to focus a beam of light on to the globe and then move the cover up and down to show students how the shape of the light changes.

Practice doing this a little bit so you are ready to do it when it comes time to do the demonstration in front of the class. Read over the instructions in Step 8 of Conducting this part for more details about the demonstration.

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

Begin this part by reviewing sunlight hours and seasons. Ask students to describe what kind of weather they associate with summer. They will usually suggest that the weather in summer is hotter. When asked why summer is warmer, students often suggest that longer days in summer provide more time for things to heat up.

Suggest that there is more to this story and bring out the materials for the beam-spreading demonstration. Dim the lights, point the beam from your flashlight straight down on the paper, move the system different angles, so the shape of the light on the paper changes. Do this several times.

Now, have a student trace the shape of the light spot as you shine the beam straight down. Then angle the stick and have the student trace the light spot again.

Tell students that light is a form of energy. This flashlight and the Sun are both sources of light energy. Point out that the paper shows the area that the beam of solar energy covered at two different angles.

Distribute copies of the lab notebook sheet called Beam Spreading. Have students discuss the demonstration in their groups and work together to answer the first three questions on the sheet. After

they have had time to answer the three questions, have students share their ideas with the class. You can find answers to the questions in the Teacher Answer Masters section of the Teacher Guide.

Use the mini-lecture in Step 5 and Transparency no. 5 Solar Angle to expand on the idea of beam spreading. Draw students' attention to the fourth question on the Beam Spreading sheet. Give them a few minutes to consider the question and then discuss their responses. Bring out the globe demonstration and explain that this is a model of the Earth. Tell them sunlight travels in straight lines 150 million km from the Sun to the Earth. When sunlight hits the Earth, it spreads because Earth's surface is curved. Show the students the demonstration like you practiced in getting ready.

While you move the beam of light around on the globe, use the questions in Step 9 to guide student observations. Use transparency no. 6, Solar Angle on Earth, and transparency no. 7, Sunlight on Earth's Surface, to reinforce what students have learned from the demonstration. Continue this part by reviewing the results of the two demonstrations. Have students write these results on a blank page in their lab notebooks.

- The greater the solar angle, the greater the density of radiant energy.
- Light shining from directly above is most intense; light coming in at an angle is less intense.
- Solar energy is most intense during the middle of the day in the tropical regions.
- Energy is less intense in the morning and evening and in the extreme north and south regions of Earth.

Ask students to discuss question 5 on the Beam Spreading sheet with their groups: What influence does solar angle have on heating of Earth?

After a bit, ask students to offer their ideas about solar energy and heating the Earth. Summarize their ideas after the discussion. When you think students are ready, have them take Mid-summative Exam 3.

This is a good spot to take a break. Why there are seasons is a difficult concept for students to understand because they have to consider so many factors and relationships. It's important for them to reflect on how their knowledge and ideas have changed over the course of their study of weather and water.

After you have scored Mid-summative Exam 3, return the exam, the quick write, and Response Sheet 3 to the students. Give students an opportunity to reflect on how their thinking has changed. Take one more opportunity to clarify any remaining misunderstandings before moving on to Investigation 4.

#### **<Investigation 4, Introduction>**

Narrator: In Investigation 4, Heat Transfer, students learn that the movement of heat energy in and out of the atmosphere is an important element of weather.

Look over the At a Glance chart paying close attention to the objectives, assessment opportunities, preparation, outline for conducting the investigation, and when to use the student resources book and multimedia.

Be sure to read through the Scientific and Historical background pages for information about forms of energy and what the difference is between heat and temperature. You will also find information about energy transfer by radiation and conduction.

The Why Do I Have to Learn This? section discusses what students think they know about heat and temperature and what they should know about solar energy and heat transfer and how it relates to Earth's atmosphere and global warming.

**<Investigation 4, Part 1>**

Narrator: In this part, students are introduced to energy transfer by radiation. They put earth materials in the Sun and the shade and observe what happens. They learn that differential heating of earth materials is one factor that contributes to weather.

Here's what you will need from the kit for this part: For each group of 4 students, four ¼-liter containers and slotted lids and four thermometers, 4 Weather and Water Student Resources books, and 4 copies of lab notebook pages 14, Earth-Material Temperatures Chart, and page 15, Earth-Material Temperatures Graph.

For the class, from the kit, you'll need four 100-mL beakers, sand, and dry soil. You'll need transparencies 8, Setting Up Earth Materials; 9, Earth-Materials Temperatures Chart; 10, Earth-Materials Temperatures Graph; and 11, Earth-Materials Temperatures Questions.

You'll also need the FOSS Weather and Water CD ROM, and the assessment chart for Investigations 3 and 4. For each group, you'll need to provide a sheet of newspaper, a watch or stopwatch, and colored pencils. For the class you'll need to provide a pitcher for water, and 2 shallow basins. You'll need a blank transparency, an overhead projector and overhead transparency pens, and a multimedia setup.

You may also want to have this equipment available if the weather is cloudy the day you plan to do this part. One or more infrared heat lamps with a 250-watt bulbs (You can find these at most hardware stores). One or more lamp fixtures, with clamps and ceramic sockets.

To get ready for this part, you need to prepare the earth materials. Check to see if your soil supply is dry. If it is still moist, spread it on some newspaper for a day or so to dry. Place the soil and sand into separate shallow basins so students can easily scoop samples up with the 100-mL beakers.

Make sure you have enough newspapers so that each group has some folded newspaper to place under their earth-material containers for insulation. You'll also want to do a trial run of the experiment to familiarize yourself with the setup and outcomes. Check out the availability of outdoor space. You need a location with direct sunshine away from strong breezes.

Think about timekeeping. Each group will record temperatures every 3 minutes for a half hour. If students don't have watches, plan to coordinate the recording with you as the timekeeper calling out the three-minute intervals.

If the weather is too cloudy for this part, you can set up the infrared heat lamps in the classroom. Detailed instructions for conducting the experiment indoors can be found in step 7 of Getting Ready for

this part. You will use the FOSS multimedia to reinforce the concept of energy transfer by radiation. You can view and discuss the Heat and Energy: Radiation animation with the entire class.

Navigate to the animation through the Teacher Guide or through the Matter and Energy section in the Control Room. Read over the article that you will assign students in the Resources book, called Thermometer: A Device to Measure Temperature. Decide if you want students to read the article in class or as homework.

You'll also need to make a transparency of a weather report, either a new one from the newspaper or Internet, the same report you used in Investigation 1 Part 2, or by creating one in class as students read from a newspaper report.

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

To begin this part, project the transparency of the weather report and review the main elements of weather—heat, moisture, pressure, and air movement or wind. Use the questions in the teacher guide to direct the discussion. End this discussion by asking: Do you think the surface of Earth affects how hot air gets?

Tell students that they are going to investigate what happens to different earth materials when the Sun shines on them. Students should know that soil, rock, water, and air are examples of earth materials. They should also be able to respond that the Sun is the main source of energy that heats earth materials, like these.

Show students the materials they will use for the investigation and demonstrate the set-up referring to Transparency no. 8, Setting Up Earth Materials, as you work.

To prepare a set of earth materials, first take 100 mL of sand, pour it into one of the ¼-liter containers, take a thermometer, and insert it through the lid slots coming up from the bottom like that, snap the lid on, make sure that the bulb of the thermometer is under the material. Do the same for the soil and the water.

For the air container, put a thermometer through one of the lids and snap the lid on the container containing only air. Distribute copies of the lab notebook sheet called Earth-Materials Temperatures Chart. Use Transparency 9 to explain how students will collect data.

Students first read the temperatures of the materials in each container before going outside. They record this temperature in the first row of their lab notebook sheet under the appropriate earth material. Then they take this lab notebook sheet, their set of earth materials, and some newspaper outside. They fold the newspaper in half three times for insulation and place the earth materials on top. Go over the rules for working outside and then head outside. Record the starting time on the data chart in row 1, the same row where the starting temperatures have been recorded.

Each student in a group will monitor the temperature of one of the earth materials, taking the temperature every 3 minutes and recording it on the chart. They will monitor the temperatures for 15

minutes. After 15 minutes in the Sun, students will move the containers to the shade and continue monitoring and recording temperatures for 15 more minutes.

Your last class can disassemble the materials and return the sand and soil to the appropriate bins. The water can be recycled. This is a good spot to take a break.

Have students show the temperature data they collected with the other members of their groups. Everyone should have temperature data recorded for all four materials on the Earth-Materials Temperature charts.

Use transparency no. 9, Earth-Materials Temperature chart as you explain the next step. Students should refer to their own data during this discussion. Call attention to the column labeled temperature change. Students should calculate the change in temperature between each reading and the starting temperature. In this example, the starting temperature was 22°C and after three minutes the temperature had risen to 28°C. So the temperature change would be 6°C. After another three minutes the temperature was up to 35°C, so the temperature change from the starting temperature was 13°C. Have students continue to calculate the temperature changes for their earth materials and then share the results with their groups.

Now, explain how students will use their temperature data to create a graph. Use transparency no. 10, Earth-Material Temperatures Graph to explain the best way to graph the data. Students will complete their graphs on the lab notebook sheet called Earth-Materials Temperature Graph. You should include these points:

- Display the temperature change for all four earth materials on the same graph, using different colored pencils to identify the different materials.
- The x-axis should display the independent variable, which in this case is time. The y-axis should display the temperature data.
- Students should select appropriate and uniform intervals for the variables and write them on the axes of the graph. Numbers should start at origin, 0, 0.

A typical graph might look something like this. As you observe their graphs, make notes about things you might want to work on with the class later, such as the placement of the origin, unit intervals, and point plotting.

You will use the Assessment Chart for Investigations 3 and 4 to keep track of your observations of students' abilities to set up and complete a two-coordinate graph.

Project transparency no. 11, Earth-Materials Temperature Questions. Ask students to discuss the questions in their groups, and then as a class. Students should refer to their data charts and graphs.

Students may have a number of ideas to answer the last question, Which properties of the earth materials do you think may have caused the temperature differences? Your Teacher Guide lists some of student's possible responses. Students should have noticed that the temperature of the water increased the least and went down the slowest. Ask the class, "If each earth material received the same amount of solar energy, how can you explain the differences in temperature?"

Have students discuss this question in their groups and call on volunteers to explain their answers to the whole class. Now, explain this important property of water: It takes five times more heat energy to raise an amount of water one degree than it takes to raise the temperature of an equal amount of dry soil or sand one degree.

When the same amount of heat energy is absorbed equally by all of the materials, the temperature of the solid earth materials goes up faster than water. Continue the discussion, using the questions and mini-lecture in the teacher guide.

You will introduce the terms radiant energy, radiation, and differential heating. Show students the Heat and Energy: Radiation animation. Click on the "Radiation" button to focus on energy transfer through radiation. Turn the heating coil on, and discuss how the transfer results in a temperature increase of the material receiving the energy.

Refer to the multimedia user guide at the end of the teacher guide for additional suggestions about using this animation effectively. Have students read the article in the resources book called Thermometer: A Device to Measure Temperature.

#### **<Investigation 4, Part 2>**

Narrator: In this part, students observe two examples of heat transfer by conduction: movement of heat from a container of hot water and movement of heat from one end of a metal strip to another.

Here's what you will need from the kit for this part. For each group of 4 students, you'll need 2 vials, 4 thermometers, two 250-mL plastic cups, two 200 mL plastic-foam cups, two large 500 mL plastic cups, an aluminum bar, a steel bar, and two temperature strips in the 30 to 36 degree Celsius range.

You'll also need 4 Weather and Water Resources books, and 4 copies of lab notebook pages 17, Heat Conduction; and page 19, Conduction through Materials. For the class you'll need a one liter beaker, the red food coloring, the FOSS Weather and Water CD ROM or access to the internet, and transparencies 12, Hot Water Inquiry; 13 Hot Water Setup, and 14, Conduction through Materials.

You'll need the assessment chart for Investigations 3 and 4, and copies of the Mid-summative Exam 4. You will need to provide these materials for the class: notebook paper, transparent tape, paper towels, cold water, hot water, and an insulated container. Be sure to establish class guidelines for hot water safety. You'll need a multimedia setup, and an overhead projector.

Before beginning this part, take a look at transparencies no. 12 and 13. You can conduct this as an open-ended inquiry or as a more structured investigation, so you'll need to decide which transparency is appropriate for your students.

Make sure you have access to hot water and cold water for this part. The cold water should be between 10–20°C. The temperature of the hot water should be between 45 and 50°C. You could use a coffee pot or hot pot to heat the water and store in a thermos or ice chest.

To make the fake "salt" water, take the red food coloring and add a few drops to the hot water. By making the hot water red, you'll be able to tell if your students just mixed the hot and cold water.

Use a permanent black marking pen to mark a small “A” and a small “S” on the end of each of the metal strips. Take time to preview the Heat and Energy: Conduction animation in the Matter and Energy section of the multimedia.

Check out the other recommended animations for this part. Review the article called Heating the Atmosphere in the resources book and decide whether you want students to read it in class or as homework. Students should respond to the questions at the end of this article. Plan to discuss the questions in class. Suggested responses are located in the Teacher Answer Masters section of the teacher guide.

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

Begin this part with a review of radiation and heat transfer. Ask students to answer these questions on a blank sheet in their lab notebooks: What is radiant energy? How does radiation affect the surface of Earth?

Then have students share their answers with the class. Ask students to recall walking barefoot on a sidewalk on a hot day. What did they feel and why did their feet felt hot? How did the heat get from the cement to their feet?

Introduce the energy transfer challenge by showing students a container of water. Tell them, I have this water here and I’d like to get it to 30°C. I have some warm water, but it’s red and salty and I don’t want to mix the two. What can I do to get the water hot?

Use the transparency you have chosen to explain how students should proceed, either the inquiry described on transparency no. 12 or the more structured investigation on transparency no. 13. Have students work in teams of two, and when they are ready, have them pick up their materials and get to work. Continue to project the transparency as reference.

