Digging In

Digging In was originally developed at the Georgia Institute of Technology as part of the Learning by Design™ initiative and was titled *Earth Science: Digging In*.

Digging In

PBIS Editorial Team:
Michael T. Ryan
Victoria Deneroff

Georgia Institute of Technology Team

Project Director
Janet L. Kolodner

Lead Authors
Paul Camp
Jennifer Holbrook

Contributing Authors
David Crismond
Mike Ryan
Jennifer Turns

Formative Development
David Crismond
Joanna Fox
Jackie Gray
Cami Heck
Jennifer Holbrook
Susan McClendon
Kristine Nagel
Lindy Wine
Janice Young

Pilot Teachers
Barbara Blasch
Audrey Daniel
Emily Dickson
Carmen Dillard
Yvette Fernandez
Joyce Gamble
Dorothy Hicks
Daphne Islam-Gordon
Rudo Kashiri
Marni Klein
Toni Laman
Paige Lefont
Susan McClendon
Bernie Moore
Kelly Rowsey
Mike Ryan
Beth Smith
Delilah Springer
Lindy Wine
Avis Winfield
Mary Winn
Ann Yergin

The development of *Earth Science: Digging In* was supported by the National Science Foundation under grant nos. 9553583, 9818828 and 0208059 and by grants from the McDonell Foundation, the BellSouth Foundation, the Woodruff Foundation, and the Georgia Tech Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Table of Contents

Welcome to Project-Based Inquiry Science!

Dear Students,

This year, you will be learning the way scientists learn. You will explore interesting questions and challenges. You will learn new things. You will also learn exciting, new ways to think about the world around you.

Scientists learn as they are trying to answer a big question or solve a big challenge. To help them work on these big questions or challenges, scientists break them into smaller ones. For each smaller question or challenge, they read what other scientists already know, and they investigate, explore, gather evidence, and form explanations. This way, scientists build new knowledge as they answer these smaller questions. Then they use what they have learned to try to answer the big question or solve the big challenge. Along the way, scientists share what they have learned with other scientists. These other scientists can then use this new knowledge to address other questions and challenges.

Like scientists, you will be trying to answer big questions and solve big challenges this year. You will break these into smaller questions or challenges. For each smaller question or challenge, you'll read, investigate, explore, gather evidence, and form explanations. As you do these things, you will share what you are learning and work closely with your classmates. You and your classmates will help each other learn and successfully answer each unit's question or solve its challenge. At the end of each unit, you'll answer the big question or address the big challenge based on what you've learned. And you will have learned a lot!

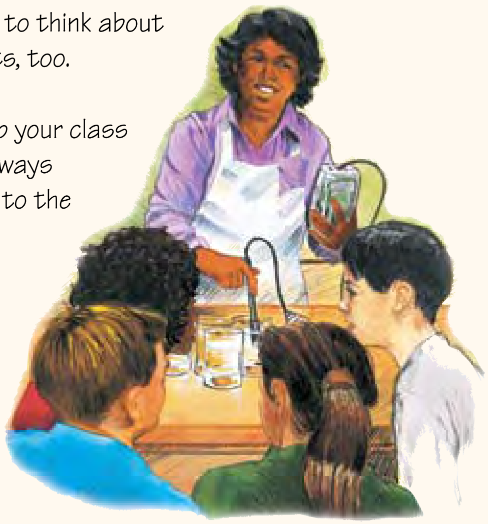
PBIS was designed to support you as you become a student scientist. In fact, PBIS units were written by scientists who study how people learn and who want to help you become the best scientist you can be. We used what we know about learning to design ways to help you answer big questions and solve big challenges. What you learn this year about science will help you learn science in the future. The way you learn to think about questions and challenges will help you learn other subjects, too.

Each year begins with a launcher unit. Launcher units help your class learn to work together, help you become familiar with the ways scientists think and have discussions, and introduce you to the activities and tools you'll use throughout PBIS.

Have fun being a student scientist!

Janet L. Kolodner

Janet Kolodner (for the whole PBIS team)

