The kit is designed for typical classroom settings and does not usually require a laboratory. Although it is convenient to have an available source of running water and a sink, you can substitute several containers of water and a few liquid-waste buckets or plastic bins. More information about the kit appears in the Lab Materials and Safety section.

THE STUDENT BOOK

The Student Book guides students in their investigations and contains related readings. If you have only one classroom set of books, you might photocopy some of the readings for homework assignments. As long as you have a classroom set of books, you have SEPUP's permission to photocopy some of the readings so that students can work on them at home. This permission applies only to copies made for students in your classes. Students are unlikely to need other sections of the book outside of class.

ACTIVITIES

The activities in each unit of Issues and Science address students' learning styles through the use of a variety of approaches. Activity types include Laboratory, Investigation, Field Study, Design, Modeling, Reading, Role Play, Talking It Over, View and Reflect, Computer Simulation, Project, and Problem Solving. Three of these— Reading, Role Play, and Talking It Over—are text- dependent activities presented in very different ways.

Laboratory activities usually involve experiments and traditional science equipment. Investigations are hands-on activities that often simulate real-world experiments but substitute specialized or nontraditional materials. Modeling activities explore scientific concepts through simulated or physical models. Readings present scientific information in a format appropriate for individual work or homework, while text-based Talking It Over activities are geared to classroom discussion and employ strategies that facilitate discussion. Field Study activities engage students in experiments outside the classroom. Design activities involve students utilizing an engineering design approach. As the name suggests, Computer Simulation activities utilize a computer.

Project activities are less common. Projects require student research and may extend over several days or weeks.

STUDENT BOOK FORMAT

Every activity begins with an **Introduction** that sets the stage for the activity, often relating it to previous activities. In some cases, this section helps to explain a new concept or term. The Teaching Steps in the Teacher Edition will usually provide recommendations for how to use the introduction.

A **Guiding Question** helps students focus on the purpose of the activity.

The list of **Materials** shows how materials are to be distributed to groups of four, pairs, and individual students.

Safety information appears in highlighted text boxes in the Student Book.

The **Procedure**, the central part of the SEPUP design for guided inquiry, provides step-by-step activity directions. These directions, often supplemented by illustrations, will support the majority of students in performing activities with minimal assistance from the teacher. This gives the teacher the opportunity to observe and listen to what groups are doing and be available for individualized assistance. In addition, the clear and complete Procedure steps serve as a model for students to design and conduct variations of the investigations. As a unit progresses, activities become more open-ended and contain less specific directions. Activities may be made more (or less) open-ended at any time by modifying the instructions and the amount of teacher intervention.

Analysis items probe students' understanding of the content of an activity. In some cases, an Analysis item calls for interaction among students to help deepen their understanding. For this reason, not all items require a written response, and not all items need to be answered individually. Depending on the class, Analysis items may be best answered by an individual student, a pair of students, a group of four students, or the full class. Decide in advance how you will use the items to guide students' learning, but be prepared to alter your plan if students' responses suggest a different path. You may choose to skip certain items or to use them as quick checks of students' progress (as a short quiz or an exercise to open the next class period). For a detailed explanation of the use of quick checks, see Teacher Resources III, "Assessment."

7 *Another Kind Of Wave*
INVESTIGATION

SOUND IS ONE of many kinds of waves. Other common waves include those on the surface of water, light waves, radio waves, and seismic waves. Digital sound transmission, as described in the last activity, involves more than one kind of wave. For example, a sound wave could be transformed into a microwave for transmission. When it arrives at its destination, the digital information encoded on the microwave is reconstructed back into the sound wave.

All waves share some of the same characteristics, but they also differ in certain ways. A good example of this becomes apparent when comparing sound and light. As with all waves, sound and light both carry energy. Like sound, light is an integral part of our everyday life. However, there are important differences. One difference is that light travels over 800,000 times faster in air than does sound. Another difference is that light is not a longitudinal wave like sound but, instead, behaves as a transverse wave. A **transverse** wave consists of vibrations that are perpendicular to the direction that the energy travels. A transverse wave may travel through a medium, such as secondary waves (s-waves) in an earthquake, or without a medium, such as light through a vacuum. This means that a transverse wave does not have compressions and rarefactions like sound. In this activity, you will model the characteristics of transverse waves using a long metal spring.