When students have finished the investigation, ask for students who were successful in heating their water to 30° C to share their procedures. Many will have dunked a vial of cold water in a hot-water bath until it reached 30°C.

Ask students, How did heat transfer from the hot water to the cold water? This question is important. Allow time for students to discuss their ideas in their groups and then share their ideas. Now provide a model for what happened using the mini-lecture in Step 7.

Students should know that:

- Heat is motion of atoms and molecules.
- More motion equals more heat.
- Energy transfer happens between molecules or atoms when they come in contact. This type of heat transfer is called conduction.

Use the multimedia simulations to help students understand the idea of energy transfer at the molecular level. First show the Molecules in Solids, Liquids, and Gases animation. When you click the Add Energy button, this animation shows that, when energy is absorbed by a solid, liquid, or gas, molecular

motion increases. That is, the molecules in a solid vibrate faster and the molecules in a liquid or gas move past each other faster.

Next show the Heat and Energy—Conduction animation in the Matter and Energy section. Turn the heating coil on and off several times so students can see the molecular activity increase as energy moves from molecule to molecule in the different materials. Students should understand that heat equals molecules in motion; heat transfer happens by conduction when molecules collide.

Bring students back to the original energy transfer challenge. Ask them to explain the energy transfers between the hot water and the water in the vial and between the water and the alcohol in the thermometer. A completed diagram to show the various energy-transfers might look like this.

Distribute copies of the lab notebook sheet called Heat Conduction and have students respond to the questions while the investigation is still fresh in their minds. Use these sheets as an assessment as described in the teacher guide.

This is a good spot to take a break.

Review what students learned about conduction from the hot water investigation. When two materials at different temperatures make contact, energy transfers from the hotter material to the colder material. As materials gain heat energy, the motion of their atoms and molecules increases. Molecular motion is heat.

Show the Thermometer animation in the Matter and Energy section of the multimedia. Use the animation to review the sequence of energy transfers as outlined in the teacher guide. Reinforce the idea that as the alcohol molecules receive more energy, they move faster, and take up more space. This is what makes the alcohol rise in the thermometer, indicating a higher temperature.

Pose the next inquiry question, starting with the experience of a metal spoon getting hot in a pot of cooking soup. Ask, How did the spoon handle get so hot? Listen to some explanations and if conduction is suggested, introduce the materials that students can use to investigate conduction further. Show students the aluminum and steel bars, the foam cups, the large plastic cups, the tape, the thermometers, and the temperature strips. Make sure you have enough for the class.

Point out that the aluminum and steel bars. They look similar, but the steel is heavier. If you have labeled the bars, point out the “S” for steel and the “A” for aluminum.

Hold up one of the temperature strips. Explain that the strips contain a mix of different crystals that change color between 30 and 36°C. When the temperature is below 30°C or above 36°C, there will be no color. Use can see the color change here from my finger.

Distribute copies of the lab notebook sheet called Conduction through Materials and review the sheet with the students. Show students how to tape a temperature strip to the metal bars, using the tape you provide. You’ll want to be sure that students tape the shiny side facing out since that’s the side that shows temperature change.

Getters get the materials for their groups and begin assembling their setups. After they attach the temperature strips to the bars, they get hot water and set the foam cup inside the larger plastic cup. Then they put the two strips at the same time into the hot water.

Students should record temperatures and observations on the Conduction through Materials sheet. Once they complete their observations, they should answer the questions at the bottom of the sheet. Use these questions to guide class discussion.

Students should have noticed that the temperature strips displayed color after the metal had been in the hot water for awhile, and that the color change moved up the strip from the hot water. Students should be able to explain what happened in terms of conduction. That is, the heat energy, or molecular motion, in the hot water transferred to the metal molecules making them vibrate faster. The energy was transferred through the metal molecule by molecule. They should recognize that the aluminum conducted heat energy faster than the steel.

Click on the Multimedia, Video Resources: Conduction Through Metals to view a video showing conduction in the aluminum and steel bars in a different setup. As your students view the video, help them make connections between their investigation results and what happened to the pasta bowties in the video setup. They should be able to figure out that as energy was transferred up to the two metal bars, it happened faster in the aluminum so the pasta fell off faster as the margarine melted.

The Heat Conduction student sheet can be used to assess student understanding of heat transfer by conduction. Keep notes about what students understand and which concepts you may need to review. Ask the students, the Sun shines on Earth and the air gets warm. How do you think that happens?

Let them talk about this in their groups for a few minutes and then volunteer their answers, using the steps in Conducting the Investigation to guide the discussion.

Use the mini-lecture in Step 24 to introduce the idea of reradiation, another more important way that heat energy enters the atmosphere. Students should understand that hot matter radiates more energy than cold matter. That's why the containers of earth material cooled down when they were placed in the shade—they reradiated the energy they absorbed from the Sun. This reradiated energy warmed the gases in the atmosphere.

Have students read the article in the Resources book called Heating the Atmosphere. Have them answer the questions at the end of the article and then discuss them in class. Suggested responses are located in the Teacher Answer Masters section of the teacher guide. When you think students are ready, have them take Mid-summative Exam 4. A scoring guide is available in the Assessment chapter of the teacher guide.

### **<Investigation 5, Introduction>**

Narrator: In this investigation, students learn the concept of density on their way to developing an understanding of convection.

Look over the At a Glance chart for a synopsis of each part, the objectives, assessment opportunities, preparation, and outline for conducting the investigation. You'll 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 changing states of water, density, and energy transfer by convection. The Why Do I Have to Learn This? Section describes the importance of density in the study of weather.

### <Investigation 5, Part 1>

Narrator: In this part student investigate the density of fluids by layering colored salt solutions in a straw.

This is what you'll need from the kit for each group of 4 students: 4 vials with caps, 4 pipettes, 2 bases for the straws, 2 clear jumbo straws, and one half-liter container. You'll also need 4 copies of Lab Notebook page 21, Liquid Layers, page 23, Calculating Density, and page 25, *Response Sheet—Convection*.

Each group will need 4 Weather and Water Resources books. For the class, you'll need these materials from the kit: Kosher salt, for teacher use in preparing the solutions, a 15-mL spoon, 4, 250 mL plastic cups, the package of food coloring, a 50-mL graduated cylinder, the foam cubes, red beans, and the hole punch.

You'll also need transparency number 15, Calculating Density and the Assessment Chart for Investigations 5 and 6. For each group of four students you'll need to provide colored pencils, calculators, 2 paper towels, and 1 piece of white paper. For the class you'll need to provide 4 clear 1-liter plastic bottles with screw caps, two clear plastic ½-liter bottles with screw caps, a bottle of mineral oil, and a bottle of lamp oil. You'll need at least 250 mL of each. You'll also need an overhead projector and transparency markers. If you have one, make an accurate balance available to the class.

Before you start this part, you need to prepare four salt solutions, each with a different density. Instructions for doing this can be found in Step 1 of Getting Ready for this part. Here's what you need to do: You'll need four 1-liter water or soda bottles, the food coloring, the kosher salt, and water. You should assemble a set of solutions for each group of four students. Take the 1-liter bottles and add about 500 mL of water to each, then you'll add 50 drops of food coloring, and end up with one color per bottle.

Use the 15-mL spoon to measure salt into the four bottles, using this table as a guide. If you have a funnel available, it will help get the salt into the bottles. I'm doing green first, so I'm going to put 60 mL of salt, 15, 30, 45, 60.

Next, cap the bottle and shake. The salt won't dissolve in all of the bottles. Next, you'll add water to the bottles to make them one liter. That's about right and shake again if you have any undissolved salt. Cut one straw in half for each pair of students. You'll want to cut the straw at a slight diagonal.

If this is the first time the vials have been used, you'll need to punch holes in the caps. Use the hole punch available in the kit and punch a hole in each cap as close to the center as you can get. Doesn't have to be exact. You'll need to prepare four vials with caps for each group. You should assemble a set of solutions for each group of four students. Put about 10 mL of the blue solution in eight 12-dram vials and cap the vials. Prepare eight vials of each of the other solutions. Put one vial of each color solution in

a ½-liter container. Put a pipette in each of the vials and four of the half straws you cut in the half-liter container.

If this is the first time you are using the Weather and Water Course, you'll need to prepare a set of density demonstration bottles. You'll need two clear ½-liter bottles, mineral oil (which you can find in most drug stores), food coloring, and lamp oil. You'll want the food coloring and lamp oil to be the same color.

Pour 250 mL of the lamp oil into one of the bottles. Then, fill the rest of the bottle with plain water and cap it add put 250 mL of water in another bottle. Label the bottle with lamp oil in it, bottle 1. Next, you'll add food coloring, drop by drop to your water, until it matches the color of your lamp oil. When you got the colors matched put the cap on, give the bottle a little swirl to make sure you dissolve all the food coloring. That looks pretty good. Then you're going to add 250 mL of mineral oil to the bottle you just added food coloring to.

Fill a plastic cup with beans and another with foam cubes. The cups should be filled to the brim. You'll use these cups in a demonstration to introduce density. Preview transparency no. 15, Calculating Density, before beginning this part and become familiar with the calculations required and suggestions for helping your students think about the concept of density.

Calculating density will require working with decimals. You may want to review working with decimals before beginning this part with your students.

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

Begin this part by showing students the two density bottles. Hmm, what's going on here? Ask students if they can explain the behavior of the liquid? Tell students that they'll be investigating the behavior of liquids and will return to these bottles later.

Show students the four liquids. Their challenge will be to layer these four liquids in a straw. They'll work in pairs, but each group will share one of these setups. Each group also gets to of these bases. They'll take the straws and using the angled end, insert it over the knob in the middle of the base. Tell students the pipettes should not move from one liquid to another; they should always go back in the same vial they came from.

To use the pipettes, students squeeze the bulb and release it. You then can take the pipette, insert the tip into the straw, and gently squeeze the bulb to release some of the liquid. To empty the straws, students simply pull the straw from the base and let it drain. They can then put it back on the knob and continue working. When a base is full, students can empty it into the waste cup and continue working.

Distribute copies of the lab notebook sheet called Liquid Layers. Explain that students can use colored pencils to fill in the rectangles for their trials. This information will help them figure out the sequence of liquids.

Each group needs the container with the liquids, pipettes, and straws; the straw bases, the colored pencils, a sheet of white paper for holding behind the layered straws to see the colors more clearly, a waste cup, and paper towels.

Remind students to not mix the solutions, especially since the liquids will be used by other classes. It can take as little as ten minutes or as long as half an hour for students to develop layering in a straw. When students have successfully layered the liquids, have them clean up. Check the vials between classes and add liquid as needed.

Once students have cleaned up, they should answer the question in Part 2 of the Liquid Layers sheet. Call on students from several groups to draw their successful four-layer results on the board. Verify that these are the results the rest of the students got. Ask students what they think caused the solutions to layer in this way.

Students will probably suggest that some of the solutions were heavier than the others so they sank. Tell students that all of the solutions are made of water and salt. Ask them to think about why some salt solutions might be heavier than others. Have them turn back to the question in Part 2 on the lab notebook sheet called Liquid Layers. Tell students they will have time later to review and modify their responses once they have done a few more investigations.

This is a good spot to take a break.

Show students the two demonstration bottles. Ask them, how are the bottles similar and how are they different from the investigation they did yesterday with the layered straws. They may suggest that they're similar and that the liquids in the bottles and the straws layer and different in that the bottles never mix, but the straws eventually do.

Ask the students, Which is heavier, gold or feathers? Students will likely say the gold is heavier, but others may recognize this as a trick question. Explain that the amount of either makes a difference in how heavy it is, but what is it that makes most of us think about gold as being heavy.

Show students the cup of beans and the cup of foam and ask them, Which cup is heavier? Students will probably choose the beans. Let several students lift the cups for comparison. Ask them, if both cups are full, why is one heavier?

Introduce the term density using the text in Step 12. Students should know that density is the amount of matter in a volume of material and that different materials contain different amounts of matter. All materials have density, including all solids, liquids, and gases.

Have students recall the sequence of salt solutions in a straw and have a student draw the sequence on the board. Tell students that they can determine the density of the salt solutions and this might help them figure out why the solutions layered the way they did. Show them the four bottles of salt solution and the balance.

Have one group of students measure 25 mL of the red solution and another group measure 25 mL of the yellow solution. They can use the pipettes to add or remove any solution. Have the two groups of

students pour the solutions into two cups. Remind students that each cup has 25 mL of the solution. Ask the class, if these have the same volume, do they have the same mass?

Have students make their predictions and then weigh their containers. Zero the balance with an empty cup before you find the mass of the solutions. Record the masses on the board. The masses should be close to this example. It should be obvious to the students that the yellow solution has more mass than the red solution. They should say they know this because the yellow solution weighed more.

Continue the discussion by asking students to state which solution layers on top of the other. They should be able to remember that the red layered on top of the yellow. Students should be able to state that less-dense liquids layer on top of denser liquids.

Have two teams of students measure and weigh the blue and green solutions. Have the other students predict the results. Record the results for the blue and green solutions on the board. Have students transcribe these data into the table on the Liquid Layers sheet, writing them in order by mass with blue on the bottom, then yellow, green, and red on top.

Now pose this density problem: I have two samples of salt water. Sample 1 is 45 mL, and its mass is 54 g. Sample 2 is 120 mL and its mass is 132 g. Which sample is denser? Have students work on the problem and then share their results. Have a student who determined that sample 1 is denser share his or her strategy.

Tell students that density is the ratio between the mass of a sample of matter and its volume. Mass is the amount of stuff in the sample. You find mass by weighing an object or sample of a material. Mass is measured in grams. Volume is how much space a sample of matter occupies; all matter has volume. We measure liquid volume with a graduated cylinder. Solids and gases are measured in cubic centimeters. Cubic centimeters and milliliters are the same. Density can be expressed with the equation density equals mass divided by volume. Use transparency no. 15, Calculating Density, to demonstrate how to calculate the density of sample 1.

