1 HOW TO Use Chapter Organizers

Some of the skills you will improve this year will be your skills of organization. You know that an organized room or file system is easier to work with than one that is disorganized. Knowledge can be organized as well. You will work this year at organizing your thoughts and knowledge in a science notebook. In addition, you will learn to use the organizational tools that the student book provides. You will notice one of these tools as you look through your student book. You will see that we have included a chapter organizer at the beginning of each chapter. This organizer will help you see the big picture. Your understanding will deepen and strengthen as you see that what you have learned today connects to what you will learn tomorrow.

Work with a partner to complete the following tasks. Record your answers and thoughts in your science notebook. Organize your science notebook by including the title "using the chapter organizers."

1. Look through the table of contents of your student book and find a chapter title that most interests you. Do not turn to your chapter yet; just look at the title. Make sure that you and your partner choose *different* chapters. If you both like the same one, work out a plan to have 2 different chapters. Learning to compromise in a group is another skill you will develop this year. Complete the following tasks based on the chapter you select.
   - **a.** Explain to your partner why you think this chapter will be interesting to you. Listen as your partner explains his or her thinking to you. Record the title of your chapter and at least 1 statement explaining why you think this chapter will be interesting.
   - **b.** Think of as many concepts and ideas as you can that might be included in your chapter. List these concepts in your science notebook.
   - **c.** Share your list with your partner and listen as your partner shares with you. Think about your partner's chapter selection. Can you add to his or her list of topics? Add new topics to your list that emerge during this discussion.
2. Turn to your chapter and find the chapter organizer. It is found at the beginning of the chapter. Look at it carefully. All the chapters in this book follow the BSCS 5E instructional model. The 5Es provide a structure for active learning that will have you *doing* and *understanding* science, not just reading about it. Taken together, the

5Es will help you build a strong understanding of science. Can you find each of the 5Es included in your chapter organizer? List them in your science notebook.

3 What do you think each *E* represents in the learning sequence? Record your ideas in your science notebook.

Include in your answer what you think you should be doing in each activity. For example, what will you be doing in the explore activity? How will you be interacting with your teacher and with your teammates?

4 Every *E* is an activity that builds on the previous one and helps prepare you for the next one—the next *E*. Do you notice that between each activity there is a linking question? Discuss with your partner what you think the purpose of the linking question might be. Record your best ideas in your science notebook.

5 Look back at your original ideas from Steps 1b–c about the concepts you thought would be included in your chapter.

a. Circle the ones that appear to be covered in this chapter.

b. Look at the other chapters in this same unit. Highlight topics that will be covered in those other chapters.

c. What feature of the chapter organizer helped you determine the topics covered in your chapter?

6 Look at another chapter organizer from your book. Discuss with your partner how this organizer can help you with your learning. Record at least 3 ways that you can use the chapter organizers to enhance your learning.

7 Look at your list. Are there things that you will do at the beginning of the chapter, during the middle of the chapter, and at the end of the chapter? Add them to your list so that you have at least 1 from each place.

8 From the chapter organizer that you chose in Step 1, record what you think is the main idea of that chapter. Try to sum it up in 1 sentence.

9 What part or parts of the chapter organizer did you use in Step 8 to write your main idea sentence? What part of the organizer helped you the most?

2 HOW TO Use the Science Notebook

In *BSCS Science: An Inquiry Approach*, you will use a science notebook on a regular basis. Science notebooks serve many purposes. They provide a place to record data, take notes, reflect on your progress, or respond to questions. This science notebook will become your permanent record of your work, and you will refer to it often during discussions and assessments. The more complete your science notebook is, the more valuable it will be for you.

Your science notebook should be a spiral notebook or a hardcover book that is permanently bound. (Do not use a loose-leaf notebook or a spiral notebook with perforated pages that tear out.) A notebook with square-grid (graph paper) pages will make any graphing that you do much easier.

The following sections describe the major ways in which you will use your science notebook in this program.

Recording Data

Science depends on accurate data. No one—not even the original observer—can trust the accuracy of confusing, vague, or incomplete data. Scientific record keeping is the process by which you maintain neat, organized, and accurate records of your observations and data. Use a pen to record data. Although your interpretation of the data may change, *the original data are a permanent record*. If you learn new or additional things and your thinking changes, make changes in your science notebook in a different-colored pen or pencil. That way, both you and your teacher have a record of your ongoing learning.

Keep records in a diary form, and record your name and the date at the beginning of each entry. Keep the records of each activity separate. Be brief but to the point when recording data in words. It may not be necessary to use complete sentences, but single words seldom are descriptive enough to represent accurately what you have observed or done.

Sometimes the easiest way to record data is in the form of a drawing or sketch. Such drawings need not be works of art, but they should be accurate representations of what you have observed. Place your sketches or drawings in the middle of the page, leaving room for captions, revisions, and highlights. Keep the drawings simple, use a hard pencil, and include clearly written labels. Often, the easiest way to record numerical data is in the form of a table. When you record data for counts or measurements with numbers, include the units of the measurements you used, for example, degrees Celsius or centimeters.

Do not record your data on other papers and then copy them into your science notebook. Doing so may increase neatness, but it will decrease accuracy. Your science notebook is your book, and blots and stains are a normal circumstance of field and laboratory work.

You will do much of your laboratory work as a member of a team. Your science notebook, therefore, will contain data that other team members have contributed. Keep track of the source of those observations by circling (or recording in a different color) the data that others reported.

Responding to Questions

When you answer discussion or activity questions in your science notebook, record the date and the activity title. Then number each response. You also may find it useful to record the questions. Sometimes you will respond to questions individually and sometimes with your team; indicate whether your responses are your own or those of your team. As you are writing your responses, practice writing in complete sentences; this will help you when you synthesize and present ideas. After each answer that you write, leave a blank space where you can add questions or comments that arise as your understanding grows.

Taking Notes

Always begin with the date. Then record the source of information. Often, this is a person or a book, but it could be a video, a Web site, or a computer program. When recording notes, start each new idea on a new line. Try to group related ideas under broad headings that will help you remember the important ideas and how they are connected. Write down more than you think you will need; it is hard to make sense of a few words when you look back at them later. Include diagrams and charts to clarify ideas.

It is often valuable to take notes during team and class discussions as well as when your teacher is presenting ideas or instructions. In addition, taking notes in your science notebook as you read helps you better absorb the written information.

You can use the information in your science notebook to prepare for discussions or to review what you have learned. At times, you also will use the information that you have recorded in your science notebook to complete assessment activities.

Keeping Track of Your Questions

Often, as you read or work through an activity, a question will come to mind or you will find that you are confused about something. If you cannot talk with your teammates or your teacher right away, jot down your question or confusion in your science notebook so that you will remember to ask about it when you have the opportunity. You also may use this technique to record questions that you want to answer yourself.

Keeping Track of Your Responsibilities

Because you will use your science notebook every day in science class, this notebook is a good place to record your class assignments and responsibilities. Each day, you may want to record these in red in the upper corner of your science notebook page.

Using Your Science Notebook during Assessment

At times throughout this program, you will use your science notebook during assessments—both ongoing assessments, such as class discussions and team presentations, and more formal, end-of-unit assessments. Your teacher will collect your science notebook periodically to assess your progress. Using a science notebook for assessment will be a rewarding experience if your entries are complete, detailed, and well organized. Remember to make it easy for someone else reading your science notebook to understand what you have recorded. Use blank space to separate activities, notes, and data. This will make your science notebook easier to assess, and it will provide space for you to add new information if needed. Keep this in mind as you make entries in your science notebook.

Learning Strategies

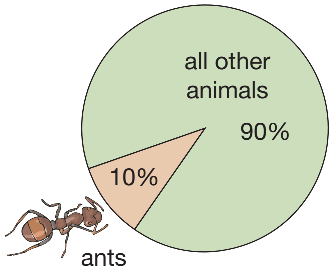
3A HOW TO Use Multiple Forms of Representation

Sometimes what you're asked to do in school seems like a waste of your time. How do you evaluate whether it's worthwhile? One way is to examine the evidence. Does what you're being asked to do benefit you now and in the future?

Using multiple forms of representation for the same information is an example. That is, your teacher asks you to make a sketch of what you read, convert a line graph into an equation, or write a paragraph about lab observations. Why represent what you know in more than one way?

Generating different ways to represent knowledge helps you solve problems, enhances your memory, and improves your ability to communicate. Just think how these outcomes affect your performance in school and ultimately in your chosen profession. You can start learning now how to represent knowledge in a variety of ways. First, become aware of the common forms of representation. Second, know which situations use what forms of representation. Third, practice translating among the forms.

1. Read the table in figure H3A.1 and study the example it contains.
2. Practice generating your own tables, similar to this one, for the following scenarios.
   - **a.** A comparison of the number of males to females in your classroom
   - **b.** The force of wind needed to move a sailboat
   - **c.** How fast trees grow

Forms of representation	Source	Example
Language	Textbooks, science notebook, the Web, magazines, text messages, conversations, lectures, music lyrics	Ants are ten percent of the animal biomass on Earth.
Mathematics/Logic	Equations, science notebook, proportions, comparisons, percents, differences, summation	$\frac{M_{\text{ants}}}{M_{\text{all animals in biomass}}} \times 100 = 10$ Key: M = mass
Spatial/Dimensional	Sketches, charts, real objects, maps, demonstrations, science notebook, lab equipment	

▲ **Figure H3A.1** **Forms of representation.**

Learning Strategies

3B HOW TO Use the Think-Share-Advise-Revise (TSAR) Strategy

Does learning stop when your paper comes back with a grade on it? It shouldn't. The same is true for experiences *during* class. That is, you get the most out of school when you get ongoing feedback on your thinking, then revise your original ideas to reflect what you've learned. This cycle of thinking on your own, sharing your ideas, getting advice from others, and revising what you think is essential in the workplace as well as in school. Work with a partner to learn about the think-share-advise-revise (TSAR) strategy.

1. Chapter 2, *Collision Course*, has an example of using the TSAR strategy for answering a science question. Find it in the engage activity, *Forces Make a Lovely Pair* (p. 52), and read through the process.
2. Match each step from chapter 2 to the descriptions listed in the table in figure H3B.1. You'll see generalized tasks in the table and specific examples in chapter 2. The combination of the tasks and the examples provides you with why, what, and how to use the TSAR process. Use this strategy for any problem, especially in team situations.

Step	What you do	What others do
Think	• access what you already know and understand and the skills you already have • work individually • pinpoint what you do and don't know • generate questions • document your thoughts in your science notebook	• respect your private thinking time
Share	• read aloud your thinking to a teammate • explain any diagrams, charts, or sketches • respond to requests for clarification	• listen attentively • ask questions respectfully
Advise	• offer suggestions, elaborations, or alternative explanations to what your teammate read • respond to questions about your advice	• listen to your advice without interruption • ask for clarification if needed
Revise	• record what you changed in your original answer in response to advice • record why you changed your original answer in response to advice (remember, not all advice leads to changes)	• respect your private time to revise your first thoughts

▲ **Figure H3B.1** **TSAR table.**

Learning Strategies

3C HOW TO Use and Create Organizing Tables

Organizing information helps you see patterns and better understand text materials. There are many different kinds of organizing tables. For example, you can use tables to organize data in an investigation, to make comparisons and analogies, and to show relationships between information in reading passages. Here are 3 common organizing tables you might use.

1. *T-tables* show relationships between information listed in the horizontal rows. T-tables can have 2, 3, or even 4 columns. You can use T-tables to show similarities or differences or to organize what you know before or after you read.

Reading about genetics

Fact or idea I read	Questions I have about the fact or idea

▲ **Figure H3C.1 T-table example.** This is an example of a T-table you could use as you read about genetics. As you read a passage, record your ideas in a table to help you organize your thoughts.

2 *Analogy maps* are a special type of table that allows you to connect new ideas with ideas you are familiar with.

Feature of a road trip	is like . . .	aspect of scientific inquiry . . .	because . . .
A detour on the road	is like . . .	getting unexpected results from an investigation	when you encounter something you do not expect, you change the way you approach your investigation.
Circling back on a portion of the road to look for a turn	is like . . .	adjusting the design of an investigation	you return to your design and adjust it to get the results you need to answer your question.
Trying different routes on a road trip	is like . . .		
Encountering car trouble and returning home	is like . . .		
Abandoning your car on the road	is like . . .		
Starting your trip and changing the destination	is like . . .		

▲ **Figure H3C.2 Analogy map example.** This analogy map is one you could use to compare a road trip you might take with the process of scientific inquiry.

3 *Data tables* provide a place to record observations or data from an investigation. You can create graphs from the information in these tables or interpret your data directly from the tables themselves.

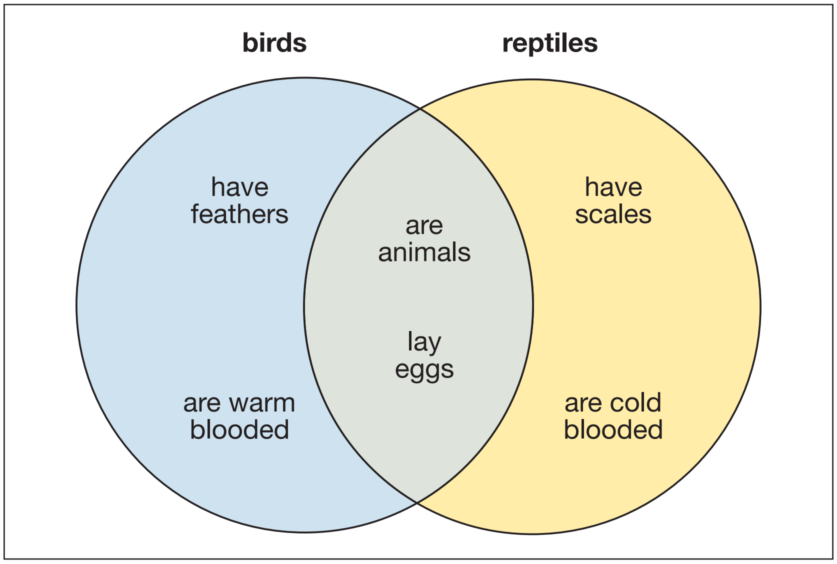
Material	Volume of liquid sample (mL)	Mass of cylinder with liquid sample (g)	Mass of cylinder alone (g)
Sample A	100	142.54	2.54
Sample B	100	93.21	2.54
Sample C	100	83.44	2.54

▲ **Figure H3C.3 Data table example.** Data tables are a place to record both qualitative and quantitative observations or data from an investigation. This data table shows data recorded as students conduct an investigation about density. The data can be used to make a graph or do calculations.

Learning Strategies

3D HOW TO Use and Create Venn Diagrams

Venn diagrams are a powerful strategy for comparing topics or concepts. You can use them to visually show similarities and differences. A Venn diagram is made up of two or three overlapping circles. Each circle represents one topic or concept. The region inside each circle lists characteristics of the topic or concept. The part of the circle that overlaps contains characteristics common to both concepts. See the example in figure H3D.1. Then try creating your own Venn diagrams using Steps 1–5 to help you.



▲ **Figure H3D.1** **Venn diagram comparing birds and reptiles.**

Venn Diagram Guidelines

1. Draw 2 overlapping circles like the ones shown in figure H3D.1. Use at least a half sheet of paper for the circles to give you enough room to write inside the circles.
2. Label each circle with the topics or concepts you are comparing.
3. Identify the important characteristics of the topics or concepts.
4. Write the characteristics that are specific to only 1 of the 2 topics or concepts in the circle, outside the overlapping area.
5. Write the characteristics that are common to the topics or concepts in the area where the circles overlap.

Learning Strategies

3E HOW TO Make Better Observations

You were not born knowing how to make good-quality scientific observations. But you can learn. Effective scientists have made good-quality observations for centuries. The following questions related to making observations are not a step-by-step procedure. Rather, they are guidelines (in the form of questions) to help you *think* your way through observations. When done well, observations help you link what you see to what it means—the very heart of science.

Observation Guidelines

- How is each procedural step related to the focus question or problem you are investigating?
- What is the best way to represent the initial conditions (with tables, sketches, graphs, equations, or sentences)?
- What is the best way to record the final conditions?
- What is the best way to record what happens *during* the investigation?

You need to focus on what is happening during the investigation, but sometimes changes occur very quickly. In these cases, you must plan carefully so that you are not distracted by writing down your data.

- How do you know that the changes you see are the result of the variable that you are manipulating and not other variables?
- Will multiple trials increase your confidence in what you see?
- What is the best way to keep a record of your initial ideas and how those ideas change during the course of the investigation?

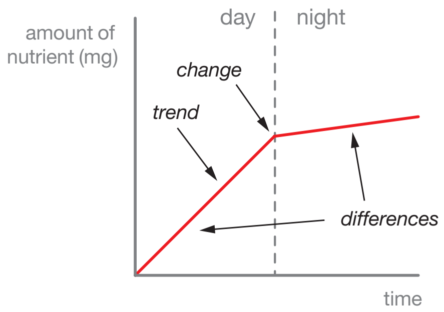
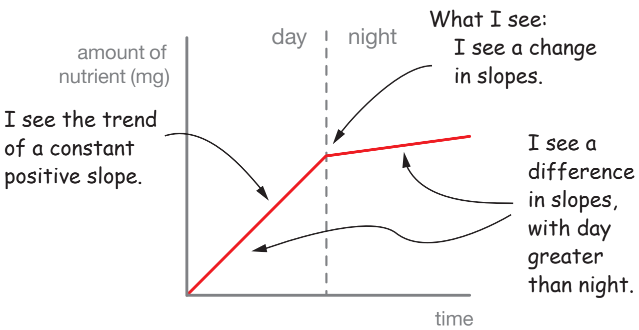
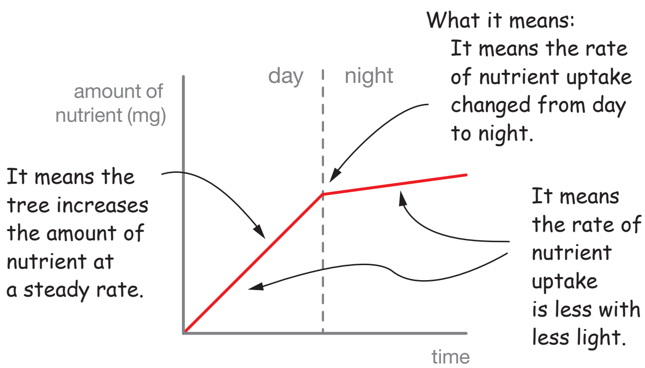
Learning Strategies

3F HOW TO Write Highlight Comments and Captions

How do you make sense of charts, diagrams, graphs, and sketches? You do what scientists have been doing for centuries. You note what you see, then you try to say what it means. This process helps you connect evidence to interpretations—a hallmark of scientific inquiry.

Highlight comments help you link observations from graphs, charts, and other spatial forms of representation to possible interpretations. Captions assemble highlight comments into sentences that form a coherent paragraph. This paragraph tells the story of the graph, chart, or sketch and communicates the "executive summary" of the essential understandings displayed. The combination of highlight comments and captions helps you communicate scientific information with increasing effectiveness, improving your performance and deepening your understanding of the natural world.

Suppose you investigated the uptake of a nutrient by a tree over 24 hours. How would you make sense of the data? Follow the steps in figure H3F.1 and use them as a general guide for any graph, chart, diagram, or sketch you make.

<table>
<tr><th>Commenting step</th><th>Example and comments</th></tr>
<tr><td>1. Look for changes, trends, or differences. Draw an arrow to each of these you notice in the graph.</td><td>
</td></tr>
<tr><td>2. Write what you see. Each arrow has a different description. Be concise. Write only the essence, or highlights, of what you see.</td><td>
</td></tr>
<tr><td>3. Interpret what you see. Write what each observation means. Don't interpret the entire figure at once, just one observation at a time.</td><td>
</td></tr>
<tr><td>4. Write a caption. Think of the caption as an executive summary. Start by joining each "What I see" to its "What it means" to form a sentence. Then build a coherent paragraph out of the sentences. Begin your caption with a topic sentence describing the overview of the figure.</td><td>Caption: This graph shows the uptake of nutrients in a tree over a 24-hour period. During the day, the graph shows a constant, positive slope, meaning there is a steady rate of uptake. At night, the rate changes as shown by change in slopes. This suggests that light changes the rate of uptake. Finally, the night slope is less than the day slope, meaning the uptake of nutrients slows at night.</td></tr>
</table>

▲ **Figure H3F.1** **Steps for writing highlight comments and captions.**

Learning Strategies

3G HOW TO Use the *Learn from Mistakes* (*LFM*) *Protocol*

School isn't just a place to deposit right answers. Sometimes we make mistakes. In fact, most humans make mistakes when they try to learn something, especially when the subject is difficult or new. When you learn to identify and explain what's incorrect about a wrong answer, you have a better chance of avoiding that mistake next time.

The *Learn from Mistakes* (*LFM*) *Protocol* was designed to help you learn from wrong answers. You will use it after you take certain tests. For each of the questions you missed on the test, perform the following steps. If you do, you can earn up to 50 percent of the difference between your raw percentage score and 100 percent. Be sure to write your raw percentage score at the top of the test along with a list of the numbers of the questions you missed.

Learn from Mistakes Protocol

1. Represent the original question in a different way than it was represented on the test. For example, if the question was mostly words, represent it as a sketch. If it was mostly a sketch, represent it in words. When you use words, paraphrase the question in your own words. Do not copy the question word for word. Label any sketch with all the variables, especially the unknown. If the problem mentions any change in condition, then show a before-and-after sketch.
2. Identify and explain the mistake you made in the answer you selected. Focus on explaining any conceptual misunderstanding. When you explain what is incorrect, show how the misconception would lead to a contradiction with what you see in nature. Explanations like, "I read the problem wrong" and "I pushed the wrong button on the calculator" will receive no credit.
3. Show the correct solution or answer. When necessary, show all governing equations, first in symbol form, then followed by substitution with number values. Always place proper units and labels on answers. Include why the answer is reasonable.

Learning Strategies

3H HOW TO Solve Problems

Humans aren't born knowing how to build dams, determine why a baby is crying, or understand when *i* comes before *e*. We have to learn how to solve these problems. That's one of the primary benefits of school. You learn how to solve problems.

Every problem seems different. But successful problem solvers use a general approach that works for a large variety of everyday and school problems. Read the following problem, then learn how expert problem solvers find a solution. Try to use this approach with the next problem you're asked to solve. An example follows.

Problem-Solving Guidelines

1. *Read the problem.* Often, reading the problem aloud helps you to understand what the problem is asking you to do.

   Example problem: You push a 20-kilogram (kg) box across the floor at 3.0 meters per second (m/sec) with a constant force of 10 newtons (N). What force does the box exert on you?

2. *Adjust your mind-set.* Your attitude toward problem solving matters. The brain that thinks, also feels. Get rid of fears of failure or incompetence. Don't allow resentment or anger to cloud your thinking.

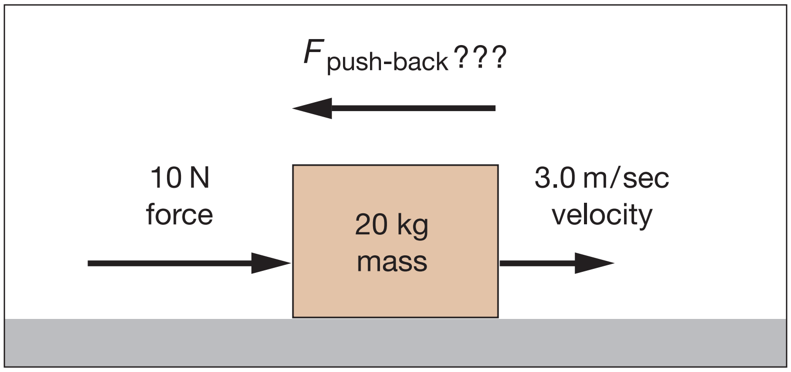
   Example mind-set statements to avoid: "I can't do science, so I'm not going to try." "I never get these right. I give up." "I'll never use this. Why should I do the problem?" "I hate not knowing what to do, so I'm not going to do it."

3. *Sort the problem.* Read the problem and use your prior experiences to determine what you know and don't know in the problem. This step clears your mind so that it can focus on the important features of the problem. It starts you thinking about the real question, not the things that distract you from the solution. The following table is an example of a way to organize your thoughts.

What I know, understand, or assume	What I don't know or understand
I pushed with 10 N force.	How does the box exert a force?
The box has a mass of 20 kg.	How do I find out the amount of box force?
The velocity is 3.0 m/sec.	Why is the box force "pushing back" on me?
The box moves in the same direction as the push and doesn't leave the floor (my assumption).	

▲ **Figure H3H.1** **Problem-solving table.**

4 *Represent the problem*. Translate what you know and don't know into some form other than writing. Sketches, graphs, charts, and lists are examples. Be sure to transfer the items from your problem-solving table to the representation.



▲ **Figure H3H.2** **Example representation of forces on mass.**

5 *Apply a strategy*. Expert problem solvers use a variety of methods, not just one. Successful methods include applying key concepts, using logic, trying to guess and then check, finding a pattern, working backward, and acting it out. Don't let yourself get stuck! If one method isn't working, try another.

Example application of the key concepts to the strategy: "I remember learning that all objects push back if you push on them. That makes me think of Newton's third law—forces come in pairs that are equal in size and opposite in direction. So if I push with 10 N, that means the box pushes back with 10 N. The velocity isn't important in the problem."

6 *Check for reasonableness*. Build confidence in your answer. Check it against your everyday experience or scientific theory. If there's a contradiction, then repeat the problem-solving steps as needed.

Example: "I feel something when I push on a box or a wall. That must mean the object pushes back. I remember that a net force causes acceleration. Since the box has a constant velocity, the net force must be zero. That means the push-back force has to be equal to my force. If I thought my force was greater, then the box would accelerate, which contradicts the problem statement."

4 HOW TO Construct a Concept Map

Concept maps are tools that help you organize ideas in a way that shows the relationships among them. There is no one right concept map for a body of information. But together, the concept words, connecting lines, and linking words should be an accurate representation of the content. To create a concept map, follow these steps.

Concept Map Guidelines

1. Identify the major concept that you will map. Then list several words or phrases that are important to understanding this concept. These should be words or phrases that identify parts of your major concept, such as parts of a system, a key idea, or an important process.
2. On a new page in your science notebook, write the major concept that you will map at the top of the page and draw a box around it. Arrange the related words or phases below this box. Arrange these words so that the bigger ideas are near the top and the more specific ideas are near the bottom. Draw boxes around these words as well.
3. Draw lines between the boxes to show relationships between the concept words. Lines can crisscross to show complex relationships.
4. Label the lines with linking words that describe the relationships.

Study the sample concept map in figure H4.1 of AIDS concept words, connecting lines, and linking words on the map.

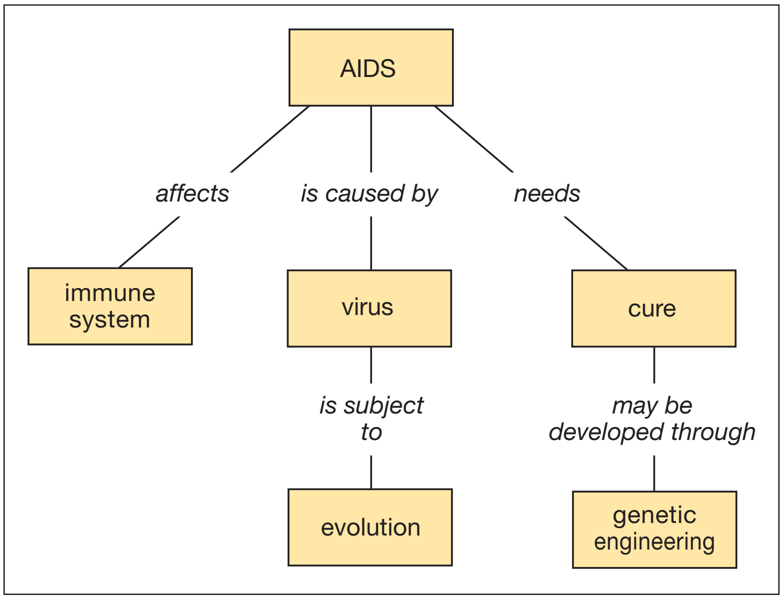


Figure H4.1 **AIDS concept map.**

Improving Math Skills

5A HOW TO Use Graphs, Measure Slopes, and Estimate Uncertainty

Do you like sports? Do you follow how certain teams or players do in football, baseball, or basketball? Or do you note how the price of music CDs or snack foods changes? Perhaps you need to show results from an investigation in a business, science, or math class.

For these and other cases, it is important to be able to show observations or data in graphs and plots. This skill helps you show a bigger picture of trends in data. Similarly, you also need to be able to read and interpret a few basic types of charts and graphs. This is true for many professions and for fields besides science.

The Basics: Labels and Limits

For most graphs, you typically show a variable across the bottom of the graph. This direction of the graph is called the *x-axis*, or *horizontal axis*. The amount that this variable changes is shown in a horizontal direction. The amount that a variable changes in the vertical direction is shown on the *vertical axis*, or *y-axis*. The axes have these names because you often plot data points with x and y values. The data points are also called the *xy coordinates*, written as (x,y). Examples of this follow.

An important next step in plotting a group of data is deciding the limits for the x-axis and the y-axis. To do this, examine your data and write down the high values and the low values for the x and y variables. Your axes must extend a little bit beyond the highest number, typically about 10–20 percent further. For a variable you measured, the difference between the high value and the low value is called the *spread*, or w. Starting the x- and y-axes at the value of zero is useful, depending on the data you are plotting.

You will see examples where the x-axis represents a category of a thing. The section titled *The Bar Graph* shows this. The type of thing is on the x-axis, while the amount of each thing is shown on the y-axis.

Let's look at examples of types of graphs that you will use in science and other fields.

The *xy* Plot

The *xy* plot is a simple plot where pairs of *xy* data are plotted as data points in a graph. Sometimes people call an *xy* plot a scatter plot. As you will see, this name really isn't appropriate because the data can define very straight lines (correlations) rather than scattered points.