Direction of particle motion

Direction of wave transmission
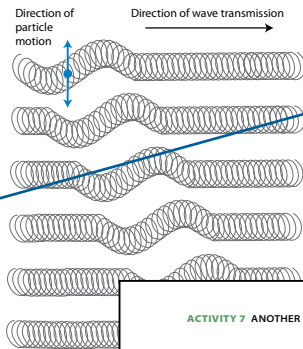
GUIDING QUESTION

What are the characteristics of a transverse wave?

Transverse wave

The introduction presents information students will need for the activity. It often includes vocabulary words that will help them understand what they are learning and help them participate in scientific discussions. Make sure they read it thoroughly before they begin the activity.

Each activity in *Issues and Science* asks a Guiding Question, which students should be able to answer by the time they complete the activity.

ACTIVITY 7 ANOTHER KIND OF WAVE

MATERIALS

For each group of four students
    1 long metal spring
For each student
    1 pair of safety goggles
   1 sheet of graph paper

SAFETY

Handle the springs with care and never let go suddenly when the spring is under tension. If released when tension is being applied, the spring can move rapidly and unpredictably and could scratch someone. Wear safety goggles to protect your eyes from such an event.

PROCEDURE

Part A: Wave Pulses

1. Put the spring on the floor or a long table, holding the ends about 2 m apart.

2. Near one end of the spring, pull a coil away from its resting position toward one side of the spring, as shown below. When everyone is ready, release the coil to make a wave pulse.

Resting position
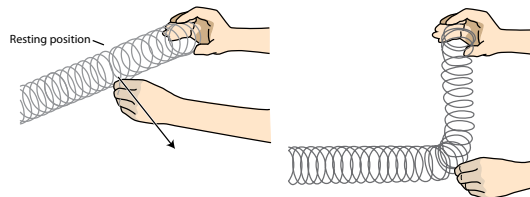
3. All group members should observe the pulse as it travels down the spring.

4. Record the group's observations in your science notebook.

5. Create additional pulses by pulling and releasing more coils. Each time, observe and record what happens as the pulse travels down the spring.

A list of materials shows what students will need for the activity. Note that they will share many items with a partner or group.

Students should always read carefully and closely follow safety guidelines!

Successfully completing the activity requires reading and accurately following the entire Procedure.

and create maps showing regions at risk of earthquakes. All of these examples illustrate ways in which people have invented devices that use wave energy to measure things we would not ordinarily see or hear.
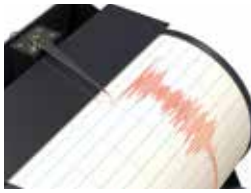
STOP TO THINK 5

What is another example of a device that uses sound waves?

Seismograph

ANALYSIS

1. If you started the motor of a boat in the middle of a lake, who would detect the sound of the motor first: a friend sitting on the shore of the lake or a friend snorkeling just below the surface of the water at the same distance from the boat? Explain your answer.

2. Lightning and thunder occur at the same time, yet we see the flash of lightning before we hear the clap of thunder. What does this indicate about the speed of light compared with the speed of sound?

3. Whales communicate with other whales by making low-frequency sounds. They navigate by making high-frequency sounds that echo back to them. Military sonar systems on ships produce sounds as loud as 200 dB, and these sounds travel great distances across oceans. Describe how such systems might affect whales.