This is a good spot to take a break.

Distribute copies of the lab notebook sheet called Calculating Density. Have students transfer the data from the Liquid Layers sheet to the table on the Calculating Density sheet. Then have them use the density equation to calculate the densities of the four colored liquids.

Depending on how accurate the various measurements to create the solutions were and how accurate the masses were determined, students should get density results close to the ones shown here. Continue the discussion with the questions in Step 20.

Bring out the demonstration bottles once again and have students explain what they observe in the bottles in terms of density. You can tell them that there is plain water and another liquid in both bottles. Reinforce that changing the volume of a solution does not affect the density, since if you change the volume you also change the mass. Density is the ratio between an object or materials mass and its volume.

If students need more experience with the concept of density, consider using the extension at the end of this investigation. Distribute copies of the response sheet and have students work alone to respond to the situation presented.

Have students read the article called Density in the Weather and Water Resources book, either in class or as homework. Have them answer the questions at the end of the article and discuss the questions in class. You'll find an answer sheet for the questions in the Teacher Answer Masters Section of the teacher guide.

### **<Investigation 5, Part 2>**

Narrator: In this part, students observe the interaction of liquid of different temperatures to observe that warm water rises while cold water descends. They are introduced to convection in liquids as a means for energy transfer.

Here's what you'll need from the kit for this part: For each group of four students you'll need 4 pipettes; two 250 mL plastic cups; four 200 mL foam cups; and 6 vials with four caps. You'll also need four Weather and Water Resources books, and four copies of lab sheet 27, Layering Hot and Cold Water.

For the class you will need 2 dispensing bottles and red and blue food coloring, and the assessment chart for Investigations 5 and 6. For the class, you will need to provide a 2-liter soda bottle, two pitchers for room-temperature water, hot water, and ice water. Be sure to establish class guidelines for hot water safety.

Before starting this part, plan on how you will get and store the hot water, ice water, and room temperature water. Detailed instructions are included in the Getting Reading section. Room-temperature water can be prepared in two pitchers or gallon jugs by letting tap water stand for at least an hour to reach room temperature.

Each class will need a ½-liter of blue ice water. You'll make this by adding 25 drops of the blue food coloring to a ½-liter of water. The dispensing bottles hold about ½-liter. Each class also needs a ½-liter of hot red water. You'll make this by adding 25 drops of red food coloring to a ½-liter of water. You'll want your water to be at least 50°C, but not hotter than 75 or this may happen.

Review the article called Convection in the Resources book and decide whether you will have students read the article in class or as homework.

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

Begin this part by reviewing the ways heat is transferred. Explain what happens to solids and fluids when they are heated, using the mini-lecture in Step 2. Remind students that they know how to make layers with salt water. Today their challenge is to make layers of plain water of different temperatures.

Distribute copies of the lab notebook sheet called Layering Hot and Cold Water and review the sheet with your students. Ask them to record their predictions for the order of the layers in the vial. Describe the procedure using these general instructions. Fill a vial about three-fourths full with room-temperature water. Use the pipettes and colored water to create red, blue, and clear layers in the vial.

Here's what getters will need for their groups: a vial  $\frac{1}{2}$ -full of the blue ice water from the supply, a vial  $\frac{3}{4}$ -full of room-temperature water from the supply, and a vial  $\frac{1}{2}$ -full of the red hot water from the supply, caps for the two vials of colored water, pipettes, and two foam cups. You'll put the vials of colored water into the foam cups to provide just a little bit of insulation.

Have students get to work, allowing about 15 minutes for students to complete the investigation. Here's some hints you might want to offer as students work. A piece of white paper held behind the experimental vial makes it easier to see the layers. Try not to move or bump the vials while working.

More hints can be found in Step 7. While students work, observe their efforts and take notes on the Assessment Chart for Investigations 5 and 6.

To create successful layering, students first wait for the vial of room-temperature water to stop moving, then take up a pipette full of the blue cold water, put the pipette right down at the bottom, and squeeze slowly and steadily to release the blue ice water. Then they take one pipette of the red hot water, put the tip of the pipette just under the surface of water and slowly and steadily release. You can use a sheet of water paper to more clearly see the layers.

Tell students that once they have created the three layers they should allow the vial to stand undisturbed for five minutes while they observe and compare their observations with other teams.

Ask students to describe what they observed in their vials after five minutes. They'll probably have noticed that the red water started to form strands that sank to the bottom. Ask students to consider why this might be happening.

Have students complete the rest of the Layering Hot and Cold Water sheet. Continue with a class discussion using the questions in Step 11 as a guide. Ask students what they think might happen if they put a layered vial in 1 cm of hot water. Have them recreate their layered vials and give it a try. They'll want to be careful when they put the layered vial in the hot water, so they don't mix it up.

Once students have observed the results, have them report what they saw and explain their observations. Ask them to explain how energy transferred in the system to make the blue water ascend. Reinforce the idea that water becomes less dense as its temperature increases. Explain that as heat is absorbed by water, the molecules move faster and bang into each other more often and with greater force. This drives the molecules farther apart, and the water becomes less dense because there are fewer molecules in a volume of water.

Make sure that students understand the relationship between density and temperature. They should know that: As temperature increases, density decreases. As temperature decrease, density increases. Introduce the term convection as what happens in a fluid, either liquid or gas, when there are temperature differences in the surrounding fluid. The colder fluids will sink; the warmer fluids will rise. The movement of masses or streams of fluid, due to difference in density caused by temperature differences, is convection. Convection happens only in fluids and is the third way heat moves from place to place.

At this point, have students read the article called Convection in the Resources book. Collect the Layering Hot and Cold Water sheet to get a closer look at students' understanding of the relationship

between temperature and density and how materials of different density interact. See the answer sheet in the Teacher Answer Masters section for suggest responses.

**<Investigation 5, Part 3>**

Narrator: In this part, students observe a model convection chamber to confirm that convection cells operate in air.

Here's what you'll need from the kit for this part. For each student, a copy of lab notebook page 29, Convection Chamber, and Mid-summative Exam 5. For the class, you'll need the materials for the convection chambers. Each chamber consists of a clear plastic basin, an aluminum cover with two holes, 2 small binder clips, a funnel, a candle, a plastic tube, and an incense cone. The incense cones come in a box like this. There are enough materials in the kit to make two chambers.

You'll also need a sheet of black construction paper from the kit, the FOSS Weather and Water CD ROM or access to the internet, and the assessment chart for Investigations 5 and 6. You'll need to supply two flashlights, safety matches for teacher use only, a small plastic bag, ice, and paper towels. You'll need to provide cardboard, which you'll cut into 6×6 cm squares and aluminum foil for wrapping the squares. You'll also need a multimedia setup.

Before starting this part, make sure you have ice available to use with the convection chamber during each of your classes. To practice setting up and using the convection chamber, view the video resource: Convection Chamber in the multimedia for this part. Be prepared to show the convection animation after students have observed the convection chamber.

You can reach the animation from the Control Room by clicking on Matter and Energy, selecting Heat and Energy, and clicking on Convection. Make sure you review candle safety before beginning this part.

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

Begin this part by asking students to think about Earth's atmosphere as a mass of fluid. Ask them what happens to the air above a blacktop parking lot that has absorbed solar radiation. Guide the discussion to the idea that the blacktop would transfer energy to the air by conduction and reradiation, and the heated air might become less dense and begin to rise.

Explain to students that since they can't color air like they did with the water, you have a model called a convection chamber. The air inside the chamber represents the air in the atmosphere; the candle represents a hot place on Earth; the ice represents cold temperatures high in the atmosphere; the incense is to show movement of air; and the flashlight and black paper are so they can see what's happening inside the chamber.

Have students help you set up the two chambers. Make sure the chambers are set up properly, remind students of candle safety, light the candles and incense, and dim the lights. Make sure everyone gets a chance to observe.

This is footage from the Convection Chamber video found in the multimedia. Shut down the convection chambers and distribute copies of the lab notebook sheet called Convection Chamber. Ask students to

complete the sheet, drawing a diagram to show the movement of smoke and air in the chamber and completing the explanations at the bottom of the page.

Then discuss student's observations and responses, using Steps 6 and 7 to guide discussion. Introduce the term convection cell, using the information in Step 8. Convection cells play an important role in weather.

Show students the Heat and Energy convection animation. Have students complete question 2 on the Convection Chamber sheets and then collect the sheets to use for assessment. Check to see if students can explain basic convection and heat transfer in a convection cell on Earth. When you think the students are ready, give them Mid-summative Exam 5.

### **<Investigation 6, Introduction>**

Narrator: In Investigation 6: Water in the Air, students investigate humidity—which is water vapor in the air—to understand some of the variables that influence the transition of water from liquid to gas and from gas to liquid.

Look over the At a Glance chart paying close attention to the objectives, assessment opportunities, preparation, outline for conducting the investigation, and when to use the student resources books and multimedia.

Be sure to read through the Scientific and Historical background pages for information about the changing states of water and the processes through which it changes. You will also read about dew point and its relationship to clouds and about humidity and how it is measured. A section about weather balloons and their use for upper-air soundings is also included.

The Why Do I Have to Learn This? section focuses on students ideas about water vapor and clouds. Many students will have some basic understanding of the types of clouds, but this investigation challenges them to think about how clouds are formed.

### **<Investigation 6, Part 1>**

Narrator: In this part, students are challenged to come up with investigations to show that water vapor is in the air all around them.

For each group of 4 students you'll need 2 large plastic cups from the kit. For the class, from the kit, you'll need a set of weather tools, thermometers, food coloring, graduated cylinders, zip bags, and syringes. Be sure to review proper use of syringes with the class.

You'll also need the assessment chart for Investigations 5 and 6. You'll need the Class Weather Chart transparency that you made in Investigation 1, and students will need their Class Weather Charts from Investigation 1.

You'll need to provide water, pitchers or other water containers, and ice. You may also want to provide various shaped containers and plastic wrap. Or have students bring in these materials. You'll also need an overhead projector.

To get ready for this part, schedule another 8 days of weather observations using the weather tools. Add these observations to the Class Weather Chart and to the multimedia spreadsheet if you've started one. Students will analyze these data later.

You need to find out what your local dew point is for the day you begin this investigation. You can usually find this information by checking your favorite weather website or, if your school already has a weather station, get the dew point reading there.

If the dew point is below 5°C it may be difficult to produce condensation on a cup of ice water. If that's so, you'll want to consider increasing the humidity in your classroom by maybe using a humidifier, leaving out pans of water, or leaving a hot pot boiling. You may also want to consider doing this part on a more humid day.

This investigation part provides a good opportunity for inquiry by your students. Give students time to ponder the question of where does the water come from that appears on a glass of ice water and where does it go. Depending on their investigation plans, you may need to wait day or two for students to bring in materials from home to carry out their plans. Make sure you have plenty of ice available.

Students may want to use food coloring for their investigations. You should probably be in charge of the food coloring to avoid excessive use by students.

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

Begin this part by reviewing water vapor. Propose a water-vapor inquiry with this question: Do you think there is water vapor in the air around us? How could you demonstrate that there is or is not?

Challenge the students to come up with investigations to show that there is water vapor in the air around them. Show them the equipment you have available and explain that they can use any of these materials as long as they have a supportable reason to do so. Tell them they can also bring in other materials, if they need them.

Go over how students should write up their investigation plans. The plans should include: the procedure, a list of materials they need, and labeled sections to record their observations and results. You should approve their plans before they start their investigations.

When all of the groups' plans have been approved and all of the materials obtained, have the students conduct their investigations. As they work, help them refine their procedures and think critically about the outcomes, using questions like these:

- Why did you choose to use ice in your investigation?
- How can you tell that the dew on the cup didn't pass through the side of the cup?
- Could you get dew to form on a cup of room-temperature water?

When students complete their investigations, have them clean up and summarize their results. Tell students that each group will present their results to the rest of the class. Their presentations should include a: Statement of the challenge, a description of what they did, and a statement of their

conclusions and the evidence supporting those conclusions.

Have each group make a short presentation. Allow time for student questions and critique. You might also ask questions, like:

- Why did you set up your investigation in this particular way?
- How did you determine that the water just didn't soak through the container?
- What evidence do you have that the water on the side of the cup came from the air?

Assessment for this part involves teacher observation. When students make their presentations, score them on three aspects of inquiry: planning and conducting an investigation, constructing explanations, and communicating their ideas.

After the presentations, introduce the word condensation and poll the class to see if they think that their investigations demonstrated that water vapor exists in the air. Ask what other examples of condensation they have seen.

### **<Investigation 6, Part 2>**

Narrator: In this part students think about how water vapor gets in the air and measure temperature change that occurs during evaporation. Humidity is introduced as the measure of water vapor in the air.

Here's what you will need from the kit for this part. For each group of 4 students, you will need one 250 mL plastic cup, 2 thermometers, 2 muslin squares, which you'll cut from the larger squares in the kit, 2 rubber bands, and 4 copies of lab notebook page 31, Relative Humidity and page 33, Water in the Air.

For the class, you'll need a hygrometer from the weather tools box, transparency no. 16 called Relative Humidity, and the assessment chart for Investigations 5 and 6. You need to provide for each group, a watch with a second-hand or a stopwatch, and paper towels. For the class you'll need to provide room-temperature water, pitchers or other water containers, and an overhead projector.

If this hasn't been done already, you'll need to cut the muslin squares that come in the kit. Cut each of the 16×16 cm squares using a pair of scissors or a paper cutter into four 8×8 cm squares.

Use the hygrometer to determine the relative humidity is in your room. Plan to do this part when the relative humidity is below 80%. Before starting this part, put aside a couple of liters of tap water to reach room temperature.