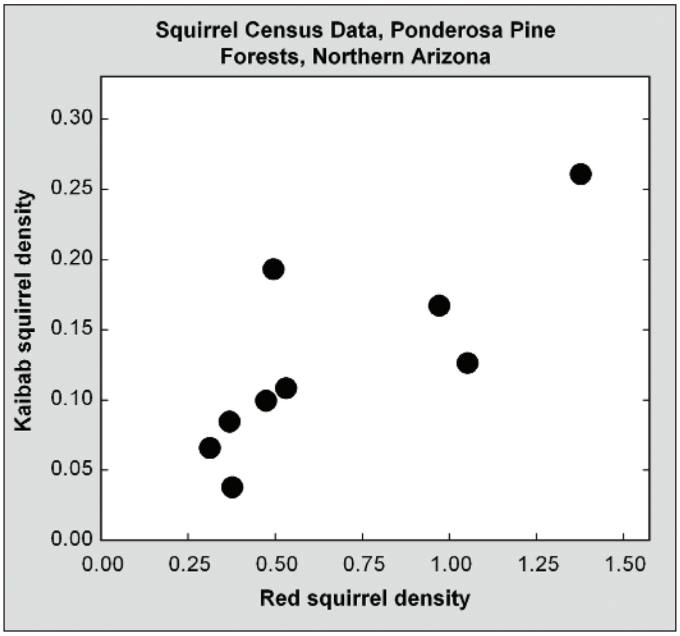
For example, the table in figure H5A.1 shows the population densities of two kinds of squirrels that live in the ponderosa pine forests in northern Arizona. The population density is the number of squirrels counted for an area 100 × 100 meters, about the area of two soccer fields. By examining the table, you can quickly see that red squirrels are more common overall than Kaibab squirrels in these forests. Note the shading on the high and low values in the table. You can see that the spread, w, for the red squirrel is about 1.1 (= 1.38−0.31) and the spread for the Kaibab squirrel is about 0.23 (= 0.26−0.038).

Red squirrel	Kaibab squirrel
0.3685	0.0844
0.4955	0.1931
0.5317	0.1083
0.4739	0.0993
0.9713	0.1671
1.0529	0.1263
1.3779	0.2607
0.3126	0.0657
0.3770	0.0377

▲ **Figure H5A.1 Data on red and Kaibab squirrels.**

The values in the table help you decide the limits for the graph. You have some options, but the values of $x = 1.6$ and $y = 0.4$ work well for plot limits in this example.

The *xy* plot in figure H5A.2 helps you see relationships much better than the data table. The *xy* plot shows clearly that as the number of red squirrels



▶ **Figure H5A.2 Plot for red and Kaibab squirrels.** *xy* plot showing the relationship between the density of red and Kaibab squirrels in northern Arizona ponderosa forests.

increases, the number of Kaibab squirrels also increases. We say that such data show a *correlation* between red and Kaibab squirrel populations. But why would that be? After viewing these data, a biologist might be interested in further exploring the factors that might cause the number of red and Kaibab squirrels to change together. In Level 1 of *BSCS Science: An Inquiry Approach*, you actually learn about the culprit behind why the numbers of red and Kaibab squirrels are correlated in these ponderosa forests.

Determining the Slope

An important feature of xy plots is that they show relationships between pairs of x and y values. When xy pairs define a line, you can calculate the slope to find out how much the y value changes for each change in the x value. You are probably familiar with this as rise over run, or $\frac{\Delta y}{\Delta x}$. When the variable on the x-axis is time, slope is very important because it gives you a rate of change. You have seen that this is part of calculating velocities.

Take an example of a car. You have a record of the total distance that the car has traveled at certain points in time. The data are shown in the graph in figure H5A.3. For example, after about 3 hours (hr), the car has traveled about 190 miles (mi). On average, what is the velocity of the car?

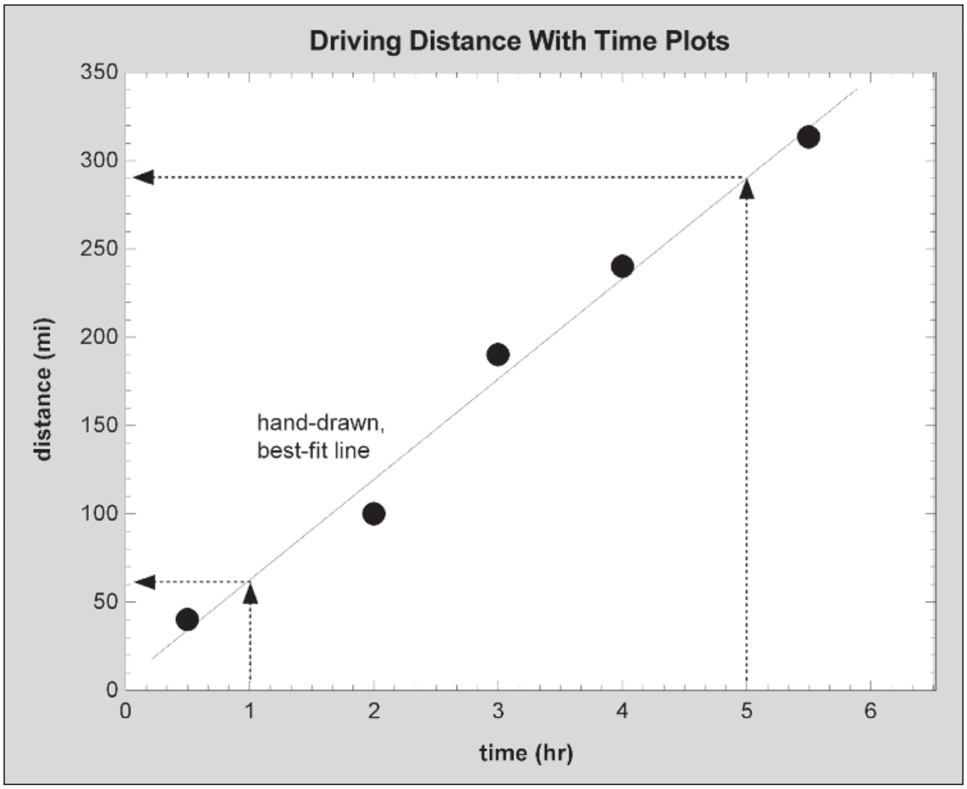


Figure H5A.3 Driving distance with time plots.

You can determine the average velocity by finding the slope using Steps 1–5.

1. Draw a line that goes as closely as possible through the points.
2. Pick any 2 values on the x-axis, even if they do not have actual data points. You can select values of 1 and 5 hr from the graph in figure H5A.3.
3. Project these points up to where they intersect the best-fit line that you have drawn.
4. Read the y-axis value where the x-axis intersects the slope. By doing this, you obtain the xy coordinates of 2 locations on the line. You can show these locations in a T-table or designate them as x_1,y_1 and x_2,y_2.
5. You calculate the slope with a series of points on the line. By being careful to keep units for the x- and y-axes, this example shows that slope also tells you velocity when time is on the x-axis.

$$slope = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

$$= \frac{(290 - 61)\ \text{mi}}{(5 - 1)\ \text{hr}} = \frac{229\ \text{mi}}{4\ \text{hr}} = 57.3\ \frac{\text{mi}}{\text{hr}}$$

You'll want to remember a few extra points. First, the slope, $\frac{\Delta y}{\Delta x}$, is a rate when the change in the denominator of the slope, Δx, is time. For example, the car's velocity was a rate with units of miles per hour. Second, at times you can draw a best-fit line, but keep in mind that not all physical relationships are linear. You'll see a nonlinear example using radioactivity in the next section, *The Time-Trend Plot*. Other examples in this program use acceleration, population growth, erosion of mountains, and cyclical changes. Thus, slope is only valid for lines, or nearly linear relationships.

The Time-Trend Plot

The *time-trend plot* is a kind of xy plot where the x-axis has the units of time. These types of plots are used for testing whether a variable changes in a predictable way as a function of time. The measured variable is shown on the y-axis, with time on the x-axis.

Take records of monthly temperatures in Denver, Colorado, for example. Figure H5A.4 shows temperature data for 5 years from 2000–2004. Temperature is on the y-axis, with year and month on the x-axis. The bold line shows the average monthly temperature. This line is bound by the average high temperature (the average of daily high temperatures for the month) and the average low temperature (usually the average of daily low temperatures for the month). The plot shows annual temperature cycles. Moreover, the graph shows differences among the years.

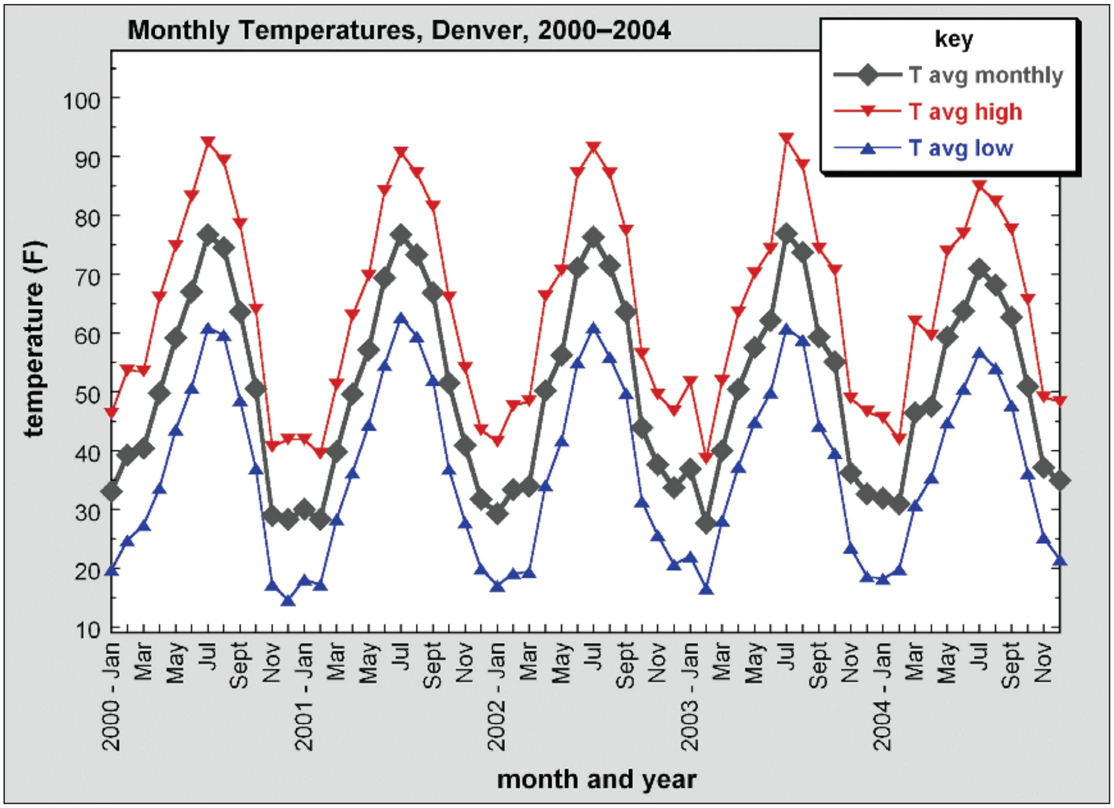
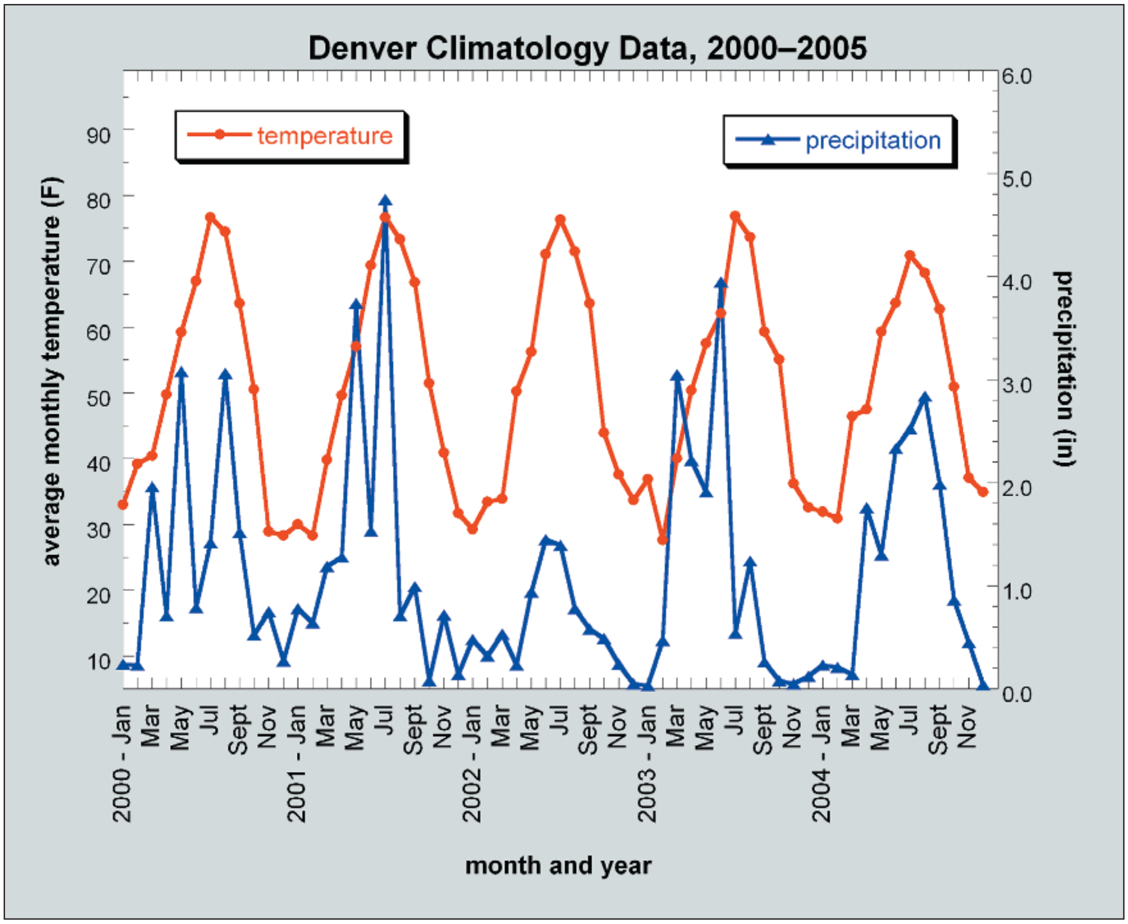


Figure H5A.4 Temperature plot for Denver, Colorado.

Another useful type of *xy* plot is called a “double *y*” plot. This plot uses both the left and the right *y*-axes to show the values for two variables against a common variable on the *x*-axis. Double *y* plots are useful for time trends, as shown in figure H5A.5 for temperature and rainfall over 5 years in Denver. (Note that low rainfall in winter correlates with snow.)



▲ **Figure H5A.5** **Denver temperature and precipitation using a double *y* plot.**

The *xy* graph can also be used to show another technique for graphing. Often, we use a regular scale for tick marks on the axes. These plots are *linear.* At other times, the major tick marks on the axes are compressed and show factors of 10. Usually, these axes denote a logarithmic pattern. We call these *log* axes.

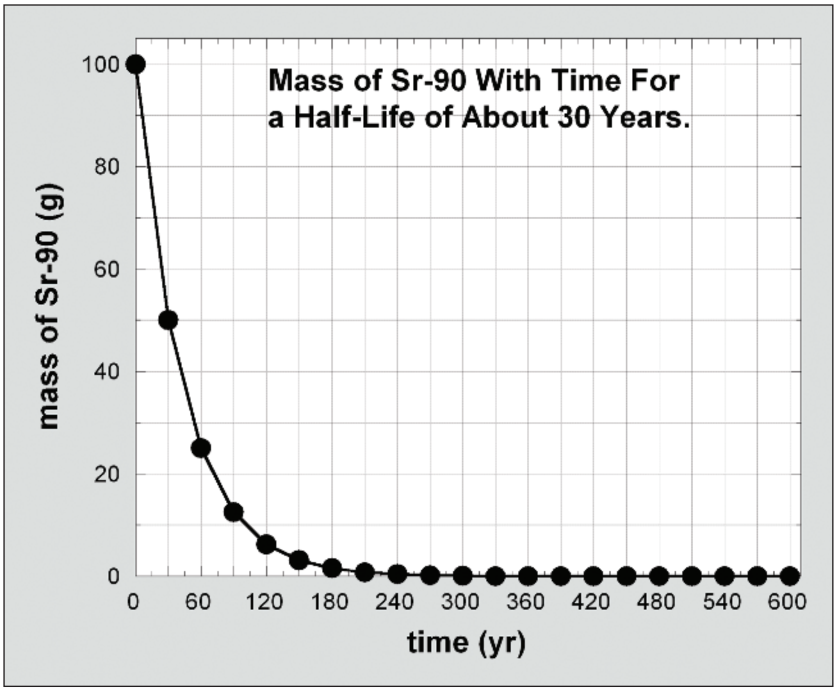
Consider a nuclear disaster. A product of nuclear reactions with the element uranium (U-235) is radioactive atoms of strontium-90 (Sr-90). Authorities have been concerned about radioactive Sr-90 because it is similar to calcium and it lodges rapidly in the bones of humans. Human bodies use calcium for bones. Radioactive atoms of Sr-90 in your bones are not good.

The mass of radioactive Sr-90 in a sample decreases by one-half (50 percent) in about 30 years (28.8 years, to be exact). This is the *half-life* of Sr-90. The table in figure H5A.6 shows that starting with an initial mass of 100 grams (g) of Sr-90, the mass of Sr-90 decreases by half, or 50 percent, every 30 years.

The data from the table are much easier to see and examine in a graph. For every 30 years that pass, the mass of Sr-90 decreases by about half. For example, after 60 years (two half-lives), only about 25 percent of the initial Sr-90 atoms remain. It appears from the plot in figure H5A.7 that the Sr-90 is gone after about 240 years. But on this linear scale, how would you tell if amounts still existed that were too small to show up on this graph? Even a gram or less of Sr-90 can be a health hazard.

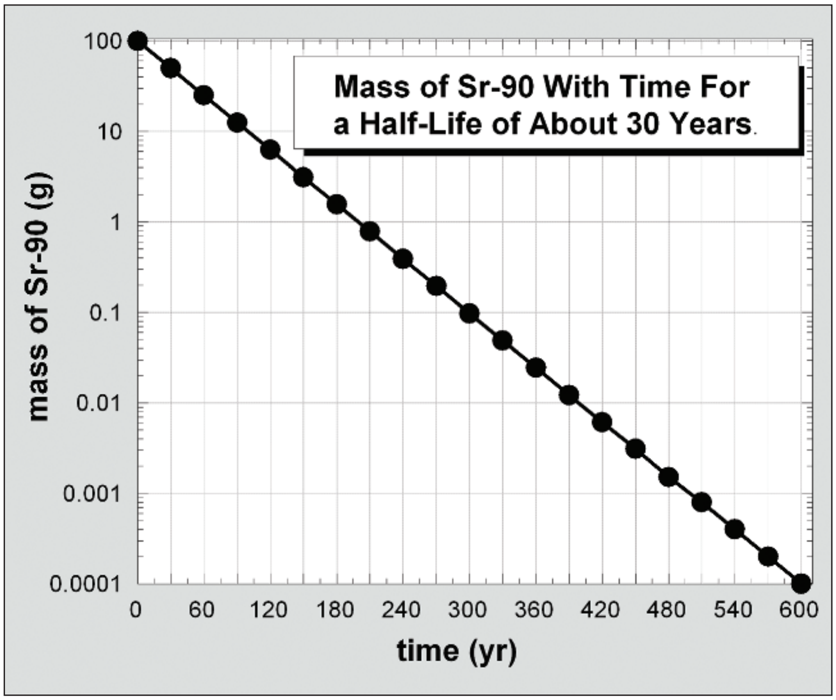
Years	Mass of Sr-90 (g)
0	100.0000
30	50.0000
60	25.0000
90	12.5000
120	6.2500
150	3.1250
180	1.5625
210	0.7813
240	0.3906
270	0.1953
300	0.0977
330	0.0488
360	0.0244
390	0.0122
420	0.0061
450	0.0031
480	0.0015
510	0.0008
540	0.0004
570	0.0002
600	0.0001

Figure H5A.6 Sr-90 decay table.



▲ **Figure H5A.7** Linear plot of Sr-90.

You would use a log scale on an axis in what's called a *log plot*. In a log plot, the scale of the *y*-axis is modified so that increments are divided for each factor of 10. In general, values increase from 0.01, 0.1, 1.0, 10, 100, 1,000, and so on.



▲ **Figure H5A.8** Log plot of Sr-90.

A key feature of the log plot is that the y-axis never goes to zero. Also, a value halfway between factors of 10 is roughly three, compared with five (between 0 and 10) on a linear scale. The graph in figure H5A.8 shows the same Sr-90 data in a log plot.

The Bar Graph

Bar graphs show the values or frequencies (on the y-axis) as a function of categories of things (on the x-axis). The x-axis does not have a numeric scale, either linear or log.

How could we show the frequency by month of tropical storms or hurricanes for the Atlantic Ocean in 1998? Bar graphs are perfect for this. Figure H5A.9 shows that for 1998, tropical storms occurred from July to September, with hurricanes occurring from August to November. Hurricanes also had a pronounced peak in September. Given such data, a scientist could then examine other years to test whether the pattern applies to those years.

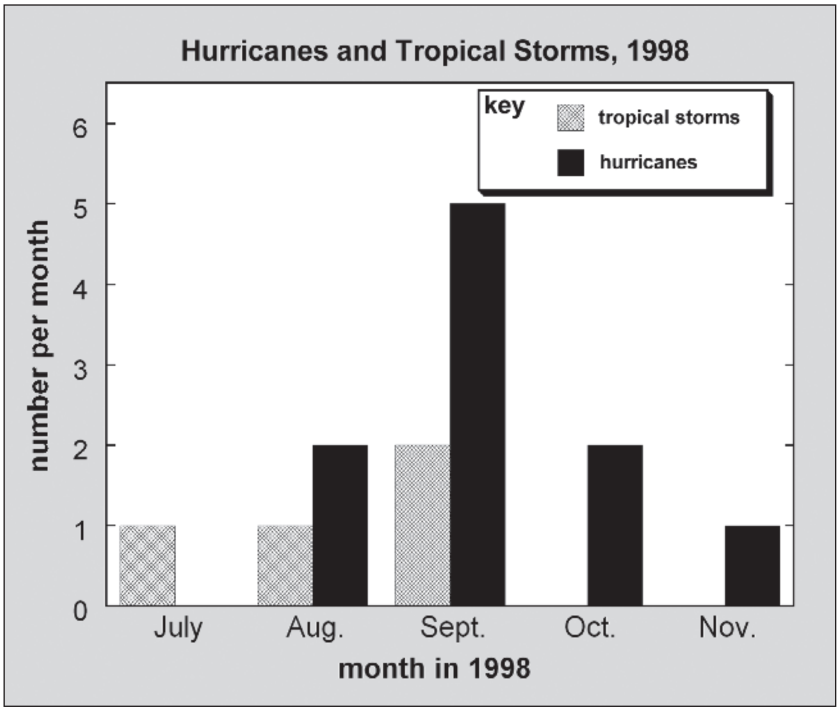


Figure H5A.9 Hurricanes and storms bar graph. This bar graph shows the frequency in 1998 of tropical storms and hurricanes in the Atlantic Ocean.

The Histogram

Histograms are another type of graph. They show how often a result occurs. Let's take an example showing scores in geology class. The following histograms show the scores for 27 students on a final mapping project for a geology class. The first histogram (figure H5A.10) shows compartments, or *bins*, where the scores are tallied. Bin sizes of two and five are shown for the same set of scores. The average score is 88.1, which falls in the bar with the highest value in figure H5A.10. The histograms show the *variability* of data about the mean.

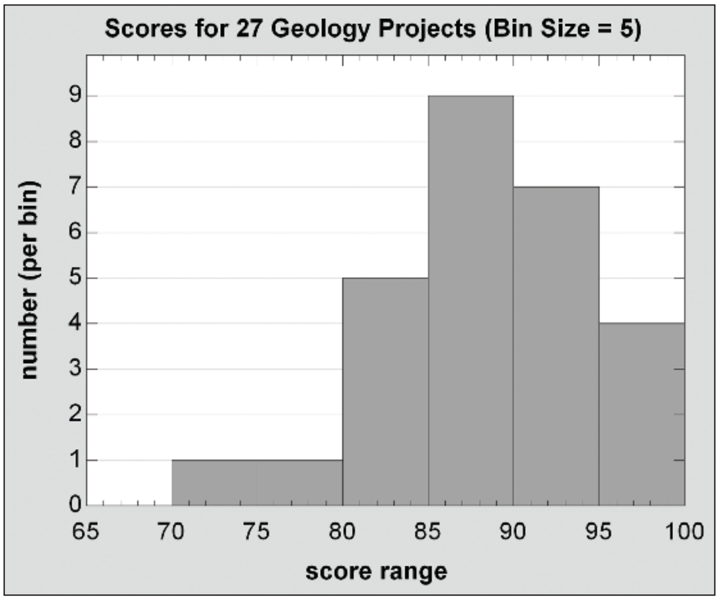


Figure H5A.10
Geology scores histogram where bin = 5. This histogram shows scores for 27 geology projects with a bin size of five.

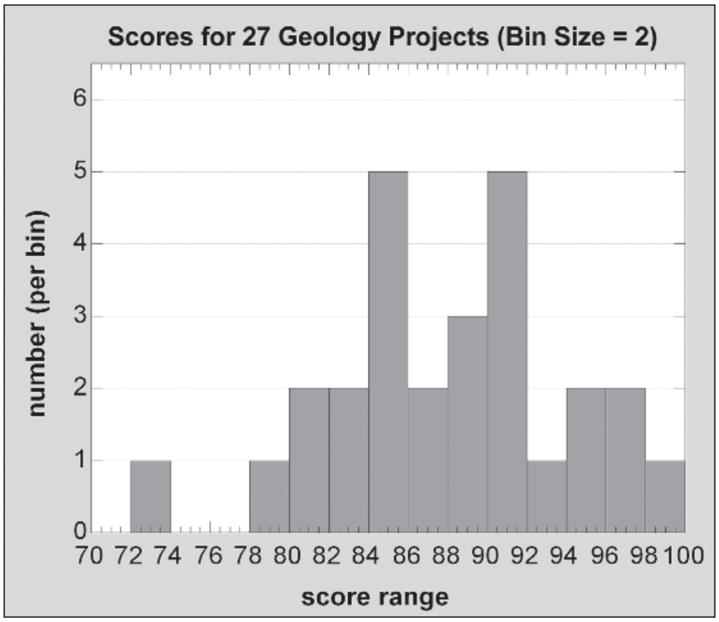


Figure H5A.11
Geology scores histogram where bin = 2. Histogram of scores for 27 geology projects with a bin size of two.

For comparison, the second histogram (figure H5A.11) shows the same scores ($n = 27$) using a finer bin size of two. The result is similar, but shows two distinct peaks on each side of the mean of 88.1. You may wish to test different bin sizes to show important points in a histogram that you wish to make.

Note several things about histograms. In the histogram where the bin size equals five, values are distributed about a peak in the center. Sometimes this is called a *bell-shaped curve*. This happens when the number and positions of observations to the right and to the left of the peak are approximately equal. You might see a pattern like this by plotting a histogram of the heights of all students in your class. Your graph might have a peak value around 5.5 feet (ft), with a smattering of values in bins above and below 5 ft, 6 inches.

The key to making histograms is to first record your data or observations in a long column. Then decide the size of your bins. Finally, tabulate how many values in your column fall in each bin. Following these suggestions will help you successfully plot your histogram.

The Pie Chart

Another way to represent measurements or data is with a *pie chart*. This type of graph is called a pie chart because categories are spread around a circle, rather than along an x-axis, and look like slices of pie. The amount per category is given as a percentage of a total. Your teacher can show you how to take percentages for categories and divide them proportionately into a circle of 360 degrees.

Consider the human body. You may have heard statements such as, "Most of the human body is water." But what elements are in the human body? The pie chart in figure H5A.12 shows clearly that we are about 92 percent oxygen, carbon, and hydrogen.

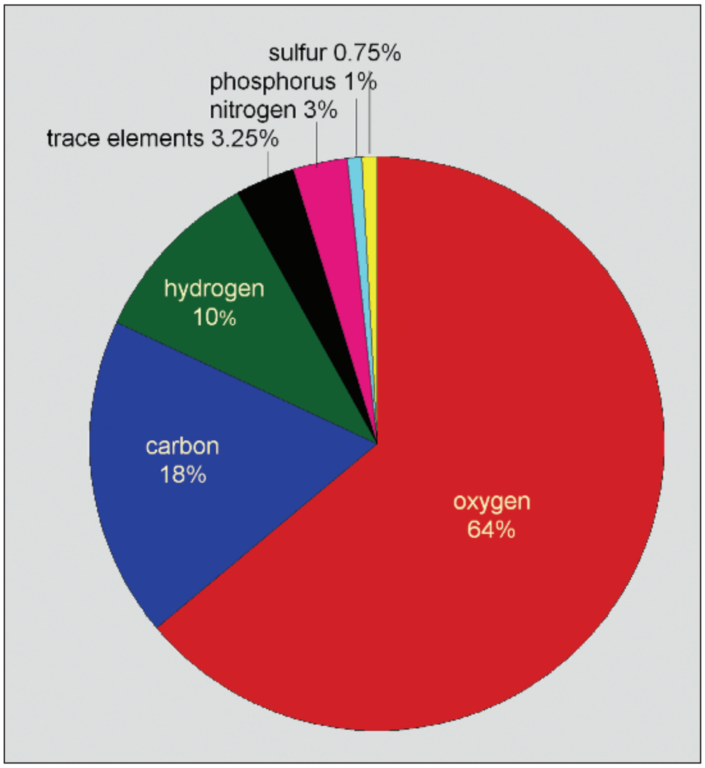


Figure H5A.12 **A pie chart showing the body's elements.**

Showing Uncertainty (or Error) in Measurements

A good experimental design often requires that you repeat a measurement several times. Because experiments are not perfect, it is unlikely that you will get the same exact measurement in each trial. An average, $\bar{x}$ or "mean," is one way to estimate the actual value from your measurements. You are used to calculating averages. But how would you show the variability of your measurements around that mean? There are several ways to do this.

One way is to show all measured values around the average. Consider the scores on the final project in the geology class from the section *The Histogram*. The plot in figure H5A.13 shows all 27 student scores, along with a large symbol for the mean. For comparison, individual scores with means are plotted for two prior assignments (a quiz and a midterm) in that geology class.

A second way to represent all measured values is to calculate an indicator of uncertainty around the average. This is a quick way to estimate the standard deviation, another term that you might have heard. First, calculate the spread, w, between the high and low values. Next, to estimate the uncertainty (or error), e, divide the spread by the square root of the number of measurements, n.

$$e = \frac{w}{\sqrt{n}}$$

For the final project, the spread is $w = (98.3 - 73.1) = 25.2$. For 27 scores ($n = 27$), this gives an uncertainty of ± 4.8. The $\pm$ sign shows that the uncertainty in scores extends both above and below the mean. This estimate of uncertainty indicates that about 60–70 percent of the scores will have values bracketed by $\bar{x} \pm e$. With the geology final projects, this is 88.1 ± 4.8. (That is, about 60–70 percent of the scores fall in a range from 83.3 to 92.9.) This can also be shown graphically by error bars on the graph in figure H5A.14.