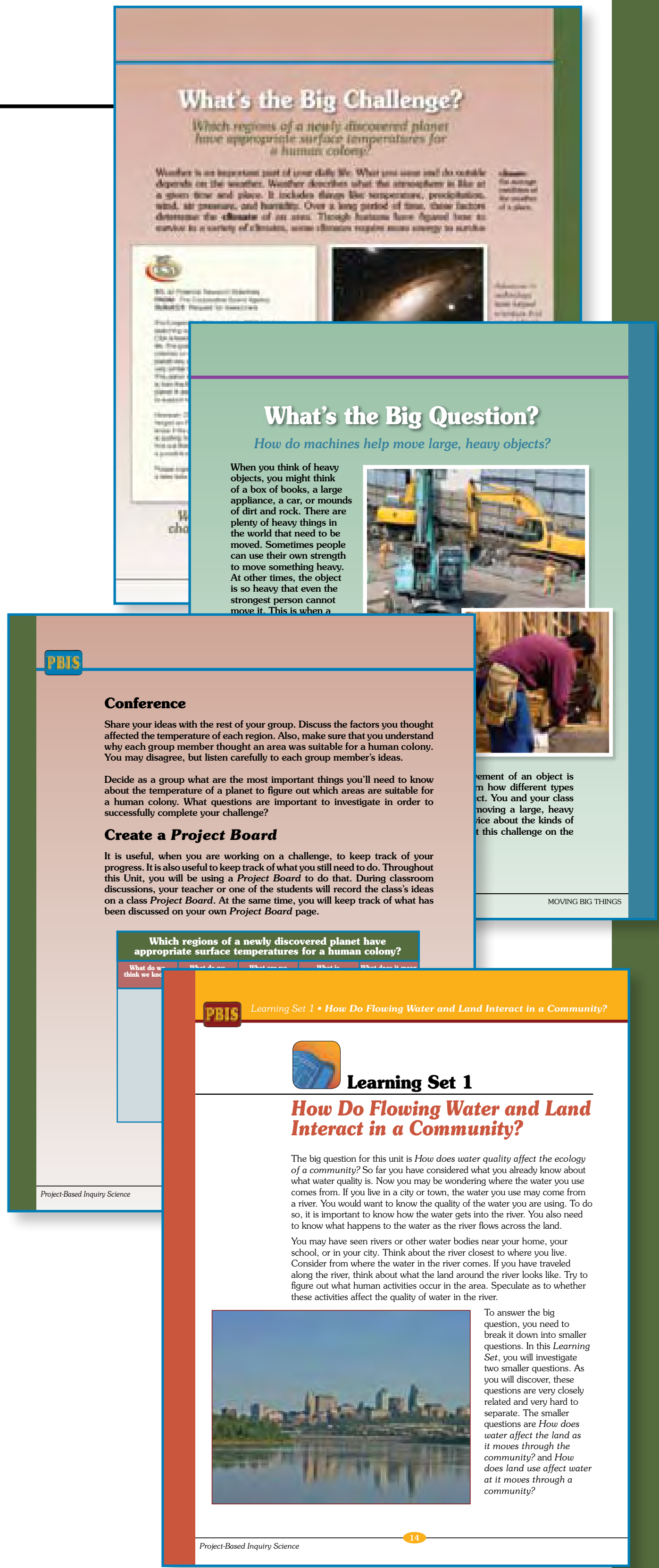


Introducing PBIS

What Do Scientists Do?

1) Scientists...address big challenges and big questions.

You will find many different kinds of *Big Challenges* and *Questions* in *PBIS* Units. Some ask you to think about why something is a certain way. Some ask you to think about what causes something to change. Some challenge you to design a solution to a problem. Most of them are about things that can and do happen in the real world.



Understand the Big Challenge or Question

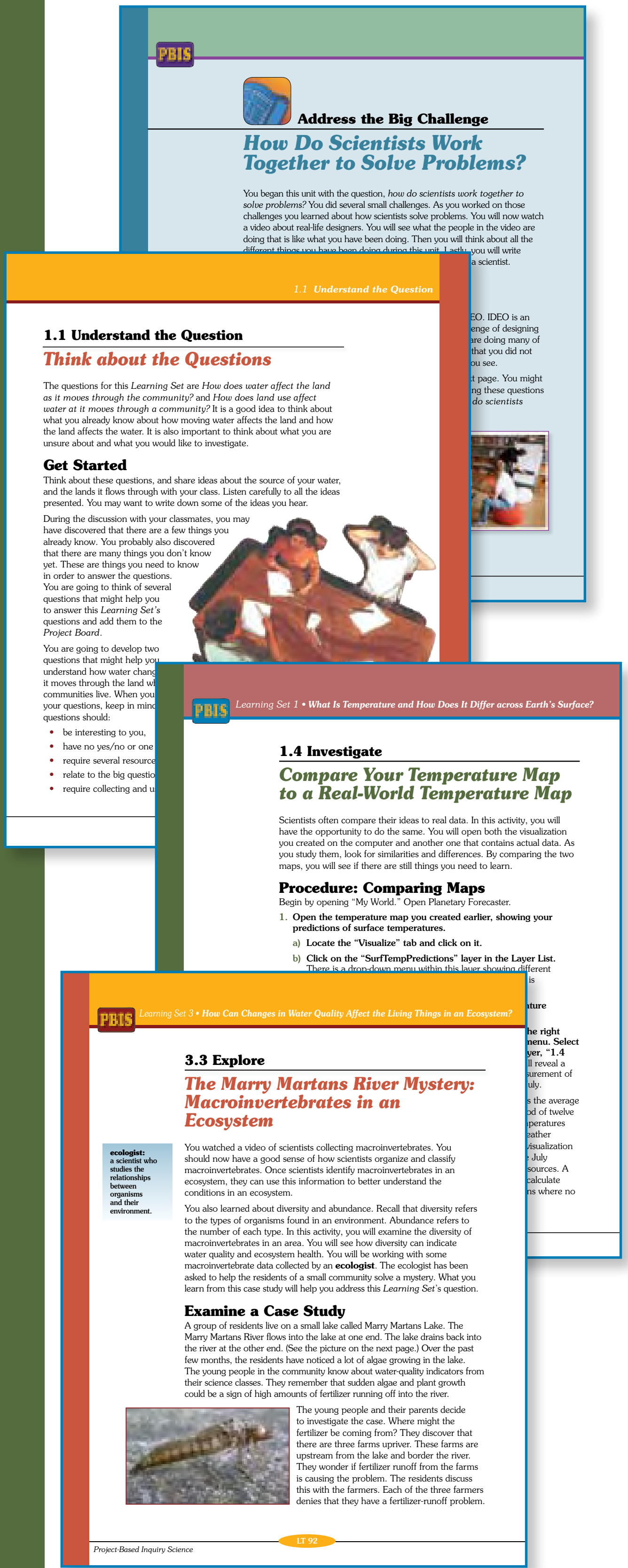
As you get started with each Unit, you will do activities that help you understand the *Big Question* or *Challenge* for that Unit. You will think about what you already know that might help you, and you will identify some of the new things you will need to learn.