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

Begin this part by reviewing Part 1. Then ask, How does water vapor get into the air? Many students will be familiar with evaporation. Be sure they write this definition in their notebooks. Evaporation is the process by which liquid water becomes a gas called water vapor. Have Getters get a cup of water for their group. Ask students to dampen the back of both hands, and then gently blow on the moist area on the back of their left hand to simulate wind. Ask, What effect does wind have on the wet spot? Where did the water go that was on your hands? Why did the wet spot feel cold?

Students should respond that the water dried up faster when they blew on their hands and that the water evaporated and went into the air. They may figure out that heat was transferred from their hand to the water in order for the water to evaporate. So their hand felt colder. Show students the materials you have to measure temperature change: thermometers, muslin, rubber bands, paper towel, and cups of water. Ask them how they might use these materials to measure temperature change during evaporation.

Give students a few moments to discuss this and write their ideas in their science notebooks. Use students' ideas to come up with a procedure that looks something like this:

- Each group gets two thermometers, two muslin pieces, two rubber bands, a paper towel, and a cup of water. They record the starting temperature on the thermometers.
- They attach a piece of muslin around the bulb of each of the thermometers, using a rubber band.
- Then they take one of the thermometers and dip it in the water. Use a paper towel to blot off any extra water so it's not dripping wet. This one actually looks pretty good.

The other thermometer and muslin must stay dry. After students have set up their thermometers have them wait for a minute and record the temperatures again. Ask them, how might we increase evaporation from the fabric. They'll probably suggest blowing on the muslin. You'll want to have them rest their elbows on the table. Have students take 20 to 30 seconds at a time, taking turns. After about 5 minutes, ask students to record final temperatures and report their results. They should find that the temperature decreased for the wet-bulb thermometer. Discuss the results using the series of questions in Step 9.

Introduce the term humidity using the transparency called Relative Humidity and the mini-lecture in Step 10. Use the example and explanations at the bottom of the transparency to reinforce the idea of relative humidity and its relationship to the amount of water vapor in the air.

This is a possible place for a break.

Distribute copies of the lab notebook sheet called Relative Humidity. Use the Relative Humidity transparency to introduce the sheet. Work through the example on the lab notebook sheet together. Have students complete the next three questions on their own.

Discuss student answers and provide assistance with calculating percentages as needed. You can find answers for this sheet in the Teacher Answer Masters of the teacher guide. Summarize what students have learned about water vapor in the air, using the mini-lecture in Step 12.

Distribute copies of Response Sheet—Water in the Air, and have students respond individually to the statements on the sheet. Collect the sheets when students have completed them. You will use the Response Sheet for assessment in this part. Suggest responses are available in the Teacher Answer Masters section of the teacher guide.

Make notes about students' understanding of the relationship between temperature, evaporation, and condensation. If the class as a whole doesn't understand this relationship, plan a self-assessment session, as described in Step 4 of Getting Ready for this part.

**<Investigation 6, Part 3>**

Narrator: In this part, students explore the temperature at which water vapor condenses and determine the dew-point temperature in their classroom.

Here's what you'll need from the kit for this part. For each group of 4, you'll need three 250 mL plastic cups and a thermometer, the Weather and Water Resources books, and 4 copies of lab notebook page 35, Dew-Point Questions. For the class, you will need two thermometers that read the same temperature, a piece of muslin, a rubber band, and the hygrometer.

You'll need transparency no. 17 called Humidity Calculator and transparency 18 called Temperature Number Line. You'll also need the Assessment Chart for Investigations 5 and 6. You'll need to provide paper towels for each group, and for the class, room-temperature water, and ice cubes. You'll also need an overhead projector.

To get ready for this part, look up the dew point for your location on the day you plan to conduct this part. It should be at least 5°C or 41°F for this investigation to work. Plan to have a supply of ice for this part. You will need 2–3 ice cubes per group.

Students may need to add and subtract negative numbers in this part. If necessary, use transparency no. 18 to review the difference between a positive and a negative number. You need to set up the wet- and dry-bulb thermometers you will use for demonstration in this part. If you want the students to find the relative humidity themselves make sure you have the materials available.

Review the article in the Resources book called Dragon's Breath and decide whether you want to have students read it in class or as homework.

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

Begin this part with a review of condensation and heat transfer, using the questions and mini-lecture in Steps 1 and 2. Have students consider whether there is a temperature at which condensation starts to happen and how they might plan an investigation to find out. You can either conduct this part as an open investigation or provide more structure by following this procedure.

- Students first set up a recording chart like this one in their science notebooks. Groups get their materials and record the starting temperature of a half a cup of room-temperature water.
- They add a piece of ice and gently stir, watching for condensation on the outside of the cup.
- That piece of ice melts and no condensation has formed they add another piece of ice, continuing to gently stir.
- As soon as they see condensation, they should stop; they take the ice out right away after reading the temperature, and pour this water into a dry cup. Give this to my group member to dry out and record the temperature of this water and see if any condensation forms. I've got a little bit on the side there. So I'll take my dry cup back and pour the water again, take the temperature of this water, and watch—I've got condensation right away. Take my dry cup again, pour, take the temperature of this water, watch the condensation, don't see any forming this time—oh there's a little bit. So, take my dry cup; no condensation. So let's take that final temperature. Looks like 12°.

Students should set up a recording chart in their lab notebooks that looks like this. They record the highest temperature at which condensation occurred. Ask each group to report its condensation temperature. Write the temperatures on the board. Students may notice some variation in recorded temperatures. A difference of three or four degrees is reasonable considering the accuracy of the thermometers.

Ask students what they think dew is and how they think it forms. Describe dew as droplets of water seen on plants and other surfaces, usually in the morning. Dew forms on surfaces cool enough to cause the water vapor in the air to condense. Use the explanation in Step 8, introduce dew point.

Distribute copies of the lab notebook sheet called Dew-Point Questions. Have students work alone or in groups to answer the questions. Give them about 10 minutes and then discuss their answers. You'll find the answer sheet in the Teacher Answer Masters section.

This is a possible place for a break.

Remind students what they did the other day with the wet- and dry-bulb thermometers. What happened to the temperatures? The wet-bulb thermometer was lower. We can use that information to help determine relative humidity.

Tell students that you have chosen two thermometers that read the same temperature. Have a student read both thermometers and report the temperatures to the class. Record the temperatures on the board. Dampen the muslin on the wet-bulb thermometer and have students take turns waving the two thermometers as you continue with the discussion.

Bring out the hygrometer and explain that meteorologists use hygrometers to measure relative humidity. A hygrometer measures the water vapor in the air and compares that to the amount of water vapor needed to saturate the air. The hygrometer displays relative humidity as a percentage.

Remind students that relative humidity is what percentage of the possible volume of water vapor is in the air. Ask them to consider if things would dry up very fast if the relative humidity was 100%. They should decide since the air would be saturated with water vapor, and there wouldn't be room for any more. So no evaporation could occur and things wouldn't dry out.

It's now time to read the wet- and dry-bulb thermometers and report the temperatures to the class. Have students turn to the Humidity Calculator chart in the resources book. Explain that they can use the data from the wet- and dry-bulb thermometers to calculate relative humidity in their room. Meteorologists have a chart that be used to convert the temperature readings into relative humidity.

Use transparency 17 called Humidity Calculator to show students how to determine relative humidity. Subtract the wet-bulb temperature from the dry-bulb temperature to determine the temperature difference. Find the dry-bulb temperature on the left column of the chart. Find the temperature difference in the row across the top of the chart. Locate the square where the dry-bulb thermometer row and the temperature difference column meet. This is the humidity.

Use the chart to determine the humidity in your classroom and compare it to the hygrometer reading. Discuss what factors may be making a difference in the two readings. Collect the Dew-Point Questions sheets when students finish to review as an assessment.

Have students read the article called Dragon's Breath in the Weather and Water Resources book, in class or as homework. Discuss the questions after they complete the reading. See the answer sheet in the Teacher Answer Masters section.

**<Investigation 6, Part 4>**

Narrator: In this part students investigate the relationship between pressure and temperature in a gas. They use this relationship between pressure and temperature to explore cloud formation.

Here's what you will need from the kit for this part. For each group of 4 students, the resources books and 4 copies of lab notebook page 37, Pressure/Temperature Demonstration.

For the class, from the kit, you'll need the soda-bottle pump and liquid-crystal thermometers. You'll need the Weather and Water CD ROM or access to the internet, transparency number 19, Raindrops and Cloud droplets, and the assessment chart for Investigations 5 and 6.

You'll need to provide two 2-liter soda bottles, masking tape, matches and water. If you want, have students bring in more 2-liter bottles so that each group or pair can experience making clouds. You'll be in charge of the matches, but be sure to review match safety with the students as well. You'll also need an overhead projector, and a multimedia setup.

To get ready for this part, start collecting 2-liter soda bottles with caps. You will need at least two for the demonstration and more if you want each group or pair to make clouds. You can access the videos showing you how to set up the 2-liter bottles for the three different demonstrations via the Video Resources menu found in the Control Room. There are three videos. Teacher demonstration on how to demonstrate to your class that temperature increases in air under pressure, and how to demonstrate the cloud in a bottle, and a student demonstration on how students can make the cloud in a bottle. Watch the videos and take some time to practice the Pressure/Temperature demonstrations and Making Clouds in a bottle.

Review the article called Observing Clouds in the resources book and decide whether you want to have students read it in class or as homework.

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

Begin this part by asking students what they think might happen to the temperature of a gas if they could squeeze it into a smaller volume. Show them the demonstration materials: the 2-liter soda bottles, liquid-crystal thermometers, soda-bottle pump, and masking tape.

Distribute copies of the lab notebook sheet called Pressure/Temperature Demonstration. Ask students to record their observations during the demonstration and their conclusions after thinking about the demonstration results.

Assemble the demonstration bottle with the soda-bottle pump as you saw the Getting Ready section. Assemble another bottle in a similar manner, except close it with the bottle cap. This bottle can be passed around from group to group.

As shown in this video from the multimedia, demonstrate the effect on temperature in the bottle with the soda-bottle pump, having a student or two observe and report the changes in temperature. For the bottle that is being passed around here's what the students should do:

- Observe and record the starting temperature.
- Apply pressure to the bottle and hold it. Observe and record the temperature.
- Release the pressure and once again observe and record the temperature.

When everyone has had a chance to observe the temperature changes in the bottles, have students talk in their groups to answer the questions on the Pressure/Temperature Demonstration sheet. They should summarize the demonstration results in a statement of the relationship between pressure and temperature.

As a class, have students discuss their conclusions and responses to the questions on the student sheet. Review what students have learned about compression and pressure, using the questions in Step 7. Check student answers on the lab sheet to make sure they understand the relationship between pressure and temperature.

This is a possible place for a break.

Tell students it's time to turn to the study of clouds. Guide the discussion with these questions:

- Have you seen any clouds lately? What did they look like?
- Where are clouds? Are they always in the same place?
- What is a cloud? What is it made of?

Students will probably suggest that clouds are made of water. Ask them what form the water is in. Some will suggest that it's water vapor since it's up in the air. Remind them that water vapor is invisible, and ask: Where do clouds come from? How do you think they form? For the following discussion and demonstration, make sure you follow the teacher guide to show students how clouds form.

Here's how you make a cloud in a bottle. First, pour about 25 mL of water into the bottle, then screw on the pump cap, shake the bottle vigorously, so you are adding water vapor to the air inside the bottle, then unscrew the cap. Light a match and blow it out, drop it in to the bottle, and quickly replace the cap. Start pumping. Remember, when you're pumping you're adding pressure to the bottle, so the temperature is increasing. You might need to pump, maybe 30 to 40 times. Then slowly unscrew the bottle cap, releasing the pressure, watch what happens inside the bottle. You've made a cloud, or something more like fog.

Condensation has occurred on the inside of the bottle on the plastic and on the smoke particles that you've added to the air. You can make a cloud several times in this bottle, watching what happens each

time to the condensation. Notice when I rub my finger over the outside of the bottle, nothing comes off. The condensation is on the inside of the bottle.

This is how your students can make a cloud in a bottle. First, add about 25 mL of water to a plastic soda bottle, then screw on the cap, and shake the bottle vigorously adding water vapor to the air inside the bottle. Then unscrew the cap, light a match, and blow it out. Drop the match inside of the bottle and screw on the cap quickly. Now, you want to add pressure to the bottle, so squeeze the bottle. Remember squeezing adds pressure, pressure increases temperature. Then release and watch what happens. Doing this several times will increase the amount of condensation inside of the bottle

Again, remember to follow the teacher guide for the specific sequence and questions that need to happen during this demonstration.

Now is a good time for students to make clouds in bottles, using the squeeze method as outlined in your teacher guide. You should be in charge of the matches. Collect the lab sheet, Pressure/Temperature Demonstration, at the end of this part and check student responses to assess their understanding of the relationship between pressure and temperature. An answer sheet is located in the Teacher Answer Masters section of the teacher guide.

This is a possible place for a break.

Ask students, What is precipitation? Describe precipitation as any form of water that falls from clouds and reaches the ground. Students should figure out from this definition that dew and frost are not forms of precipitation since they don't fall from clouds.

Have students name as many forms of precipitation as they can and write the list on the board. Ask them what the difference is between snow and rain. They should respond that rain is liquid water, and snow is solid, or frozen, water.

Have them turn to the page in their resources books called Raindrops and Cloud Droplets. Ask them to consider how precipitation might form. Discuss the picture on transparency no. 19, using the information in Step 19 in the teacher guide.

Use the information in Step 20 to introduce how important precipitation is and what meteorologists do to study it. Have students read the article called Observing Clouds in the resources book. Discuss the questions after they finish reading the article.

An answer sheet for the questions is located in the Teacher Answer Masters section of the teacher guide.