4. Look at the following graphs that show the relationship between the amplitude and energy for a wave. Which one was supported by the patterns you observed in the reading?
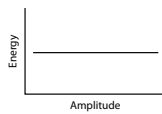
Graph A
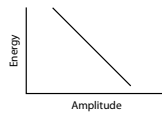
Graph B
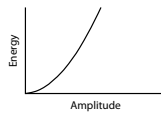
Graph C

Analysis items follow each activity. Answering these items allows students to check their understanding, put together what they have learned in an activity, and explain how it connects to other activities in the unit. Students cannot just look up the answers — many are based on their own investigations. Make sure they show what they have learned!

5. If you want to increase the amount of energy a wave transfers over time, will it be most effective to double the frequency or double the amplitude? Explain using the graphs in the Reading and provide an example.

6. A student stands 100 m in front of a large smooth wall and claps loudly. Another student figures out the time for the sound to travel to the wall and back. If the sound takes 0.58 s for the sound to leave and return, what is the speed of the sound?

EXTENSION

Find through research an example of a technology not found in the Reading that uses sound to extend the way we measure, explore, model, and compute during scientific investigation. Explain how the technology uses sound.

In many activities, you will see opportunities for Extensions. An Extension placed immediately after the Procedure generally provides a way in which the activity itself can be expanded or revised. An Extension placed after the Analysis section suggests ways in which students can explore a topic further.

At the back of the Student Book there is an Appendix containing resources for students. Some of these resources can also be found in Teacher Resource II, "Diverse Learners". The resources include:

- Appendix A: Science and Engineering
- Appendix B: Science Safety
- Appendix C: Science Skills
    - Reading a Graduated Cylinder
    - Using a Dropper Bottle
    - Bar Graphing Checklist
    - Scatterplot and Line Graphing Checklist
    - Interpreting Graphs
    - Elements of Good Experimental Design
    - Using Microscopes
- Appendix D: The International System of Units
- Appendix E: Literacy Strategies
    - Oral Presentations
    - Reading Scientific Procedures
    - Keeping a Science Notebook
    - Writing a Formal Investigation Report
    - Instructions for Constructing a Concept Map
    - Developing Communication Skills
- Appendix F: Media Literacy
    - Evaluating Media Messages
    - Evaluating Internet Sources
- Appendix G: Crosscutting Concepts

LITERACY STRATEGIES AND ASSESSMENTS

SEPUP's integrated literacy strategies help students process new science content, develop their analytical skills, connect related concepts, become more proficient readers, and express their knowledge orally and in writing. The built-in assessment system helps you identify each student's strengths and weaknesses from the beginning of the course. This allows you to adjust activities when needed so that all students get the best chance to build their knowledge and appreciation of science, as well as to improve their reading and communication skills. In-depth explanations of these strategies appear in Teacher Resources II, "Diverse Learners" and Teacher Resources III, "Assessment."

VOCABULARY DEVELOPMENT

The vocabulary introduced in *Issues and Science* is essential to students' ability to describe their experiences. In many science classes, a textbook lesson or laboratory begins with the teacher introducing new terms in a list on the board. The number of new words is often overwhelming. Students soon learn that memorizing these words and their definitions helps them to succeed on the "end-of-chapter test," but they soon forget the words—until they need to memorize the words again for another exam.

Issues and Science instead introduces new words operationally. Students learn about a word in context. Terms are developed in relation to the activities students perform, and soon students are expected to use the words themselves. As a result, new vocabulary enhances their ability to communicate effectively about science, and students master definitions through their observations and discussions of phenomena.

The vocabulary load of *Issues and Science* is deliberately lower than in many science programs to ensure that students learn the most important terms well and use them in as many situations as possible. Formal definitions and descriptions are not necessarily included when a term first appears in the student text. However, key terms are bolded when they are defined. The index at the back of the Student Book contains page references for all key vocabulary and shows in bold type the number of the page on which a word is formally introduced and defined. In this way, students are encouraged to review the term in the context that prompted its use. The Key Vocabulary section of the Teacher Edition provides a list of important terminology that students are expected to learn or become familiar with as the unit progresses. Teachers are not encouraged to assess students directly on the spelling or definitions of vocabulary words but, rather, on how they use them. For each activity, the Teaching Steps section of the Teacher Edition contains ideas on how to introduce specific terms.