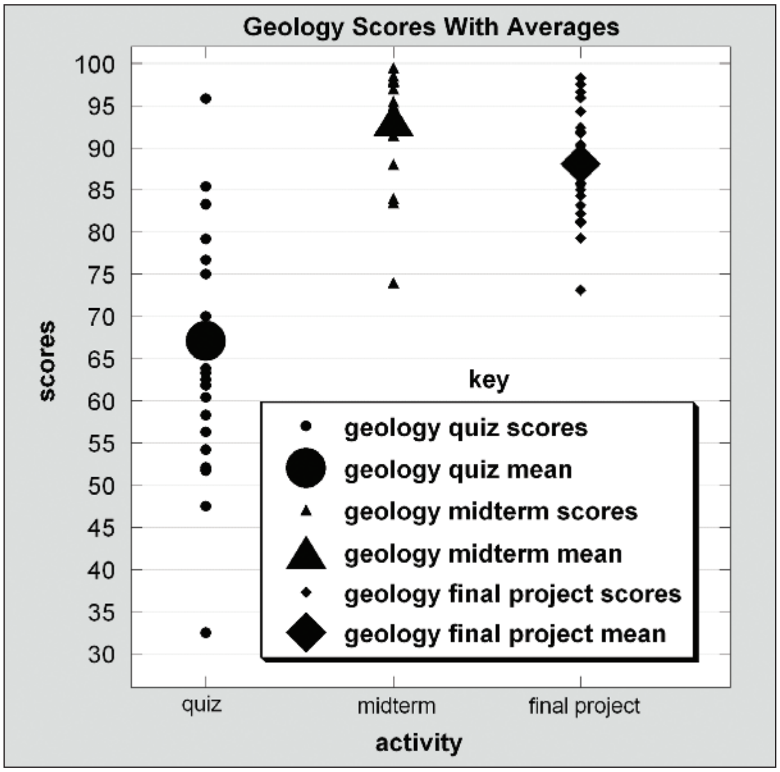


Figure H5A.13 Geology scores with averages.

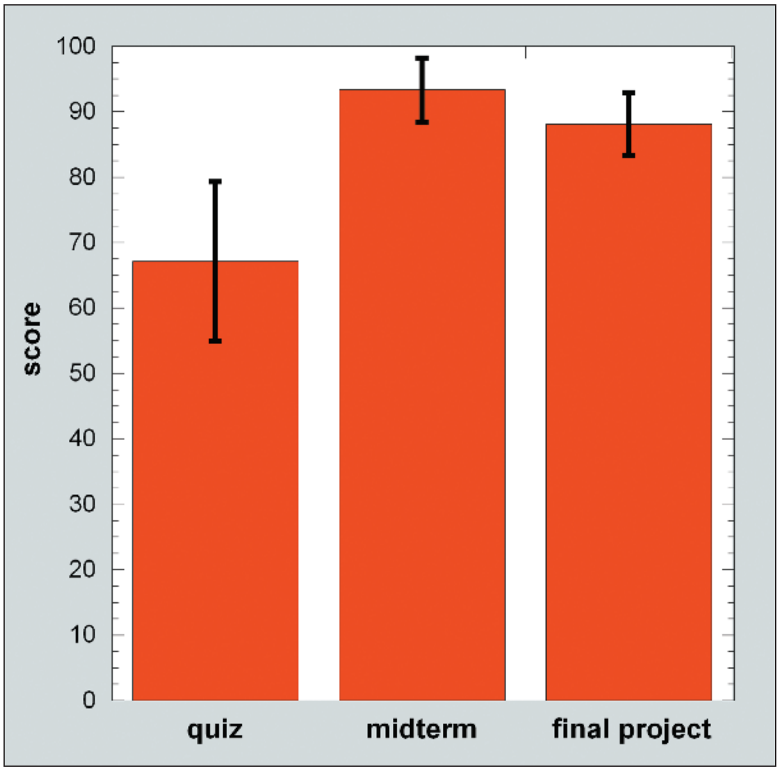


Figure H5A.14 Geology scores with errors.

Improving Math Skills

5B HOW TO Do Unit Conversions

When you measure something, you always need to indicate what units you are using. For example, suppose someone told you that her cat had a weight of "20." That doesn't mean much without units. Does the cat weigh 20 pounds, 20 newtons, 20 ounces, or 20 tons? Distance measurements (length) also need units such as feet, inches, meters, kilometers, and miles. If you are measuring time, you use units such as seconds, minutes, hours, and years.

Converting between units is also very important. For example, what if a friend told you that he would phone you in 86,400 seconds (sec)? When would that be? After this activity, you will be able to show that this is the same as 1 day. Unit conversions are also important for comparing two measurements made with different units. For example, suppose a person who is 5 feet (ft) 8 inches (in) tall has a hat on that is 0.30 meters (m) tall. What is the total height of the person, including the hat? Unfortunately, you cannot simply add the lengths. You must convert all of them to the same unit, and then you can add the lengths. You may have to convert again to a more reasonable unit. The total height of the person would be 79.8 in, 6 ft 7.8 in, or 2.03 m tall.

How do you make these conversions? The method is called unit analysis (or dimensional analysis). These terms may sound complicated, but the method is pretty simple. The method uses conversion factors to convert units step-by-step, canceling units at each step. Using these guidelines, unit analysis is simple.

Unit Analysis Guidelines

1. Conversion factors relate different units and are different ways of expressing the number 1. For example, there are 12 in in 1 ft, or

   $12 \text{ in} = 1 \text{ ft, or } \left(\dfrac{12 \text{ in}}{1 \text{ ft}}\right) = 1.$

2. Conversion factors can be flipped (inverted) as long as the units stay with the number. For example, you can write

   $\left(\dfrac{12 \text{ in}}{1 \text{ ft}}\right) = 1, \text{ or } \left(\dfrac{1 \text{ ft}}{12 \text{ in}}\right) = 1.$

   This is the same thing.

3. Units behave as numbers do when you multiply fractions. The units in the numerator of fractions will cancel the same units in the denominator of fractions. For example, $\left(\frac{12\ \cancel{in}}{3\ \cancel{in}}\right) = 4$.
4. In unit analysis, your goal is to cancel the same units in the numerators and denominators until you end up with the units you want.
5. When you convert between units, follow these steps.
   a. Identify the units that you have.
   b. See which units you want.
   c. Note the conversion factors that get you from Steps 5a and 5b.
6. Work through the following example to practice using the guidelines for unit analysis from Steps 1–5.

   How many inches are there in 1 mile (mi)?

Conversion steps (from Step 5)	Answers
What unit do you have now?	1 mi
What unit do you want?	"How many inches"
What are the conversion factors?	$1\text{ mi} = 5{,}280\text{ ft}$ or $\left(\frac{5{,}280\text{ ft}}{1\text{ mi}}\right) = 1$ $1\text{ ft} = 12\text{ in}$ or $\left(\frac{12\text{ in}}{1\text{ ft}}\right) = 1$

Figure H5B.1 **Conversion table for miles to inches.**

To convert miles to inches, start with what you know (1 mi). Then use conversion factors (figure H5B.1) to cancel units as you go until you get to the units that you want (inches). When the same units are on both the bottom and the top, they cancel. Work with your teacher to see how to cancel these units on the top and bottom.

$$(1\ \cancel{mi}) \times \left(\frac{5{,}280\ \cancel{ft}}{1\ \cancel{mi}}\right) \times \left(\frac{12\text{ in}}{1\ \cancel{ft}}\right)$$

The units cancel, so you are left with units of inches. You can then multiply the numerator numbers together for the answer in inches.

$$(1\ \cancel{mi}) \times \left(\frac{5{,}280\ \cancel{ft}}{1\ \cancel{mi}}\right) \times \left(\frac{12\text{ in}}{1\ \cancel{ft}}\right) = \left(\frac{1 \times 5{,}280 \times 12\text{ in}}{1 \times 1}\right) = 63{,}360\text{ in}$$

7 Work through a more complicated example using dimensional analysis. Suppose that you want to convert 75 miles per hour (mph) into feet per second (ft/sec).

Conversion steps (from Step 5)	Answers
What unit do you have now?	$75 \dfrac{\text{mi}}{\text{hr}}$ (mph)
What unit do you want?	$\dfrac{\text{ft}}{\text{sec}}$ (ft/sec)
What are the conversion factors?	1 hour (hr) = 60 minutes (min) 1 minute (min) = 60 seconds (sec) 1 mi = 5,280 ft

Figure H5B.2 **Conversion table for miles per hour to feet per second.**

Now what? Take your conversions (figure H5B.2) one step at a time, canceling units as you go until you arrive at the units you want.

$$\left(\frac{75\ \cancel{\text{mi}}}{1\ \cancel{\text{hr}}}\right) \times \left(\frac{5{,}280\ \text{ft}}{1\ \cancel{\text{mi}}}\right) \times \left(\frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}}\right) \times \left(\frac{1\ \cancel{\text{min}}}{60\ \text{sec}}\right) =$$

$$\left(\frac{75 \times 5{,}280\ \text{ft} \times 1 \times 1}{1 \times 1 \times 60 \times 60\ \text{sec}}\right) = \left(\frac{396{,}000\ \text{ft}}{3{,}600\ \text{sec}}\right) = \left(\frac{110\ \text{ft}}{1\ \text{sec}}\right) = 110\ \frac{\text{ft}}{\text{sec}}$$

8 Try the conversions in Steps 8a–c on your own. Use the following conversion factors, and show your calculations for each conversion.

1 slink = 7 zips
1 sliff = 5 zips
4 voles = 3 sliffs
8 lampos = 7 flies
12 voles = 1 lampo

a. How many sliffs are in 1 lampo?
b. One vole is how many zips?
c. How many flies are in 1 slink?

Improving Math Skills

5C HOW TO Understand Very Large and Very Small Numbers

When it comes to studying the universe, scientists must work with very large and very small numbers. Scientists use numbers in the millions and billions because quantities, distances, timescales, and temperatures in the universe are so vast. Consider this:

- Our galaxy has billions of stars, and the universe has hundreds of billions of galaxies.
- Distances between objects in the universe can be greater than billions of miles; it would take light over 10 billion years to travel across the universe.
- Astronomers measure time spans of the universe in billions of years.
- Temperatures in the universe once were hotter than billions of degrees Celsius.

You know that 1 million is a lot—but how much is it? For instance, if someone offered you a million dollars in a pile, you'd sure take it. But how could you test that the pile actually had 1 million dollar bills in it? Would you count dollar bills one by one? How long would this take? Now suppose that someone gave you a billion dollars in $1 bills. How much more is this, really?

In *How to Understand Very Large and Very Small Numbers*, you'll explore how big the numbers million and billion really are. Get ready to share your ideas with your classmates.

Part I: How Many Is 1 Million?

Materials

none

1. With your teammate, find or think of a million of 1 type of item. You do not need to actually collect the items, but decide how you will convince the rest of the class that you could gather 1 million of the item. Think through this step carefully. You can change items to arrive at the best example.

2. Work with your partner on a method to prove that you have 1 million of the objects. You will share your ideas and prove your work to your classmates.

3. Discuss these questions in your class and write your answers in your science notebook.
   a. What were some of the difficulties you had finding a million of something?
   b. What were some different methods that groups used to prove their findings?

Part II: Millions or Billions: What's the Difference?

Materials

stopwatch or clock with second hand

calculators

In Part I, you had to prove that you have 1 million of an item. This might have seemed difficult at first, but you probably quickly figured out how to meet the challenge. As you worked, you should have seen how big 1 million of something really is. You also probably saw that counting every single item would not work too well.

Astronomers work with numbers even larger than 1 million. In fact, numbers in the billions and larger are quite common in astronomy. You will work again with your partner to better understand the real size of 1 billion (1,000,000,000).

1. Individually, predict how long you think it would take you to count to 1 million saying each number aloud without stopping. Write this prediction in your science notebook and title it "prediction." What did your partner predict?

2. With your partner, calculate how long it takes to count to 1 million (1,000,000).
   a. Have one person say the number 383,262 ("three hundred eighty-three thousand two hundred sixty-two") while the other person times how long it takes to say the number. Record the time in your science notebook.

You said this number because most numbers between 1 and 1 million are in the hundred thousands.

b. It took you a certain number of seconds to say that single number. How many numbers are there between 1 and 1 million? Using multiplication, calculate how many seconds it would take you to say all these numbers and, thus, count to 1 million. Record your calculations and this number in your science notebook.

3 You probably calculated many millions of seconds, which probably doesn't make a lot of sense. Convert your answer from seconds to a more appropriate unit. Show your calculations in your science notebook. What did others in your class find?

4 You now know that it takes a significant amount of time to count to 1 million. But many measurements in the universe need billions or even hundreds of billions. Let's see how 1 billion compares with 1 million. Predict how long it would take you to count to 1 billion by ones. Record your prediction in your science notebook.

5 Calculate how long it would take you to count to 1 billion (1,000,000,000) by ones. Use the same method you used in Step 2 and record your answer in the units that make the most sense. Review the unit conversions as necessary.

A good number to say is 504,394,568 (pronounced "five hundred four million three hundred ninety-four thousand five hundred sixty-eight") because most numbers from 1 to 1 billion are in the hundreds of millions.

6 Share your calculation from Step 5 with the class. What did you find?

7 Discuss Questions 7a–c with your class and write your answers in your science notebook.

a. Were you surprised at how long it would take you to count to a billion versus counting to a million? Explain your thoughts.
b. How did measuring 1 million of an object help you to understand the enormity of 1 million?
c. What was the range of values your class had for counting to 1 billion? What might account for this range of results?

Improving Math Skills

5D HOW TO Use Very Large and Very Small Numbers

By now, you understand numbers like million and billion better. Astronomers have to work with numbers in the billions—and bigger—all the time. For example, how many stars are in the sky? Are there more stars that you cannot see? All stars that you see are part of the galaxy in which we live, the Milky Way Galaxy. A galaxy is an enormous group of stars in a massive cluster. The Milky Way has more than 100 billion stars. The universe contains hundreds of billions of different galaxies, many of which are made up of hundreds of billions of stars. How do astronomers know this?

Astronomers are scientists who study the matter in outer space, particularly the many types of stars. When they cannot count stars or galaxies, they need to calculate estimates based on what they can clearly see and count. For example, astronomers cannot see each star in our galaxy because some stars are behind other stars or clouds of gas and dust. So astronomers base their estimates on mass. The laws of physics also allow astronomers to estimate the mass of the Milky Way Galaxy. Dividing this by the mass of an average star like the Sun gives estimates of up to several hundred billion stars in the Milky Way Galaxy.

Part I: Big Numbers

Materials

calculators

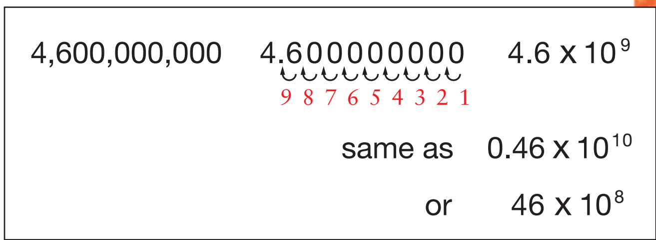
You have seen how large numbers can be difficult to manage. It would be awkward for astronomers to use terms such as a million billion billion or to write out numbers like 1,000,000,000,000,000,000,000,000. Rather, astronomers (and other scientists) use a special way of expressing numbers called scientific notation.

Scientific notation is a way to abbreviate numbers to make them easier to work with. To show numbers with scientific notation, you must first be comfortable with exponents. Exponents are shorthand for the number of times a number, called the base, is multiplied by itself. A base with an exponent is said to be "raised to the power" of that exponent. For example, the number 2^4 means $2 \times 2 \times 2 \times 2$, or 16. Here, 2 is the base and 4 is the exponent. In scientific notation, the base number is always 10. Having

10 as the base works well because the exponent shows how many zeros you would need to write out in the long form of the number. So 10,000 is expressed as 10^4, because $10 \times 10 \times 10 \times 10 = 10{,}000$.

Numbers in astronomy work best with powers of 10. With scientific notation, you simply move the decimal point of a number to obtain a more manageable number. Then you write the number of places you moved the decimal as an exponent of 10. For example, you would write the number 4,600,000,000 as 4.6×10^9 with scientific notation. The second number is a lot simpler, and it says the same thing as the first. You write it like this because you moved the decimal nine places to the left to get to the numeral 4.6. This is shown in figure H5D.1.

Other large numbers are also easy to write using scientific notation. You would write the number 34,000 as 3.4×10^4. You would write the number 286,000,000 as 2.86×10^8. You might remember that the metric system is based on multiples of 10. The table in figure H5D.2 shows how large numbers convert to powers of 10. It also shows prefixes for these numbers in the metric system. Using the example above, 286,000,000 is also the same as 286×10^6, or just 286 million.



▶ **Figure H5D.1 Example of moving decimals for positive exponents.** This diagram shows the conversion of the number 4,600,000,000 to scientific notation, 4.6×10^9. The illustration in the center shows the decimal place moving left nine times. The table in figure H5D.2 explains why 4.6×10^9 is the same as 4.6 billion.

Pronounced	Number	Powers of ten (scientific notation)	Unit prefix in the metric system (SI)
Trillion	1,000,000,000,000	10^{12} or 1×10^{12}	tera-
Billion	1,000,000,000	10^9 or 1×10^9	giga-
Million	1,000,000	10^6 or 1×10^6	mega-
Thousand	1,000	10^3 or 1×10^3	kilo-
Hundred	100	10^2 or 1×10^2	hecto-
Ten	10	10^1 or 1×10^1	deka-
One	1	10^0 or 1×10^0	
Three hundred twenty-seven thousand	327,000	3.27×10^5	

▲ **Figure H5D.2 Table for large numbers.**

Work through these problems individually and write your answers in your science notebook. When you finish, join with another student and compare your answers. Discuss and resolve any differences you have in your answers.

1. One kilometer (km) is the same as 1,000 meters (m). How would you write 1,000 m using scientific notation?
2. A googol is one of the biggest named numbers. It is written as the number 1 followed by 100 zeros. Write this number using scientific notation.
3. The speed of light is 3.0×10^8 meters per second (m/sec). What is this value written without using scientific notation?
4. Use scientific notation to write \$87 billion and 248 million stars.

Part II: Small Numbers

Materials

calculators

Astronomers often work with countless billions of stars and galaxies, but they also work with extremely small numbers. For example, you will see that a key property of light is wavelength. Wavelengths of light are commonly about 1 billion times shorter than a meter.

You write numbers less than 1.0 in scientific notation in the same general way that you write large numbers. The key difference is that the power of 10 is a negative exponent. The exponent still tells you how many places the decimal is from the number 1.0, but the decimal is moved in the other direction (to the right). When writing small numbers using powers of 10, you imagine moving the decimal to the right. The number of places you moved the decimal is the power of 10 expressed as a negative number. We would write the number 0.0000001 in scientific notation as 1×10^{-7} because the decimal moves seven places to the right to get to the number 1.0. Another example is shown in figure H5D.3 for 0.00000035, which is the same as 3.5×10^{-7}.

0.00000035	00000003.5 1 2 3 4 5 6 7		3.5×10^{-7}
		same as	0.35×10^{-6}
		or	350×10^{-9}

Figure H5D.3 Example of moving decimals for negative exponents. This diagram shows the conversion of the number 0.00000035 to scientific notation, 3.5×10^{-7}. The illustration in the top center shows the decimal place moving to the right seven times.

Pronounced	Number	Powers of ten (scientific notation)	Unit prefix in the metric system (SI)
Tenth	0.1	1×10^{-1} or 10^{-1}	deci-
Hundredth	0.01	1×10^{-2} or 10^{-2}	centi-
Thousandth	0.001	1×10^{-3} or 10^{-3}	milli-
Millionth	0.000001	1×10^{-6} or 10^{-6}	micro-
Billionth	0.000000001	1×10^{-9} or 10^{-9}	nano-

▲ **Figure H5D.4** **Prefixes for small numbers.**

Work through these problems individually and write your answers in your science notebook. When you finish, join with another student and compare your answers. Discuss and resolve any differences you have in your answers.

1. A micron is an abbreviation for the term micrometer (μm). How would you express 1 μm using scientific notation? Look at the prefixes in the table in figure H5D.4.
2. How many meters are in 1 millimeter (mm)?
3. Scientists often measure wavelengths of light in units called nanometers (nm). A nanometer is 0.000000001 m. Write this number using scientific notation.

6 HOW TO Conduct an Effective Web Search

Searching for information on the Web can be rewarding as well as frustrating. It may take hours to sift through the thousands of sites that pop up from a poorly designed search. *How to Conduct an Effective Web Search* gives you a few pointers for using any search engine to look for information on the Web. There are times when you want to broaden the search to include more documents, and there are times when you will want to narrow the search to return fewer documents. The following 7 steps will give you a balanced search that is broad enough to find documents that pertain to your topic, but narrow enough to be useful.

Web Searching Guidelines

1. **Choose your keywords carefully.** You will type keywords that relate to your topic into a search engine. Choose nouns and objects as your keywords. For example, if you were searching for information about new planets discovered outside our solar system, using the keyword *planet* or *planets* would be a good start. Verbs, adjectives, adverbs, and similar terms will either be thrown out by the search engine or will be too variable to be useful.

2. **Use several keywords in your search.** Using six to eight appropriate keywords can greatly reduce the number of documents that are returned with your search. Using the example in Step 1, the keywords *new*, *planet*, *solar*, *system*, and *discovery* would return useful documents.

3. **Use appropriate variations in your words connected by OR.** For example, use *planet OR planets* to make sure the search engine picks up both variations of the word "planet."

4. **Use synonyms connected by OR where possible.** *Discovery OR find* is an example of using 2 synonyms connected by *OR* that will cover the different ways a concept can be described.

5. **Combine words into phrases where possible and place phrases in quotation marks (" ").** For example, *"solar system"* is a phrase in our example that should be combined and put in quotation marks. This will restrict the search to exact matches of the phrase.

6. **Combining 2 or 3 concepts in 1 search, distinguished by parentheses, will narrow your results and possibly give you just what you want.** For our current example, using *("solar system")("new planet")(discover OR find)* would be the best selection.

7. **Order your concepts with the main subject first.** Search engines tend to rank documents that match the first keywords in the search higher than those that match the later keywords. For our example search, you would order the concepts as *("new planet")(discover OR find)("solar system")*.

7 HOW TO Write a Lab Report

Adapted from BSCS. (2006). *Biological perspectives laboratory manual: Thinking biologically* (3rd ed.). Dubuque, IA: Kendall/Hunt.

When scientists have enough information, data, and evidence about a particular scientific matter, they summarize their results in a formal, scientific paper and submit it for publication in a professional journal. These papers are organized in specific sections as required by the particular journal. You, too, will be writing lab reports this year, and your report should have sections similar to a scientific paper. Those 5 sections are listed here with a brief description of what you should include in each section.

Lab Report Guidelines

1. **Introduction.** The introduction includes background information from scientific papers, textbooks, newspapers, or magazine articles. Be sure to cite your references at the end of your paper. (See *How to Cite References and Avoid Plagiarism*.) The introduction should also include the purpose of your investigation or the question you are trying to answer.
2. **Materials and methods.** List the materials that you used in the investigation. Also include your step-by-step procedure.
3. **Results.** Describe your results in written form in this section. You should also include appropriate tables, graphs, and diagrams with captions.
4. **Discussion.** This section is where you discuss the results of this particular investigation. How do the results relate to what you already know?
5. **Conclusion.** Summarize the findings of your investigation in the conclusion. Try to answer questions such as, "What trends do I see in the data?" "What general statement can I make about the results?" "What do the data mean?" "What do they tell me about what is happening with the object, organism, or phenomenon?"

8 HOW TO Cite References and Avoid Plagiarism

When doing research in your classes, you'll quickly find that you will need to rely on the results and work of others. These are usually professionals who have had the chance to consider a topic in much more detail than you. You will gain insight from their work, and their work will even make yours much stronger. The important thing is to review with your teacher how to reference that work in your write-up or presentation.

Sometimes students may forget to list sources, or they may even use other people's work without a clear reference. Claiming someone else's work as your own is cheating.

Using the creative work, scientific results, or ideas of other people without a specific reference is a form of stealing. This form of stealing is called *plagiarism*. It's easy to be sure not to plagiarize—*just cite in all your work any sources of information, data, creative work, or ideas that you are borrowing from someone else*. It's fine to borrow, but you have to be clear about when you are doing so.

Referencing any materials or facts that you use in your work is a key part of writing a good paper. Accurate references will actually make your work a lot better. If you have questions, be sure to check with your teacher on his or her methods for documenting references. Your teacher should also be able to tell you the policies at your school for plagiarism.

It is common practice to use the Web to do research on school projects. The Web sites that you use in your report must be cited just as you cite a book or an article from a journal. Your teacher can provide you with the format for citing Web resources.

When doing research or projects in any of your classes, it is vital to keep a list of all references that you use. This convention is part of doing research. It is the official way to recognize the results and prior hard work of others, and it is the proper way to confirm your research and interpretations. Two steps are needed to have accurate references.

1. *Clearly indicate, or cite, the prior research or findings directly within your text or write-up*. This is called a *citation*, and it includes the last names of the authors plus the year the work was published (see the following example). Some results in your work may be widely known facts in science (for example, the speed of light and the atomic masses for elements of the periodic table). These facts don't need text citations.

But suppose that you are researching changes in the rates of cigarette smoking among adults over the past 20 years. Here's an example of citing resources directly in your text:

> Recent data show that smoking rates are decreasing somewhat, and that about one-fourth (22.5 percent) of all Americans still smoke (Centers for Disease Control and Prevention [CDC], 2004). Factors related to smoking rates include the socioeconomic status of the person (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Sorenson, Barbeau, Hunt, & Emmons, 2004), or where the person works (Nelson, Emont, Brackbill, Cameron, Peddicord, & Fiore, 1994). Another factor is where the person learns about quitting smoking, such as at work or by television or radio (CDC, 1999; Haviland et al., 2004).

2 *Each of the resources you cite must be listed in a reference section at the end of your report*. Your teacher may have a preferred format. The following example cites the resources for the short reading on smoking in adults.

Reference List

Adler, N. E., Boyce, W. T., Chesney, M. A., Folkman, S., & Syme, L. S. (1993). Socioeconomic inequalities in health: No easy solution. *Journal of the American Medical Association*, *269*, 3140–3145.

Centers for Disease Control and Prevention. (1999). *Best practices for comprehensive tobacco control programs*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. (2004). Cigarette smoking among adults—United States, 2004. *Morbidity and Mortality Weekly Report*, *53*, 427–431.

Haviland, L., Thornton, A. H., Carothers, S., Hund, L., Allen, J. A., Kastens, B., et al. (2004). Giving infants a great start: Launching a national smoking cessation program for pregnant women. *Nicotine and Tobacco Research*, *6*, S181–188.

Nelson, D. E., Emont, S. L., Brackbill, R. M., Cameron, L. L., Peddicord, J., & Fiore, M. C. (1994). Cigarette smoking prevalence by occupation in the United States: A comparison between 1978 to 1980 and 1987 to 1990. *Journal of Occupational Medicine*, *36*, 516–525.

Sorensen, G., Barbeau, E., Hunt, M. K., & Emmons, K. (2004). Reducing social disparities in tobacco use: A social-contextual model for reducing tobacco use among blue-collar workers. *American Journal of Public Health*, *94*, 230–239.

9 HOW TO Use a Compound Microscope

The human eye cannot distinguish objects much smaller than 0.1 millimeter in diameter. The compound microscope is a technology often used in biology to extend vision. It allows observation of much smaller objects. The most commonly used compound microscope is monocular (that is, it has one eyepiece). Figure H9.1 shows a binocular microscope. Light reaches the eye after it has passed through the objects being examined. In *How to Use a Compound Microscope*, you will learn how to use and care for a microscope.

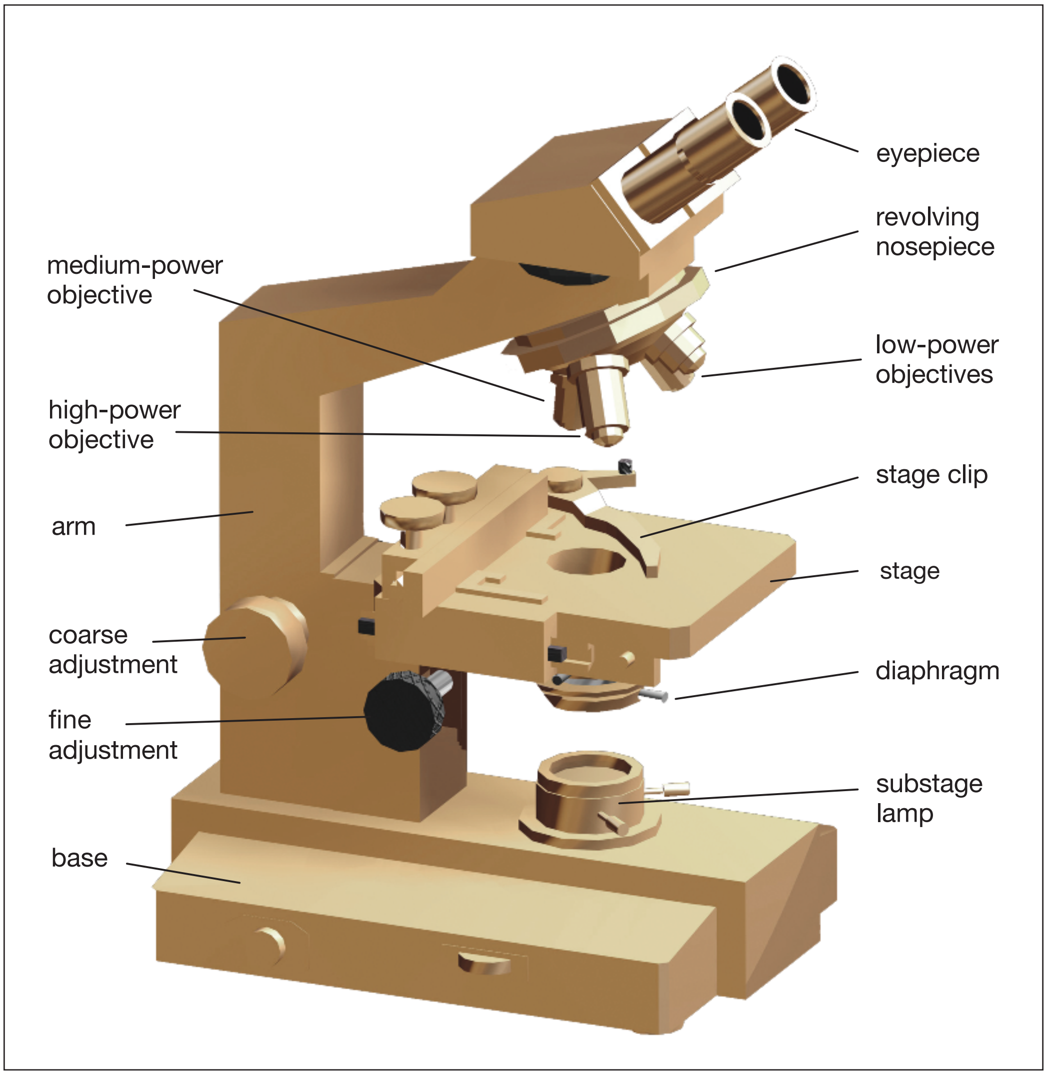


Figure H9.1 Compound microscope. Use this figure to help locate the parts of a compound microscope.