### **<Investigation 6, Part 5>**

Narrator: In this part students view a video of a weather balloon launch and use a multimedia simulation to analyze data collected by weather balloons launched in Phoenix and Chicago. They also prepare sounding charts from data collected by weather balloons launched in four cities and analyze and compare data.

Here's what you'll need from the kit for this part. For each group of 4 students, the Weather and Water

Resources books, and four copies each of pages 39 Weather-Balloon Simulation, page 40 Upper-Air Sounding Graph, and page 41 Temperature Number Line. You'll also need copies of the Mid-summative Exam 6 for each student.

For the class you'll need transparencies no. 18, Temperature Number Line, no. 20, Upper-Air Sounding Graph, no. 21, Upper-Air Sounding Graph for Oakland, and no. 22, the filled in Upper-Air Sounding Graph for Oakland. You'll also need the assessment chart for Investigations 5 and 6, and the Weather and Water CD ROM or access to the internet.

You'll need the "What is Weather" Quick Writes that students completed in Investigation 1. You need to provide colored pencils for each group and for the class, and overhead projector, and a multimedia setup.

Consider whether your students are ready for the math required in this part, which includes positive and negative numbers and graphing. If students are not ready for the math, consider limiting student engagement to reading the article about weather balloons, using the multimedia, and taking the Mid-summative Exam.

Take some time to preview the multimedia activities for this part. If you're entering from the Control Room, click Atmospheric Data and select Weather-Balloon Launch. Activity 1 is a video of a weather-balloon launch. Click on "See Video", and select the video size you'd like. Plan to show this to the whole class.

Activity 2 presents two simulated balloon launches, one in Chicago and one in Phoenix. Click one of the cities to view the simulation for that city. Click on "launch" to launch the simulated balloon. Clicking on "continue launch" sends the balloon up incrementally higher. After the balloon bursts, you can choose a variable to chart for the launch period. This simulation can be used in small groups or individually.

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

Begin this part with a brief introduction to weather balloons as a way that meteorologists get information about air in the troposphere. Then show students the multimedia video of a weather-balloon launch. Review the content of the video, if necessary using the text in Step 2. Continue the discussion with these questions.

- Why do you think meteorologists use helium or hydrogen in their balloons? Students should respond that these gases are less dense than the surrounding air so the balloon floats up.
- What do you think happens to the volume of the balloon as it rises in the atmosphere? Help students come to the conclusion that as the balloon rises, the pressure of the surrounding air decreases, so the volume of the balloon increases. Eventually it pops.

Distribute copies of the lab notebook sheet called Weather-Balloon Simulation. Students should complete this sheet as they work with the weather balloon simulation. Discuss their answers after they complete the simulation. An answer sheet is located in the Teacher Answer Masters section of the Teacher Guide.

Have students read the article called Weather Balloons and Upper-Air Soundings in the Weather and Water Resources book. Once they've read the article, discuss the questions at the end of the article. An answer sheet is included in the Teacher Answer Masters section of the Teacher Guide.

This is a possible place for a break.

Have students turn to the page called Weather-Balloon Sounding Data in their Weather and Water Resources books. Tell students that a set of data from a weather balloon is called a sounding. Ask them to list the data that is recorded on the sounding-data sheet. They should list dew point, air temperature, and altitude.

Propose plotting the sounding data on a chart. Tell students that charts meteorologists use are a little different than the graphs the students usually work with, but are put together in a similar way. Distribute copies of the lab notebook sheet called Upper-Air Sounding Graph. Use transparency no. 20 called Upper-Air Sounding Graph to show students how to create a chart from the sounding data.

Point out these features of the graph. The graph has two axes: the vertical one for altitude, measured in meters, and the horizontal one for both air temperature and dew point. Some of the temperatures will be negative, that is, below freezing. The negative numbers will be plotted on the left side of  $0^{\circ}$ , and the positive numbers will be plotted on the right side of  $0^{\circ}$ . The lines are labeled every  $10^{\circ}\text{C}$ .

Altitude is measured in meters. A weather balloon transmits data from different altitudes as it rises. Each air temperature and dew-point reading came from a different altitude. If necessary, use transparency no. 18 called Temperature Number Line to demonstrate positive and negative numbers. Use transparency no. 21 called Upper-Air Sounding Graph for Oakland to demonstrate how to plot data using the Oakland data in the table. The first air-temperature reading was  $12^{\circ}\text{C}$  and was read at an altitude of 3 meters. Find 3 m on the vertical axis and then locate  $12^{\circ}\text{C}$  on the horizontal axis. Where the two measurements intersect, make a dot.

Continue plotting the points for the rest of the air temperatures. Then connect the dots with a smooth line. Label the line "Air Temperature." Plot the dew points in the same manner. Use a different color for the line connecting these points and label this line "Dew Point." You can now show students the completed graph on transparency 22, the completed Upper-air Sounding Graph for Oakland.

Have each student select one of the cities on the Weather-Balloon Sounding Data page in the Resources book and let them begin plotting their data on the lab notebook sheet called Upper-Air Sounding Graph. Cruise the groups to monitor progress and answer questions.

Have students compare their sounding graphs to find out how they are alike and how they're different. They should notice that both air temperature and dew point decrease as the balloons rise. Some dew-point and air-temperature lines cross. Some lines don't cross or even come close.

Ask students to think about condensation and dew point, using the questions in Step 10. Students should know that where the dew point lines intersect with the air-temperature lines, condensation will probably

occur and they would see clouds at this altitude. Make sure students have the definitions of the terms used in this part up-to-date in their lab notebooks for future reference.

Return the quick writes from Investigation 1 on what is weather. Have students review their responses and expand on their explanations. Students should number sentences they think are incomplete or inaccurate, and write corresponding revisions with corresponding numbers on a separate sheet of paper. They can also add additional information. You'll find the scoring guide in the Assessment Chapter. When you think students are ready, have them take Mid-summative Exam 6. A scoring guide is available in the Assessment chapter of the teacher guide.

### **<Investigation 7, Introduction>**

Narrator: In Investigation 7 students learn that the water cycle is complex and involves water everywhere in the global environment.

Look over the At a Glance chart paying close attention to the objectives, assessment opportunities, preparation, outline for conducting the investigation, and when to use the student resources book, video, and multimedia.

Be sure to read through the Scientific and Historical background pages for information about water on Earth, why Earth has water, where it is stored, and how it travels through the water cycle.

The Why Do I Have to Learn This? section focuses on the students' experience of what seems to be an abundant resource, water. They may take water for granted, but need to develop a future view of water resources and how humans can carefully use and take care of Earth's water.

### **<Investigation 7, Part 1>**

Narrator: In this part, students consider the water cycle and why Earth is called the Water Planet. They learn about the distribution of water on Earth and participate in an activity that simulates the travels of a water molecule through the water cycle.

Here's what you will need from the kit for this part. For each group of four students you will need one die, the Weather and Water Resources books, and 4 copies of the lab notebook sheet page 43, Water-Cycle Game.

For the class, you'll need a 1-liter beaker, a pipette, a graduated cylinder, a syringe, the Water Cycle poster, and the video called Water Works: Careers in Hydrology. You'll need to provide a way to view the video. You'll also need transparencies no. 23, Earth: The Water Planet, and 24, Water-Cycle Game Tally. You'll also need the nine duplication masters, numbers 2 through 10, from the Special Teachers Masters chapter of the teacher guide, and the assessment chart for Investigations 7 and 8. You need to provide a globe, chart paper, marking pens, notebook paper, water, paper towels, an overhead projector, and overhead projector markers.

If this is the first time you have used this kit, use the nine duplication masters from the Special Teacher Masters section of the teacher guide to make a set of Water-Location Posters. Make sure you get out the posters for Investigation 7, not the Global-Warning versions used in Investigation 9. It helps to either laminate these posters or place them in sheet-protectors so you can keep them for the next time you do this investigation.

Think about where you want to hang the posters in your classroom. You'll need nine different locations. Students travel from poster to poster as they simulate moving through the water cycle. Plan to hang the "Ocean" poster where a larger number of students can congregate.

Take a few minutes before you begin teaching this part to review the water-distribution demonstration in Step 5 of Conducting this part. Gather the materials and plan where you want to do the demonstration so everyone can see.

Take a look at transparency no. 24 called Water-Cycle Game Tally. Note there are several columns. You will use the column labeled "Round 1 Total" for Part 1 of this investigation and "Round 2 Total" in Part 2. Preview the 13 minute video Water Works: Careers in Hydrology.

Review the article called Earth: the Water Planet in the Weather and Water Resources book and plan whether you want students to read this article in class or as homework.

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

Begin this part by asking, What is the water cycle? Students use a clean sheet of paper to write down everything they can about this question. They may also use a labeled drawing to answer the question. Collect the papers when they have finished.

The Quick Write will give you some ideas about student's thoughts on the water cycle before you begin instruction. Take some time to read through the students' responses before continuing to find out what their intuitive ideas about the water cycle are. Students will revisit their ideas at the end of Part 1.

Hold up the globe, rotating it so that the Pacific Ocean is toward the class. Ask them to think about how they would describe Earth if they were a visitor from another planet approaching from above the Pacific Ocean. After about a minute, tell them that Earth is often referred to as the Water Planet. If they were to view Earth from above the Pacific Ocean, they could certainly understand why. About 70% of the surface of Earth is covered by water.

Ask students to think of some of the other places water is found on Earth, besides the oceans. Keep track of their list on the board or chart paper. The possibilities include:

- Rivers and streams
- Lakes and ponds
- Atmosphere
- Aquifers or groundwater
- Glaciers, snow, and other ice
- Soil moisture
- Water in living things
- Bottled water and beverages

Ask students to consider what is meant by fresh water. Listen to their responses and confirm that fresh water contains little, if any, salt. Continue the discussion of Earth's fresh water and have students turn to

the first page of the article called Earth: the Water Planet. Draw their attention to the pie chart at the bottom of the page.

Use transparency no. 23 called Earth: the Water Planet as you guide students through the various locations water is found on Earth. Tell students that you have a demonstration that will help them visualize how Earth's water is distributed. Ask two or three students to help you with the demonstration. Follow these steps:

- Fill a 1-liter beaker to the 1-liter mark and tell students that this represents all of Earth's water, salt and fresh.
- Take a pipette, dip it in—you don't need to take any up, just dry it off quickly. Tell students that the moisture on the outside of the pipette represents all of the water in Earth's rivers and streams.
- Then have a student take up a pipette full of water and put one drop in the graduated cylinder. This represents all of the water in Earth's atmosphere.
- Another student puts two drops into the graduated cylinder and this represents all of the moisture in Earth's soil.
- Another student can put three drops and this represents all of the water in Earth's lakes and ponds.
- Three more drops and this is all of the water in Earth's inland seas. Put any water left in the pipette back in to the beaker.
- Have another student take the syringe and measure 6 mL of water and put that in to the graduated cylinder. That represents all of the water in Earth's underground aquifers.
- Have another student take up 21 mL of water and put that into the graduated cylinder. This represents all of the water frozen in Earth's ice caps and glaciers.
- The water in the graduated cylinder will total about 28 mL.
- Ask students, then how much water is left in the beaker? Students should calculate there's about 972 mL of water left in the beaker. This represents all of the water in Earth's oceans.

Introduce the Water-Cycle Game by asking students to imagine they are water molecules and that they are about to enter the water cycle. Explain the game.

- Each group of three or four students will represent one water molecule.
- Each group will begin at one of the 9 Water-Location Posters you've placed around the room.
- To begin, students roll their die.
- Students locate the number they rolled on the poster and read the statement that tells them where to go next. Depending on what they rolled, they may stay at that location to roll again or move to another Water Location Poster.
- They continue rolling the die and moving to the indicated location.

Distribute copies of the lab notebook sheet called Water-Cycle Game, one to each student. Show them the lines in the Round 1 locations column. This is where they will record the sequence of locations their molecule travels to. They will record each location that comes up for 10 rolls of the die. Explain that each member of the group has a job. Describe the jobs and then make assignments.

- The roller is in charge of rolling the die.
- The navigator reads the directions and figures out where the group heads next.
- The scribe records each stop and what happens to the molecule.

- The monitor is an optional job if the group has four members. The monitor makes sure everyone in the group stays together throughout its travels.

Distribute the dice and have students to move to their starting location. Let the game begin. It can take up to 15 minutes to complete 10 stops. Some groups may find themselves stuck in one location for several turns, especially when they find themselves in the Ocean. It can be frustrating, but have students consider why this might happen.

When each group has recorded information for 10 rolls, have them return to their seats and transcribe their water molecule's locations onto their individual Water-Cycle Game sheets. Then have them answer the questions at the bottom of the sheet.

When everyone has completed their sheets, use transparency no. 24 called Water-Cycle Game Tally to record the total number of visits to each water location during the game. Students can record the grand totals on a sheet of paper in their lab notebooks. Have them compare the class data with the data their group got.

Discuss the results of the Water-Cycle Game focusing on how the paths that their water molecules traveled are different from the paths that most people know as the water cycle. From their experiences with the Water-Cycle Game and this discussion, students should come to understand that the water cycle is actually very complex and varied. A single water molecule can follow any number of paths in the water cycle through different processes to and from different locations.

This is a good spot to take a break.

Show students the video called Water Works: Careers in Hydrology. This video follows the water cycle while discussing the uses of water and people whose jobs involve the use and management of water. Discuss the video with your class using the questions in Step 14.

Have students read the article in the Weather and Water Resources book called Earth: the Water Planet. Discuss the article, using the questions in Step 15. Tell students to think about the video and the Water-Cycle Game as you discuss these questions.

Return the water-cycle quick writes students did earlier. Have students circle and number the ideas or sentences they wish to comment on or revise. They can write about the ideas they have numbered, explaining how their thinking has changed, what additions they might want to make, or what they have learned that supports their original ideas.

At the conclusion of this part, put up the Water-Cycle Poster where students can refer to it in the future.