THE TEACHER EDITION

The Teacher Edition takes you through each activity in the Student Book and helps you see the development of concepts within the big picture of the units and the course you are teaching. It helps you set up the equipment from the kit, organize the classroom, conduct activities, and manage practical details, all of which enhance students' learning environment. The online Teacher Portal can be used to access the Student Book, Teacher Edition, and Teacher Resources, including Student Sheets, Visual Aids, and ancillary materials, such as LABsent files and PowerPoint slides.

The Teacher Edition text for each activity is divided into several sections:

The **Activity Overview** includes information on the estimated number of 40- to 50-minute class periods required to complete the activity. Depending on the needs and interests of your school and your students, you may choose to extend some activities while omitting others.

The **NGSS Connections** section describes the activity in the context of the *Next Generation Science Standards* (NGSS) while the **NGSS Correlation** section lists the performance expectations, disciplinary core ideas, science and engineering practices, crosscutting concepts, and Common Core standards associated with the activity. The concepts and practices are not intended to be mastered in a single activity; they are developed (and listed) in multiple activities as appropriate knowledge and skills build towards the activity that incorporates the assessment of the performance expectation.

The **What Students Do** section describes what goes on in the activity. A list of **Materials** for the activity matches the format of the Student Book list, with headings indicating how the materials should be distributed. Items marked with an asterisk are not supplied in the equipment kit. Any **Advanced Preparation** (planning and/or organization or purchase of materials) that is required is described immediately below the list of materials. The Teacher Edition also lists optional SEPUP scoring guides and Student Sheets for you to distribute to students at your discretion. These are not listed in the Materials list in the Student Book.

The location of Student Sheet masters for Science Skills Sheets, Literacy Student Sheets, and Scoring Guides in the Teacher Resources is noted.

Detailed **safety** notes are provided following the materials list. They also appear throughout the Teacher Edition with each activity as needed.

A **Teaching Summary** divides a step-by-step outline of the activity into three parts: Get Started, Do the Activity, and Build Understanding. These sections correspond to the teacher's role in conducting the activity (see Teaching Suggestions).

For many activities you will find **Background Information** (at the end of the activity) and **References**. This information is not intended for students; it provides a conceptual framework and preparation for questions that may arise in class. References are some of the print, video, and Internet sources of information discussed in the activity and the Background Information.

The **Teaching Steps** section elaborates on the Teaching Summary with more specific suggestions on how to accomplish the goals of the activity. Suggestions include possible discussion prompts and students' responses to questions. In

addition, you will find descriptions of embedded assessment opportunities. You may choose to follow the suggestions as they are written (especially the first time you teach this course) or modify them to fit your own instructional approach and student population. If an activity includes an **Extension**, pertinent information will be provided in this section of the Teacher Edition.

Sample Responses to Analysis Items section appears at the end of the Teaching Steps section. For questions recommended for embedded assessment, sample exemplar responses are provided. For a detailed description of the embedded assessment system refer to Teacher Resources III, "Assessment".

The **Revisit the Guiding Question** section provides information and suggestions on how to bring the class back to the original focus of the lesson—the Guiding Question.

The blackline masters for Visual Aids and Student Sheets are accessible from the links in the online Teacher Edition or through the Teacher Portal. Typically you need to make only one copy of each Visual Aid and one copy per student of each Student Sheet. SEPUP authorizes teachers to copy master pages for classroom use.

IMPLEMENTING SEPUP APPROACHES

CLASSROOM LEARNING ENVIRONMENTS

Research indicates that an appropriate learning environment is integral to student success. In addition to physical, emotional, and temporal aspects, the learning environment includes the content taught, how it is taught, and how it is assessed. In SEPUP classrooms, each of these components may change from lesson to lesson, giving science students a variety of learning environments over the course of a unit. Every activity in SEPUP offers suggestions for setting up a learning environment, but the ultimate design rests with the classroom teacher.