Project Board

The *Project Board* helps you keep track of your learning. For each challenge or question, you will use a *Project Board* to keep track of what you know, what you need to learn, and what you are learning. As you learn and gather evidence, you will record that on the *Project Board*. After you have answered each small question or challenge, you will return to the *Project Board* to record how what you've learned helps you answer the *Big Question* or *Challenge*.

Learning Sets

Each Unit is composed of a group of *Learning Sets*, one for each of the smaller questions that need to be answered to address the *Big Question* or *Challenge*. In each *Learning Set*, you will investigate and read to find answers to the *Learning Set's* question. You will also have a chance to share the results of your investigations with your classmates and work together to make sense of what you are learning. As you come to understand answers to the questions on the *Project Board*, you will record those answers and the evidence you've collected. At the end of each *Learning Set*, you will apply your knowledge to the *Big Question* or *Challenge*.


Address the Big Challenge

How Do Scientists Work Together to Solve Problems?

You began this unit with the question, *how do scientists work together to solve problems?* You did several small challenges. As you worked on those challenges you learned about how scientists solve problems. You will now watch a video about real-life designers. You will see what the people in the video are doing that is like what you have been doing. Then you will think about all the

1.1 Understand the Question

Think about the Questions

The questions for this *Learning Set* are *How does water affect the land as it moves through the community?* and *How does land use affect water at it moves through a community?* It is a good idea to think about what you already know about how moving water affects the land and how the land affects the water. It is also important to think about what you are unsure about and what you would like to investigate.

Get Started

Think about these questions, and share ideas about the source of your water, and the lands it flows through with your class. Listen carefully to all the ideas presented. You may want to write down some of the ideas you hear.

During the discussion with your classmates, you may have discovered that there are a few things you already know. You probably also discovered that there are many things you don't know yet. These are things you need to know in order to answer the questions. You are going to think of several questions that might help you to answer this *Learning Set's* questions and add them to the *Project Board*.

Learning Set 1 • What Is Temperature and How Does It Differ across Earth's Surface?

1.4 Investigate

Compare Your Temperature Map to a Real-World Temperature Map

Scientists often compare their ideas to real data. In this activity, you will have the opportunity to do the same. You will open both the visualization you created on the computer and another one that contains actual data. As you study them, look for similarities and differences. By comparing the two maps, you will see if there are still things you need to learn.

Procedure: Comparing Maps

Begin by opening "My World." Open Planetary Forecaster.

1. Open the temperature map you created earlier, showing your predictions of surface temperatures.
   a) Locate the "Visualize" tab and click on it.
   b) Click on the "SurfTempPredictions" layer in the Layer List.

Learning Set 3 • How Can Changes in Water Quality Affect the Living Things in an Ecosystem?

3.3 Explore

The Marry Martans River Mystery: Macroinvertebrates in an Ecosystem

ecologist: a scientist who studies the relationships between organisms and their environment.

You watched a video of scientists collecting macroinvertebrates. You should now have a good sense of how scientists organize and classify macroinvertebrates. Once scientists identify macroinvertebrates in an ecosystem, they can use this information to better understand the conditions in an ecosystem.

You also learned about diversity and abundance. Recall that diversity refers to the types of organisms found in an environment. Abundance refers to the number of each type. In this activity, you will examine the diversity of macroinvertebrates in an area. You will see how diversity can indicate water quality and ecosystem health. You will be working with some macroinvertebrate data collected by an **ecologist**. The ecologist has been asked to help the residents of a small community solve a mystery. What you learn from this case study will help you address this *Learning Set's* question.