### **<Investigation 7, Part 2>**

Narrator: In this part students play the multimedia version of the Water-Cycle Game and compare results to the classroom version they played in Part 1. They use what they learned in both versions to diagram the water cycle.

Here's what you'll need from the kit for this part. For each group of 4 students, you'll need the resources

Books and copies of the Mid-summative Exam 7. You'll also need lab notebook 43, the Water Cycle Game that students began in Part 1.

You need to provide a sheet of chart paper and colored marking pens for each group. For the class you'll need to provide an overhead projector and an overhead-transparency pen, and a multimedia setup.

To get ready for this part, consider how students will interact with the multimedia. If you have only one computer available, have volunteers spin the fish while the other students record how they travel through the water cycle. If you have several computers or access to a computer lab, you can have students work individually or in teams. It helps to demonstrate the game to the class before having students work on their own.

Everyone will record their multimedia results on the lab notebook sheet called Water-Cycle Game that they began using in Part 1. You will transcribe the class results on transparency no. 24 called Water-Cycle Game Tally, which you used in Part 1. You may want to have a transparency for each period.

Take a moment to preview the multimedia Water Cycle Game.

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

Begin this part by discussing the Water-Cycle Game students played in Part 1. Explain that the game has limitations, but does give a good representation of the major ways water travels through the water cycle. Review the results recorded on the tally sheet from Part 1. Ask students what they think would happen if they played the game again or could have more than 10 rolls of the die.

Then introduce the multimedia Water-Cycle Game. Demonstrate how it works for the class. Point out the picture on the first screen that shows where a molecule might start. The current location of the molecule is outlined with a red dotted line. The numbers by the nine small pictures keep track of where a water molecule has traveled. These can be moved.

The fish is the spinner. The words surrounding the fish spinner indicate what might happen to a water molecule. The number of completed spins appears in the lower left corner of the screen. Spin several times to familiarize students with the program.

Water condenses and falls on a lake. An animal drinks the water. Water is respired or evaporated from the body.

Students can review where their molecule has been. They can rearrange the locations if they want to group the locations they've visited together. After students are clear on how the game works, show them that they can get of history of where they've been by clicking on the Report button in the upper right corner. Organize students into groups according to your computer set-up and have them begin playing the multimedia game. Remind them to record what happens on the Water Cycle Game sheet in column 2. They should record the first 10 stops.

When each group has visited its ten stops, have them return to their desks and transcribe their group's molecule locations onto their individual Water Cycle Game sheets. Use transparency no. 24 called

Water-Cycle Game Tally to record class results in column 2, just as you did in column 1 in part 1. Have students compare the data and predict what might happen if they completed 25 spins. If you have time, have students continue the multimedia game until they reach 25 spins.

In a class discussion, ask students to describe the water cycle using what they found out by reading the article in the Resources book, by watching the Water Works video, and by playing both the class and multimedia water cycle games.

This is a possible place for a break.

Pass out a sheet of chart paper and marking pens to each group. Ask the students to work together in their groups to draw a labeled diagram of the water cycle, using the information from the two rounds of the Water-Cycle Game. They should include as much detail as they can and use arrows to indicate the movement of the water in the environment. When they finish, display their posters where students can compare them.

When you think students are ready, have them take Mid-summative Exam 7. The answer sheet for Mid-summative Exam 7 is located in the Assessment Chapter of the teacher guide.

### **<Investigation 8, Introduction>**

Narrator: In this investigation students explore the relationship between changing air pressure and wind.

Look over the At a Glance chart paying close attention to the objectives, assessment opportunities, preparation, outline for conducting the investigation, and when to use the student resources book and multimedia.

Be sure to read through the Scientific and Historical background pages for information about atmospheric pressure and how it changes through the atmosphere. Information is also included about how air pressure is measured and how differences in air pressure create wind.

### **<Investigation 8, Part 1>**

Narrator: In this part students investigate the effect of air pressure on a simple air-pressure indicator and consider how density affects air pressure.

Here's what you will need from the kit. For each group of four students, you'll need 1 clear plastic, 500-mL jar with a lid, one square 5 dram glass bottle, and 1 rubber stopper with a plastic tube. You'll need the Weather and Water Resources books, and four copies of lab notebook page 45, Pressure in a Jar, and page 47, Response Sheet—Air Pressure and Wind. For the class you'll need another clear plastic 500-mL jar with a lid, one square 5 dram glass bottle, 1 rubber stopper with a plastic tube, one 1-liter beaker, food coloring, 2 dispensing bottles, a barometer, and a 2-liter plastic jar with a lid.

You'll need these transparencies: no. 25 called Pressure Indicator and no. 26 called Gas in a Syringe. You'll also need the Weather and Water CD ROM or access to the internet, and the assessment chart for Investigations 7 and 8. For the class, you need to provide water, an overhead projector, and a multimedia setup.

To get ready for this part, add 15 drops of green food coloring to a liter of water. Each group will need about 50 mL of colored water. Store it in the two dispensing bottles. Practice assembling a pressure indicator. Get a 500-mL plastic jar and lid, a square glass bottle, which you'll fill full with the green liquid, and a rubber stopper with clear plastic tube.

Insert the stopper in the jar, making sure that the tube goes down into the water. Take the lid off of your large jar and set the bottle on the lid. Then you're going to hold the lid and screw the jar down. If your bottle bulges a little bit—see how mine, see how it's not working. You might want to just move the jar a little bit to the side, so you can still put the lid on, but the tubing doesn't interfere.

Squeeze the jar to increase pressure in the system. The air inside the tube is compressed as the jar is squeezed, so the level of the water is lowered.

Keep your assembled air-pressure indicator as a model for your class. Preview the multimedia sections for this part: Gas in a Syringe, Weather-Balloon Launch, and Elevator to Space.

Review the article, What Is Air Pressure? in the Weather and Water Resources book. Decide if you want to students to read and answer the questions in class or if you want to assign it as homework.

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

Begin this part with a review of pressure. Remind students of the syringe and tubing experiment they did in Investigation 2. Discuss where they may have heard the term pressure related to weather before. Some may say they've heard it on the evening news on the weather report and others may mention the class barometer.

Show students your assembled air-pressure indicator. Ask them to predict what will happen if you squeeze the jar. Use transparency no. 25, Pressure Indicator to show students how to assemble their own. Distribute copies of the lab notebook sheet called Pressure in a Jar, one to each student. Have students record their predictions in Part 1 of this sheet.

Have Getters from each group get the materials to build one pressure indicator. Don't forget to tell them that the system needs to be straight up in the jar! Students should record their observations in Part 2 of the Pressure in a Jar sheet as well as answer the remaining questions.

An Answer Sheet is available in the Teacher Answer Masters section of the teacher guide. Most students will probably be surprised by what happened when they squeezed the jar. Use the questions in Step 6 to help bring students to an understanding of what happened.

After the discussion, have students disassemble the pressure-indicator bottles and clean up. Show the Gas in a Syringe simulation from the Matter and Energy section of the multimedia.

Follow the discussion in the teacher guide to compare the multimedia syringe system to their pressure indicators. Have students consider how the syringe system in the multimedia is like the pressure indicators they built. Although they can't see the molecules in the jar, the system is airtight and they can

assume the number of molecules stays the same even when they squeeze the jar. In the pressure indicator they see the effect of increasing pressure on the water level in the tube.

Click on "show pressure gauges" to add the pressure gauges to the syringe simulation. There is an indicator for air pressure outside the syringe and one for air pressure inside the syringe. Ask students what they think will happen as the plunger is depressed. The pressure changes inside the syringe, but remains unchanged outside.

To show students the surrounding air, click the "Show surrounding air" button. Depress the plunger again so students can compare the motion of the molecules inside and outside of the syringe. The outside air pressure doesn't change at all. You can use transparency no. 26, Gas in a Syringe, for a review of what students viewed in the multimedia simulation.

Continue this part by having students consider what happened to the density of the air in the syringe and the pressure-indicator system. You can use the questions in Step 9. Write out the density formula and provide this example. You have 100 liters of gas with a mass of 4 grams. So, the density of the gas is  $4/100$  grams per liter.

When you apply pressure to the gas and compress it to 50 liters, the mass stays the same, but the density changes. The new density is  $8/100$  gram per liter. Have students read *What Is Air Pressure?* and answer the questions. Discuss the questions in class. An answer sheet for the questions is located in the Teacher Answer Masters section of the teacher guide.

This is a good spot to take a break.

Hold up the class barometer and remind students that they've used this tool to measure atmospheric pressure. In fact, the prefix *baro-* means pressure, and the suffix *-meter* means measure. Explain that meteorologist's measure air pressure in bars; one bar is equal to the pressure exerted by the air in the atmosphere at sea level. The unit usually used in measuring air pressure is the millibar. One millibar is  $1/1000$  of a bar. The average air pressure at sea level is 1013 millibars.

Continue with the discussion about barometers, using the questions in Step 11. Take the barometer and place it inside the 2-liter plastic jar. If you have one of the larger barometers you may have to distort the mouth of the jar in order to fit it inside. Take the lid and secure it and ask a student to read the barometer and record the pressure on the board.

Ask students what you might do to change the pressure reading on the barometer. They'll probably suggest squeezing the jar. Have a student come up and observe the barometer while you squeeze the jar.

They should observe that the pressure increases. Ask students why they think the pressure changed. They should realize that the molecules inside were squeezed into a smaller space, more collisions happened, and the pressure increased.

Use the *Weather Balloon Launch* multimedia to review what happens to air pressure as the weather balloon changes altitude. Review the *Elevator to Space* multimedia, pointing out the change to the percentage of atmosphere below the elevator in the lower-right corner of the screen as altitude increases.

Give students Response Sheet—Air Pressure and Wind to assess their understanding of atmospheric pressure. A scoring guide for the response sheet is available in the Assessment chapter of the teacher guide.

**<Investigation 8, Part 2>**

Narrator: In this part students use what they have learned about differential heating, energy transfer, convection, density, and atmospheric pressure to create model to show what happens in the atmosphere to create wind. They also learn about the generation of local winds.

Here's what you will need from the kit: For each group of four students, you'll need the Weather and Water Resources books, and four copies of lab notebook pages 48 and 49, Local Winds. For the class you'll need these transparencies: transparency no. 27, Wind-Model Review Questions and transparency no. 28, Wind Concepts. You'll also need the assessment charts for Investigations 7 and 8, and the FOSS Weather and Water CD ROM or access to the internet.

You need to provide the supplies for creating wind models. These include transparent tape or glue, scissors, colored pencils or pens, and for the class, construction paper in multiple colors, tag board or old file folders, cardboard scraps, and staplers. You should also have a globe, notebook paper, an overhead projector, and a multimedia setup.

To get ready for this part, pull together various supplies students can use to create models that demonstrate the atmospheric processes that produce wind. See the Materials list for this part for suggested materials.

You'll want to plan for model storage for a couple of days and be prepared for some models to be very big. To preview the multimedia for this part, from the control room, click on "local wind" under "climate factors". Here you can view the multimedia showing four different types of local winds.

This is only a brief out line of this part. Make sure you read and follow the teacher guide.

Begin this part with a review of convection by having students describe the movement of the air in the convection chamber in Part 3 of Investigation 5. Ask the students to think of where on Earth's surface a convection cell could develop. They may not be able to respond yet, but don't be too concerned.

Ask students to consider what effect rising, warm air has on air pressure at the ground. Let them talk in their groups for a few minutes and then report their ideas. Help them reason, that as air expands and rises, there is less air pushing down on the surface. So, air pressure would decrease. Then help them reason that if warm, rising air causes less pressure on Earth, cooler, sinking air would increase air pressure on Earth.

Ask students, What is wind? What causes wind? Have them answer these questions on a piece of notebook paper as a quick write. The quick writes should be collected and saved for students to use as a self-assessment in Part 3.

Have students share some of their ideas about the causes of wind. Suggest that they refer to their lab notebooks and resources books, taking into consideration what they've learned about differential heating, energy transfer, convection, air pressure and density.

Tell students that you would like each group to make a model that shows what happens in the atmosphere to create wind. Show them the supplies you have available. Each group should be prepared to explain how their model represents the interactions of the parts of the environment that produce wind. Have the getters get the supplies their group requires and have the groups begin constructing their models. Visit groups as they work and offer guidance by asking questions such as these:

- How will you show the direction that air is moving?
- How will you show energy transfer and the direction of the transfer?
- How can you use color to help show wind?

Collect the models and store them until their next class session.

Give the students a little time on the second day to complete their models, and then have the groups set up their models for display. Have groups of student's visit the models in shifts as described in Step 10.

Use transparency no. 27 called Wind-Model Review Questions to suggest what questions students should consider as they review each other's models. After reviewing all of the models, students will comment on which techniques were most effective for representing conditions that produce wind.

Use transparency no 28, Wind Concepts, to review the major processes that interact to produce wind. You may want to have students copy these concepts into their lab notebooks.

This is a possible place for a break.

Tell students that sometimes, local weather conditions influence wind. Use the globe to point out the land and water near Los Angeles. Use the questions in Step 13 to guide student's thinking about what happens when land and water absorb energy and how conduction and reradiation from warm land surfaces change air density and pressure.

Show students the Local Wind animations on the multimedia. Four kinds of local winds are included: valley breezes, mountain breezes, sea breezes, and land breezes. Start with sea breezes, reminding students that winds are named for the locations from which they come. Sea breezes blow from the sea onto the land. Students should notice that a sea breeze starts when the land is warmer than the water and transfers its energy to the air above. The air cools and sinks back down again. Be sure to repeat the animation several times.

As air expands, it produces a low-pressure area. Cool air from over the ocean is at a higher pressure, so it flows toward the low pressure over the land, creating wind. Distribute copies of the lab notebook sheet called Local Winds.