Part I: Setting Up the Microscope

Materials

For each team of 2 students

- 3 coverslips
- 3 microscope slides
- 1 100-mL beaker or small jar
- 1 dropping pipet
- 1 compound microscope
- 1 pair of scissors
- 1 transparent metric ruler
- lens paper
- newspaper
- water

1. Read *Care of the Microscope* to learn how to properly care for a microscope.

Care of the Microscope

- The microscope is a precision instrument that requires proper care. Always carry the microscope with both hands. Put one hand under its base, the other on its arm (see figure H9.2).
- Keep the microscope away from the edge of the table. If a lamp is attached to the microscope, keep its cord out of the way. Move everything not needed for microscope studies off your lab table.
- Avoid tilting the microscope when using temporary slides made with water.
- The lenses of the microscope cost almost as much as all the other parts put together. Never clean lenses with anything other than the lens paper designed for this task.
- Always return the microscope to the low-power setting before putting it away. The high-power objective extends too close to the stage to be left in place safely.

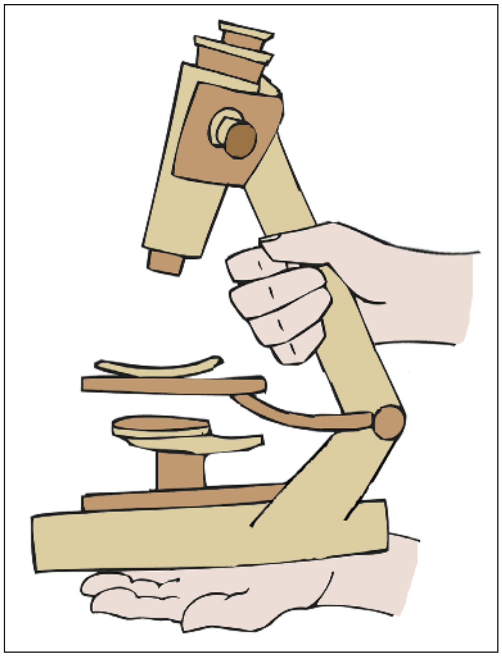


Figure H9.2 How to carry a microscope. Always place one hand under the base and the other hand on the arm.

2. Rotate the low-power objective into place if it is not already there. When you change from one objective to another, you will hear the objective click into position.

3. Move the mirror so that you obtain even illumination through the opening in the stage. Or turn on the substage lamp. Most microscopes are equipped with a diaphragm for regulating light intensity. Some materials are best viewed in dim light, others in bright light.

Cautions

Never use a microscope mirror to capture direct sunlight when illuminating objects under a microscope. The mirror concentrates light rays, which can permanently damage the retina of the eye. Always use indirect light.

4. Make sure the lenses are dry and free of fingerprints and debris. Wipe lenses with lens paper only.

Part II: Using the Microscope

Materials

For each team of 2 students

supplies from Part I

1. In your science notebook, prepare a data table similar to the one in figure H9.3.

Object being viewed	Observations and comments
Letter *o*	
Letter *c*	
Letter *e* or *r*	

Figure H9.3 **Microscope observations.**

2. Cut a lowercase letter *o* from a piece of newspaper. Place it right side up on a clean slide. With a dropping pipet, place 1 drop of water on the letter. This type of slide is called a wet mount.

3 Wait until the paper is soaked before adding a coverslip. Hold the coverslip at about a 45-degree angle, with the bottom edge of the coverslip touching both the slide and the drop of water. Then slowly lower the coverslip. Figure H9.4 shows these first steps.

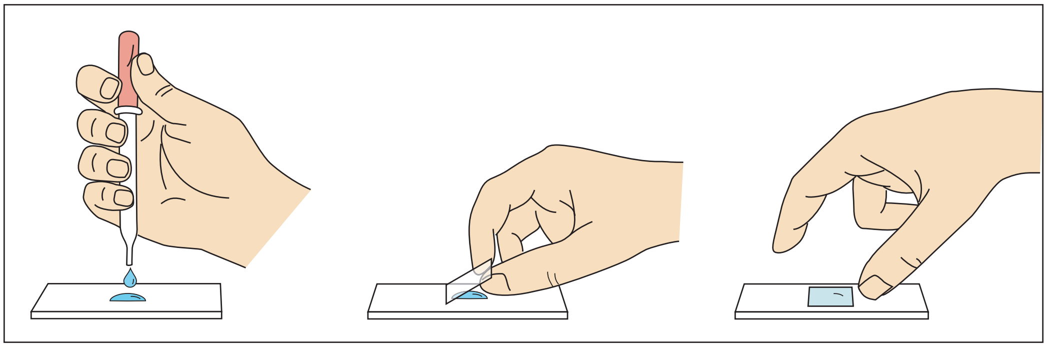


Figure H9.4 Preparing a wet mount. This figure shows the steps to prepare a wet mount with a microscope slide and coverslip.

4 Place the slide on the microscope stage. Clamp it down with the stage clips. Move the slide so that the letter is in the middle of the hole in the stage. Use the coarse-adjustment knob to lower the low-power objective to the lowest position.

5 Look through the eyepiece. Use the coarse-adjustment knob to *raise* the objective slowly, until the letter *o* is in view.

6 If you cannot find the *o* on the first try, start the process again by repeating Steps 4 and 5.

7 Once you have the *o* in view, use the fine-adjustment knob to sharpen the focus. Position the diaphragm for the best light. Compare the way the letter looks through the microscope with the way it looks to the naked eye. Record your observations in your data table.

8 To determine how magnified the view is, multiply the number inscribed on the eyepiece by the number of the objective lens being used. For example:

$$\text{eyepiece } (10\times) \times \text{objective lens } (10\times) = \text{total } (100\times)$$

9 Follow the same procedure with a lowercase *c*. Describe in your data table how the letter appears when viewed through a microscope.

10 Make a wet mount of the letter *e* or the letter *r*. Describe how the letter appears when viewed through the microscope. What new information (not revealed by the letter *c*) is revealed by the *e* or *r*?

11 Look through the eyepiece at the letter as you use your thumbs and forefingers to move the slide slowly *away* from you. Which way does your view of the letter move? Move the slide to the right. Which way does the image move?

12 Make a sketch of the letter as you see it under the microscope. Label the changes in image and in movement that take place under the microscope.

Part III: Using High Power

Materials

For each team of 2 students

supplies from Part I

1 light-colored hair

1 dark-colored hair

1 Make a wet mount of 2 different-colored hairs, 1 light and 1 dark. Cross 1 hair over the other. Sketch the hairs as they appear under low power.

2 With the crossed hairs centered under low power, adjust the diaphragm for the best light.

3 Turn the high-power objective into viewing position. Do *not* change the focus.

4 Sharpen the focus with the *fine-adjustment knob only*. *Do not focus under high power with the coarse-adjustment knob*. The high-power objective will touch the slide if it is in its lowest position. So you must not make large adjustments toward the slide. *Doing so can damage the objective and the slide by driving the objective into the slide*.

5 Readjust the diaphragm to get the best light. If you are not successful in finding the object under high power the first time, return to Step 2. Repeat the entire procedure carefully.

6 Using the fine-adjustment knob, focus on the hairs at the point where they cross. Can you see both hairs sharply at the same focus level? How can you use the fine-adjustment knob to determine which hair is crossed over the other? Sketch the hairs as they appear under high power.

Reflect and Connect

Work with your partner to answer the following questions in your science notebook.

1. Summarize the differences between an image viewed through a microscope and the same image viewed with the unaided eye.
2. When you view an object through the high-power objective, not all of the object may be in focus. Explain why.

1 HOW TO

Use Chapter Organizers

Knowledge is more coherent if it is organized. Organized knowledge gives students a sense of the big picture. And having a big-picture view of knowledge leads to more enduring understanding.

Often, though, it is difficult for students to see the overall organization of knowledge in a unit or a chapter, especially at a glance. Because of this, *BSCS Science: An Inquiry Approach* provides students with a two-page graphic organizer for each chapter. These charts use graphic design principles to map the connections among activities and concepts. Each chapter organizer helps students see the flow of activities in a chapter within the context of important concepts. Progress from one activity to another is represented by linking questions. Thus, chapter organizers use questions to drive students' construction of the big picture—the contextualized set of conceptual relationships inherent in a topic.

Both the student book and teacher edition have chapter organizers. As you might expect, the chapter organizers in the teacher edition contain planning features to help you document your progress through the unit. The teacher version gives you a summary of each activity, the order of activities, the estimated completion time, and room for you to include your notes.

How to Use Chapter Organizers is designed to take your students through their version of the chapter organizers. These organizers give the students a sense of how each activity in the chapter is connected to the previous activity and to activities they will complete later in the chapter. The organizers include key ideas of each activity along with linking questions to show the connection between activities.

Take your students through the activity in the student version of *How to Use Chapter Organizers* so that they have a sense of the purpose and design of these organizers. Then, as you lead your students through each chapter, refer to the organizers several times as you work through the activities of the chapter. There are multiple ways to use these organizers. Here are just a few:

1. Make a "blowup" of the chapter organizer to hang at the front of your class. Do the same for the concept map that is included on the *Student Resource CD* (SRCD). Use colored string or chalk to indicate connections between concepts on the map and sections of the chapter organizer. Lead a class discussion to focus on these connections.
2. Use the linking questions from the chapter organizers as a pre-engage exercise to the next activity. Have students think of possible answers to the linking questions and then use collaborative learning interactions to share answers. Students record dialogue in their science notebooks.
3. Use the chapter organizer as an alternative assessment. Have students convert or translate the organizer into a short story so that the reader can recognize key concepts, linking questions, and activities. The big ideas of the chapter should be recognized as the moral of the story.

In the activity for *How to Use Chapter Organizers*, students examine many of the features of the chapter organizers as well as some features of the entire program.

1 HOW TO **Use Chapter Organizers**

Some of the skills you will improve this year will be your skills of organization. You know that an organized room or file system is easier to work with than one that is disorganized. Knowledge can be organized as well. You will work this year at organizing your thoughts and knowledge in a science notebook. In addition, you will learn to use the organizational tools that the student book provides. You will notice one of these tools as you look through your student book. You will see that we have included a chapter organizer at the beginning of each chapter. This organizer will help you see the big picture. Your understanding will deepen and strengthen as you see that what you have learned today connects to what you will learn tomorrow.

Work with a partner to complete the following tasks. Record your answers and thoughts in your science notebook. Organize your science notebook by including the title "using the chapter organizers."

1. Look through the table of contents of your student book and find a chapter title that most interests you. Do not turn to your chapter yet; just look at the title. Make sure that you and your partner choose *different* chapters. If you both like the same one, work out a plan to have 2 different chapters. Learning to compromise in a group is another skill you will develop this year. Complete the following tasks based on the chapter you select.
   - **a.** Explain to your partner why you think this chapter will be interesting to you. Listen as your partner explains his or her thinking to you. Record the title of your chapter and at least 1 statement explaining why you think this chapter will be interesting.
   - **b.** Think of as many concepts and ideas as you can that might be included in your chapter. List these concepts in your science notebook.
   - **c.** Share your list with your partner and listen as your partner shares with you. Think about your partner's chapter selection. Can you add to his or her list of topics? Add new topics to your list that emerge during this discussion.
2. Turn to your chapter and find the chapter organizer. It is found at the beginning of the chapter. Look at it carefully. All the chapters in this book follow the BSCS 5E instructional model. The 5Es provide a structure for active learning that will have you *doing* and *understanding* science, not just reading about it. Taken together, the

How to Use Chapter Organizers 815

The answers to the nine steps and accompanying questions are included here. This would be a good activity to begin the year.

In Step 1, students look through their books at the table of contents. Students are working in pairs, and this may be the first collaborative learning activity they have done this year. Encourage teamwork and praise groups that work well together. Students have to decide on 2 different chapters to look at. Watch for their ability to make decisions and to compromise if needed.

Students use a collaborative technique in Step 1a called *turn and talk* to explain to their partners why they are interested in the chapter they selected. Watch for students who don't participate or cannot explain why they might be interested in a particular topic. There are many topics that students should find interesting, from genetic engineering to the physics of amusement park rides. Encourage shy students to share their ideas and praise all students for their participation. You should be able to gauge your students' ability to work in small groups. They will use and develop this skill all year.

In Step 1b, student pairs think of and list concepts in their science notebooks. Accept all reasonable answers. Encourage those who have difficulty getting started by asking probing questions such as, "What does this topic make you think of?" "What would a scientist in this field study?" "What have you seen on TV or in newspapers or magazines about this topic?"

Students share with their partners and add to their lists in Step 1c. Encourage them to think about their partner's topic and to add to their lists. Make sure that they are recording their ideas in their science notebooks.

In Step 2, students identify the 5Es. The 5Es are (in order) engage, explore, explain, elaborate, and evaluate. All chapters have these 5Es. Some chapters may have more than one particular *E*, for example, 2 explore activities, or they may contain a combination such as an explore-explain activity.

In Step 3, students record their ideas about each *E*. You may want to have a more detailed class discussion at this point and use the tables describing the BSCS 5Es that are located in *Program Overview* in the teacher edition.

Accept all reasonable answers for the question in Step 4. The linking questions are designed to connect one activity to the next. The linking question is the question scientists or even students might ask after completing the current activity. The linking question supplies the learner with the reason for learning the next concept or the reason for doing the next activity.

In Step 5, students revisit the lists they made in Step 1b–c and compare them with the topics they see on the chapter organizer. They should circle the ideas they listed that appear to be addressed in the chapter, and highlight topics that appear to be addressed in other chapters of the same unit. The student book is divided into 4 units: unit 1, *Interactions Are Interesting* (chapters 2–5); unit 2, *Inside Life* (chapters 6–9); unit 3, *Moving Matter* (chapters 10–13); and unit 4, *Sustaining Earth Systems* (chapters 14–16). Students who choose chapter 1, *Investigations by Design*, have chosen a chapter designed to teach them about scientific inquiry; it is the only chapter in this "unit."

Students may say the chapter title, key ideas, or linking questions were helpful in determining the topics covered in the chapter they selected. However, the key ideas should be the most helpful.

5Es will help you build a strong understanding of science. Can you find each of the 5Es included in your chapter organizer? List them in your science notebook.

3. What do you think each *E* represents in the learning sequence? Record your ideas in your science notebook.

   Include in your answer what you think you should be doing in each activity. For example, what will you be doing in the explore activity? How will you be interacting with your teacher and with your teammates?

4. Every *E* is an activity that builds on the previous one and helps prepare you for the next one—the next *E*. Do you notice that between each activity there is a linking question? Discuss with your partner what you think the purpose of the linking question might be. Record your best ideas in your science notebook.

5. Look back at your original ideas from Steps 1b–c about the concepts you thought would be included in your chapter.
   a. Circle the ones that appear to be covered in this chapter.
   b. Look at the other chapters in this same unit. Highlight topics that will be covered in those other chapters.
   c. What feature of the chapter organizer helped you determine the topics covered in your chapter?

6. Look at another chapter organizer from your book. Discuss with your partner how this organizer can help you with your learning. Record at least 3 ways that you can use the chapter organizers to enhance your learning.

7. Look at your list. Are there things that you will do at the beginning of the chapter, during the middle of the chapter, and at the end of the chapter? Add them to your list so that you have at least 1 from each place.

8. From the chapter organizer that you chose in Step 1, record what you think is the main idea of that chapter. Try to sum it up in 1 sentence.

9. What part or parts of the chapter organizer did you use in Step 8 to write your main idea sentence? What part of the organizer helped you the most?

816 How to Use Chapter Organizers

In Step 6, students look at another chapter organizer. Students should recognize that the chapter organizer shows a path for their learning throughout a chapter. It will show where they are, where they have been, and where they are going. It gives reasons for studying the next topic through the linking questions. Students can use it to help organize their science notebooks and assignments. It summarizes the key ideas for each activity and the major concepts for the chapter to help them see the big picture. Students can also use the organizer to review what they have done in previous activities and prepare for future ones. It can also serve as a review template for their evaluate exercises.

In Step 8, students try to formulate a main idea from the chapter they chose. Students will practice this skill throughout this year. Accept all reasonable answers that are based on the information found in the chapter organizer. Encourage students to look at the complete organizer for their answers.

In Step 9, students describe the part of the organizer that helped them the most. Accept all answers that use the chapter organizer. The major concepts section should help students formulate their answers.

2 HOW TO

Use the Science Notebook

What is the best indication of student learning: a test score or evidence of steady growth over a long period? It's a loaded question. Both are important. So why doesn't documenting students' ongoing progress get the attention it should?

One reason is the perceived difficulty of assessing the daily, incremental changes in students' minds that form the evidence for growth. In *BSCS Science: An Inquiry Approach*, however, there is a well-researched and successful method for documenting ongoing learning. It is the science notebook.

The student version of *How to Use the Science Notebook* describes how to use the science notebook effectively. The version here is for you. Described in this section are strategies for you to get the most out of your students' science notebooks and to be able to assess them effectively and efficiently. Factors leading to the success of the science notebook fall into two general categories, pragmatic and philosophical.

Pragmatic Issues

Pragmatic issues often limit the success of science notebooks. These issues revolve around the teacher time allotted to grading. Clearly, teachers must find ways to assess student notebooks efficiently. Some tips that address the pragmatic issues follow:

1. **Limit time spent per notebook.** On average, take no more than *3 minutes* per science notebook. For a class of 25, that is well over an hour.
2. **Distribute grading time.** Spend no more than 2 minutes for key figures, sketches, diagrams, important *Stop and Think* answers, significant *Reflect and Connect* answers, plus answers to pivotal questions within procedural steps. For checking general completeness, notebook organization, and documentation of ongoing learning, spend 1 minute. At first, you'll require more time, but work toward these time averages. Don't let fatigue due to the time requirements of assessing science notebooks force you to discard this valuable form of formative assessment.

2 HOW TO **Use the Science Notebook**

In *BSCS Science: An Inquiry Approach*, you will use a science notebook on a regular basis. Science notebooks serve many purposes. They provide a place to record data, take notes, reflect on your progress, or respond to questions. This science notebook will become your permanent record of your work, and you will refer to it often during discussions and assessments. The more complete your science notebook is, the more valuable it will be for you.

Your science notebook should be a spiral notebook or a hardcover book that is permanently bound. (Do not use a loose-leaf notebook or a spiral notebook with perforated pages that tear out.) A notebook with square-grid (graph paper) pages will make any graphing that you do much easier.

The following sections describe the major ways in which you will use your science notebook in this program.

Recording Data

Science depends on accurate data. No one—not even the original observer—can trust the accuracy of confusing, vague, or incomplete data. Scientific record keeping is the process by which you maintain neat, organized, and accurate records of your observations and data. Use a pen to record data. Although your interpretation of the data may change, *the original data are a permanent record*. If you learn new or additional things and your thinking changes, make changes in your science notebook in a different-colored pen or pencil. That way, both you and your teacher have a record of your ongoing learning.

Keep records in a diary form, and record your name and the date at the beginning of each entry. Keep the records of each activity separate. Be brief but to the point when recording data in words. It may not be necessary to use complete sentences, but single words seldom are descriptive enough to represent accurately what you have observed or done.

Sometimes the easiest way to record data is in the form of a drawing or sketch. Such drawings need not be works of art, but they should be accurate representations of what you have observed. Place your sketches or drawings in the middle of the page, leaving room for captions, revisions, and highlights. Keep the drawings simple, use a hard pencil, and include clearly written labels. Often, the easiest way to record numerical data is in the form of a table. When you record data for counts or measurements with numbers, include the units of the measurements you used, for example, degrees Celsius or centimeters.

3. **Determine the frequency.** Pick up and grade notebooks at least every 2 weeks. More time in between increases your grading burden per class and fails to provide the needed reinforcement of proper thinking habits for your students.
4. **Decide what to grade.** Don't read everything. Use your professional judgment to select one to two key sketches, graphs, or charts; two to five *Stop and Think* or *Reflect and Connect* answers; and one to three answers to questions from procedural steps.
5. **Insist on notebook organization.** Grading goes much faster if science notebooks are organized in predictable ways. Consider enforcing the following format:
   - the date and name appear on each activity;
   - a bold double line separates days;
   - answers to questions are in different-colored pens or pencils (or highlighters set answers apart visually);
   - changes and modifications are in different-colored pens or pencils (which helps you quickly find them);
   - graphs, charts, tables, sketches, and other spatial representational forms of knowledge are placed toward the center of a new page with plenty of room for highlight comments and captions.
6. **Have a contingency plan.** What if the student
   - forgets the science notebook: Use loose paper that can be taped or glued into the notebook.
   - has special needs: Accommodate the student with the help of support staff; consider an electronic version of the science notebook.
   - loses the science notebook: Difficult situation; use professional judgment and your knowledge of the individual student to decide on fair but instructive action.

Philosophical Issues

Philosophical factors include teachers' attitudes about grading, what constitutes knowledge, and the role of teachers in teaching process skills versus content. These tips will help you with philosophical issues that arise.

1. **Determine grading categories. Narrow grading categories usually involve assigning points for every detailed response. Final scores distribute over a continuum from low to high with many steps along the way. Broad grading categories often use a check-mark system (check, check+, check–). Final scores fall into one of a few groups. Broad grading categories take less time**

Do not record your data on other papers and then copy them into your science notebook. Doing so may increase neatness, but it will decrease accuracy. Your science notebook is your book, and blots and stains are a normal circumstance of field and laboratory work.

You will do much of your laboratory work as a member of a team. Your science notebook, therefore, will contain data that other team members have contributed. Keep track of the source of those observations by circling (or recording in a different color) the data that others reported.

Responding to Questions

When you answer discussion or activity questions in your science notebook, record the date and the activity title. Then number each response. You also may find it useful to record the questions. Sometimes you will respond to questions individually and sometimes with your team; indicate whether your responses are your own or those of your team. As you are writing your responses, practice writing in complete sentences; this will help you when you synthesize and present ideas. After each answer that you write, leave a blank space where you can add questions or comments that arise as your understanding grows.

Taking Notes

Always begin with the date. Then record the source of information. Often, this is a person or a book, but it could be a video, a Web site, or a computer program. When recording notes, start each new idea on a new line. Try to group related ideas under broad headings that will help you remember the important ideas and how they are connected. Write down more than you think you will need; it is hard to make sense of a few words when you look back at them later. Include diagrams and charts to clarify ideas.

It is often valuable to take notes during team and class discussions as well as when your teacher is presenting ideas or instructions. In addition, taking notes in your science notebook as you read helps you better absorb the written information.

You can use the information in your science notebook to prepare for discussions or to review what you have learned. At times, you also will use the information that you have recorded in your science notebook to complete assessment activities.

Keeping Track of Your Questions

Often, as you read or work through an activity, a question will come to mind or you will find that you are confused about something. If you cannot talk with your teammates or your teacher right away, jot down

818 How to Use the Science Notebook

because you do not have to add up points from several items, but they seem more subjective. Select a method that suits your approach and fits into your schedule.

2. **Assess ongoing learning.** "Real-time" learning can be documented and assessed in a valid and reliable way. Science notebooks are a key source of data. Here are examples of the type of information to look for and evaluate in order to document ongoing learning:
   - **Writing.** Look for changes in grammar and syntax, the amount of writing, logical constructions in written form, the number of details included, the ability to discern important facts from surface features, and links between cause and effect. Also look for decreases in hedging, teacher-pleasing comments, and the use of imprecise terms such as "some," "a few," and "a number of."
   - **Representation of knowledge.** Flexible thinkers represent knowledge in many ways. Look for students' use of language (written and oral), mathematics (equations and logic), and dimensions (graphs and sketches). Students should demonstrate a growing ability to reconfigure what they know and understand in multiple forms and to translate fluently among these forms.
   - **Organizing knowledge.** Experts organize knowledge differently than novices do. Look for changes in the way students record, display, and annotate experiences. For example, novices tend to draw graphs too small and place them on a page in a way that prevents including highlight comments and captions. You can monitor how this and other organizational tendencies change over time.
3. **Model ongoing assessment.** Students learn from effective modeling. You can model ongoing assessment by practicing it in front of them often. During activities, for example, walk around the room and talk to small groups of students about what they are doing. Ask questions like, "How does this step connect to the focus question?" "Why did you use those labels on the graph?" or "How do the data you have so far affect your hypothesis?" After some conversation, make a note in the student's science notebook, recording how he or she showed progress.

your question or confusion in your science notebook so that you will remember to ask about it when you have the opportunity. You also may use this technique to record questions that you want to answer yourself.

Keeping Track of Your Responsibilities

Because you will use your science notebook every day in science class, this notebook is a good place to record your class assignments and responsibilities. Each day, you may want to record these in red in the upper corner of your science notebook page.

Using Your Science Notebook during Assessment

At times throughout this program, you will use your science notebook during assessments—both ongoing assessments, such as class discussions and team presentations, and more formal, end-of-unit assessments. Your teacher will collect your science notebook periodically to assess your progress. Using a science notebook for assessment will be a rewarding experience if your entries are complete, detailed, and well organized. Remember to make it easy for someone else reading your science notebook to understand what you have recorded. Use blank space to separate activities, notes, and data. This will make your science notebook easier to assess, and it will provide space for you to add new information if needed. Keep this in mind as you make entries in your science notebook.

How to Use the Science Notebook | 819

NOTES:

Learning Strategies Introduction

Much of what students learn comes in the form of printed text or graphical images such as charts, tables, graphs, and diagrams. A literate student moves fluidly among these forms of information, acquiring, interpreting, and applying knowledge. Few students are born with this level of literacy. They must be explicitly taught literacy strategies (Thier, 2002).

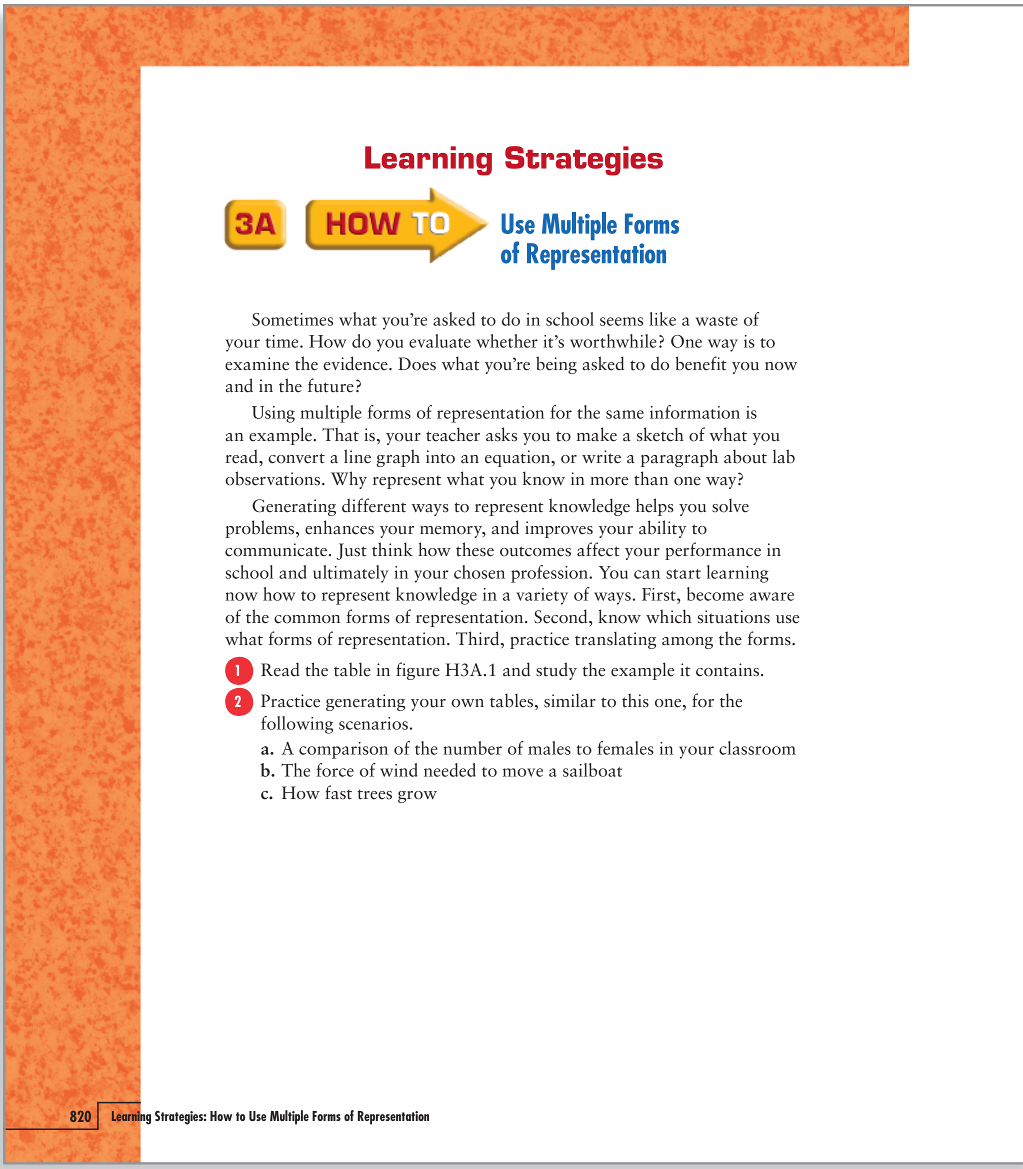
BSCS Science: An Inquiry Approach includes research-based, effective learning strategies for day-to-day progress through each chapter. You'll better recognize each strategy and be able to use them more effectively if you read an overview of each one before the lessons begin.

3A HOW TO

Use Multiple Forms of Representation

Not every learner sees things the same way (Gardner, 1983; Eisner, 1982). We don't expect them to. But we do expect them to see the value of looking at ideas and concepts from multiple perspectives. It is a natural part of building a rich context around anything new. To encourage this, we help students learn from multiple perspectives.

Four ways broadly represent the knowledge commonly encountered in school. These ways are the linguistic, the mathematical and logical, the spatial, and the performance forms.