Examine a Case Study

A group of residents live on a small lake called Marry Martans Lake. The Marry Martans River flows into the lake at one end. The lake drains back into the river at the other end. (See the picture on the next page.) Over the past few months, the residents have noticed a lot of algae growing in the lake. The young people in the community know about water-quality indicators from their science classes. They remember that sudden algae and plant growth could be a sign of high amounts of fertilizer running off into the river.

The young people and their parents decide to investigate the case. Where might the fertilizer be coming from? They discover that there are three farms upriver. These farms are upstream from the lake and border the river. They wonder if fertilizer runoff from the farms is causing the problem. The residents discuss this with the farmers. Each of the three farmers denies that they have a fertilizer-runoff problem.

Project-Based Inquiry Science

LT 92

Answer the Big Question / Address the Big Challenge

At the end of each Unit, you will put everything you have learned together to tackle the *Big Question or Challenge*.

2) Scientists…address smaller questions and challenges.

What You Do in a Learning Set

Understanding the Question or Challenge

At the start of each *Learning Set*, you will usually do activities that will help you understand the *Learning Set's* question or challenge and recognize what you already know that can help you answer the question or achieve the challenge. Usually, you will visit the *Project Board* after these activities and record on it the even smaller questions that you need to investigate to answer a *Learning Set's* question.

Investigate/Explore

There are many different kinds of investigations you might do to find answers to questions. In the *Learning Sets,* you might

- design and run experiments;
- design and run simulations;
- design and build models;
- examine large sets of data.

Don't worry if you haven't done these things before. The text will provide you with lots of help in designing your investigations and in analyzing your data.

Read

Like scientists, you will also read about the science you are learning. You'll read a little bit before you investigate, but most of the reading you do will be to help you understand what you've experienced or seen in an investigation. Each time you read, the text will include *Stop and Think* questions after the reading. These questions will help you gauge how well you understand what you have read. Usually, the class will discuss the answers to *Stop and Think* questions before going on so that everybody has a chance to make sense of the reading.

Design and Build

When the *Big Challenge* for a Unit asks you to design something, the challenge in a *Learning Set* might also ask you to design something and make it work. Often, you will design a part of the thing you will design and build for the *Big Challenge.* When a *Learning Set* challenges you to design and build something, you will do several things:

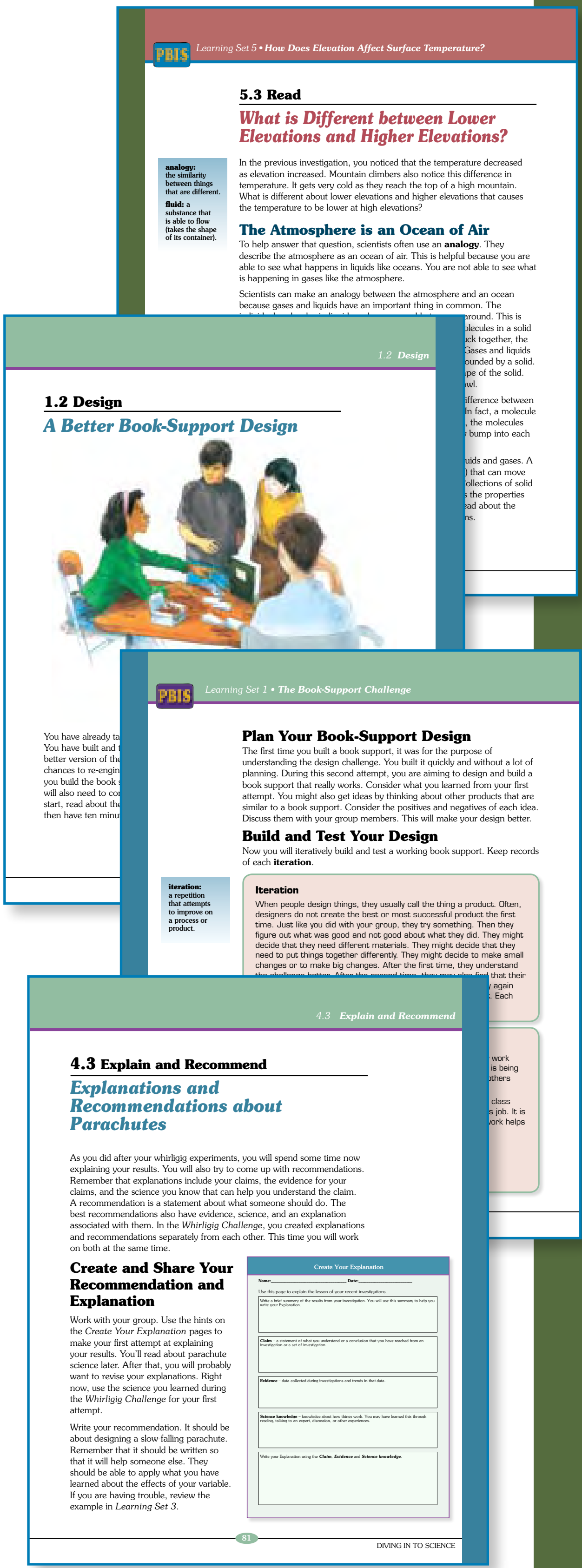
- identify what questions you need to answer to be successful
- investigate to find answers to those questions
- use those answers to plan a good design solution
- build and test your design.