Review the challenge with your students and then give them 3 minutes to draw the sea-breeze simulation they just observed on the multimedia, including labels and arrows.

View the remaining multimedia animations before having students complete the notebook sheet. An answer sheet is available in the Teacher Answer Masters section of the teacher guide. Review what students have learned about local winds, then assign the article called Where the Wild Wind Blows in the Resources book. Have students answer the questions at the end of the article. An answer sheet is available in the Teacher Answer Masters section of the teacher guide.

### **<Investigation 8, Part 3>**

Narrator: In this part students construct a sample anemometer and use it to take wind speed readings at various locations on the school grounds. They then compare their wind speed readings to air pressure and temperature data from those same locations.

Here's what you'll need from the kit for this part. For each group of four students, you'll need 2 index cards, 2 super jumbo straws, 1 jumbo straw, 7 small paper clips, and a thermometer. You'll also need the Weather and Water Resources books, and copies of lab notebook pages 50 and 51, Making an Anemometer.

For the class you'll need the two class barometers and 2 hole punches from the kit. You'll also need the assessment chart for Investigations 7 and 8, and the Wind Quick Writes from Part 2. You'll need to provide metric rulers, scissors, and pencils or ballpoint pens for each group.

For the class, you'll need to provide a map of the school grounds, transparent tape, blank transparencies, and a sheet of chart paper and markers. You'll also need a copy of the local weather report, similar to what you used in Investigation 1 Part 2, and an overhead projector.

Before starting this part, make a transparency of a current weather report just like you did in Part 2 of Investigation 1. Note the time at which the data were posted. Follow the instructions on the lab notebook sheet called Making an Anemometer to construct a sample anemometer. It will take about 15 minutes to create one.

When you make copies of the two lab notebook sheets called Making an Anemometer, if possible, print the sheets front to back to save paper. You could also store these instructions in sheet protector to keep for the next time you teach the Weather and Water course.

Check out the hints in Step 2 of Getting Ready for this part. Here are the materials you'll need to make your sample anemometer. I'll show you how. First, take one of the index cards and fold the edges in right angles. To do this, you'll make a line 1.2 cm in from the side. You can press down firmly with a pencil or pen when you draw the line to help make a crease that will help you fold. Then take your hole punch and punch holes near the top of each side like this. You'll add six paper clips to the bottom of the card. To measure the wind speed, the second card should end up looking like this.

Here's your template for making the card. Students will take an index card; line it up with the lines in the template. They then can move it down just slightly making sure it's still lined up on the sides and make little marks. You can move it up just slightly and make little marks. And then for the marks that go to the side you can move it just slightly that way mark it. Then what they'll do is take a straight edge and they'll make lines like this.

An alternative method that some teachers have come up with is to take a straight edge and extend the lines in the template beyond the edges. This way you can just lay the index card over the template lines and make sure still to line up the sides and using a straight edge draw your lines, again I'll just do a couple for demonstration. Students can also see an origin point for the lines.

When making copies of the Making an Anemometer sheet, make sure your copy machine is set to print at 100% and if you're printing from a PDF that you're also printing from a 100%. This copy was made from a PDF that was reduced and you can see that it just doesn't line up.

Using the fold line you've drawn on the card, bend the edge up at a right angle. Punch a hole 2½ cm from one end of each of the jumbo straws. Cut a jumbo straw to a length of 12 cm and slide it through the holes you've made in the super jumbo straws. Tape the super jumbo straws at the top and bottom. Take the index card with the lines drawn and slide it between the two super jumbo straws. Push it up to the jumbo straw as far as it will go and then tape the edge down.

Take the first index card and insert the jumbo straw through it like this and attach a paper clip to the end of the straw to keep the card in place.

When held in the wind this card will raise up and students will be able to read the wind speed and kilometers per hour. I'll give it a little test here. Pretty good. If you haven't already, calibrate the two barometers in the kit using the instructions provided with the versions you received. They should read the same pressure.

Locate a map of the school buildings and grounds. A fire-drill evacuation map might work. Make a copy of the map for each group and a transparency to use with your class. You can also enlarge the map on chart paper.

Students will go outdoors to gather weather data on the school grounds. You might want to have them read the story in the Resources book called Laura's Big Day after returning from the second measurement session, or as homework. Make sure students have read the story before doing the self-assessment at the end of this part.

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

Begin this part by reviewing the local weather report for your city, pointing out the various weather elements, particularly wind speed and direction. Tell students that winds are named for the direction from which they come, not the direction they are going. For example, a north wind is blowing from the north to the south.

Describe the various weather tools used to gather information about wind including:

- Weather-balloon flight paths to track wind speed and direction.
- Rotating-cup and swinging-ball anemometers to measure wind speed.
- Wind vanes to show from which direction the wind is blowing.
- Wind socks to measure wind direction and speed and
- Flags indicate wind direction and to some degree, wind speed.

Show students the sample anemometer you made earlier and introduce the term anemometer. Explain that each group will make one. Tell students when there's no wind, the card hangs straight down, but when they hold it directly in the wind and wind hits the surface, the card rises up. The greater the wind, the greater the angle. You'll want to blow on the card to demonstrate this for students.

Students use the directions on lab notebook sheet Making an Anemometer to help them construct their own anemometers. Place your sample anemometer where students can study its construction as needed. Offer these suggestions as students work:

- Make sure you have two super jumbo straws (the larger ones) and one jumbo straw.
- Use a ruler as a straight edge and pencil or ballpoint pen to score the fold lines on the two index cards. Go over the fold several times.
- Align and position the hole punch carefully to center the holes in the super jumbo straws.

Once students have completed the construction of their anemometers tell them you'd like them to make a school weather map. Each group will measure three weather factors: temperature, pressure, and wind speed.

Refer to the teacher guide for the mapping guidelines. Students will repeat their measurements and mapping for two more days. Pass out copies of the school map. Ask each group to select an area to gather their weather information, such as the playing field, front of the school, outdoor eating area, and so on. Students will take measurements at three different locations within that area.

Have students get out a blank sheet of paper and sketch in as much detail as possible for the area where they plan to make their measurements. Their maps might look like this one. Students should label the three places where they'll make their observations.

Remind students that they need to take accurate measurements. For example, their hands shouldn't touch the thermometer bulb nor should they let sunshine fall directly on it. If the winds are not steady, students should record the highest gusts and their best determination of the average sustained wind speed. Have students gather their materials and begin their observations.

Have students gather weather-data for 2 more days. Consider reading the story called Laura's Big Day in the Resources book after students have finished collecting weather data on day 2.

Either immediately after acquiring data each day or after collecting data on day 3, ask students to find the average temperature, wind speed, and pressure for their area for each day. They will end up with three average temperatures, three average wind speeds, and three average pressures. Have them transcribe their averages onto the class map.

When all of the data has been added to the class map, ask students to study the map and look for patterns and relationships in the readings. Ask them to look for changes day to day and from place to place. Use the questions in Step 13 to guide their study of the map. Once they have analyzed the map, have students read Laura's Big Day in the Resources book if they haven't done so yet.

Then, return the quick writes from part 2 and have students review their original explanations for wind and revise and improve their earlier work, based on their new understandings. An answer sheet is located in the Assessment Chapter of the teacher guide.

### **<Investigation 8, Part 4>**

Narrator: In this part students are introduced to pressure maps and isobars as a means for representing air pressure over a large region. They locate high- and low-pressure areas on maps and predict where winds will blow and in what direction.

Here's what you'll need from the kit for this part. You'll need the Weather and Water Resources books, and copies of Mid-summative Exam 8 for each group of 4 students. For the class, you'll need transparency number 29, Pressure Map of the U.S., and the assessment chart for Investigations 7 and 8. You'll need to provide an overhead projector.

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

Distribute copies of the lab notebook sheet called Pressure Map of the U.S., point out the lines and numbers, and explain that a weather map is a tool used by meteorologists. The information on the map comes from data collected by weather balloons, satellites, and other weather-data sources. Air pressure is one of the elements included on the map.

Use transparency no. 29, Pressure Map of the U.S., to orient students to the information on the map and to cover the points in Step 2. Have students locate the lowest pressure and highest pressure on the map.

Then ask them to decide which direction the wind is blowing, from Billings, MT to Kansas City, MO, or from Kansas City to Billings. They should note the high-pressure area over Kansas and the low-pressure area north of Billings. The wind is probably blowing toward Billings from Kansas City. Ask students to determine which direction the wind is blowing between Kansas City and Buffalo, NY. They should decide that the wind is blowing from Kansas City to Buffalo as the pressure is lower in Buffalo. Point out that isobars represent different pressures. Use the questions in Step 4 to guide the discussion.

Conclude this study of pressure maps by telling students that air flows from areas of high pressure towards areas of low pressure in order to balance the differing pressures. This air movement is called wind. When you think students are ready, have them take Mid-summative Exam 8.

### **<Investigation 9, Introduction>**

Narrator: In this investigation students learn the distinction between weather and climate, become familiar with air masses and fronts, and are introduced to the concept of global warming.

Look over the At a Glance chart paying close attention to the objectives, assessment opportunities, preparation, outline for conducting the investigation, and when to use the student resources book and multimedia.

Be sure to read through the Scientific and Historical background pages for information about air masses and fronts, the difference between weather and climate, and how Earth's climate has changed over time and may continue to change in the future.

The Why Do I Have to Learn This? section focuses on the understanding students need to have of Earth's changing climate and how it affects and will continue affect their lives.

**<Investigation 9, Part 1>**

Narrator: In this part students are introduced to the concept of air masses and how they form. They will observe a solar hot-air balloon and use it as a model for a warm air mass.

Here's what you will need from the kit for this part. For each group of four students, you'll need the Weather and Water Resources books, and lab notebook sheet page 55, Solar-Balloon Observations. For the class you'll need the solar hot-air balloon, fishing line, and 2 thermometers, the Weather and Water CD ROM or access to the internet, transparency number 30, North American Air Masses, and the assessment chart for Investigation 9.

You need to provide a globe, a clipboard, transparent tape, notebook paper, and an overhead projector. You may also want to provide inexpensive black trash bags, glue sticks, and scissors, if you want to students to construct their own solar balloons. You'll need to provide a multimedia setup if you want students to access the multimedia through the CD ROM or online.

Choose a sunny day with very little wind for the solar-balloon demonstration. It doesn't have to be hot, but you do need sunlight falling on the bag for the demonstration to work. It may be more difficult in the early morning hours for observing results.

Take some time practice with your balloon. Instructions are included with the balloon and are also reprinted in Step 2 of the Getting Ready for this part.

A solar balloon video is included in the Video Resources section of the Control Room. You can show the video to your students, as a whole class or in small groups. Or make it available to students who were absent the day you demonstrated the solar hot-air balloon in class. The video you see here shows a much longer solar balloon in action, but your 9-foot version should function in the same way.

You may want to have students make their own homemade solar balloons. They can try flying inexpensive, black trash bags, which they can cut and stick together with or use as is. You can provide the materials or encourage students to try this home. They might even conduct a controlled experiment to find out if other colors of bags might work.

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

Ask Where does Earth's weather happen? and review the characteristics of the troposphere. Introduce the term stagnant air as a large mass of air that stays over an area of Earth's surface for a long time and doesn't move. Explain that these areas where stagnant air forms are called source regions. The air above a source region depends on the type of surface found there. Most source regions have uniform surfaces with few mountains.

Bring out the globe and point to the Gulf of Mexico. Ask students what kind of changes might happen to stagnant air over the Gulf. Guide them to the idea that the air would become warm and humid because the Gulf is warm and made of water.

Introduce the term air mass as the name meteorologists use for these large bodies of stagnant air. Tell students that air masses are large, thick bodies of air that are uniform in temperature and humidity. Air masses can be hundreds or thousands of kilometers across and reach to the top of the troposphere, 10–13 kilometers above Earth's surface.

Explain that meteorologists name air masses for their source regions. For example, an air mass forming over the Gulf of Mexico is called a maritime tropical air mass because it forms over tropical waters. Maritime means anything to do with oceans or seas.

Have students turn to the page in their Resources books called North American Air Masses. Use transparency no. 30 called North American Air Masses to guide students in finding Location B in northern Canada. Ask them what characteristics an air mass forming in this area would have. They should suggest that it would be colder and maybe drier than the other masses on the page since it is positioned over colder land.

Explain that a cool, dry air mass is a continental polar air mass—continental because it is forming over land and polar because it is in the cold, polar latitudes. Go over the codes that meteorologists use to take notes about air masses. Point out the codes at the bottom of the North American Air Masses page in their resources books: lowercase c = continental, lowercase m = maritime, capital P = polar, capital T = tropical.

Tell students that the kind of surface over which the air mass forms, either continental or maritime, is written first in a lowercase letter, followed by the tropical or polar code in a capital letter. So the notation for a continental polar air mass would be cP.

Have students work in their groups to determine the code for each of the air masses on the North American Air Masses page in the Resources book. They can write their answers on a blank sheet of paper. Discuss their answers after a few minutes. Ask students to consider why air masses rarely, if ever, form over the United States below Canada. Help them to consider the characteristics of the land surface and the effect of global winds in the lower 48 and decide that most of the land is not uniform and that the air doesn't stay still long enough to become stagnant.

Ask students when and where they think the coldest and warmest air masses form. They'll probably suggest that the coldest air masses form in the northern latitudes during winter and warmest air masses form in the tropics during summer.

Students the large black plastic bag, but don't call it a solar balloon yet. Explain that they'll use this to help figure out how an air mass forms. As a couple of students to inspect the bag: they'll notice that it's thin, 3 meters long, and black. Explain that the bag is fragile and should be handled carefully.

Tell them they're going to be taking the bag outside. Help them figure out because of the bag's color, it will absorb solar energy. The air inside will heat up. Ask them what other tools they might want for this investigation.