Learning Strategies

3A HOW TO **Use Multiple Forms of Representation**

Sometimes what you're asked to do in school seems like a waste of your time. How do you evaluate whether it's worthwhile? One way is to examine the evidence. Does what you're being asked to do benefit you now and in the future?

Using multiple forms of representation for the same information is an example. That is, your teacher asks you to make a sketch of what you read, convert a line graph into an equation, or write a paragraph about lab observations. Why represent what you know in more than one way?

Generating different ways to represent knowledge helps you solve problems, enhances your memory, and improves your ability to communicate. Just think how these outcomes affect your performance in school and ultimately in your chosen profession. You can start learning now how to represent knowledge in a variety of ways. First, become aware of the common forms of representation. Second, know which situations use what forms of representation. Third, practice translating among the forms.

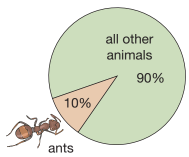
1. Read the table in figure H3A.1 and study the example it contains.
2. Practice generating your own tables, similar to this one, for the following scenarios.
   a. A comparison of the number of males to females in your classroom
   b. The force of wind needed to move a sailboat
   c. How fast trees grow

820 Learning Strategies: How to Use Multiple Forms of Representation

Students construct knowledge in these forms during activities such as investigations, readings, mathematical exercises, graph generation, and authentic assessments. They also encounter knowledge in these forms throughout the text. As they assimilate and process these experiences, they continue to construct a deeper understanding. Then students show what they know by representing knowledge in one of these forms.

Any overemphasis on one form over the other produces students with a narrow perspective on knowledge. Such narrowness limits students' ability to solve authentic problems, the ones they find in an increasingly complex work world. For example, a student who is asked to explain the relationship among gas volume, gas pressure under constant temperature, and the number of particles might fail if the only way he represented this relationship was in a formula he couldn't remember. But the student who could sketch a graph *and* include highlight comments with a caption (not necessarily with numbers) could pass even though he had no equation.

Good problem solvers exhibit a balanced ability to represent what they know (Eisner, 1982). That ability in turn leads to increased problem-solving capacity and transfer. On an ongoing basis, this program requires students to draw, sketch, chart, and *do* science in equal proportions to writing, formulating, and speaking. Moreover, it helps students connect the meaning of these multiple forms of representation into a coherent conceptual framework. That framework results in students with the intellectual flexibility requisite to solving today's problems.

Forms of representation	Source	Example
Language	Textbooks, science notebook, the Web, magazines, text messages, conversations, lectures, music lyrics	Ants are ten percent of the animal biomass on Earth.
Mathematics/Logic	Equations, science notebook, proportions, comparisons, percents, differences, summation	$\frac{M_{\text{ants}}}{M_{\text{all animals in biomass}}} \times 100 = 10$ Key: M = mass
Spatial/Dimensional	Sketches, charts, real objects, maps, demonstrations, science notebook, lab equipment	

▲ **Figure H3A.1** Forms of representation.

NOTES:

Learning Strategies: How to Use Multiple Forms of Representation 821

3B HOW TO

Use the Think-Share-Advise-Revise (TSAR) Strategy

Talking about what you read helps you *understand* what you read (Rosenshine & Meister, 1994; Lemke, 1990). That is because reading involves input, and speaking involves generating (Wittrock, 1990), hallmarks of information processing. When we generate sentences in speech, we reconfigure knowledge based on its meaning to us. Other people listen to what we say and give us feedback on whether our explanations make sense. That feedback tells us if we need to reread or rethink. This back-and-forth process is essential to constructing understanding (Vygotsky, 1962).

BSCS Science: An Inquiry Approach asks students to read a passage or view a graph, then *turn and talk* to a classmate about the reading or graph. As you would expect, the rules of discussion are explicit and aimed at improving students' ability to acquire, interpret, and apply written and graphical information. You will see these turn-and-talk strategies as part of every aspect of the activities, including laboratory work, text questions, and team projects. These strategies form a major component of the collaborative learning and problem-solving strategies integral to this program.

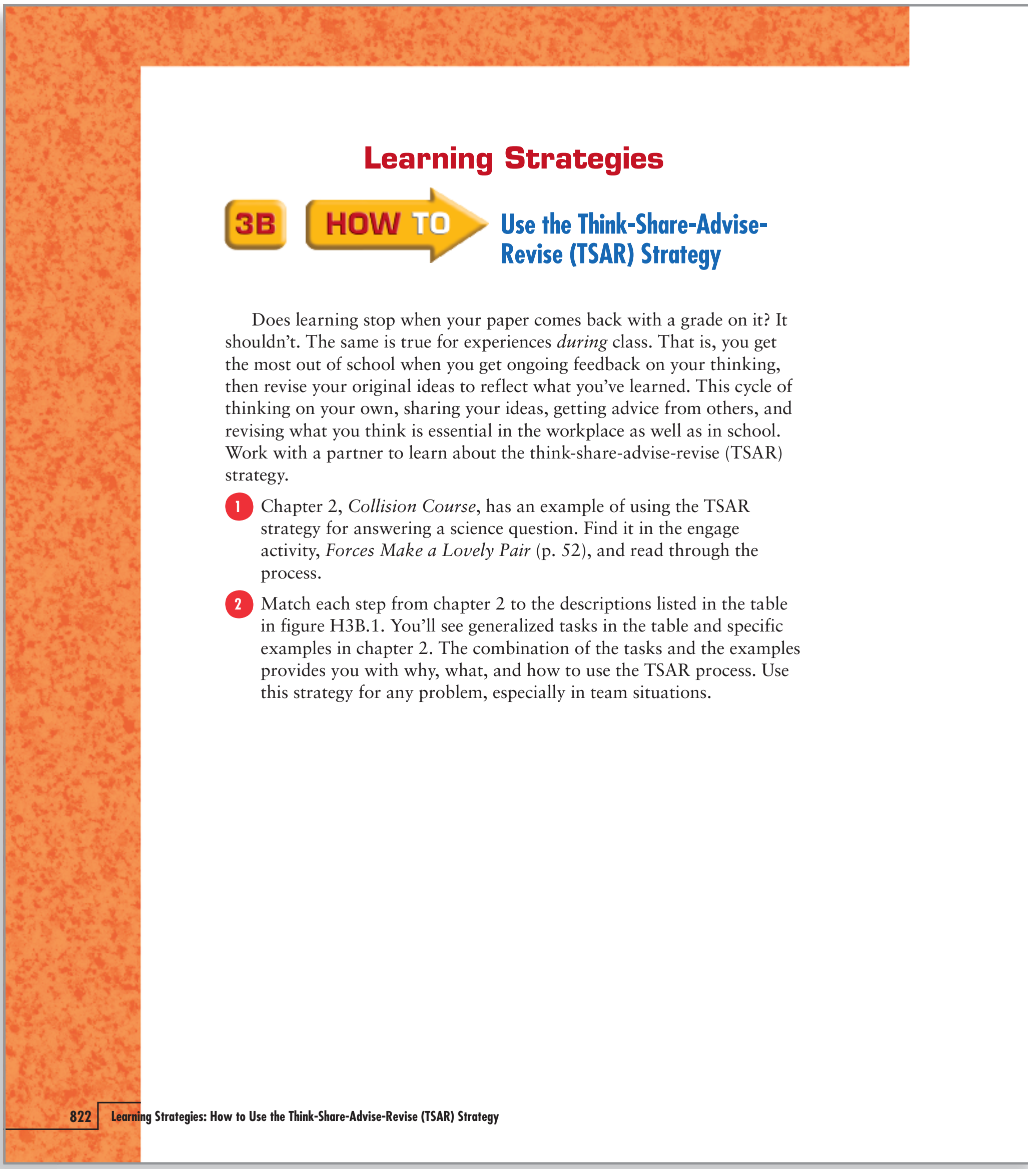
In Level 2 of this program, students use a specific turn-and-talk strategy developed for students called *think-share-advise-revise* (*TSAR*). In TSAR, we assume that students do not automatically know what you mean by "share." Actually, to share effectively is a complex cognitive task requiring expertise that comes with experience and training. TSAR represents one of a family of teaching techniques used to help students learn how scientists share what they are thinking in a way that promotes learning and understanding.

Chapter 2, *Collision Course*, provides a context-rich example of the TSAR strategy. Refer to it and the student version of *How to Use the Think-Share-Advise-Revise (TSAR) Strategy* as you read the remainder of this section.

In Steps 1 and 2, students use the example from the engage activity in chapter 2, *Forces Make a Lovely Pair*, to compare each step in the TSAR strategy to a table of descriptions of student behavior for the strategy. This table is set up similar to the 5E descriptions given in *Program Overview* in the front of the teacher edition. Following are sample prompts from each stage of the TSAR strategy and hints for you to make the process run more smoothly in your classroom.

1. Sample *think* prompt: "Review silently and *think* about the connection between what you sketched and what you wrote. Look for the most important ideas you represented."

Students need explicit prompts to elicit their prior knowledge. Steps 1 and 2 begin that thinking process. But asking them to connect 2 forms that represent the same information takes it further by promoting reconfiguration of knowledge. That is, students have to examine each answer, map or associate one answer to the other, and determine if the answers are consistent. In effect, they translate between forms of representing what they know. Translation involves reconfiguring knowledge in one form to knowledge in another. As this occurs, students may note discrepancies or differences, which engender


Learning Strategies

3B HOW TO **Use the Think-Share-Advise-Revise (TSAR) Strategy**

Does learning stop when your paper comes back with a grade on it? It shouldn't. The same is true for experiences *during* class. That is, you get the most out of school when you get ongoing feedback on your thinking, then revise your original ideas to reflect what you've learned. This cycle of thinking on your own, sharing your ideas, getting advice from others, and revising what you think is essential in the workplace as well as in school. Work with a partner to learn about the think-share-advise-revise (TSAR) strategy.

1. Chapter 2, *Collision Course*, has an example of using the TSAR strategy for answering a science question. Find it in the engage activity, *Forces Make a Lovely Pair* (p. 52), and read through the process.

2. Match each step from chapter 2 to the descriptions listed in the table in figure H3B.1. You'll see generalized tasks in the table and specific examples in chapter 2. The combination of the tasks and the examples provides you with why, what, and how to use the TSAR process. Use this strategy for any problem, especially in team situations.

822 Learning Strategies: How to Use the Think-Share-Advise-Revise (TSAR) Strategy

reexamination of their prior experiences. Naturally, you encourage students to work to resolve these discrepancies or differences. The end effect is each student thinking about his or her answer in a rich mix of contexts—prior personal experience and school experience.

It is crucial that students work through this *think* step individually. Ultimately, it's how individuals grow that counts as meaningful achievement. Foster a classroom climate of respect for individual thinking time. Usually, this means a few minutes of quiet reflection.

2. Sample *share* prompt: "Share your sketch with your partner and discuss each feature of it, including labels and explanations."

Model for students how to hold sketches and display them to each other as they share information about the sketches. This may seem overprescriptive, but it is not. An important part of sharing is making sure the other person can see or hear clearly. For example, act out holding a sketch in a science notebook at an angle in front of an observer and using a pencil to point out each important aspect. Mimic a minipresentation in which you explain a feature and pause for a reaction, then proceed to the next feature, and so on, until the sharing is complete. If you do not show students how to share explicitly, many will gloss over the details of the sketches. Further, verbally articulating spatial and dimensional representations of knowledge is another chance for students to reconfigure knowledge.

3. Continuation of *share* prompt: "Read your answer aloud as you wrote it."

Emphasize this step strongly. Reading aloud helps students self-diagnose problems with logic and evidence. And when you help them learn how to catch their mistakes, you effectively shrink the size of the class because you are no longer the only source of corrections. This ability to self-monitor represents an essential feature of adult, independent learning—a key goal of this program. Further, reading aloud gives you important assessment information about abilities that affect performance in science, such as reading level and information processing. Finally, reading aloud is a part of how students learn effective scientific communication through giving and receiving feedback.

4. Sample *advise* prompt: "Ask for advice on how to make either the sketch or the answer better."

Learning from feedback is very important to lifelong learning. But students may not know how to listen to advice from peers. You can help them learn by calling attention to the role of peer feedback in successful learning. Remind them that advice is one way for a peer to communicate how his or her prior knowledge applies to a situation. Thus, peer advice is a way to broaden students' perspective, an essential part of effective problem solving. Also, learning how to pay attention to peer feedback reinforces good observation skills.

Pay attention to inappropriate feedback. Examples include, "That's dumb," "No way!" and "You've got to be kidding." Let students know how common it is for scientists to disagree, but remind them that the focus should be on the thoughtful analysis of each position, not on

Step	What you do	What others do
Think	• access what you already know and understand and the skills you already have • work individually • pinpoint what you do and don't know • generate questions • document your thoughts in your science notebook	• respect your private thinking time
Share	• read aloud your thinking to a teammate • explain any diagrams, charts, or sketches • respond to requests for clarification	• listen attentively • ask questions respectfully
Advise	• offer suggestions, elaborations, or alternative explanations to what your teammate read • respond to questions about your advice	• listen to your advice without interruption • ask for clarification if needed
Revise	• record what you changed in your original answer in response to advice • record why you changed your original answer in response to advice (remember, not all advice leads to changes)	• respect your private time to revise your first thoughts

▲ **Figure H3B.1** **TSAR table.**

Learning Strategies: How to Use the Think-Share-Advise-Revise (TSAR) Strategy | 823

personalities, hurt feelings, and interpersonal politics.

5. Sample *revise* prompt: "Revise your work if you think your partner's understanding is better than yours."

   Show how important this step is to you by giving students time to accomplish it. But they probably are not used to having class time to consider the advice of peers by revising their science notebooks. So students may need some initial encouragement to make this step part of effective scientific communication. Be sure to inform them that such revisions are part of the evidence you use to assess their ongoing progress toward increased scientific thinking. Learning from mistakes and keeping a careful record of the what and why of mistakes or miscues is a mark of successful scientists. Consider providing different-colored pens or pencils for students to record their revisions. This will make it easier to assess the evolution of your students' learning. It will also reinforce and set apart this learning event for you and your students.

6. Sample *role-switching* prompt: "Switch roles and listen carefully to your partner."

   Monitor role-switching very carefully. It can be done after each step in TSAR or after one student has completed the entire process. Some students may not want to share after the first student has done so. This reticence can be due to low self-esteem, fundamental bashfulness, or any number of phenomena that pop up instantly in a teenager's life. Regardless of the reason, develop strategies to ensure each student's full participation in the full gamut of feedback techniques. Learning how to express what is in your mind is not easy. Starting with relatively "low-pressure" feedback environments, as with peers within an activity, helps. Eventually, students use their experiences from methods such as think-share-advise-revise as a bridge to increasingly formal forms of scientific communication such as scientific papers and public presentations.

   Some classes will need more explicit teacher modeling of the TSAR strategy than other classes. Based on your professional judgment, act out the role of each team member during each step. When you play the role of listener, for example, model a respectful, attentive posture. But also scrunch up your face or raise your eyebrows occasionally to model questioning. Explain how the person sharing must look for such body language clues and think of them as part of the feedback. Model proper techniques of expressing and working through differences in explanations. Most important, use an overhead or flip chart to model your expectations of documentation. Write an example of an initial student response and then show the revisions to students' original thinking.

Learning Strategies

3C HOW TO **Use and Create Organizing Tables**

Organizing information helps you see patterns and better understand text materials. There are many different kinds of organizing tables. For example, you can use tables to organize data in an investigation, to make comparisons and analogies, and to show relationships between information in reading passages. Here are 3 common organizing tables you might use.

1. *T-tables* show relationships between information listed in the horizontal rows. T-tables can have 2, 3, or even 4 columns. You can use T-tables to show similarities or differences or to organize what you know before or after you read.

Reading about genetics

Fact or idea I read	Questions I have about the fact or idea

Figure H3C.1 **T-table example.** This is an example of a T-table you could use as you read about genetics. As you read a passage, record your ideas in a table to help you organize your thoughts.

824 Learning Strategies: How to Use and Create Organizing Tables

3C HOW TO

Use and Create Organizing Tables

Organizing and relating information helps readers form coherent meaning from text materials (Fisher, Frey, & Williams, 2002). For example, when students read a passage about cell division, they read many new words. Completing a T-table with the headings "feature" and "function" helps students pinpoint what is new to them, then connect it to the essential meaning. In this way, students learn to parse text materials into important relationships. Students represent these relationships in the horizontal rows of a T-table. Further, vertical organization can show a hierarchy of ideas—what is most important and why. Often, a third column allows students to keep track of questions they have from readings. Used in conjunction with turn-and-talk protocols, T-tables consistently increase students' ability to learn from text-based material (Block & Pressley, 2002). A variety of T-tables are used in this program: reading comprehension, prereading, analogy mapping, similarities and differences, and observation and interpretation.

NOTES:

2 *Analogy maps* are a special type of table that allows you to connect new ideas with ideas you are familiar with.

Feature of a road trip	is like . . .	aspect of scientific inquiry . . .	because . . .
A detour on the road	is like . . .	getting unexpected results from an investigation	when you encounter something you do not expect, you change the way you approach your investigation.
Circling back on a portion of the road to look for a turn	is like . . .	adjusting the design of an investigation	you return to your design and adjust it to get the results you need to answer your question.
Trying different routes on a road trip	is like . . .		
Encountering car trouble and returning home	is like . . .		
Abandoning your car on the road	is like . . .		
Starting your trip and changing the destination	is like . . .		

Figure H3C.2 Analogy map example. This analogy map is one you could use to compare a road trip you might take with the process of scientific inquiry.

3 *Data tables* provide a place to record observations or data from an investigation. You can create graphs from the information in these tables or interpret your data directly from the tables themselves.

Material	Volume of liquid sample (mL)	Mass of cylinder with liquid sample (g)	Mass of cylinder alone (g)
Sample A	100	142.54	2.54
Sample B	100	93.21	2.54
Sample C	100	83.44	2.54

Figure H3C.3 Data table example. Data tables are a place to record both qualitative and quantitative observations or data from an investigation. This data table shows data recorded as students conduct an investigation about density. The data can be used to make a graph or do calculations.

3D HOW TO

Use and Create Venn Diagrams

Venn diagrams are a type of graphic organizer used to compare topics or concepts. They visually show similarities and differences. Students can use them to compare processes they have observed in an investigation or read about in a reading. Venn diagrams consist of two or three overlapping circles, each representing a topic or concept. The regions inside the circles provide characteristics of the topics or concepts. In most cases, your students will have information to put where the circles overlap—this overlap represents characteristics that both concepts have in common. However, when three circles overlap, students may not be able to find commonality for all three topics. If your students have little experience with Venn diagrams, consider providing time for them to practice by giving them a few simple topics to compare.

3E HOW TO

Make Better Observations

What does it mean to your students when you ask them to make observations? Chances are "to observe" means something different to them than it means to you. That causes problems when you expect them to link evidence to interpretations. And when they can't link evidence to interpretations, they can't do science.

Students need explicit training in how to make observations. This doesn't mean telling them exactly what they were supposed to see. Instead, you help them form good habits, all of which together lead to high-quality observations. These habits are not a step-by-step procedure. Rather, they are generalized guidelines that can be accomplished in a variety of sequences and methods.

Example

A set of observation guidelines is printed in chapter 4, *Physics Is Moving*, of the student book and are reproduced here. Read through each guideline and the commentary that follows. Add or subtract guidelines to meet your students' needs. Regardless of your student group, insist that each student improve his or her ability to make scientific observations.

Observation Guidelines

- How is each procedural step related to the focus question or problem you are investigating?

The purpose of this guideline is twofold. One, it links actions to goals. Two, it fosters self-monitoring. When students can't connect their actions to goals, they rarely attain those goals. They might collect a lot of data, but they tend not to know why they collected it. This situation makes generating meaningful interpretations very difficult. Too often, teachers resort to telling students what they were supposed to see and what they were supposed to conclude. To prevent this, teachers need to reinforce how each action students take relates to the general goal of the investigation. Teachers can reinforce the link between actions and goals by informal monitoring during the investigation. Simply asking students what a certain step has to do with the goal gives valuable instant feedback that you can apply to instructional decisions.

Learning Strategies

3D HOW TO **Use and Create Venn Diagrams**

Venn diagrams are a powerful strategy for comparing topics or concepts. You can use them to visually show similarities and differences. A Venn diagram is made up of two or three overlapping circles. Each circle represents one topic or concept. The region inside each circle lists characteristics of the topic or concept. The part of the circle that overlaps contains characteristics common to both concepts. See the example in figure H3D.1. Then try creating your own Venn diagrams using Steps 1–5 to help you.

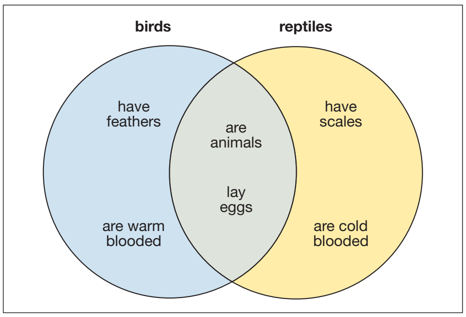


Figure H3D.1 Venn diagram comparing birds and reptiles.

Venn Diagram Guidelines

1. Draw 2 overlapping circles like the ones shown in figure H3D.1. Use at least a half sheet of paper for the circles to give you enough room to write inside the circles.
2. Label each circle with the topics or concepts you are comparing.
3. Identify the important characteristics of the topics or concepts.
4. Write the characteristics that are specific to only 1 of the 2 topics or concepts in the circle, outside the overlapping area.
5. Write the characteristics that are common to the topics or concepts in the area where the circles overlap.

826 Learning Strategies: How to Use and Create Venn Diagrams

Linking actions to goals fosters self-monitoring (metacognition). This means students learn how to recognize and troubleshoot problems during lab activities. Students who know how each action links to an overall goal notice when results are contrary to the goal. These students tend to make corrections on their own, freeing you to work with other students.

- What is the best way to represent the initial conditions (with tables, sketches, graphs, equations, or sentences)?

This guideline, along with the next three, calls attention to documenting change. Without changes, few conceptual relationships can be discerned. Of course, the first requirement for noting change is to record the initial conditions fully and accurately. The method of representation should fit the type of information. For example, sketches using colored pencils might be best for an acid-base indicator lab in which color changes are the major observation.

- What is the best way to record the final conditions?

Use appropriate means to document the final condition of an investigation. Students should note when a change resulted in the final condition. Thus, they should record when the independent variable stopped affecting the dependent variable. Only data between the start and finish should be analyzed.

- What is the best way to record what happens *during* the investigation?

This guideline requires the most coaching from you. It is difficult for students to anticipate the most efficient configuration of data tables. They often do not think about the measurements (what type, how many, and how often) they need to make in order to accomplish the investigation's goal. Help them develop this skill by prompting them with questions like, "What would you have to measure in order to answer the focus question?" or "What should the data table look like in order to hold all the data you anticipate collecting?" As the year progresses, decrease these prompts and assess whether students have made this guideline a habit.

- How do you know that the changes you see are the result of the variable you are manipulating and not other variables?

This guideline gets at an understanding of controls. Not every investigation will have only one independent and one dependent variable. But in high school, investigations frequently do. Most students will understand the link between these two variables. But often, they don't recognize or they fail to account for variables that also change during the course of the investigation. You should expect to take extra time, especially during the first few investigations, to help students control these other variables.

- Will multiple trials increase your confidence in what you see?

Reliability is a crucial feature of sound conclusions. If an effect can be reproduced, it increases the confidence in any interpretation from the investigation. Students might complain about doing the same thing over again. Think of everyday situations in which reliability is important and help students see the connection to lab data. Then help them determine

Learning Strategies

3E HOW TO Make Better Observations

You were not born knowing how to make good-quality scientific observations. But you can learn. Effective scientists have made good-quality observations for centuries. The following questions related to making observations are not a step-by-step procedure. Rather, they are guidelines (in the form of questions) to help you *think* your way through observations. When done well, observations help you link what you see to what it means—the very heart of science.

Observation Guidelines

- How is each procedural step related to the focus question or problem you are investigating?
- What is the best way to represent the initial conditions (with tables, sketches, graphs, equations, or sentences)?
- What is the best way to record the final conditions?
- What is the best way to record what happens *during* the investigation?

You need to focus on what is happening during the investigation, but sometimes changes occur very quickly. In these cases, you must plan carefully so that you are not distracted by writing down your data.

- How do you know that the changes you see are the result of the variable that you are manipulating and not other variables?
- Will multiple trials increase your confidence in what you see?
- What is the best way to keep a record of your initial ideas and how those ideas change during the course of the investigation?

NOTES:

efficient ways to document multiple trials in their science notebooks.

- What is the best way to keep a record of your initial ideas and how those ideas change during the course of the investigation?

Investigations produce more than data in number form. Labs force students to see nature in ways they may never have experienced. This results in a potentially powerful learning opportunity. But students can't monitor and therefore cannot be confident of their progress if they do not have a clear record of how their thinking changed. As with lab data, students should record their initial and final ideas, then compare them. Often, they will produce evidence of significant learning. In this way, students link their high-quality observations to increases in their learning.

3F HOW TO

Write Highlight Comments and Captions

Graphs, tables, charts, and diagrams are not always easy for students to interpret. Explicit strategies that include these forms of information can help broaden students' scientific literacy. Highlight comments and captions represent two such strategies.

BSCS Science: An Inquiry Approach regularly asks students to interpret information from

Learning Strategies

3F HOW TO

Write Highlight Comments and Captions

How do you make sense of charts, diagrams, graphs, and sketches? You do what scientists have been doing for centuries. You note what you see, then you try to say what it means. This process helps you connect evidence to interpretations—a hallmark of scientific inquiry.

Highlight comments help you link observations from graphs, charts, and other spatial forms of representation to possible interpretations. Captions assemble highlight comments into sentences that form a coherent paragraph. This paragraph tells the story of the graph, chart, or sketch and communicates the "executive summary" of the essential understandings displayed. The combination of highlight comments and captions helps you communicate scientific information with increasing effectiveness, improving your performance and deepening your understanding of the natural world.

Suppose you investigated the uptake of a nutrient by a tree over 24 hours. How would you make sense of the data? Follow the steps in figure H3F.1 and use them as a general guide for any graph, chart, diagram, or sketch you make.

828 Learning Strategies: How to Write Highlight Comments and Captions

graphs and charts by answering two highlight questions: “What do I see?” and “What does it mean?” Students answer these questions *on their graphs* near a trend line or key information. In this way, students make physical and conceptual connections between graphical information and interpretation (Sweller, 1988). They accomplish this by linking highlight comments to graphical information, thus building cause-and-effect relationships. From these relationships, they are able to construct a meaningful caption.

The student book requires students to write captions under each graph, chart, or diagram they generate. Captions help students assemble highlight comments into a coherent, short paragraph that explains what is important in the figure. In effect, the combination of highlight comments and captions is a reverse literacy strategy compared to T-tables. That is, with T-tables, students reconfigure what they know from text into organized structures or tables; with highlight comments and captions, students generate meaning by shifting from dimensional structures (graphs, charts, and tables) to text. The built-in, back-and-forth process among these various strategies makes for more literate, intellectually flexible students.

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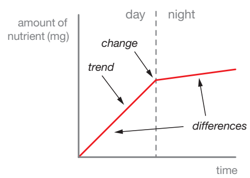
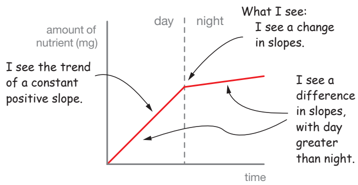
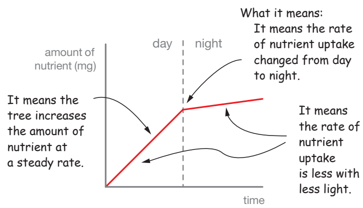
Commenting step	Example and comments
1. Look for changes, trends, or differences. Draw an arrow to each of these you notice in the graph.	
2. Write what you see. Each arrow has a different description. Be concise. Write only the essence, or *highlights*, of what you see.	
3. Interpret what you see. Write what each observation means. Don't interpret the entire figure at once, just one observation at a time.	
4. Write a caption. Think of the caption as an executive summary. Start by joining each "What I see" to its "What it means" to form a sentence. Then build a coherent paragraph out of the sentences. Begin your caption with a topic sentence describing the overview of the figure.	Caption: This graph shows the uptake of nutrients in a tree over a 24-hour period. During the day, the graph shows a constant, positive slope, meaning there is a steady rate of uptake. At night, the rate changes as shown by change in slopes. This suggests that light changes the rate of uptake. Finally, the night slope is less than the day slope, meaning the uptake of nutrients slows at night.

▲ **Figure H3F.1** **Steps for writing highlight comments and captions.**

3G HOW TO

Use the *Learn from Mistakes (LFM) Protocol*

Mistakes are information. But many students have been conditioned to think mistakes reflect something negative about them. A scientific view of mistakes suggests that they represent understanding in process. That is, mistakes help us learn. But how do we teach students how to learn from mistakes?

Like many complex cognitive skills, learning from mistakes requires explicit instruction for most students (Bruer, 1994). *BSCS Science: An Inquiry Approach* helps you teach this important, lifelong skill to students by making learning from mistakes a natural part of evaluations.

The *Learn from Mistakes* (*LFM*) *Protocol* used in this program is particularly effective with conceptually oriented, multiple-choice test questions, the kind often used in various high-stakes tests. The *LFM Protocol* helps students perform better on these kinds of tests without forcing you to "teach to the test" (Pinkerton, in press). The procedure uses the common sense steps of (1) representing the original question in an alternative way, (2) identifying the mistake, (3) describing the conceptual reason it was wrong, and (4) generating the correct solution. In conjunction with other cognitive skill techniques, the *LFM Protocol* allows you to teach by using inquiry methods and still meet the content demands of state and national standards.

In this program, students learn the *LFM Protocol* early so that you can build on its effectiveness when you opt for constructing tests using our test bank questions. This way, you foster student use of active learning and simultaneously enhance their ability to take an important type of test.

NOTES:

Learning Strategies

3G HOW TO Use the *Learn from Mistakes (LFM) Protocol*

School isn't just a place to deposit right answers. Sometimes we make mistakes. In fact, most humans make mistakes when they try to learn something, especially when the subject is difficult or new. When you learn to identify and explain what's incorrect about a wrong answer, you have a better chance of avoiding that mistake next time.

The *Learn from Mistakes* (*LFM*) *Protocol* was designed to help you learn from wrong answers. You will use it after you take certain tests. For each of the questions you missed on the test, perform the following steps. If you do, you can earn up to 50 percent of the difference between your raw percentage score and 100 percent. Be sure to write your raw percentage score at the top of the test along with a list of the numbers of the questions you missed.