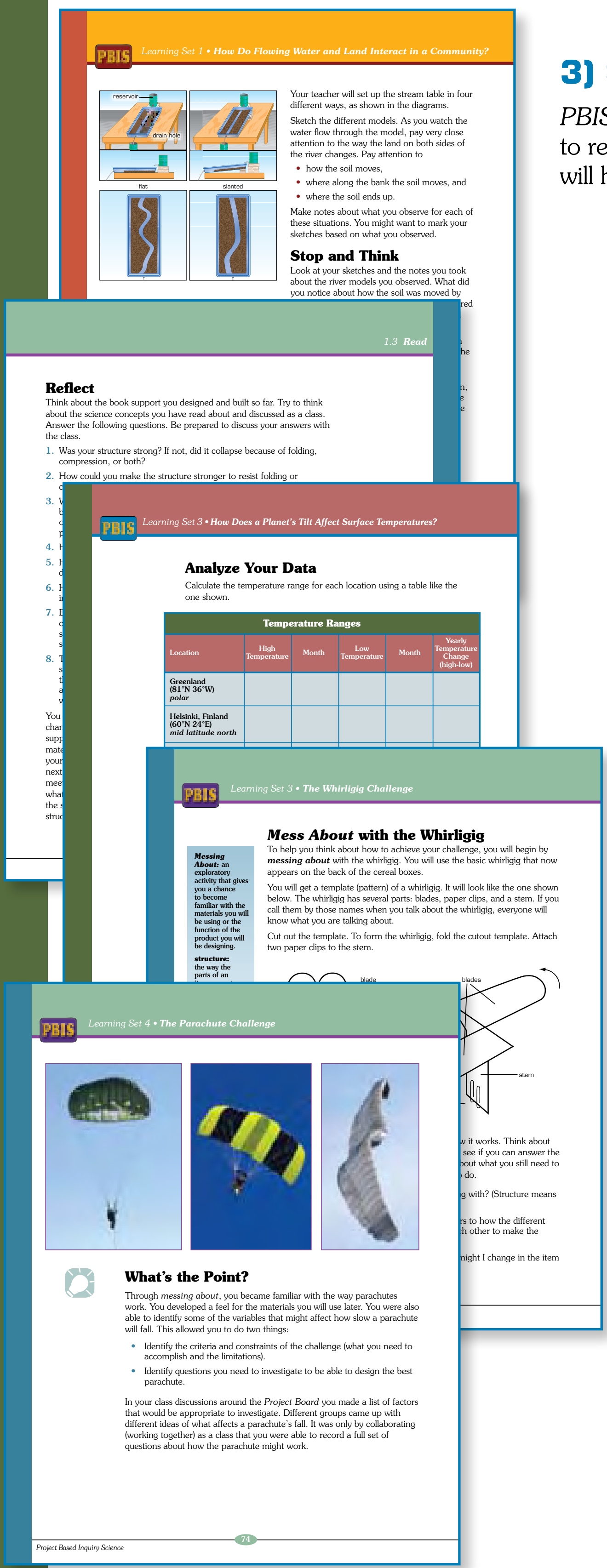
Because designs don't always work the way you want them to, you will usually do a design challenge more than once. Each time through, you will test your design. If your design doesn't work as well as you'd like, you will determine why it is not working and identify other things you need to investigate to make it work better. Then, you will learn those things and try again.

Explain and Recommend

A big part of what scientists do is explain, or try to make sense of why things happen the way they do. An explanation describes why something is the way it is or behaves the way it does. An explanation is a statement you make built from claims (what you think you know), evidence (from an investigation) that supports the claim, and science knowledge. As they learn, scientists get better at explaining. You'll see that you get better, too, as you work through the *Learning Sets*.

A recommendation is a special kind of claim—one where you advise somebody about what to do. You will make recommendations and support them with evidence, science knowledge, and explanations.





3) Scientists...reflect in many different ways.

PBIS provides guidance to help you think about what you are doing and to recognize what you are learning. Doing this often as you are working will help you be a successful student scientist.

Tools for Making Sense

Stop and Think

Stop and Think sections help you make sense of what you've been doing in the section you are working on. *Stop and Think* sections include a set of questions to help you understand what you've just read or done. Sometimes the questions will remind you of something you need to pay more attention to. Sometimes they will help you connect what you've just read to things you already know. When there is a *Stop and Think* in the text, you will work individually or with a partner to answer the questions, and then the whole class will discuss the answers.

Reflect

Reflect sections help you connect what you've just done with other things you've read or done earlier in the Unit (or in another Unit). When there is a *Reflect* in the text, you will work individually, with a partner or your small group to answer the questions. Then, the whole class will discuss the answers. You may be asked to answer *Reflect* questions for homework.

Analyze Your Data

Whenever you have to analyze data, the text will provide hints about how to do that and what to look for.