Distribute copies of the lab notebook sheet called Solar-Balloon Observations and have them respond to the first item. Then head outside with the solar balloon, some fishing line, two thermometers, a clipboard and any other materials suggested by students such as a hygrometer or barometer. Have one student measure the air temperature before the balloon experiment starts. Remind them that the thermometer bulb should not be in direct sunshine. Have this student monitor the temperature every 3 minutes as the demonstration progresses, recording it on the clipboard.

Follow Steps 11 through 15 in the teacher guide to continue this demonstration. During the demonstration note students' comments about their solar balloon observations and the relationship to the formation of air masses. Have students complete items 2 through 4 on the Solar-Balloon Observations sheet and discuss their responses. An answer sheet is available in the Teacher Answer Masters section. Summarize how the black-bag demonstration provided a useful model for air-mass formation and how it is limited. Make sure students include the points found in Step 15.

### **<Investigation 9, Part 2>**

Narrator: In this part students review air masses and consider what happens when two air masses meet, creating a front. They view an air mass model, study weather that occurs when warm and cold fronts pass over, and study the types of severe weather that occur over the United States.

Here's what you will need from the kit for this part. For each group of four students, you will need the Weather and Water Resources books, and lab notebook pages 57, Reading Weather Maps, and 59, Response Sheet—Weather and Climate.

For the class you'll need the Weather and Water CD ROM or access to the internet, transparency no. 31, Fronts, no. 32, Sample Weather-Map Symbol, no. 33, Surface Observations, and no. 34, Weather-Satellite Image. You'll also need the assessment chart for Investigation 9, and one of the density bottles from Investigation 5, Part 1. You'll need to provide an overhead projector and a multimedia setup.

To get ready for this part, consider whether you want students to do more research on types of severe weather, either individually or in groups. They could prepare a written report or an oral presentation. Take some time to preview the Weather and Landforms map in the Climate Factors menu of the Control Room. You can set the multimedia up for viewing as a class or in small groups at several computers. There are optional readings included in the Resources book, one called Mr. Tornado and the other called Severe Weather. Decide whether you want to read these articles in class or assign them as homework.

You should also preview the four transparencies used in this part. You will use them to illustrate the weather that occurs with passing fronts and to introduce conventions used in the preparation and interpretation of weather maps.

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

Begin this part by reviewing what students learned about air masses in Part 1. Tell students that air masses don't stay in one place forever. After awhile, differences in air pressure between two locations move air masses from high-pressure areas to lower pressure areas. In North America, cold air masses from the north move south and east across the U.S. Warm air masses usually originate in the tropics and move north and east.

Show students one of the density bottles from Investigation 5. Tell them you're going to model air masses when they collide. As you move the bottle, ask students what's happening. The layers don't mix. The denser liquid stays below the less-dense liquid.

Ask students what might happen if they were able to put a continental polar air mass and a tropical air mass inside a bottle. Give students a few minutes to discuss their ideas with their groups and then share their ideas with the class. They should suggest that the polar air mass would sink to the bottom of the bottle, and the tropical air mass would be warmer and less dense than the polar air mass, so it would float on top. The big difference between the two air masses is their density.

Remind students that the bottle is a model for air masses coming in contact. Draw their attention to the boundary. The boundary between the two liquids is like the boundary between two air masses, very little mixing occurs.

Introduce the term front as the boundary between two air masses. Tell students that both warm and cold air masses move generally eastward across the U.S. Some air masses move faster than others, so they can collide when one overtakes another. The collisions create a front where the two air masses come in contact.

Use the questions in Step 7 to help guide the discussion. Transparency no. 31 called Fronts will help illustrate the boundaries between air masses.

Have students turn to the page in their Resources books called Fronts to follow the discussion. Use the mini-lecture and questions in Steps 8 and 9 to guide the discussion. Have students turn to the Observing Clouds article in their Resources book to review the types of clouds and consider why they might appear where they do in a warm front.

Students should know the types of weather that occur with cold and warm fronts are due to differences in temperature, humidity, and pressure between the two air masses. They can read more about the types of weather associated with fronts on the page called Weather and Fronts in the resources books.

Tell students that meteorologists receive weather observations from stations all over the United States and to world to help them make weather forecasts. The observations are called surface observations. Surface observations include readings for temperature, humidity, air pressure, wind speed and direction, cloud cover and types, and precipitation type and amounts. Computers help plot the information maps, which meteorologists analyze for their forecasts.

Have students turn to the page Sample Weather-Map Symbol page in their resources books. Use transparency no. 32 called Sample Weather-Map Symbol to point out parts of a weather symbol.

Explain that meteorologists use a special code or symbol to represent weather data on a map. This is what one of the symbols look like. Each part of the symbol includes information about a particular weather observation.

Use the information in the teacher guide to review the parts of the symbol and what they mean. Ask students to turn to the page called Surface Observations in their resources books. Use transparency no. 33 called Surface Observations to orient students to the map. Distribute copies of the lab notebook sheet called Reading Weather Maps and work through the first item together, filling in the data for San Francisco.

Then have students use the weather map and the Sample Weather-Map Symbol page to complete the sheet. An answer sheet is available in the Teacher Answer Masters section of the teacher guide. Tell students that a front “officially” pass through an area when the boundary passes by at ground level. Ask them which type of front might bring the more rapid changes in weather.

They should suggest that cold fronts usually bring more rapid changes in weather, while warm fronts bring more gradual changes. Have students turn to the GOES-8 Weather Satellite Image in the Resources book.

Project transparency no. 34 which includes the same image. Explain that there are two satellites that orbit above the U.S., recording images of the atmosphere below. Tell students to compare the satellite image with the weather map for October. Ask them to try to match the recorded weather on the map to what they observe on the satellite image.

This is a good spot to take a break.

Remind students that thunderstorms and heavy rains can happen when a cold front passes and that these are examples of severe weather. Review other types of severe weather and what students know about them.

Show students the Weather and Landforms map in the Climate Factors area of the Control Room. Let them explore the distribution of the various types of severe weather in the U.S. They can click on: Tornadoes, Tornado Alley, Thunderstorms, Lightning, Lake Effect Snow, Heavy Snowfall, Hail and Hail Days, and Hurricanes. Ask them to look for regions of the country where severe weather is common and areas that seem to experience little, if any, severe weather. They can also change the month to see the data displayed for different months. If they click the US Topography box they can see the topography for the United States.

This is a good time to assign the readings, Mr. Tornado and Severe Weather, for students to read in class or as homework. When students have completed all of the activities in this part, have them complete the Response Sheet—Weather and Climate. Collect the response sheets.

The response sheet will let you take a closer look at student understanding of the interactions between air masses and the creation of fronts. Students will use this sheet for self-assessment in Part 3. Read through students’ response and make notes about common understandings and misconceptions that might guide your teaching.

**<Investigation 9, Part 3>**

Narrator: In this part students consider how the water cycle is related to weather. They view and discuss a video and define weather and climate. They use the multimedia database to compare different climate regions around the world.

Here's what you will need from the kit for this part. For each group of four students, you will need the Weather and Water Resources books. For the class you'll need the Wonders of Weather video, (note that the Wonders of Weather video is also available in DVD format. Contact Delta Education for more information) you'll need to provide a way to view the video, transparency 23, Earth: the Water Planet, the Weather and Water CD-ROM or access to the internet, and the assessment chart for Investigation 9.

You'll need Lab notebook sheet 43, Water Cycle Game, (that students worked with in Investigation 7), and lab notebook sheet 59, Response Sheet—Weather and Climate from Part 2 of this investigation, and the water-cycle posters that students made in Investigation 7.

You need to provide blank paper and pencils for each group, an overhead projector, and a multimedia setup.

To get ready for this part, locate the water-cycle posters students made at the end of Investigation 7. They'll be used to start this investigation also make sure that you have Response Sheet page 59, Weather and Climate, and lab notebook page 43, Water-Cycle Game ready to return to the students. Preview part 1 of the Wonders of Weather video. This segment is 13 minutes long.

You'll also want to preview the Climate Regions section in the Climate Factors menu. You may want to assign groups of students to the different regions to prepare a group presentation. Consider how you'll set up multimedia for class viewing or for use by small groups.

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

Begin this part by distributing the water-cycle posters from Investigation 7 to each group. Have them turn in their lab notebooks to the sheet called Water-Cycle Game, or return this sheet to the students if you collected it. Students should have the first two columns completed. Have students refer to their posters and Lab notebook sheets as you ask them to consider, where can we find water on this planet?

Project transparency no. 23 called Earth: The Water Planet. Review the graph showing where water is on Earth and refer to the reading in the resources book called Earth: The Water Planet. Remind students that every place on Earth's surface has weather. Everything they've learned in previous investigations contributes something to weather. Tell them that they are going to see another part of the Wonders of Weather video. They have a pencil and paper ready to take notes and record three things they already know about weather from their investigations and three things they didn't know or are confused about. Show the video. Note that the Wonders of Weather video is also available in DVD format. Contact Delta Education for more information. Ask students to share their ideas and questions.

Continue the discussion with the questions in Step 2 and Step 3. These questions provide a review of the major concepts students should have learned in the previous investigations. Ask the students what

they think the difference is between weather and climate. Have students discuss their definitions in their groups for 5 to 10 minutes and then report back to the class. Their definitions should be something like this:

- Weather is the condition of the atmosphere over a short period of time and can change hour by hour and day by day.
- Climate is the average weather condition over a long time.

Introduce the Climate Regions database in the Climate Factors section of the control room. Show the whole class how the database works and then assign each group to a different region. On the map they can see where their climate region is located. Clicking on a highlighted area takes them to an introduction. They can click on abiotic data to read about the weather and climate factors in their area. They should also check to see what severe weather might impact their climate region. There's also information on biotic data, and issues for an area. They can return to the map by clicking on Climate Map. Give students about 15 minutes to do a quick survey.

Ask students if they've heard of global warming. Spend some time discussing student ideas, questions, and concerns about global warming. Have them record their questions in their lab notebooks for future reference.

Return the response sheets to the students and have them review their original statements and make corrections and additions to demonstrate their understanding of the concepts. You can find a scoring guide in the Assessment Chapter of the teacher guide.

#### **<Investigation 9, Part 4>**

Narrator: In this part students play the Water-Cycle Game with the global-warming variation. They analyze the results and make predictions about how global warming might affect Earth's climate.

Here's what you will need for this part. From the kit, you will need two dice for each group, the Weather and Water Resources books, and copies of the Final Summative Exam for the course.

For the class you'll need transparency no. 24 called Water-Cycle Game Tally, which you began using in Investigation 7, the 9 Water-Location Posters - Global Warming, the Weather and Water CD ROM or access to the internet, and the assessment chart for Investigation 9.

For the class, you need to provide chart paper, marking pens, an overhead projector and overhead transparency marker, and a multimedia setup. Students will need their lab notebook page 43, Water-Cycle Game used in the last part.

Make copies of the 9 Water-Cycle Game Posters for the Global Warming version of the game. You can keep the posters in sheet protectors or laminate them for future use. Take a moment to review the Water-Cycle Game Rules: Global-Warming Version in the resources book. Notice the differences between the regular rules and the global-warming rules. There are three variations of the game you can use.

- Version 1: Students can stay in their seats and use the Water-Cycle Game Rules, Global-Warming Version. Each group decides where they want to start, roll two dice, and follow the instructions on the page, keeping track of the locations they travel to on the Water-cycle Game sheet.
- Version 2: You can use the Water-Location Posters, Global-Warming Version and play the game as you did in Investigation 7. Students will need two dice per group for this version. Plan where you want to hang the posters for easy access by the students.
- Version 3: You can use the multimedia version, either as a class or in small groups in the computer lab.

Preview the Global Warming version of the Water Cycle simulation and plan a short demonstration for students. Notice that all the parts of this version are the same as the regular version, except for the area around the fish spinner.

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

Begin this part with a review of global warming. It's important that students realize that it doesn't take much change in temperature to cause big changes in the environment. Ask, what effects do you think global warming could have on Earth? Let the students brainstorm ideas and record their responses on the board or chart paper.

Tell students that one effect of global warming may be how Earth's water is distributed. Tell them that you have a variation of the Water-Cycle Game that takes into account a global temperature increase of 2 to 5°C.

Review the version of the game you want to students to play. If they are using the Resource book version or the poster version, explain that they need 2 dice this time. Have them refer to the global-warming rules in the resources book.

Explain that they should record what happens on the Water-Cycle Game sheet in their lab notebooks. They should record the locations they visit in column 3. Have students start the game. Cruise the groups to make sure they are using the global-warming rules.

When students have completed this round, have them report their results. Record the class results on transparency no. 24, Water-Cycle Game Tally, recording the numbers in column 3. Have students compare the results of Round 3 to the results of rounds 1 and 2. If the sample is large enough, students should notice that the water molecules spent more time in the atmosphere or in a liquid environment, rather than as ice in a glacier.

Ask students to predict what would happen if they could have 25 rolls of the dice or spins of the fish. If there is time, let them play until they reach 25 rolls or spins. Discuss how having more data affects the results.

Ask students to again consider how the Water-Cycle Game is like the real water cycle and how it is different. They may notice that not all the places that water may appear show up in the game, or that there are some ways that water can move from one location to another that aren't included, like animals eating plants and gaining water from the plants. End the discussion with this question: How can global

warming affect the water cycle and the movement of water about Earth? Have students read the article, *Is Earth Getting Warmer?* in the *Weather and Water* resources book either in class or as homework.

Before concluding Investigation 9, take a look at the Extension activities at the end of the investigation in the teacher guide. You might want to have students get involved with these extensions, such as reviewing the weather-satellite data on the *Weather and Water* multimedia or checking out the local water supply.

Plan to give the Final Summative Exam when you have finished this investigation and feel that students have a good understanding of the concepts in it. Students will need 30–40 minutes to complete the exam. You can find a scoring guide in the Assessment Chapter of the teacher guide.