Learn from Mistakes Protocol

1. Represent the original question in a different way than it was represented on the test. For example, if the question was mostly words, represent it as a sketch. If it was mostly a sketch, represent it in words. When you use words, paraphrase the question in your own words. Do not copy the question word for word. Label any sketch with all the variables, especially the unknown. If the problem mentions any change in condition, then show a before-and-after sketch.
2. Identify and explain the mistake you made in the answer you selected. Focus on explaining any conceptual misunderstanding. When you explain what is incorrect, show how the misconception would lead to a contradiction with what you see in nature. Explanations like, "I read the problem wrong" and "I pushed the wrong button on the calculator" will receive no credit.
3. Show the correct solution or answer. When necessary, show all governing equations, first in symbol form, then followed by substitution with number values. Always place proper units and labels on answers. Include why the answer is reasonable.

830 Learning Strategies: How to Use the *Learn from Mistakes (LFM) Protocol*

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Learning Strategies

3H HOW TO Solve Problems

Humans aren't born knowing how to build dams, determine why a baby is crying, or understand when *i* comes before *e*. We have to learn how to solve these problems. That's one of the primary benefits of school. You learn how to solve problems.

Every problem seems different. But successful problem solvers use a general approach that works for a large variety of everyday and school problems. Read the following problem, then learn how expert problem solvers find a solution. Try to use this approach with the next problem you're asked to solve. An example follows.

Problem-Solving Guidelines

1. *Read the problem.* Often, reading the problem aloud helps you to understand what the problem is asking you to do.

   Example problem: You push a 20-kilogram (kg) box across the floor at 3.0 meters per second (m/sec) with a constant force of 10 newtons (N). What force does the box exert on you?

2. *Adjust your mind-set.* Your attitude toward problem solving matters. The brain that thinks, also feels. Get rid of fears of failure or incompetence. Don't allow resentment or anger to cloud your thinking.

   Example mind-set statements to avoid: "I can't do science, so I'm not going to try." "I never get these right. I give up." "I'll never use this. Why should I do the problem?" "I hate not knowing what to do, so I'm not going to do it."

3. *Sort the problem.* Read the problem and use your prior experiences to determine what you know and don't know in the problem. This step clears your mind so that it can focus on the important features of the problem. It starts you thinking about the real question, not the things that distract you from the solution. The following table is an example of a way to organize your thoughts.

Learning Strategies: How to Solve Problems 831

3H HOW TO

Solve Problems

Many times students get "stuck" and cannot get their brains going to solve a problem. This can happen when they are trying to solve a math problem, answer a question, or manipulate lab equipment. *How to Solve Problems* gives students guidelines to get going when they are trying to solve problems.

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What I know, understand, or assume	What I don't know or understand
I pushed with 10 N force.	How does the box exert a force?
The box has a mass of 20 kg.	How do I find out the amount of box force?
The velocity is 3.0 m/sec.	Why is the box force "pushing back" on me?
The box moves in the same direction as the push and doesn't leave the floor (my assumption).	

Figure H3H.1 **Problem-solving table.**

4. *Represent the problem*. Translate what you know and don't know into some form other than writing. Sketches, graphs, charts, and lists are examples. Be sure to transfer the items from your problem-solving table to the representation.

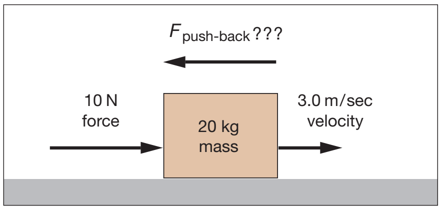


Figure H3H.2 **Example representation of forces on mass.**

5. *Apply a strategy*. Expert problem solvers use a variety of methods, not just one. Successful methods include applying key concepts, using logic, trying to guess and then check, finding a pattern, working backward, and acting it out. Don't let yourself get stuck! If one method isn't working, try another.

Example application of the key concepts to the strategy: "I remember learning that all objects push back if you push on them. That makes me think of Newton's third law—forces come in pairs that are equal in size and opposite in direction. So if I push with 10 N, that means the box pushes back with 10 N. The velocity isn't important in the problem."

NOTES:

6 *Check for reasonableness.* Build confidence in your answer. Check it against your everyday experience or scientific theory. If there's a contradiction, then repeat the problem-solving steps as needed.

Example: "I feel something when I push on a box or a wall. That must mean the object pushes back. I remember that a net force causes acceleration. Since the box has a constant velocity, the net force must be zero. That means the push-back force has to be equal to my force. If I thought my force was greater, then the box would accelerate, which contradicts the problem statement."

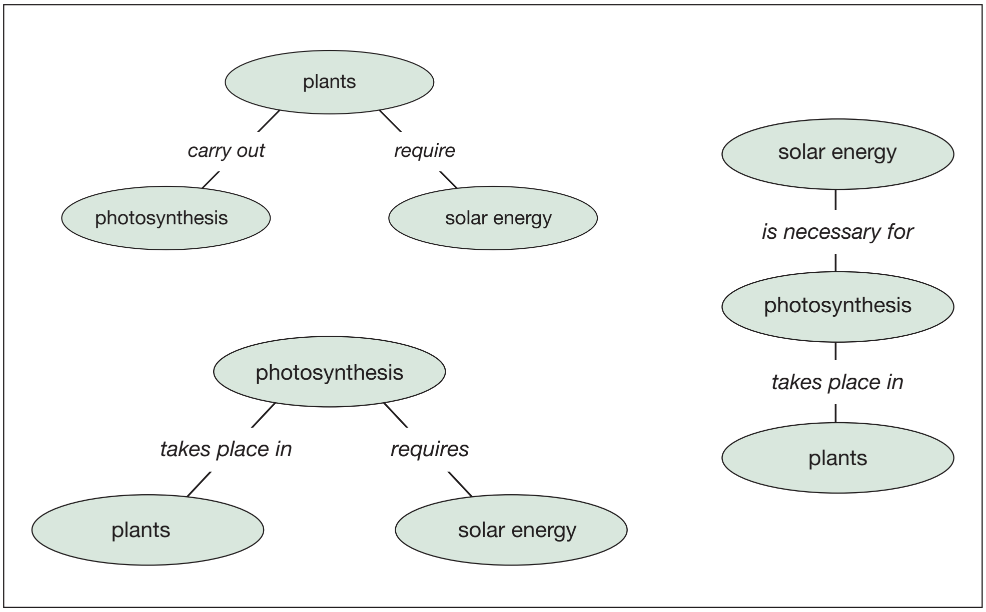


Figure H4.1 Simple concept maps.

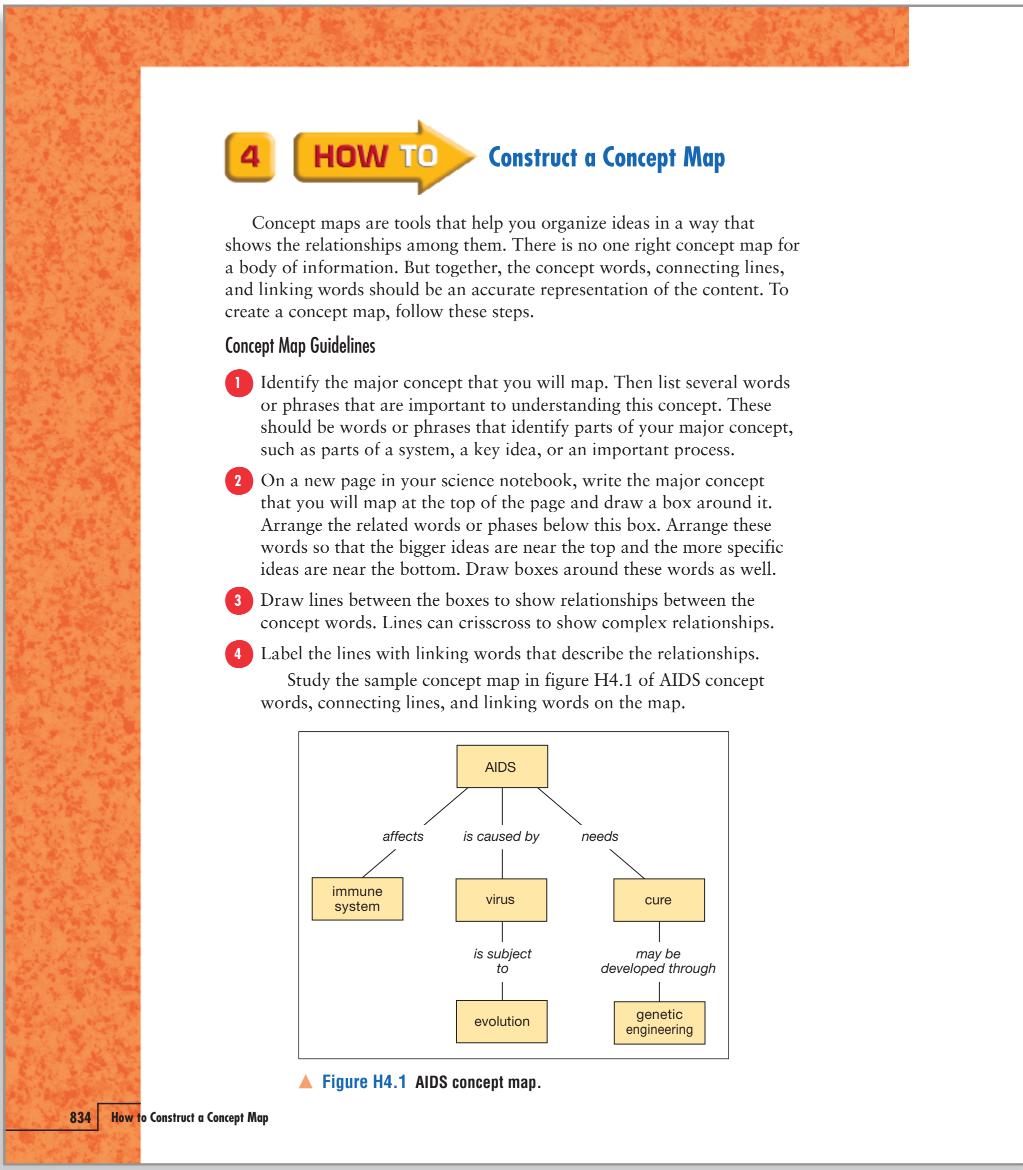
4 HOW TO

Construct a Concept Map

Adapted from BSCS. (2006). *BSCS biology: An ecological approach* [Green Version] (10th ed.). Dubuque, IA: Kendall/Hunt, p. T27.

Success in learning depends on the motivation and effort of each student. No method or process alone can guarantee meaningful learning; the students themselves must make the effort. Concept mapping is a tool that can help students learn by building on what they already know.

Concept maps demonstrate meaningful relationships between concepts through propositions. A concept is a mental image, such as plant, photosynthesis, or solar energy. A proposition consists of two or more concepts linked by words in a phrase or thought. The linking words show how the concepts are related. In developing a concept map, concepts and propositions are linked in a hierarchy, progressing from the more general and inclusive concepts at the top to the more specific at the bottom. The three concepts mentioned above could be linked in several ways (see example in figure H4.1).



4 HOW TO **Construct a Concept Map**

Concept maps are tools that help you organize ideas in a way that shows the relationships among them. There is no one right concept map for a body of information. But together, the concept words, connecting lines, and linking words should be an accurate representation of the content. To create a concept map, follow these steps.

Concept Map Guidelines

1. Identify the major concept that you will map. Then list several words or phrases that are important to understanding this concept. These should be words or phrases that identify parts of your major concept, such as parts of a system, a key idea, or an important process.
2. On a new page in your science notebook, write the major concept that you will map at the top of the page and draw a box around it. Arrange the related words or phases below this box. Arrange these words so that the bigger ideas are near the top and the more specific ideas are near the bottom. Draw boxes around these words as well.
3. Draw lines between the boxes to show relationships between the concept words. Lines can crisscross to show complex relationships.
4. Label the lines with linking words that describe the relationships.

Study the sample concept map in figure H4.1 of AIDS concept words, connecting lines, and linking words on the map.

Figure H4.1 AIDS concept map.

834 How to Construct a Concept Map

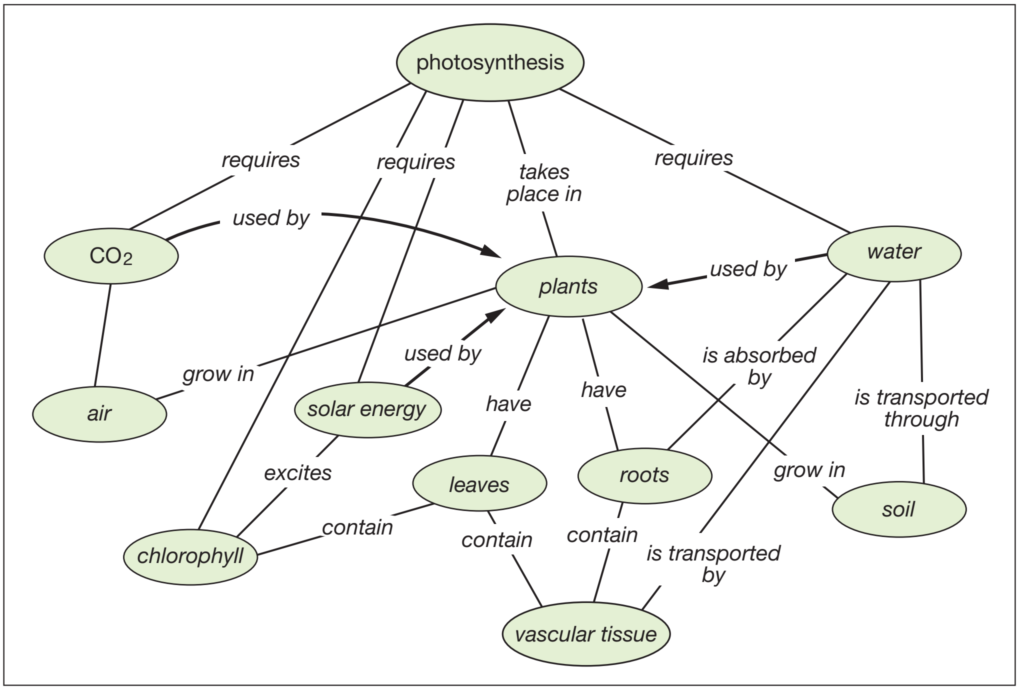
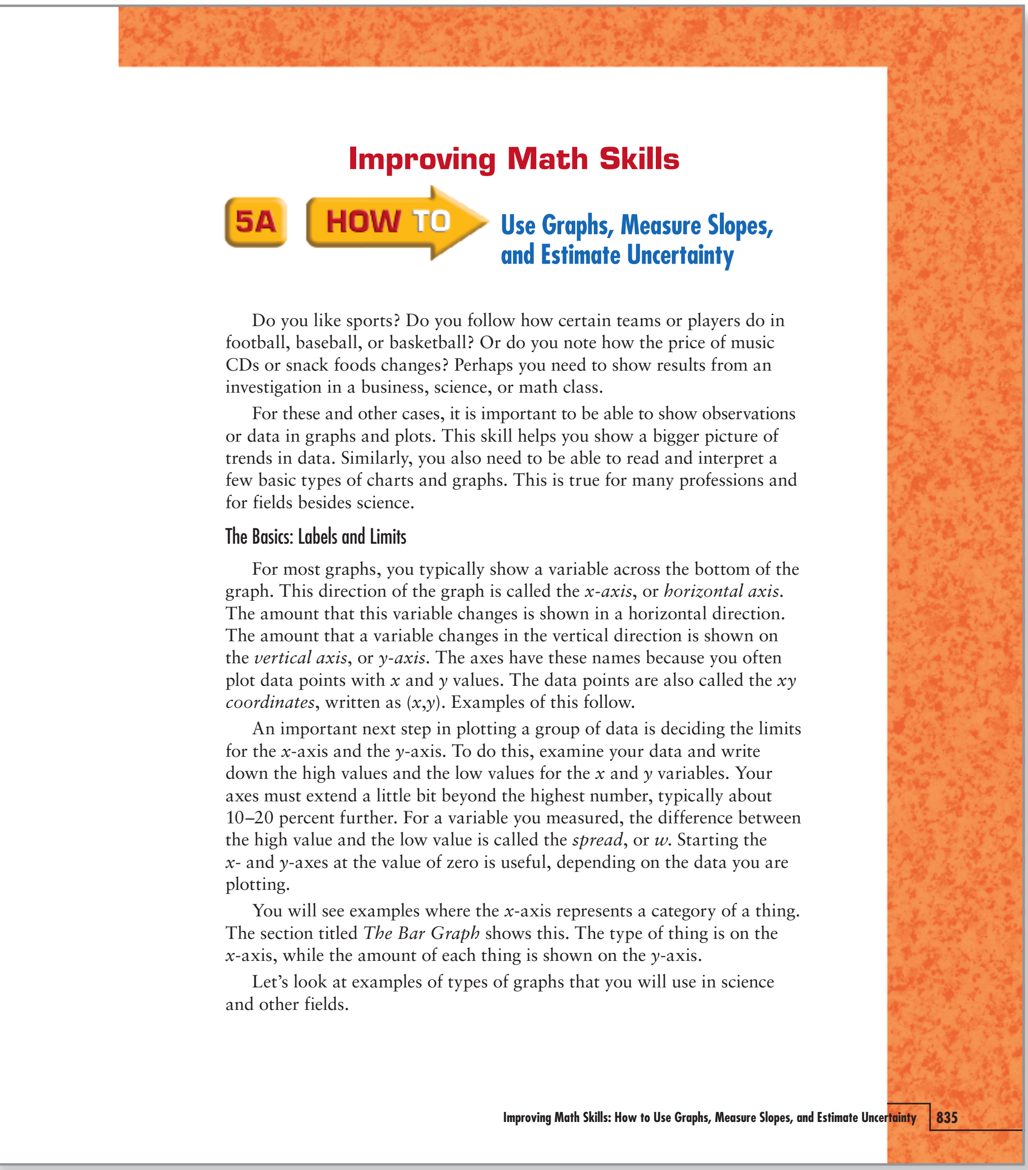


Figure H4.2
Complex concept map about photosynthesis.



Improving Math Skills

5A HOW TO Use Graphs, Measure Slopes, and Estimate Uncertainty

Do you like sports? Do you follow how certain teams or players do in football, baseball, or basketball? Or do you note how the price of music CDs or snack foods changes? Perhaps you need to show results from an investigation in a business, science, or math class.

For these and other cases, it is important to be able to show observations or data in graphs and plots. This skill helps you show a bigger picture of trends in data. Similarly, you also need to be able to read and interpret a few basic types of charts and graphs. This is true for many professions and for fields besides science.

The Basics: Labels and Limits

For most graphs, you typically show a variable across the bottom of the graph. This direction of the graph is called the *x-axis*, or *horizontal axis*. The amount that this variable changes is shown in a horizontal direction. The amount that a variable changes in the vertical direction is shown on the *vertical axis*, or *y-axis*. The axes have these names because you often plot data points with *x* and *y* values. The data points are also called the *xy coordinates*, written as (*x*,*y*). Examples of this follow.

An important next step in plotting a group of data is deciding the limits for the *x*-axis and the *y*-axis. To do this, examine your data and write down the high values and the low values for the *x* and *y* variables. Your axes must extend a little bit beyond the highest number, typically about 10–20 percent further. For a variable you measured, the difference between the high value and the low value is called the *spread*, or *w*. Starting the *x*- and *y*-axes at the value of zero is useful, depending on the data you are plotting.

You will see examples where the *x*-axis represents a category of a thing. The section titled *The Bar Graph* shows this. The type of thing is on the *x*-axis, while the amount of each thing is shown on the *y*-axis.

Let's look at examples of types of graphs that you will use in science and other fields.

Improving Math Skills: How to Use Graphs, Measure Slopes, and Estimate Uncertainty | 835

As much as possible, links should be functional rather than descriptive (for example, "plants *use* energy" rather than "plants *such as* trees"). Using these three concepts, it is possible to construct a useful concept map with the addition of a few related concepts, such as leaves, chlorophyll, water, air, carbon dioxide, roots, soil, and vascular tissue (see figure H4.2).

There is no single correct way to develop or use a concept map. You may choose to use a concept map to see what your students already know about a concept. Or you may use it as a review of concepts or as an assessment. In *BSCS Science: An Inquiry Approach*, concept maps are used in several different ways and you are free to add them whenever you see fit.

The student version of *How to Construct a Concept Map* describes a simple, step-by-step method for constructing concept maps. As you assess student concept maps, look for meaningful connections and linking language. Note the choices students make for the most general and inclusive concept. Is it the big idea of the chapter? Or have they selected a specific concept? Students should be able to explain their maps and add details in their discussion. In this way, you can assess their understanding of the concept.

NOTES:

Improving Math Skills

5A HOW TO

Use Graphs, Measure Slopes, and Estimate Uncertainty

All of the information for this *How To* appears in the student version.

The *xy* Plot

The *xy* plot is a simple plot where pairs of *xy* data are plotted as data points in a graph. Sometimes people call an *xy* plot a scatter plot. As you will see, this name really isn't appropriate because the data can define very straight lines (correlations) rather than scattered points.

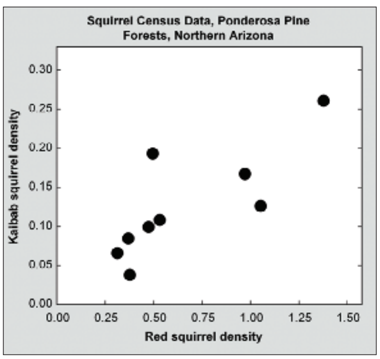
For example, the table in figure H5A.1 shows the population densities of two kinds of squirrels that live in the ponderosa pine forests in northern Arizona. The population density is the number of squirrels counted for an area 100 × 100 meters, about the area of two soccer fields. By examining the table, you can quickly see that red squirrels are more common overall than Kaibab squirrels in these forests. Note the shading on the high and low values in the table. You can see that the spread, w, for the red squirrel is about 1.1 (= 1.38−0.31) and the spread for the Kaibab squirrel is about 0.23 (= 0.26−0.038).

Red squirrel	Kaibab squirrel
0.3685	0.0844
0.4955	0.1931
0.5317	0.1083
0.4739	0.0993
0.9713	0.1671
1.0529	0.1263
1.3779	0.2607
0.3126	0.0657
0.3770	0.0377

▲ **Figure H5A.1** **Data on red and Kaibab squirrels.**

The values in the table help you decide the limits for the graph. You have some options, but the values of $x = 1.6$ and $y = 0.4$ work well for plot limits in this example.

The *xy* plot in figure H5A.2 helps you see relationships much better than the data table. The *xy* plot shows clearly that as the number of red squirrels



▶ **Figure H5A.2** **Plot for red and Kaibab squirrels.** *xy* plot showing the relationship between the density of red and Kaibab squirrels in northern Arizona ponderosa forests.

NOTES:

increases, the number of Kaibab squirrels also increases. We say that such data show a *correlation* between red and Kaibab squirrel populations. But why would that be? After viewing these data, a biologist might be interested in further exploring the factors that might cause the number of red and Kaibab squirrels to change together. In Level 1 of *BSCS Science: An Inquiry Approach*, you actually learn about the culprit behind why the numbers of red and Kaibab squirrels are correlated in these ponderosa forests.

Determining the Slope

An important feature of *xy* plots is that they show relationships between pairs of *x* and *y* values. When *xy* pairs define a line, you can calculate the slope to find out how much the *y* value changes for each change in the *x* value. You are probably familiar with this as rise over run, or $\frac{\Delta y}{\Delta x}$. When the variable on the *x*-axis is time, slope is very important because it gives you a rate of change. You have seen that this is part of calculating velocities.

Take an example of a car. You have a record of the total distance that the car has traveled at certain points in time. The data are shown in the graph in figure H5A.3. For example, after about 3 hours (hr), the car has traveled about 190 miles (mi). On average, what is the velocity of the car?

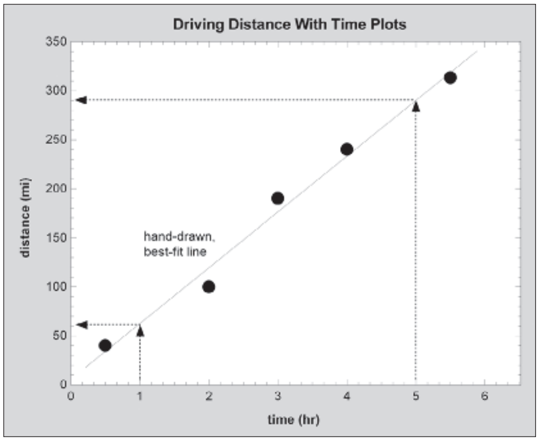


Figure H5A.3 Driving distance with time plots.

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You can determine the average velocity by finding the slope using Steps 1–5.

1. Draw a line that goes as closely as possible through the points.
2. Pick any 2 values on the x-axis, even if they do not have actual data points. You can select values of 1 and 5 hr from the graph in figure H5A.3.
3. Project these points up to where they intersect the best-fit line that you have drawn.
4. Read the y-axis value where the x-axis intersects the slope. By doing this, you obtain the xy coordinates of 2 locations on the line. You can show these locations in a T-table or designate them as x_1, y_1 and x_2, y_2.
5. You calculate the slope with a series of points on the line. By being careful to keep units for the x- and y-axes, this example shows that slope also tells you velocity when time is on the x-axis.

$$slope = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

$$= \frac{(290 - 61)\text{ mi}}{(5 - 1)\text{ hr}} = \frac{229\text{ mi}}{4\text{ hr}} = 57.3\,\frac{\text{mi}}{\text{hr}}$$

You'll want to remember a few extra points. First, the slope, $\frac{\Delta y}{\Delta x}$, is a rate when the change in the denominator of the slope, Δx, is time. For example, the car's velocity was a rate with units of miles per hour. Second, at times you can draw a best-fit line, but keep in mind that not all physical relationships are linear. You'll see a nonlinear example using radioactivity in the next section, *The Time-Trend Plot*. Other examples in this program use acceleration, population growth, erosion of mountains, and cyclical changes. Thus, slope is only valid for lines, or nearly linear relationships.

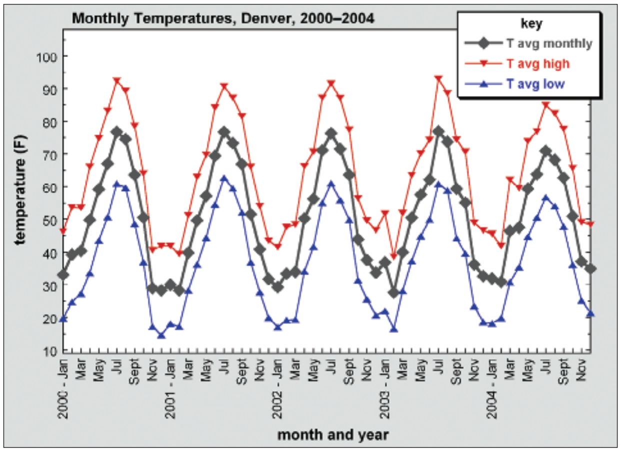
The Time-Trend Plot

The *time-trend plot* is a kind of xy plot where the x-axis has the units of time. These types of plots are used for testing whether a variable changes in a predictable way as a function of time. The measured variable is shown on the y-axis, with time on the x-axis.

838 Improving Math Skills: How to Use Graphs, Measure Slopes, and Estimate Uncertainty

NOTES:

Take records of monthly temperatures in Denver, Colorado, for example. Figure H5A.4 shows temperature data for 5 years from 2000–2004. Temperature is on the *y*-axis, with year and month on the *x*-axis. The bold line shows the average monthly temperature. This line is bound by the average high temperature (the average of daily high temperatures for the month) and the average low temperature (usually the average of daily low temperatures for the month). The plot shows annual temperature cycles. Moreover, the graph shows differences among the years.



▲ **Figure H5A.4** Temperature plot for Denver, Colorado.

Improving Math Skills: How to Use Graphs, Measure Slopes, and Estimate Uncertainty 839

NOTES:

Another useful type of xy plot is called a "double y" plot. This plot uses both the left and the right y-axes to show the values for two variables against a common variable on the x-axis. Double y plots are useful for time trends, as shown in figure H5A.5 for temperature and rainfall over 5 years in Denver. (Note that low rainfall in winter correlates with snow.)

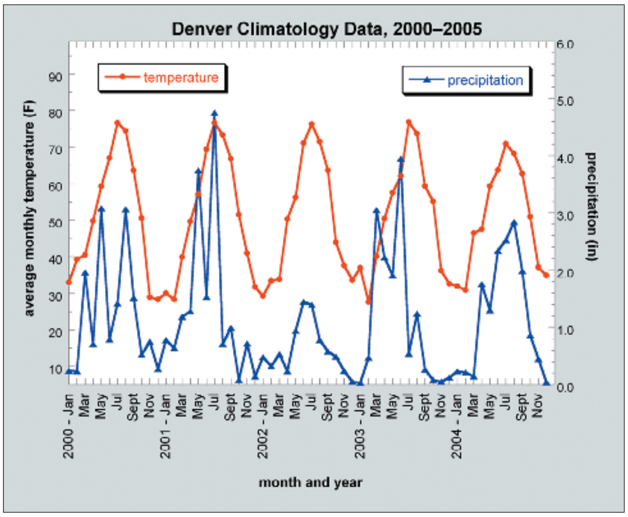


Figure H5A.5 Denver temperature and precipitation using a double y plot.

The xy graph can also be used to show another technique for graphing. Often, we use a regular scale for tick marks on the axes. These plots are *linear*. At other times, the major tick marks on the axes are compressed and show factors of 10. Usually, these axes denote a logarithmic pattern. We call these *log* axes.

Consider a nuclear disaster. A product of nuclear reactions with the element uranium (U-235) is radioactive atoms of strontium-90 (Sr-90). Authorities have been concerned about radioactive Sr-90 because it is similar

NOTES:

to calcium and it lodges rapidly in the bones of humans. Human bodies use calcium for bones. Radioactive atoms of Sr-90 in your bones are not good.

The mass of radioactive Sr-90 in a sample decreases by one-half (50 percent) in about 30 years (28.8 years, to be exact). This is the *half-life* of Sr-90. The table in figure H5A.6 shows that starting with an initial mass of 100 grams (g) of Sr-90, the mass of Sr-90 decreases by half, or 50 percent, every 30 years.

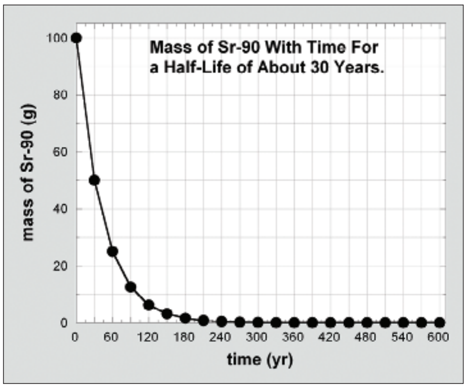
The data from the table are much easier to see and examine in a graph. For every 30 years that pass, the mass of Sr-90 decreases by about half. For example, after 60 years (two half-lives), only about 25 percent of the initial Sr-90 atoms remain. It appears from the plot in figure H5A.7 that the Sr-90 is gone after about 240 years. But on this linear scale, how would you tell if amounts still existed that were too small to show up on this graph? Even a gram or less of Sr-90 can be a health hazard.