In *How People Learn: Brain, Mind, Experience, and School* (Bransford et al., 1999), the authors suggest four perspectives to keep in mind when designing a learning environment. You may find it helpful to consider them and how they relate to each other as you plan your classes. The four environments are as follows:

Learner-centered: The teacher seeks information about what students know and builds on this existing knowledge. Teachers plan classroom activities to elicit students' ideas and interests and incorporate them in instruction.

Knowledge-centered: A focus on scientific concepts, inquiry skills, and evidence fosters an environment where students gain knowledge and an understanding of science and the role of scientists in society.

Assessment-centered: In assessment-centered science instruction, teachers use formative assessments to give students constant feedback and opportunities to revise their work. Teachers employ summative assessments after segments of instruction to determine what students have learned. The most appropriate assessments are consistent with classroom learning goals and instructional approaches.

Community-centered: The classroom itself is a stimulating learning community when teachers create a safe place for students to express ideas and listen and learn from each other. Teachers can make the connection between instruction and the larger community by asking the class to explore community issues and by engaging family and outside experts in inquiry activities.

QUESTIONS AND THE LEARNING ENVIRONMENT

What kinds of questions do you ask in an average class period? What kinds of questions do your students ask you and each other? By paying attention to the types of questions and the nature of students' answers, you can determine if your approach to questioning is consistent with the type of learning environment you hope to create.

Straightforward questions to check on students' knowledge of basic facts, vocabulary, and procedures are almost certainly part of your daily questioning. When you ask these questions, you are looking for specific responses. With SEPUP courses, you are also asking more open-ended questions to learn what your students are thinking, to help them build conceptual understanding, and to help them relate what they have learned to new situations. By asking these types of questions, allowing students adequate time to respond, and encouraging them to comment and elaborate on each other's answers, you relay an important message to your students that science is more than memorization of facts, you think their ideas are important, and they can learn from each other.

Effective questioning requires planning and flexibility to respond to students' comments and answers. Most SEPUP activities include suggestions for questions to ask at different stages of an activity. Once classroom discussion begins, your skills at questioning and guiding discussion come into play. In the opening section of most activities, certain questions elicit students' ideas and get them thinking about the specific topic of the lesson. This helps you create an environment that is both knowledge- and learner-centered. If you base your instruction in the days ahead on what you have learned about your students, the questions will contribute to formative assessment. As the activity continues, the questions may relate specifically to the investigations students are conducting. These questions focus

on building students' knowledge, and may again help determine how you lead the discussion after the investigation. Toward the end of the activity, you will find a variety of questions in the Teaching Steps and as Analysis items that help students form conclusions from their investigations, and connect their new ideas to previous knowledge or revise their earlier ideas.

REFERENCES

Bransford, J.D., Brown, A.L. & Cocking, R. (Eds.). (1999). *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C.: National Academy Press.

DiRanna, K., & Siegel, M.A. (2004). *Facilitating Learning: The Role of the Teacher: Elementary Science Teacher Leadership* (ESTL) 2. Berkeley, CA: SEPUP, Lawrence Hall of Science, University of California, Berkeley. Available free of charge at www.sepuplhs.org/ profdev/educators/estlguides.html.

Fetters, M. K., Czerniak, C. M., Fish, L., & Shawberry, J. (2002). Confronting, challenging, and changing teachers' beliefs: Implications from a local systemic change professional development program. *Journal of Science Teacher Education, 12*(2), 101–130.

National Research Council. (2002). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, D.C.: National Academy Press.

Are you new to teaching or to SEPUP?
See "Classroom Management Tips" on page 16
and "Hints for First-Time SEPUP Teachers" on page 18.

INQUIRY IN SEPUP

According to the National Research Council's *Inquiry and the National Science Education Standards*, (2000), there are five essential features of inquiry in the science classroom:

- Learner engages in science-oriented questions.
- Learner gives priority to evidence in responding to questions.
- Learner formulates explanations from evidence.
- Learner connects explanations to scientific knowledge.
- Learner communicates and justifies explanations.