Mess About

"Messing about" is a term that comes from design. It means exploring the materials you will be using for designing or building something or examining something that works like what you will be designing. Messing about helps you discover new ideas—and it can be a lot of fun. The text will usually give you ideas about things to notice as you are messing about.

What's the Point?

At the end of each *Learning Set*, you will find a summary, called *What's the Point?*, of the important information from the *Learning Set*. These summaries can help you remember how what you did and learned is connected to the *Big Question or Challenge* you are working on.

4) Scientists…collaborate.

Scientists never do all their work alone. They work with other scientists (collaborate) and share their knowledge. *PBIS* helps you be a student scientist by giving you lots of opportunities for sharing your findings, ideas, and discoveries with others (the way scientists do). You will work together in small groups to investigate, design, explain, and do other things. Sometimes you will work in pairs to figure out things together. You will also have lots of opportunities to share your findings with the rest of your classmates and make sense together of what you are learning.

Investigation Expo

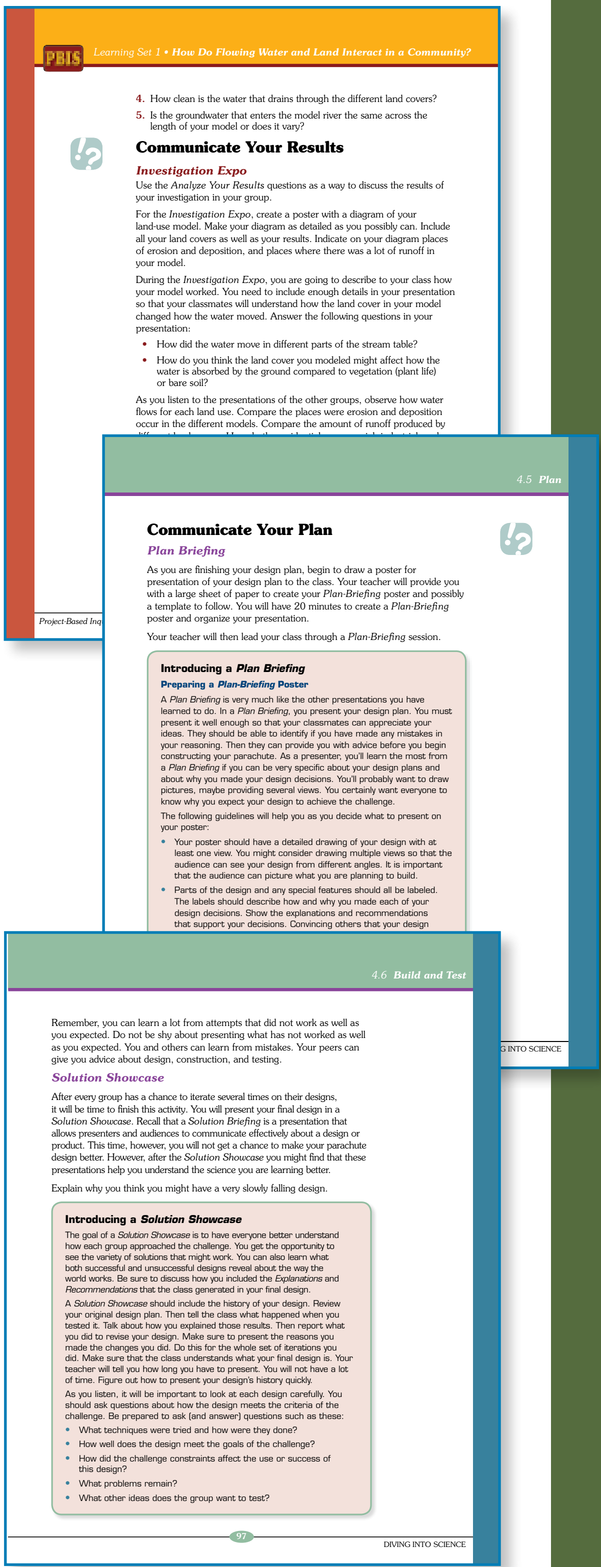
In an *Investigation Expo*, small groups report to the class about an investigation they've done. For each *Investigation Expo*, you will make a poster detailing what you were trying to learn from your investigation, what you did, your data, and your interpretation of your data. The text gives you hints about what to present and what to look for in other groups' presentations. *Investigation Expos* are always followed by discussions about the investigations and about how to do science well. You may also be asked to write a lab report following an investigation.

Plan Briefing/Solution Briefing/Idea Briefing

Briefings are presentations of work in progress. They give you a chance to get advice from your classmates that can help you move forward. During a *Plan Briefing*, you present your plan to the class. It might be a plan for an experiment or a plan for solving a problem or achieving a challenge. During a *Solution Briefing*, you present your solution in progress and ask the class to help you make your solution better. During an *Idea Briefing*, you present your ideas. You get the best advice from your classmates when you present evidence in support of your plan, solution, or idea. Often, you will prepare a poster to help you make your presentation. Briefings are almost always followed by discussions of your investigations and how you will move forward.