Years	Mass of Sr-90 (g)
0	100.0000
30	50.0000
60	25.0000
90	12.5000
120	6.2500
150	3.1250
180	1.5625
210	0.7813
240	0.3906
270	0.1953
300	0.0977
330	0.0488
360	0.0244
390	0.0122
420	0.0061
450	0.0031
480	0.0015
510	0.0008
540	0.0004
570	0.0002
600	0.0001

Figure H5A.6 Sr-90 decay table.

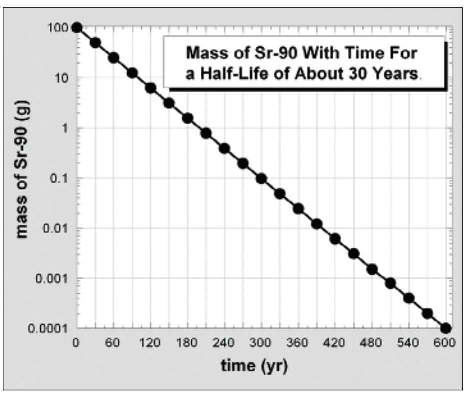
Improving Math Skills: How to Use Graphs, Measure Slopes, and Estimate Uncertainty 841

NOTES:



▲ Figure H5A.7 Linear plot of Sr-90.

You would use a log scale on an axis in what's called a *log plot*. In a log plot, the scale of the *y*-axis is modified so that increments are divided for each factor of 10. In general, values increase from 0.01, 0.1, 1.0, 10, 100, 1,000, and so on.



▲ Figure H5A.8 Log plot of Sr-90.

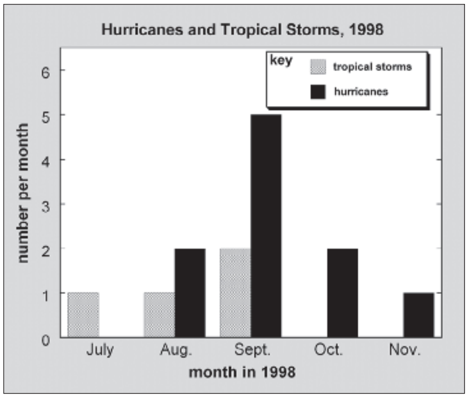
NOTES:

A key feature of the log plot is that the *y*-axis never goes to zero. Also, a value halfway between factors of 10 is roughly three, compared with five (between 0 and 10) on a linear scale. The graph in figure H5A.8 shows the same Sr-90 data in a log plot.

The Bar Graph

Bar graphs show the values or frequencies (on the *y*-axis) as a function of categories of things (on the *x*-axis). The *x*-axis does not have a numeric scale, either linear or log.

How could we show the frequency by month of tropical storms or hurricanes for the Atlantic Ocean in 1998? Bar graphs are perfect for this. Figure H5A.9 shows that for 1998, tropical storms occurred from July to September, with hurricanes occurring from August to November. Hurricanes also had a pronounced peak in September. Given such data, a scientist could then examine other years to test whether the pattern applies to those years.



▲ **Figure H5A.9 Hurricanes and storms bar graph.** This bar graph shows the frequency in 1998 of tropical storms and hurricanes in the Atlantic Ocean.

NOTES:

The Histogram

Histograms are another type of graph. They show how often a result occurs. Let's take an example showing scores in geology class. The following histograms show the scores for 27 students on a final mapping project for a geology class. The first histogram (figure H5A.10) shows compartments, or *bins*, where the scores are tallied. Bin sizes of two and five are shown for the same set of scores. The average score is 88.1, which falls in the bar with the highest value in figure H5A.10. The histograms show the *variability* of data about the mean.

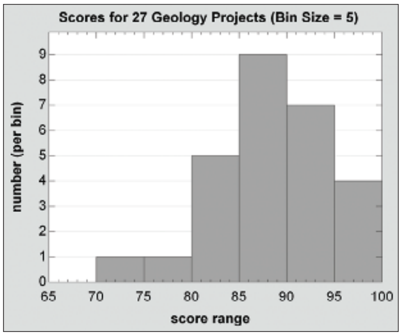


Figure H5A.10 Geology scores histogram where bin = 5. This histogram shows scores for 27 geology projects with a bin size of five.

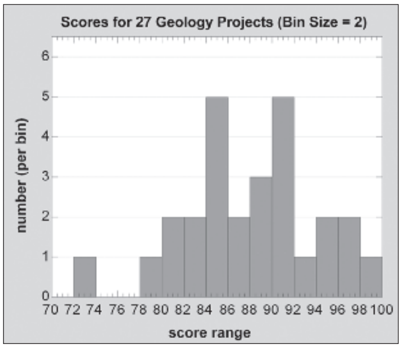


Figure H5A.11 Geology scores histogram where bin = 2. Histogram of scores for 27 geology projects with a bin size of two.

NOTES:

For comparison, the second histogram (figure H5A.11) shows the same scores ($n = 27$) using a finer bin size of two. The result is similar, but shows two distinct peaks on each side of the mean of 88.1. You may wish to test different bin sizes to show important points in a histogram that you wish to make.

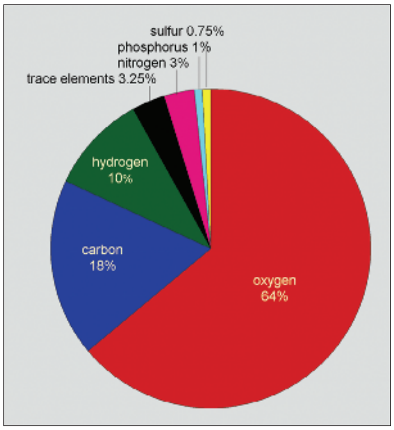
Note several things about histograms. In the histogram where the bin size equals five, values are distributed about a peak in the center. Sometimes this is called a *bell-shaped curve*. This happens when the number and positions of observations to the right and to the left of the peak are approximately equal. You might see a pattern like this by plotting a histogram of the heights of all students in your class. Your graph might have a peak value around 5.5 feet (ft), with a smattering of values in bins above and below 5 ft, 6 inches.

The key to making histograms is to first record your data or observations in a long column. Then decide the size of your bins. Finally, tabulate how many values in your column fall in each bin. Following these suggestions will help you successfully plot your histogram.

The Pie Chart

Another way to represent measurements or data is with a *pie chart*. This type of graph is called a pie chart because categories are spread around a circle, rather than along an x-axis, and look like slices of pie. The amount per category is given as a percentage of a total. Your teacher can show you how to take percentages for categories and divide them proportionally into a circle of 360 degrees.

Consider the human body. You may have heard statements such as, "Most of the human body is water." But what elements are in the human body? The pie chart in figure H5A.12 shows clearly that we are about 92 percent oxygen, carbon, and hydrogen.



▶ **Figure H5A.12** **A pie chart showing the body's elements.**

Improving Math Skills: How to Use Graphs, Measure Slopes, and Estimate Uncertainty 845

NOTES:

Showing Uncertainty (or Error) in Measurements

A good experimental design often requires that you repeat a measurement several times. Because experiments are not perfect, it is unlikely that you will get the same exact measurement in each trial. An average, $\bar{x}$ or "mean," is one way to estimate the actual value from your measurements. You are used to calculating averages. But how would you show the variability of your measurements around that mean? There are several ways to do this.

One way is to show all measured values around the average. Consider the scores on the final project in the geology class from the section *The Histogram*. The plot in figure H5A.13 shows all 27 student scores, along with a large symbol for the mean. For comparison, individual scores with means are plotted for two prior assignments (a quiz and a midterm) in that geology class.

A second way to represent all measured values is to calculate an indicator of uncertainty around the average. This is a quick way to estimate the standard deviation, another term that you might have heard. First, calculate the spread, w, between the high and low values. Next, to estimate the uncertainty (or error), e, divide the spread by the square root of the number of measurements, n.

$$e = \frac{w}{\sqrt{n}}$$

For the final project, the spread is $w = (98.3 - 73.1) = 25.2$. For 27 scores ($n = 27$), this gives an uncertainty of ± 4.8. The $\pm$ sign shows that the uncertainty in scores extends both above and below the mean. This estimate of uncertainty indicates that about 60–70 percent of the scores will have values bracketed by $\bar{x} \pm e$. With the geology final projects, this is 88.1 $\pm$4.8. (That is, about 60–70 percent of the scores fall in a range from 83.3 to 92.9.) This can also be shown graphically by error bars on the graph in figure H5A.14.

NOTES:

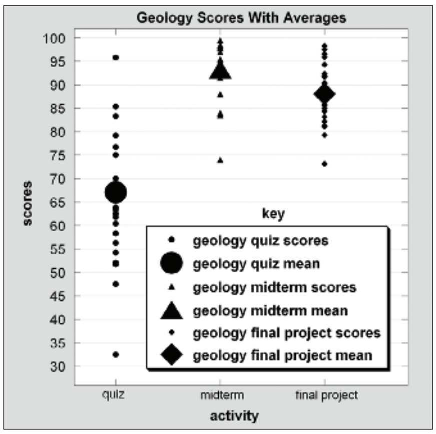


Figure H5A.13 Geology scores with averages.

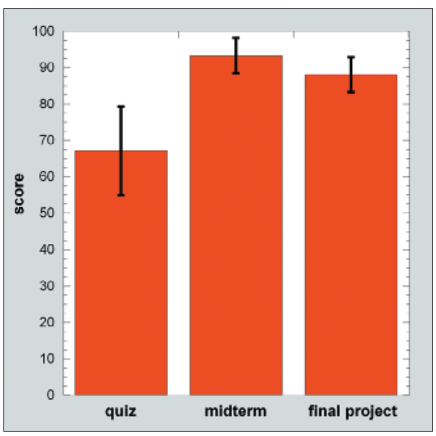


Figure H5A.14 Geology scores with errors.

Improving Math Skills: How to Use Graphs, Measure Slopes, and Estimate Uncertainty 847

5B HOW TO

Do Unit Conversions

Converting units is an essential skill, whether in science, business, or your finances. The key in all the examples and questions in the *How to Do Unit Conversions* activity is for students to carefully write out all units and conversions. If units don't cancel and give the desired units, then it is a clue to the student that there may be an error.

Another tip is to draw a slash through units in the numerator and denominator that cancel. This helps students see which units have canceled each other, and which units remain. For example, here's how you would show that 86,400 seconds is the same as 1 day:

$$(86{,}400\ \cancel{\text{sec}}) \times \left(\frac{1\ \cancel{\text{min}}}{60\ \cancel{\text{sec}}}\right) \times \left(\frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}}\right) \times \left(\frac{1\ \text{day}}{24\ \cancel{\text{hr}}}\right) = 1\ \text{day}$$

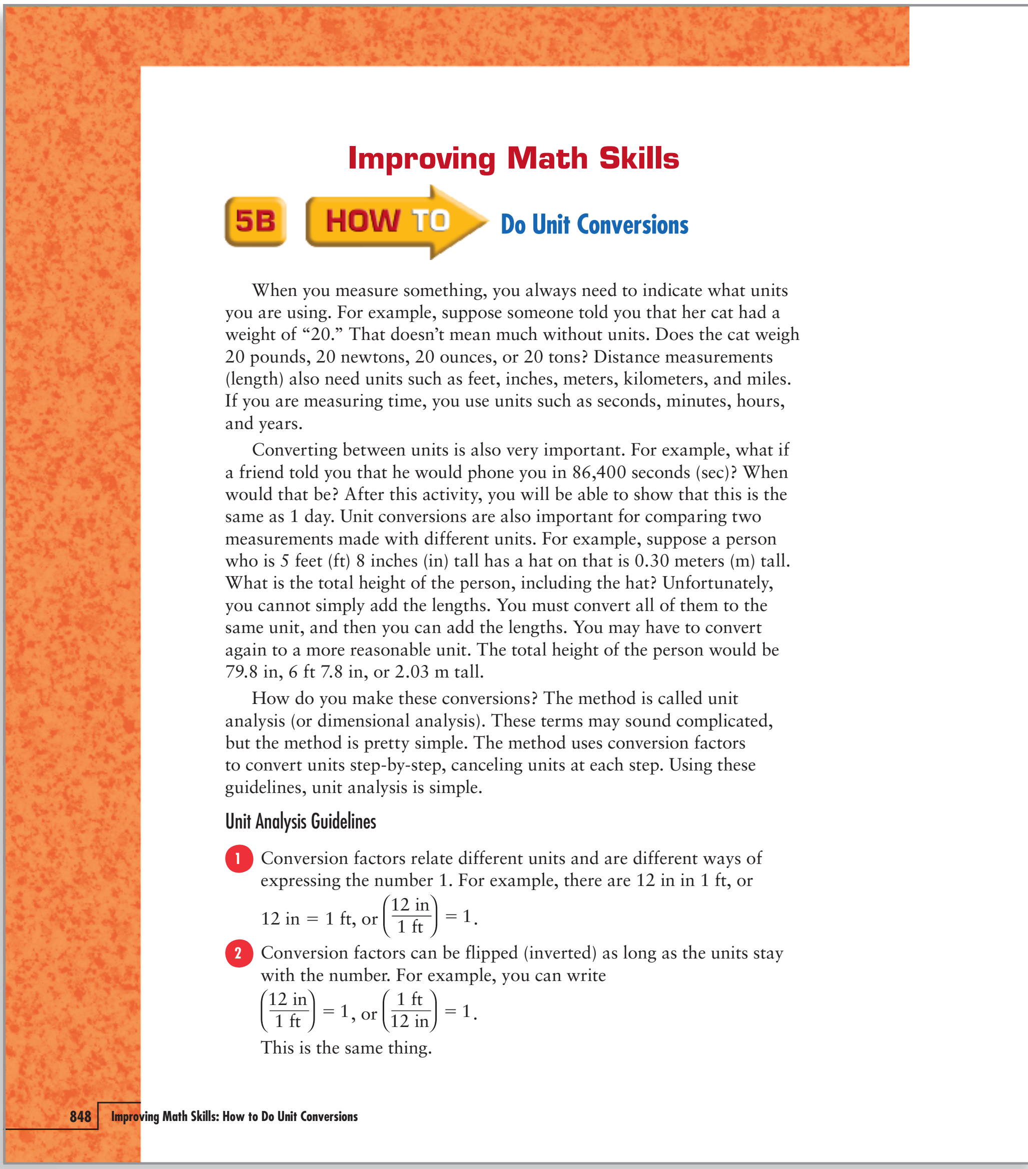
Seconds (sec), hours (hr), and minutes (min) are on both the top and the bottom, so they cancel, leaving just days. You can use the same method to show that 259,200 seconds is the same as 3 days. Similarly, you can show that a foot (ft) is 30.48 centimeters (cm).

$$(1\ \cancel{\text{ft}}) \times \left(\frac{12\ \cancel{\text{in}}}{1\ \cancel{\text{ft}}}\right) \times \left(\frac{2.54\ \text{cm}}{1\ \cancel{\text{in}}}\right) = 30.48\ \text{cm}$$

TRCD

For additional practice, see the practice set in the *Toolbox* activity, *Conversions*, on the *Teacher Resource CD* (*TRCD*).

NOTES:



Improving Math Skills

5B HOW TO Do Unit Conversions

When you measure something, you always need to indicate what units you are using. For example, suppose someone told you that her cat had a weight of "20." That doesn't mean much without units. Does the cat weigh 20 pounds, 20 newtons, 20 ounces, or 20 tons? Distance measurements (length) also need units such as feet, inches, meters, kilometers, and miles. If you are measuring time, you use units such as seconds, minutes, hours, and years.

Converting between units is also very important. For example, what if a friend told you that he would phone you in 86,400 seconds (sec)? When would that be? After this activity, you will be able to show that this is the same as 1 day. Unit conversions are also important for comparing two measurements made with different units. For example, suppose a person who is 5 feet (ft) 8 inches (in) tall has a hat on that is 0.30 meters (m) tall. What is the total height of the person, including the hat? Unfortunately, you cannot simply add the lengths. You must convert all of them to the same unit, and then you can add the lengths. You may have to convert again to a more reasonable unit. The total height of the person would be 79.8 in, 6 ft 7.8 in, or 2.03 m tall.

How do you make these conversions? The method is called unit analysis (or dimensional analysis). These terms may sound complicated, but the method is pretty simple. The method uses conversion factors to convert units step-by-step, canceling units at each step. Using these guidelines, unit analysis is simple.

Unit Analysis Guidelines

1. Conversion factors relate different units and are different ways of expressing the number 1. For example, there are 12 in in 1 ft, or 12 in = 1 ft, or $\left(\frac{12\ \text{in}}{1\ \text{ft}}\right) = 1$.
2. Conversion factors can be flipped (inverted) as long as the units stay with the number. For example, you can write $\left(\frac{12\ \text{in}}{1\ \text{ft}}\right) = 1$, or $\left(\frac{1\ \text{ft}}{12\ \text{in}}\right) = 1$. This is the same thing.

848 Improving Math Skills: How to Do Unit Conversions

NOTES:

3 Units behave as numbers do when you multiply fractions. The units in the numerator of fractions will cancel the same units in the denominator of fractions. For example, $\left(\frac{12 \cancel{\text{in}}}{3 \cancel{\text{in}}}\right) = 4$.

4 In unit analysis, your goal is to cancel the same units in the numerators and denominators until you end up with the units you want.

5 When you convert between units, follow these steps.

a. Identify the units that you have.
b. See which units you want.
c. Note the conversion factors that get you from Steps 5a and 5b.

6 Work through the following example to practice using the guidelines for unit analysis from Steps 1–5.

How many inches are there in 1 mile (mi)?

Conversion steps (from Step 5)	Answers
What unit do you have now?	1 mi
What unit do you want?	"How many inches"
What are the conversion factors?	$1 \text{ mi} = 5{,}280 \text{ ft}$ or $\left(\frac{5{,}280 \text{ ft}}{1 \text{ mi}}\right) = 1$ $1 \text{ ft} = 12 \text{ in}$ or $\left(\frac{12 \text{ in}}{1 \text{ ft}}\right) = 1$

▲ **Figure H5B.1** Conversion table for miles to inches.

To convert miles to inches, start with what you know (1 mi). Then use conversion factors (figure H5B.1) to cancel units as you go until you get to the units that you want (inches). When the same units are on both the bottom and the top, they cancel. Work with your teacher to see how to cancel these units on the top and bottom.

$$(1 \cancel{\text{mi}}) \times \left(\frac{5{,}280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}}\right) \times \left(\frac{12 \text{ in}}{1 \cancel{\text{ft}}}\right)$$

The units cancel, so you are left with units of inches. You can then multiply the numerator numbers together for the answer in inches.

$$(1 \cancel{\text{mi}}) \times \left(\frac{5{,}280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}}\right) \times \left(\frac{12 \text{ in}}{1 \cancel{\text{ft}}}\right) = \left(\frac{1 \times 5{,}280 \times 12 \text{ in}}{1 \times 1}\right) = 63{,}360 \text{ in}$$

NOTES:

The unit conversions in Step 8 of the activity show whether your students understand the concept and significance of unit conversions. This is because they have not worked with the units, such as zips, sliffs, or lampos.

Answers to Step 8

8a. The answer for the conversion from lampos to sliffs follows.

$$(1\ \cancel{\text{lampo}}) \times \left(\frac{12\ \cancel{\text{vole}}}{1\ \cancel{\text{lampo}}}\right) \times \left(\frac{3\ \text{sliff}}{4\ \cancel{\text{vole}}}\right) = 9\ \text{sliff}$$

8b. The answer for the conversion from voles to zips follows.

$$(1\ \cancel{\text{vole}}) \times \left(\frac{3\ \cancel{\text{sliff}}}{4\ \cancel{\text{vole}}}\right) \times \left(\frac{5\ \text{zip}}{1\ \cancel{\text{sliff}}}\right) = 3.75\ \text{zip}$$

8c. The answer for the conversion from slinks to flies follows.

$$(1\ \cancel{\text{slink}}) \times \left(\frac{7\ \cancel{\text{zip}}}{1\ \cancel{\text{slink}}}\right) \times \left(\frac{1\ \cancel{\text{sliff}}}{5\ \cancel{\text{zip}}}\right) \times \left(\frac{4\ \cancel{\text{vole}}}{3\ \cancel{\text{sliff}}}\right) \times \left(\frac{1\ \cancel{\text{lampo}}}{12\ \cancel{\text{vole}}}\right) \times \left(\frac{7\ \text{fly}}{8\ \cancel{\text{lampo}}}\right) = 0.136\ \text{flie}$$

7 Work through a more complicated example using dimensional analysis. Suppose that you want to convert 75 miles per hour (mph) into feet per second (ft/sec).

Conversion steps (from Step 5)	Answers
What unit do you have now?	$75\ \frac{\text{mi}}{\text{hr}}$ (mph)
What unit do you want?	$\frac{\text{ft}}{\text{sec}}$ (ft/sec)
What are the conversion factors?	1 hour (hr) = 60 minutes (min) 1 minute (min) = 60 seconds (sec) 1 mi = 5,280 ft

▲ **Figure H5B.2** **Conversion table for miles per hour to feet per second.**

Now what? Take your conversions (figure H5B.2) one step at a time, canceling units as you go until you arrive at the units you want.

$$\left(\frac{75\ \cancel{\text{mi}}}{1\ \cancel{\text{hr}}}\right) \times \left(\frac{5{,}280\ \text{ft}}{1\ \cancel{\text{mi}}}\right) \times \left(\frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}}\right) \times \left(\frac{1\ \cancel{\text{min}}}{60\ \text{sec}}\right) =$$

$$\left(\frac{75 \times 5{,}280\ \text{ft} \times 1 \times 1}{1 \times 1 \times 60 \times 60\ \text{sec}}\right) = \left(\frac{396{,}000\ \text{ft}}{3{,}600\ \text{sec}}\right) = \left(\frac{110\ \text{ft}}{1\ \text{sec}}\right) = 110\ \frac{\text{ft}}{\text{sec}}$$

8 Try the conversions in Steps 8a–c on your own. Use the following conversion factors, and show your calculations for each conversion.

1 slink = 7 zips   1 sliff = 5 zips
4 voles = 3 sliffs   8 lampos = 7 flies
12 voles = 1 lampo

a. How many sliffs are in 1 lampo?
b. One vole is how many zips?
c. How many flies are in 1 slink?

5C HOW TO

Understand Very Large and Very Small Numbers

When thinking about the universe, it is difficult to imagine its size and mass. There are hundreds of billions of stars in our galaxy and then billions of galaxies in the universe. Distances in the universe are trillions of kilometers. Temperatures in the universe were once billions of degrees Celsius. The age of the universe is billions of years. Sometimes numbers like millions and billions are used often enough that people do not realize how large these quantities really are. In the activity in *How to Understand Very Large and Very Small Numbers*, students experience how immense million and billion are.

Materials—Part I

calculators, rulers, or meter sticks (optional)
1 Becker "One in a Million" bottle (optional)

Materials—Part II

stopwatch or clock with second hand
calculators

Advance Preparation

In Part I, students may wish to use a calculator or some way of measuring. Have calculators, rulers, and meter sticks available. Next, look around your classroom, hallway, and outside to get an idea of what students might want to use as their "million of something." Items they might find include blades of grass on the football field, little dots on ceiling tiles, grains of sand, the number of colored fibers in a carpet, and the number of letters (or words, pages, and so on) in a textbook.

If you choose to show the students a Becker "One in a Million" bottle, locate it or order it. It can be purchased from Flinn Scientific, Inc., at http://www.flinnsci.com/ or toll free at 1-800-452-1261.

In Part II, students will need a timer and calculators. Gather stopwatches or check if your classroom clock has a second hand that students can easily view.

Part I: How Many Is 1 Million?

Have the class read the introduction and work in pairs. You may wish to pair students who have different ability levels in math. You might ask them, "If a rich uncle left you an inheritance of $1 million, how long would it take you to count that much money if it were in $1 bills?" Pose the same question as if it were $1 billion. Explain that astronomy involves enormous numbers. This activity will help them understand how large the numbers 1 million and 1 billion are.

Circulate to help the students with their math or to give them hints on what objects they might use. The way that the students likely will approach the task is to find a pattern that is repeated. They count the number in one area and then divide 1 million by that number to determine how much area they would need to get a million of that item. For example, if they counted 200 dots in one ceiling tile, they could assume that ceiling tiles had an average of 200 dots on them (or they could get the average of a few tiles). They then would divide 1 million by 200 to determine that they would need 5,000 ceiling tiles to have 1 million dots. They likely would not find 5,000 ceiling tiles, but their method would prove how to get 1 million ceiling tile dots.

Improving Math Skills

5C HOW TO **Understand Very Large and Very Small Numbers**

When it comes to studying the universe, scientists must work with very large and very small numbers. Scientists use numbers in the millions and billions because quantities, distances, timescales, and temperatures in the universe are so vast. Consider this:

- Our galaxy has billions of stars, and the universe has hundreds of billions of galaxies.
- Distances between objects in the universe can be greater than billions of miles; it would take light over 10 billion years to travel across the universe.
- Astronomers measure time spans of the universe in billions of years.
- Temperatures in the universe once were hotter than billions of degrees Celsius.

You know that 1 million is a lot—but how much is it? For instance, if someone offered you a million dollars in a pile, you'd sure take it. But how could you test that the pile actually had 1 million dollar bills in it? Would you count dollar bills one by one? How long would this take? Now suppose that someone gave you a billion dollars in $1 bills. How much more is this, really?

In *How to Understand Very Large and Very Small Numbers*, you'll explore how big the numbers million and billion really are. Get ready to share your ideas with your classmates.

Part I: How Many Is 1 Million?

Materials

none

1. With your teammate, find or think of a million of 1 type of item. You do not need to actually collect the items, but decide how you will convince the rest of the class that you could gather 1 million of the item. Think through this step carefully. You can change items to arrive at the best example.

When finished, have the pairs share what they found and how they can prove it. Again, it is best if they can use numbers to prove their approach convincingly. Having groups show and argue their evidence and a proof (with numbers) is likely the most important point.

Part II: Millions or Billions: What's the Difference?

It's quite a bit different talking about 1 billion of something than 1 million. The difference is 1,000, but your students might not yet get this point, particularly if they are unfamiliar with scientific notation. Have them work through the estimate of how long it would take to count to 1 million, then 1 billion.

In Step 1, students predict how long they think it will take them to count to 1 million. Any student prediction is OK at this point. Students will time each other saying "383,262" in Step 2a. This number takes about 3 seconds (sec) to say. In Step 2b, students calculate how long it takes to count to 1 million based on their answers to Step 2a. This should be 3 sec times 1 million, or 3 million sec.

In Step 3, students should convert their answer to days. Three million seconds might not make a lot of sense, even though the answer is accurate. Convert seconds to an appropriate unit, which in this case is days. Check that all students show their calculations. This shows why the answer is about 35 days.

$$(3{,}000{,}000\ \cancel{\text{sec}}) \times \left(\frac{1\ \cancel{\text{min}}}{60\ \cancel{\text{sec}}}\right) \times \left(\frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}}\right) \times \left(\frac{1\ \text{day}}{24\ \cancel{\text{hr}}}\right) = 34.7\ \text{days}$$

TRCD

There are practice sets in the *Toolbox* activities, *Decimals, Exponents*, and *Conversions* on the *TRCD* if your students need additional practice working with large and small numbers, exponents, decimals, or unit conversions.

In Step 4, students predict the time needed to count to 1 billion. Check that students record in their science notebooks their prediction for the time to count to 1 billion.

NOTES:

2. Work with your partner on a method to prove that you have 1 million of the objects. You will share your ideas and prove your work to your classmates.

3. Discuss these questions in your class and write your answers in your science notebook.
   a. What were some of the difficulties you had finding a million of something?
   b. What were some different methods that groups used to prove their findings?

Part II: Millions or Billions: What's the Difference?

Materials

stopwatch or clock with second hand

calculators

In Part I, you had to prove that you have 1 million of an item. This might have seemed difficult at first, but you probably quickly figured out how to meet the challenge. As you worked, you should have seen how big 1 million of something really is. You also probably saw that counting every single item would not work too well.

Astronomers work with numbers even larger than 1 million. In fact, numbers in the billions and larger are quite common in astronomy. You will work again with your partner to better understand the real size of 1 billion (1,000,000,000).

1. Individually, predict how long you think it would take you to count to 1 million saying each number aloud without stopping. Write this prediction in your science notebook and title it "prediction." What did your partner predict?

2. With your partner, calculate how long it takes to count to 1 million (1,000,000).
   a. Have one person say the number 383,262 ("three hundred eighty-three thousand two hundred sixty-two") while the other person times how long it takes to say the number. Record the time in your science notebook.

You said this number because most numbers between 1 and 1 million are in the hundred thousands.

In Step 5, students calculate the time it takes to count to a billion by ones. They use the same method as before by timing how long it takes to say "504,394,568." This takes about 5.1 sec to say. Multiplied by 1 billion, it takes 5,100,000,000 sec to count to 1 billion. You can show that this is about 162 years.

$$(5{,}100{,}000{,}000\ \cancel{\text{sec}}) \times \left(\frac{1\ \cancel{\text{min}}}{60\ \cancel{\text{sec}}}\right) \times \left(\frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}}\right) \times \left(\frac{1\ \cancel{\text{day}}}{24\ \cancel{\text{hr}}}\right) \times \left(\frac{1\ \text{year}}{365.25\ \cancel{\text{days}}}\right) = 161.6\ \text{years}$$

In Step 6, students share and compare their answers with the class. In Step 7, students answer 3 questions about the activity. Note that the difference between 1 million and 1 billion for objects is just 1,000. However, the difference in time for counting is somewhat larger because it takes longer to state the numbers in the hundreds of millions. The differences above are a factor of about 1,700 (161.6 years / 34.7 days = 161.6 years / 0.095 years = 1,700).

Be open to all ideas as students discuss their answers to Step 7b. In Step 7c, see whether students are noting uncertainties in the time it takes different students to say the number. This factor would lead to different results.

b. It took you a certain number of seconds to say that single number. How many numbers are there between 1 and 1 million? Using multiplication, calculate how many seconds it would take you to say all these numbers and, thus, count to 1 million. Record your calculations and this number in your science notebook.

3. You probably calculated many millions of seconds, which probably doesn't make a lot of sense. Convert your answer from seconds to a more appropriate unit. Show your calculations in your science notebook. What did others in your class find?