In the science classroom, the degree of support for each of these aspects of inquiry may vary from highly guided to minimally guided with greater responsibility

placed on students. These five features of inquiry and the continuum from guided to open inquiry help you plan your own teaching of *Issues and Science* units.

The degree to which you decide to guide inquiry for a given activity will depend on your students' prior experience. When students are first introduced to new scientific concepts and scientific procedures, closely guided inquiry is usually appropriate. In such instances, *Issues and Science* Student Books state the purpose of the activity and provide a comprehensive Procedure. These guided-inquiry activities have students investigate important science concepts that they could not easily discover through open-ended inquiry. During guided inquiry, students collect, test, evaluate, and apply scientific evidence.

Once students have the background knowledge and experience with scientific inquiry to work with less guidance, the Procedures become more open, requiring students to assume greater responsibility for collecting, recording, analyzing, and explaining data. Open-ended inquiry encourages students to develop, ask, and investigate questions; think critically; and apply their deeper understanding of science to real contexts.

Although each activity has a built-in approach, it is up to you to adjust it for optimal student learning. If your students have had little experience with inquiry lessons, you may have to provide more support. If they have had extensive experience with inquiry, you could opt not to use the Procedures and questions provided in the Student Book and, instead, open the activities to student-designed investigations and analyses.

The Teacher Edition contains specific suggestions for modifying some of the activities to provide more or less support for students as they move toward more self-directed learning. For example, the guide may provide a sample procedure that can be distributed to students who are not yet prepared for open-ended inquiry. For those students who are ready to be more independent, you may incorporate suggestions that reduce the level of guidance. Teachers may base their strategies on their student populations, but the essential features of inquiry remain the same. For more discussion of ways to adapt instruction see Teacher Resources II, "Diverse Learners."

Teachers support inquiry-based learning with classroom discussion and by prompting students to devise their own questions about a lab or investigation. Whether the lesson involves open-ended or guided inquiry, students should be able to answer the following questions:

- What is the purpose of the investigation?
- What types of data are or would be the most useful?
- What is the best way to organize and display the data?

- What evidence does the data set provide?
- Do the results support the hypothesis?
- What conclusions can be made from the data?
- How well does the conclusion fit the data collected?

The four principles in the box below can be used to promote student learning through inquiry.

FOUR PRINCIPLES TO GUIDE INQUIRY AND PROMOTE LEARNING

1. Relate the science to students' current knowledge.

If students have very little knowledge about a topic, it is up to you to provide that knowledge. Begin by planning time to draw out and build on students' initial ideas. Help them confront their misconceptions by suggesting alternative ideas, and require students to weigh the plausibility of each idea.

2. Emphasize the science focus of the lesson.

Students can often become wrapped up in a fun hands-on investigation and not think about the science involved. Always emphasize the science concepts and processes that underlie an inquiry-based lesson, and provide time for discussion and elaboration of scientific ideas.

3. Allow students to reflect on new knowledge.

Make sure students have the opportunity to reflect on the results of inquiry by asking them to consider what new ideas they have learned and how these new ideas fit into what they learned in previous lessons. Help students make connections so their new knowledge will carry them forward. The Analysis items in SEPUP activities help guide this reflective learning.

4. Use assessments to build understanding.

Take advantage of the variety of assessment opportunities embedded in the SEPUP activities. In addition to evaluating students' understanding, assessments reveal what your students think, which will help you plan further instruction. You may want to ask students to revise their work on an assessment after you have provided specific feedback on how to improve its quality. Students appreciate this chance to improve their work, and they see that assessments can help them strengthen their understanding and skills. The SEPUP assessment system includes scoring rubrics for tasks related to the following inquiry skills:

- Planning and carrying out investigations
- Organizing data for analysis
- Analyzing and interpreting data
- Communicating concepts and ideas
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Applying evidence and identifying trade-offs
- Developing and using models