Solution Showcase

Solution Showcases usually appear near the end of a Unit. During a *Solution Showcase*, you show your classmates your finished product—either your answer to a question or your solution to a challenge. You also tell the class why you think it is a good answer or solution, what evidence and science you used to get to your solution, and what you tried along the way before getting to your answer or solution. Sometimes a *Solution Showcase* is followed by a competition. It is almost always followed by a discussion comparing and contrasting the different answers and solutions groups have come up with. You may be asked to write a report or paper following a *Solution Showcase*.


PBIS Learning Set 1 • How Do Flowing Water and Land Interact in a Community?

4. How clean is the water that drains through the different land covers?
5. Is the groundwater that enters the model river the same across the length of your model or does it vary?

Communicate Your Results

Investigation Expo

Use the *Analyze Your Results* questions as a way to discuss the results of your investigation in your group.

For the *Investigation Expo*, create a poster with a diagram of your land-use model. Make your diagram as detailed as you possibly can. Include all your land covers as well as your results. Indicate on your diagram places of erosion and deposition, and places where there was a lot of runoff in your model.

During the *Investigation Expo*, you are going to describe to your class how your model worked. You need to include enough details in your presentation so that your classmates will understand how the land cover in your model changed how the water moved. Answer the following questions in your presentation:

- How did the water move in different parts of the stream table?
- How do you think the land cover you modeled might affect how the water is absorbed by the ground compared to vegetation (plant life) or bare soil?

As you listen to the presentations of the other groups, observe how water flows for each land use. Compare the places were erosion and deposition occur in the different models. Compare the amount of runoff produced by

4.5 Plan

Communicate Your Plan

Plan Briefing

As you are finishing your design plan, begin to draw a poster for presentation of your design plan to the class. Your teacher will provide you with a large sheet of paper to create your *Plan-Briefing* poster and possibly a template to follow. You will have 20 minutes to create a *Plan-Briefing* poster and organize your presentation.

Your teacher will then lead your class through a *Plan-Briefing* session.

Introducing a *Plan Briefing*

Preparing a *Plan-Briefing* Poster

A *Plan Briefing* is very much like the other presentations you have learned to do. In a *Plan Briefing*, you present your design plan. You must present it well enough so that your classmates can appreciate your ideas. They should be able to identify if you have made any mistakes in your reasoning. Then they can provide you with advice before you begin constructing your parachute. As a presenter, you'll learn the most from a *Plan Briefing* if you can be very specific about your design plans and about why you made your design decisions. You'll probably want to draw pictures, maybe providing several views. You certainly want everyone to know why you expect your design to achieve the challenge.

The following guidelines will help you as you decide what to present on your poster:

- Your poster should have a detailed drawing of your design with at least one view. You might consider drawing multiple views so that the audience can see your design from different angles. It is important that the audience can picture what you are planning to build.
- Parts of the design and any special features should all be labeled. The labels should describe how and why you made each of your design decisions. Show the explanations and recommendations that support your decisions. Convincing others that your design

4.6 Build and Test

Remember, you can learn a lot from attempts that did not work as well as you expected. Do not be shy about presenting what has not worked as well as you expected. You and others can learn from mistakes. Your peers can give you advice about design, construction, and testing.

Solution Showcase

After every group has a chance to iterate several times on their designs, it will be time to finish this activity. You will present your final design in a *Solution Showcase*. Recall that a *Solution Briefing* is a presentation that allows presenters and audiences to communicate effectively about a design or product. This time, however, you will not get a chance to make your parachute design better. However, after the *Solution Showcase* you might find that these presentations help you understand the science you are learning better.

Explain why you think you might have a very slowly falling design.

Introducing a *Solution Showcase*

The goal of a *Solution Showcase* is to have everyone better understand how each group approached the challenge. You get the opportunity to see the variety of solutions that might work. You can also learn what both successful and unsuccessful designs reveal about the way the world works. Be sure to discuss how you included the *Explanations* and *Recommendations* that the class generated in your final design.

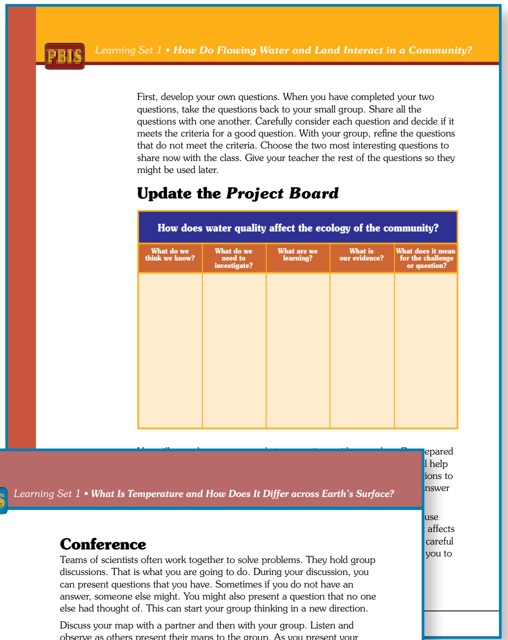
A *Solution Showcase* should include the history of your design. Review your original design plan. Then tell the class what happened when you tested it. Talk about how you explained those results. Then report what you did to revise your design. Make sure to present the reasons you made the changes you did. Do this for the whole set of iterations you did. Make sure that the class understands what your final design is. Your teacher will tell you how long you have to present. You will not have a lot of time. Figure out how to present your design's history quickly.

As you listen, it will be important to look at each design carefully. You should ask questions about how the design meets the criteria of the challenge. Be prepared to ask (and answer) questions such as these:

- What techniques were tried and how were they done?
- How well does the design meet the goals of the challenge?
- How did the challenge constraints affect the use or success of this design?
- What problems remain?
- What other ideas does the group want to test?

97

DIVING INTO SCIENCE



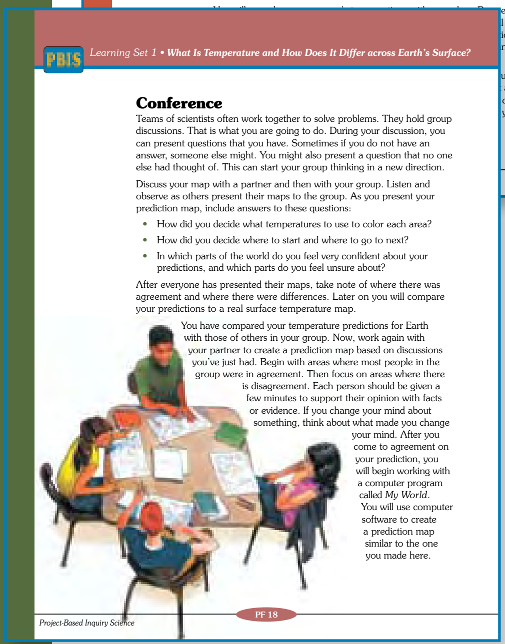
Learning Set 1 • *How Do Flowing Water and Land Interact in a Community?*

First, develop your own questions. When you have completed your two questions, take the questions back to your small group. Share all the questions with one another. Carefully consider each question and decide if it meets the criteria for a good question. With your group, refine the questions that do not meet the criteria. Choose the two most interesting questions to share now with the class. Give your teacher the rest of the questions so they might be used later.

Update the *Project Board*

How does water quality affect the ecology of the community?				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

epared
l help
ions to
nswer
use
affects
careful
you to



Learning Set 1 • *What Is Temperature and How Does It Differ across Earth's Surface?*

Conference

Teams of scientists often work together to solve problems. They hold group discussions. That is what you are going to do. During your discussion, you can present questions that you have. Sometimes if you do not have an answer, someone else might. You might also present a question that no one else had thought of. This can start your group thinking in a new direction.

Discuss your map with a partner and then with your group. Listen and observe as others present their maps to the group. As you present your prediction map, include answers to these questions:

- How did you decide what temperatures to use to color each area?
- How did you decide where to start and where to go to next?
- In which parts of the world do you feel very confident about your predictions, and which parts do you feel unsure about?

After everyone has presented their maps, take note of where there was agreement and where there were differences. Later on you will compare your predictions to a real surface-temperature map.

You have compared your temperature predictions for Earth with those of others in your group. Now, work again with your partner to create a prediction map based on discussions you've just had. Begin with areas where most people in the group were in agreement. Then focus on areas where there is disagreement. Each person should be given a few minutes to support their opinion with facts or evidence. If you change your mind about something, think about what made you change your mind. After you come to agreement on your prediction, you will begin working with a computer program called *My World*. You will use computer software to create a prediction map similar to the one you made here.

PF 18

Project-Based Inquiry Science

Update the Project Board

Remember that the *Project Board* is designed to help the class keep track of what they are learning and their progress towards a Unit's *Big Question* or *Challenge*. At the beginning of each Unit, the class creates a *Project Board*, and together you record what you think you know about answering the *Big Question* or addressing the *Big Challenge* and what you think you need to investigate further. Near the beginning of each *Learning Set*, the class revisits the *Project Board* and adds new questions and things they think they know. At the end of each *Learning Set*, the class again revisits the *Project Board*. This time you record what you have learned, the evidence you've collected, and recommendations you can make about answering the *Big Question* or achieving the *Big Challenge*.

Conference

A *Conference* is a short discussion between a small group of students before a more formal whole-class discussion. Students might discuss predictions and observations, they might try to explain together, they might consult on what they think they know, and so on. Usually, a *Conference* is followed by a discussion around the *Project Board*. In these small group discussions, everybody gets a chance to participate.

What's the Point?
Review what you have learned in each *Learning Set*.

Stop and Think
Answer questions that help you understand what you've done in a section.

Communicate
Share your ideas and results with your classmates.

Record
Record your data as you gather it.