4. You now know that it takes a significant amount of time to count to 1 million. But many measurements in the universe need billions or even hundreds of billions. Let's see how 1 billion compares with 1 million. Predict how long it would take you to count to 1 billion by ones. Record your prediction in your science notebook.

5. Calculate how long it would take you to count to 1 billion (1,000,000,000) by ones. Use the same method you used in Step 2 and record your answer in the units that make the most sense. Review the unit conversions as necessary.

A good number to say is 504,394,568 (pronounced "five hundred four million three hundred ninety-four thousand five hundred sixty-eight") because most numbers from 1 to 1 billion are in the hundreds of millions.

6. Share your calculation from Step 5 with the class. What did you find?

7. Discuss Questions 7a–c with your class and write your answers in your science notebook.
   - **a.** Were you surprised at how long it would take you to count to a billion versus counting to a million? Explain your thoughts.
   - **b.** How did measuring 1 million of an object help you to understand the enormity of 1 million?
   - **c.** What was the range of values your class had for counting to 1 billion? What might account for this range of results?

NOTES:

5D HOW TO

Use Very Large and Very Small Numbers

Astronomy is again used as the context. If your students used Level 1 of *BSCS Science: An Inquiry Approach*, this information will be familiar from unit 3, *The Earth and Beyond*. Astronomy is a study that uses extreme numbers. The distances, times, masses, and temperatures are very large, yet atomic masses, diameters, and radiation wavelengths can be incredibly small. Scientific notation is how you and your students will represent the sizes of these things. In this *How To* activity, students learn how to use scientific notation to express numbers. They also read about some of the units astronomers use to measure distances in the universe.

Materials—Part I

calculators

video player and video *Powers of Ten* (optional)

Materials—Part II

calculators

Advance Preparation

Have calculators available for student use. Students can start learning how to key in exponents on calculators. If you have access to the video *Powers of Ten*, it is helpful to show. Your math department may have a copy, or you can order it from Eames Office (search for Eames Office on the Web).

Part I: Big Numbers

Have students read the activity, the table, and the questions in Part I. Be prepared to help them move decimals back and forth. This is an important skill. You can practice this with your class by writing any number students say on the board, and then have one student come up to express the number in scientific notation. It's good to have students do a lot of examples moving decimals in both directions.

TRCD

There are *Toolbox* practice sets on the *Teacher Resource CD* (*TRCD*) if your students need additional practice working with large and small numbers, exponents, decimals, or unit conversions.

NOTES:

Improving Math Skills

5D HOW TO

Use Very Large and Very Small Numbers

By now, you understand numbers like million and billion better. Astronomers have to work with numbers in the billions—and bigger—all the time. For example, how many stars are in the sky? Are there more stars that you cannot see? All stars that you see are part of the galaxy in which we live, the Milky Way Galaxy. A galaxy is an enormous group of stars in a massive cluster. The Milky Way has more than 100 billion stars. The universe contains hundreds of billions of different galaxies, many of which are made up of hundreds of billions of stars. How do astronomers know this?

Astronomers are scientists who study the matter in outer space, particularly the many types of stars. When they cannot count stars or galaxies, they need to calculate estimates based on what they can clearly see and count. For example, astronomers cannot see each star in our galaxy because some stars are behind other stars or clouds of gas and dust. So astronomers base their estimates on mass. The laws of physics also allow astronomers to estimate the mass of the Milky Way Galaxy. Dividing this by the mass of an average star like the Sun gives estimates of up to several hundred billion stars in the Milky Way Galaxy.

Part I: Big Numbers

Materials

calculators

You have seen how large numbers can be difficult to manage. It would be awkward for astronomers to use terms such as a million billion billion or to write out numbers like 1,000,000,000,000,000,000,000,000. Rather, astronomers (and other scientists) use a special way of expressing numbers called scientific notation.

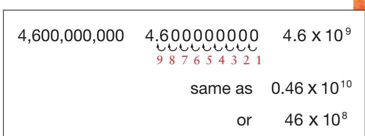
Scientific notation is a way to abbreviate numbers to make them easier to work with. To show numbers with scientific notation, you must first be comfortable with exponents. Exponents are shorthand for the number of times a number, called the base, is multiplied by itself. A base with an exponent is said to be "raised to the power" of that exponent. For example, the number 2^4 means $2 \times 2 \times 2 \times 2$, or 16. Here, 2 is the base and 4 is the exponent. In scientific notation, the base number is always 10. Having

NOTES:

10 as the base works well because the exponent shows how many zeros you would need to write out in the long form of the number. So 10,000 is expressed as 10^4, because $10 \times 10 \times 10 \times 10 = 10{,}000$.

Numbers in astronomy work best with powers of 10. With scientific notation, you simply move the decimal point of a number to obtain a more manageable number. Then you write the number of places you moved the decimal as an exponent of 10. For example, you would write the number 4,600,000,000 as 4.6×10^9 with scientific notation. The second number is a lot simpler, and it says the same thing as the first. You write it like this because you moved the decimal nine places to the left to get to the numeral 4.6. This is shown in figure H5D.1.

Other large numbers are also easy to write using scientific notation. You would write the number 34,000 as 3.4×10^4. You would write the number 286,000,000 as 2.86×10^8. You might remember that the metric system is based on multiples of 10. The table in figure H5D.2 shows how large numbers convert to powers of 10. It also shows prefixes for these numbers in the metric system. Using the example above, 286,000,000 is also the same as 286×10^6, or just 286 million.



▶ **Figure H5D.1 Example of moving decimals for positive exponents.** This diagram shows the conversion of the number 4,600,000,000 to scientific notation, 4.6×10^9. The illustration in the center shows the decimal place moving left nine times. The table in figure H5D.2 explains why 4.6×10^9 is the same as 4.6 billion.

Pronounced	Number	Powers of ten (scientific notation)	Unit prefix in the metric system (SI)
Trillion	1,000,000,000,000	10^{12} or 1×10^{12}	tera-
Billion	1,000,000,000	10^9 or 1×10^9	giga-
Million	1,000,000	10^6 or 1×10^6	mega-
Thousand	1,000	10^3 or 1×10^3	kilo-
Hundred	100	10^2 or 1×10^2	hecto-
Ten	10	10^1 or 1×10^1	deka-
One	1	10^0 or 1×10^0	
Three hundred twenty-seven thousand	327,000	3.27×10^5	

▲ **Figure H5D.2 Table for large numbers.**

Improving Math Skills: How to Use Very Large and Very Small Numbers 855

NOTES:

Answers to Steps 1–4

Student answers for these steps include the following.

1. 1,000 meter (m) = 1×10^3 m, or 10^3 m.
2. The exponent on 10 indicates the number of times that the decimal moves. This is the same as the number of zeros. Thus, a googol is 1×10^{100}, or 10^{100}.
3. 3.0×10^8 meters per second (m/sec) = 300,000,000 m/sec.
4. \$87 billion = 87×10^9 dollars, or 8.7×10^{10} dollars;

   248 million stars = 248×10^6 stars, or 2.48×10^8 stars.

Work through these problems individually and write your answers in your science notebook. When you finish, join with another student and compare your answers. Discuss and resolve any differences you have in your answers.

1. One kilometer (km) is the same as 1,000 meters (m). How would you write 1,000 m using scientific notation?
2. A googol is one of the biggest named numbers. It is written as the number 1 followed by 100 zeros. Write this number using scientific notation.
3. The speed of light is 3.0×10^8 meters per second (m/sec). What is this value written without using scientific notation?
4. Use scientific notation to write \$87 billion and 248 million stars.

Part II: Small Numbers

Materials

calculators

Astronomers often work with countless billions of stars and galaxies, but they also work with extremely small numbers. For example, you will see that a key property of light is wavelength. Wavelengths of light are commonly about 1 billion times shorter than a meter.

You write numbers less than 1.0 in scientific notation in the same general way that you write large numbers. The key difference is that the power of 10 is a negative exponent. The exponent still tells you how many places the decimal is from the number 1.0, but the decimal is moved in the other direction (to the right). When writing small numbers using powers of 10, you imagine moving the decimal to the right. The number of places you moved the decimal is the power of 10 expressed as a negative number. We would write the number 0.0000001 in scientific notation as 1×10^{-7} because the decimal moves seven places to the right to get to the number 1.0. Another example is shown in figure H5D.3 for 0.00000035, which is the same as 3.5×10^{-7}.

0.00000035	00000003.5 1 2 3 4 5 6 7	3.5×10^{-7}
	same as	0.35×10^{-6}
	or	350×10^{-9}

Figure H5D.3 Example of moving decimals for negative exponents. This diagram shows the conversion of the number 0.00000035 to scientific notation, 3.5×10^{-7}. The illustration in the top center shows the decimal place moving to the right seven times.

856 Improving Math Skills: How to Use Very Large and Very Small Numbers

NOTES:

Pronounced	Number	Powers of ten (scientific notation)	Unit prefix in the metric system (SI)
Tenth	0.1	1×10^{-1} or 10^{-1}	deci-
Hundredth	0.01	1×10^{-2} or 10^{-2}	centi-
Thousandth	0.001	1×10^{-3} or 10^{-3}	milli-
Millionth	0.000001	1×10^{-6} or 10^{-6}	micro-
Billionth	0.000000001	1×10^{-9} or 10^{-9}	nano-

▲ **Figure H5D.4** **Prefixes for small numbers.**

Work through these problems individually and write your answers in your science notebook. When you finish, join with another student and compare your answers. Discuss and resolve any differences you have in your answers.

1. A micron is an abbreviation for the term micrometer (μm). How would you express 1 μm using scientific notation? Look at the prefixes in the table in figure H5D.4.
2. How many meters are in 1 millimeter (mm)?
3. Scientists often measure wavelengths of light in units called nanometers (nm). A nanometer is 0.000000001 m. Write this number using scientific notation.

Improving Math Skills: How to Use Very Large and Very Small Numbers 857

Part II: Small Numbers

The key with small numbers (< 1) and scientific notation is remembering the negative sign with the exponent of 10. You might also recall that you can move an exponent from the numerator to the denominator by switching the sign of the exponent. This is a useful manipulation, but remember that units must stay put.

$$\left(\frac{1}{10^{3}\ \text{m}}\right) = \left(\frac{10^{-3}}{1\ \text{m}}\right) = 10^{-3}\ \text{m}^{-1}$$

TRCD

There are practice worksheets included in the *Toolbox* on the *TRCD* if your students need extra practice with these skills. See *Exponents*.

Answers to Steps 1–3

Student answers for these steps include the following.

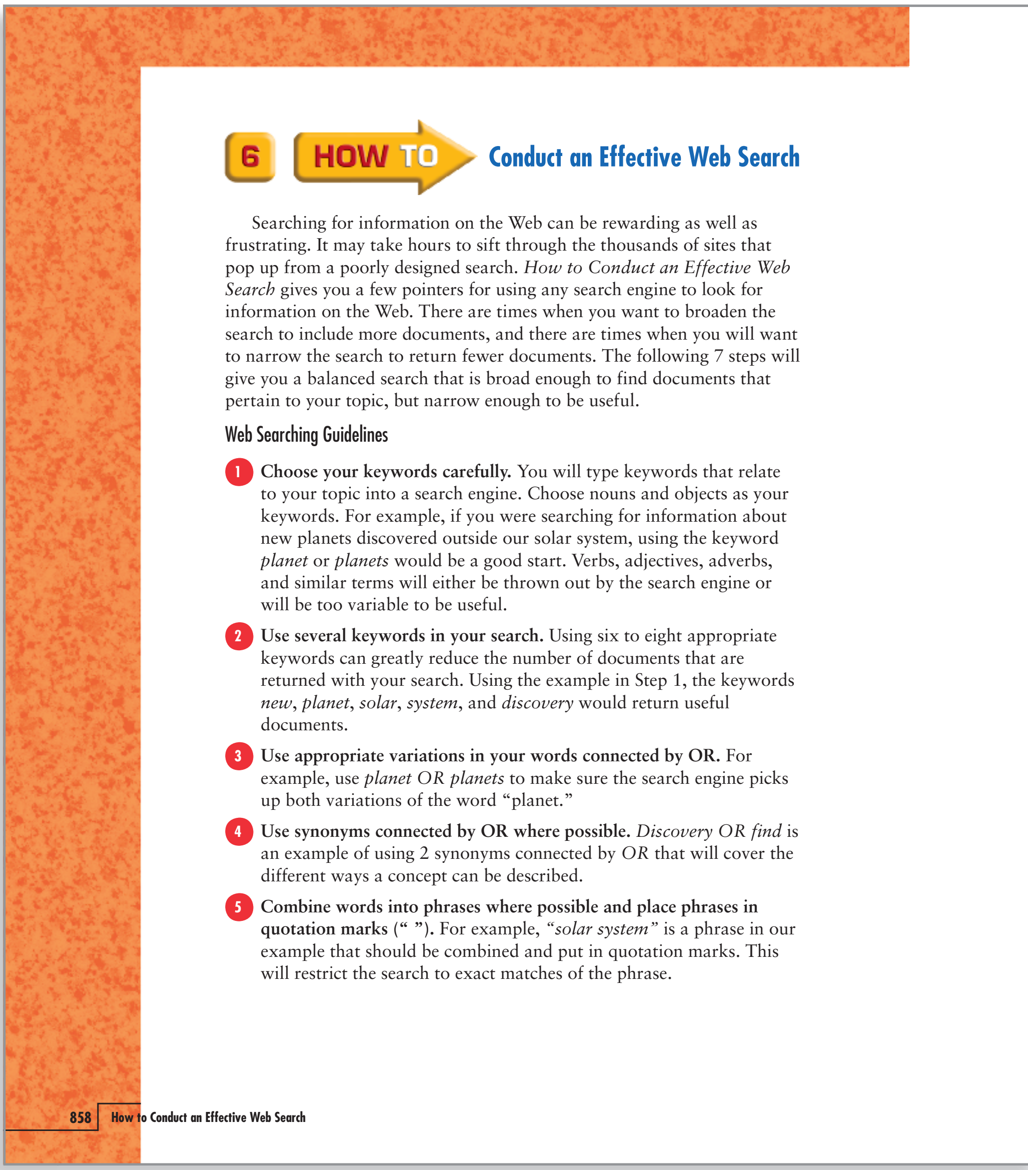
1. 1 micron (μm) = 1 μm = 1×10^{-6} m (or just 10^{-6} m).
2. 1 millimeter (mm) = 10^{-3} m = 0.001 m.
3. 1 nanometer (nm) = 1×10^{-9} m (or just 10^{-9} m).

NOTES:

6 HOW TO

Conduct an Effective Web Search

In *How to Conduct an Effective Web Search*, students are given guidelines on how to search the Web more efficiently for information. Caution students about plagiarism and refer them to *How to Cite References and Avoid Plagiarism*. Also discourage students from printing out entire Web sites that they find that relate to their topic. Sometimes clicking on the print icon will cause the entire Web site to print, which could print several pages. Encourage students to filter their information and only print what is necessary. Yu might also have students record summaries of the Web sites in their science notebooks, complete with the proper citations.



6 HOW TO **Conduct an Effective Web Search**

Searching for information on the Web can be rewarding as well as frustrating. It may take hours to sift through the thousands of sites that pop up from a poorly designed search. *How to Conduct an Effective Web Search* gives you a few pointers for using any search engine to look for information on the Web. There are times when you want to broaden the search to include more documents, and there are times when you will want to narrow the search to return fewer documents. The following 7 steps will give you a balanced search that is broad enough to find documents that pertain to your topic, but narrow enough to be useful.

Web Searching Guidelines

1. **Choose your keywords carefully.** You will type keywords that relate to your topic into a search engine. Choose nouns and objects as your keywords. For example, if you were searching for information about new planets discovered outside our solar system, using the keyword *planet* or *planets* would be a good start. Verbs, adjectives, adverbs, and similar terms will either be thrown out by the search engine or will be too variable to be useful.
2. **Use several keywords in your search.** Using six to eight appropriate keywords can greatly reduce the number of documents that are returned with your search. Using the example in Step 1, the keywords *new*, *planet*, *solar*, *system*, and *discovery* would return useful documents.
3. **Use appropriate variations in your words connected by OR.** For example, use *planet OR planets* to make sure the search engine picks up both variations of the word "planet."
4. **Use synonyms connected by OR where possible.** *Discovery OR find* is an example of using 2 synonyms connected by *OR* that will cover the different ways a concept can be described.
5. **Combine words into phrases where possible and place phrases in quotation marks (" ").** For example, *"solar system"* is a phrase in our example that should be combined and put in quotation marks. This will restrict the search to exact matches of the phrase.

858 How to Conduct an Effective Web Search

NOTES:

6. **Combining 2 or 3 concepts in 1 search, distinguished by parentheses, will narrow your results and possibly give you just what you want.** For our current example, using *("solar system")("new planet")(discover OR find)* would be the best selection.
7. **Order your concepts with the main subject first.** Search engines tend to rank documents that match the first keywords in the search higher than those that match the later keywords. For our example search, you would order the concepts as *("new planet")(discover OR find)("solar system")*.

NOTES:

7 HOW TO

Write a Lab Report

In *How to Write a Lab Report*, students are given a set of sections and criteria for a scientific lab report. You may have your own method of writing lab reports that reflects your school or state science standards. Feel free to modify or add to this set of guidelines. Students are asked to write a lab report in chapter 1, *Investigations by Design*, of this program. You should choose additional times throughout the year to incorporate this requirement for your students.

7 HOW TO

Write a Lab Report

Adapted from BSCS. (2006). *Biological perspectives laboratory manual: Thinking biologically* (3rd ed.). Dubuque, IA: Kendall/Hunt.

When scientists have enough information, data, and evidence about a particular scientific matter, they summarize their results in a formal, scientific paper and submit it for publication in a professional journal. These papers are organized in specific sections as required by the particular journal. You, too, will be writing lab reports this year, and your report should have sections similar to a scientific paper. Those 5 sections are listed here with a brief description of what you should include in each section.

Lab Report Guidelines

1. **Introduction.** The introduction includes background information from scientific papers, textbooks, newspapers, or magazine articles. Be sure to cite your references at the end of your paper. (See *How to Cite References and Avoid Plagiarism*.) The introduction should also include the purpose of your investigation or the question you are trying to answer.
2. **Materials and methods.** List the materials that you used in the investigation. Also include your step-by-step procedure.
3. **Results.** Describe your results in written form in this section. You should also include appropriate tables, graphs, and diagrams with captions.
4. **Discussion.** This section is where you discuss the results of this particular investigation. How do the results relate to what you already know?
5. **Conclusion.** Summarize the findings of your investigation in the conclusion. Try to answer questions such as, "What trends do I see in the data?" "What general statement can I make about the results?" "What do the data mean?" "What do they tell me about what is happening with the object, organism, or phenomenon?"

860 How to Write a Lab Report

NOTES:

8 HOW TO Cite References and Avoid Plagiarism

When doing research in your classes, you'll quickly find that you will need to rely on the results and work of others. These are usually professionals who have had the chance to consider a topic in much more detail than you. You will gain insight from their work, and their work will even make yours much stronger. The important thing is to review with your teacher how to reference that work in your write-up or presentation.

Sometimes students may forget to list sources, or they may even use other people's work without a clear reference. Claiming someone else's work as your own is cheating.

Using the creative work, scientific results, or ideas of other people without a specific reference is a form of stealing. This form of stealing is called *plagiarism*. It's easy to be sure not to plagiarize—*just cite in all your work any sources of information, data, creative work, or ideas that you are borrowing from someone else*. It's fine to borrow, but you have to be clear about when you are doing so.

Referencing any materials or facts that you use in your work is a key part of writing a good paper. Accurate references will actually make your work a lot better. If you have questions, be sure to check with your teacher on his or her methods for documenting references. Your teacher should also be able to tell you the policies at your school for plagiarism.

It is common practice to use the Web to do research on school projects. The Web sites that you use in your report must be cited just as you cite a book or an article from a journal. Your teacher can provide you with the format for citing Web resources.

When doing research or projects in any of your classes, it is vital to keep a list of all references that you use. This convention is part of doing research. It is the official way to recognize the results and prior hard work of others, and it is the proper way to confirm your research and interpretations. Two steps are needed to have accurate references.

1 *Clearly indicate, or cite, the prior research or findings directly within your text or write-up*. This is called a *citation*, and it includes the last names of the authors plus the year the work was published (see the following example). Some results in your work may be widely known facts in science (for example, the speed of light and the atomic masses for elements of the periodic table). These facts don't need text citations.

How to Cite References and Avoid Plagiarism 861

8 HOW TO

Cite References and Avoid Plagiarism

Proper citing of references is often neglected in high school science classes—especially in the age of the Web. Students often simply print off information and cut and paste bits and pieces together to form a report. Take time to instruct your students on how to give proper credit for scientific work.

How to Cite References and Avoid Plagiarism shows students how to document their sources and prevent plagiarism. Examples are given, but you may want students to use a different reference style.

NOTES:

But suppose that you are researching changes in the rates of cigarette smoking among adults over the past 20 years. Here's an example of citing resources directly in your text:

> Recent data show that smoking rates are decreasing somewhat, and that about one-fourth (22.5 percent) of all Americans still smoke (Centers for Disease Control and Prevention [CDC], 2004). Factors related to smoking rates include the socioeconomic status of the person (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Sorenson, Barbeau, Hunt, & Emmons, 2004), or where the person works (Nelson, Emont, Brackbill, Cameron, Peddicord, & Fiore, 1994). Another factor is where the person learns about quitting smoking, such as at work or by television or radio (CDC, 1999; Haviland et al., 2004).

2 *Each of the resources you cite must be listed in a reference section at the end of your report*. Your teacher may have a preferred format. The following example cites the resources for the short reading on smoking in adults.

Reference List

Adler, N. E., Boyce, W. T., Chesney, M. A., Folkman, S., & Syme, L. S. (1993). Socioeconomic inequalities in health: No easy solution. *Journal of the American Medical Association*, *269*, 3140–3145.

Centers for Disease Control and Prevention. (1999). *Best practices for comprehensive tobacco control programs*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. (2004). Cigarette smoking among adults—United States, 2004. *Morbidity and Mortality Weekly Report*, *53*, 427–431.

Haviland, L., Thornton, A. H., Carothers, S., Hund, L., Allen, J. A., Kastens, B., et al. (2004). Giving infants a great start: Launching a national smoking cessation program for pregnant women. *Nicotine and Tobacco Research*, *6*, S181–188.

Nelson, D. E., Emont, S. L., Brackbill, R. M., Cameron, L. L., Peddicord, J., & Fiore, M. C. (1994). Cigarette smoking prevalence by occupation in the United States: A comparison between 1978 to 1980 and 1987 to 1990. *Journal of Occupational Medicine*, *36*, 516–525.

Sorensen, G., Barbeau, E., Hunt, M. K., & Emmons, K. (2004). Reducing social disparities in tobacco use: A social-contextual model for reducing tobacco use among blue-collar workers. *American Journal of Public Health*, *94*, 230–239.

862 How to Cite References and Avoid Plagiarism

NOTES:

9 HOW TO **Use a Compound Microscope**

The human eye cannot distinguish objects much smaller than 0.1 millimeter in diameter. The compound microscope is a technology often used in biology to extend vision. It allows observation of much smaller objects. The most commonly used compound microscope is monocular (that is, it has one eyepiece). Figure H9.1 shows a binocular microscope. Light reaches the eye after it has passed through the objects being examined. In *How to Use a Compound Microscope*, you will learn how to use and care for a microscope.

Figure H9.1 Compound microscope. Use this figure to help locate the parts of a compound microscope.

How to Use a Compound Microscope 863

9 HOW TO

Use a Compound Microscope

Several investigations and activities in *BSCS Science: An Inquiry Approach* involve observing microscopic materials. It is to the students' advantage to learn to use a microscope efficiently at the beginning of the school year. Even students who have used a microscope before will find it useful to take part in this investigation along with inexperienced students.

Materials—Part I

For each team of 2 students

3 coverslips
3 microscope slides
1 100-mL beaker or small jar
1 dropping pipet
1 compound microscope
1 pair of scissors
1 transparent metric ruler
lens paper
newspaper
water

NOTES:

Materials—Part II

For each team of 2 students

supplies from Part I

Materials—Part III

For each team of 2 students

supplies from Part I
1 light-colored hair
1 dark-colored hair

In Part I, students become familiar with the basics of caring for a microscope and the parts of a microscope. In Step 1, review the reading describing how students should care for a microscope. Students need to know how to avoid dropping the microscope or damaging the lenses. In Steps 2–4, students become familiar with the parts of a microscope. Encourage them to use the labeled illustration of a microscope to help them locate all the parts. They should try adjusting the lenses and mirror or diaphragm for light. Provide lens paper for students so that they can practice cleaning the lower-power lenses.

Part I: Setting Up the Microscope

Materials

For each team of 2 students

3 coverslips	1 pair of scissors
3 microscope slides	1 transparent metric ruler
1 100-mL beaker or small jar	lens paper
1 dropping pipet	newspaper
1 compound microscope	water

1. Read *Care of the Microscope* to learn how to properly care for a microscope.

Care of the Microscope

- The microscope is a precision instrument that requires proper care. Always carry the microscope with both hands. Put one hand under its base, the other on its arm (see figure H9.2).
- Keep the microscope away from the edge of the table. If a lamp is attached to the microscope, keep its cord out of the way. Move everything not needed for microscope studies off your lab table.
- Avoid tilting the microscope when using temporary slides made with water.
- The lenses of the microscope cost almost as much as all the other parts put together. Never clean lenses with anything other than the lens paper designed for this task.
- Always return the microscope to the low-power setting before putting it away. The high-power objective extends too close to the stage to be left in place safely.

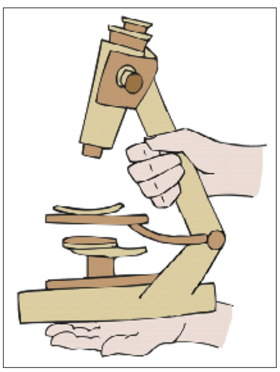


Figure H9.2 How to carry a microscope. Always place one hand under the base and the other hand on the arm.

864 How to Use a Compound Microscope

NOTES:

2 Rotate the low-power objective into place if it is not already there. When you change from one objective to another, you will hear the objective click into position.

3 Move the mirror so that you obtain even illumination through the opening in the stage. Or turn on the substage lamp. Most microscopes are equipped with a diaphragm for regulating light intensity. Some materials are best viewed in dim light, others in bright light.

Cautions

Never use a microscope mirror to capture direct sunlight when illuminating objects under a microscope. The mirror concentrates light rays, which can permanently damage the retina of the eye. Always use indirect light.

4 Make sure the lenses are dry and free of fingerprints and debris. Wipe lenses with lens paper only.

Part II: Using the Microscope

Materials

For each team of 2 students

supplies from Part I

1 In your science notebook, prepare a data table similar to the one in figure H9.3.

Object being viewed	Observations and comments
Letter *o*	
Letter *c*	
Letter *e* or *r*	

Figure H9.3 Microscope observations.

2 Cut a lowercase letter *o* from a piece of newspaper. Place it right side up on a clean slide. With a dropping pipet, place 1 drop of water on the letter. This type of slide is called a wet mount.

In Part II, students practice using a microscope and making wet mounts. In Step 1, they create a data table to record their observations. In Steps 2–3, students make a wet mount of a piece of newspaper. First, they cut letters from a newspaper, and then they follow the steps illustrated in student figure H9.4 to make the wet mount. To give them more control with the dropping pipet, students should let it rest in the palm of their hand and gently squeeze with their thumb and forefinger. It is important that they use only 1 drop of water for their wet mount. Too much water will cause the coverslip to float off the slide.

NOTES:

After placing the slide on the microscope stage, students should adjust the focus of the low-power objective until the letter is in focus. Check to make sure students understand how to get the letter into focus. They may have difficulty making small adjustments with the fine focus. Once they have the letter in focus, students record observations in their data table during Step 7. In Step 8, they record the magnification of their view. Make sure they multiply the magnification of the eyepiece by the magnification of the objective lens.

Students repeat Steps 1–7 with the letter *c* and the letter *e* or *r*. In Steps 10 and 11, students answer questions about what they see. Make sure students take time to sketch the letter *e* or *r* in Step 12. Their sketches should include changes in image and in the movement that takes place under the microscope.

Answers to Steps 10–11

10. Students will see that the letter *e* or *r* looks upside down compared with the position they placed it in for the wet mount.

3 Wait until the paper is soaked before adding a coverslip. Hold the coverslip at about a 45-degree angle, with the bottom edge of the coverslip touching both the slide and the drop of water. Then slowly lower the coverslip. Figure H9.4 shows these first steps.

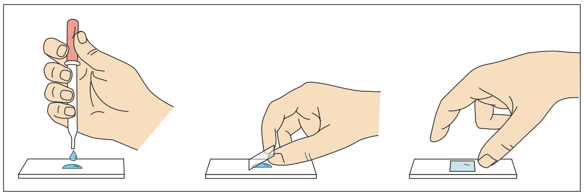


Figure H9.4 **Preparing a wet mount.** This figure shows the steps to prepare a wet mount with a microscope slide and coverslip.

4 Place the slide on the microscope stage. Clamp it down with the stage clips. Move the slide so that the letter is in the middle of the hole in the stage. Use the coarse-adjustment knob to lower the low-power objective to the lowest position.

5 Look through the eyepiece. Use the coarse-adjustment knob to *raise* the objective slowly, until the letter *o* is in view.

6 If you cannot find the *o* on the first try, start the process again by repeating Steps 4 and 5.

7 Once you have the *o* in view, use the fine-adjustment knob to sharpen the focus. Position the diaphragm for the best light. Compare the way the letter looks through the microscope with the way it looks to the naked eye. Record your observations in your data table.

8 To determine how magnified the view is, multiply the number inscribed on the eyepiece by the number of the objective lens being used. For example:

eyepiece (10×) × objective lens (10×) = total (100×)

9 Follow the same procedure with a lowercase *c*. Describe in your data table how the letter appears when viewed through a microscope.

10 Make a wet mount of the letter *e* or the letter *r*. Describe how the letter appears when viewed through the microscope. What new information (not revealed by the letter *c*) is revealed by the *e* or *r*?

NOTES:

11. Look through the eyepiece at the letter as you use your thumbs and forefingers to move the slide slowly *away* from you. Which way does your view of the letter move? Move the slide to the right. Which way does the image move?

12. Make a sketch of the letter as you see it under the microscope. Label the changes in image and in movement that take place under the microscope.

Part III: Using High Power

Materials

For each team of 2 students

- supplies from Part I
- 1 light-colored hair
- 1 dark-colored hair

1. Make a wet mount of 2 different-colored hairs, 1 light and 1 dark. Cross 1 hair over the other. Sketch the hairs as they appear under low power.
2. With the crossed hairs centered under low power, adjust the diaphragm for the best light.
3. Turn the high-power objective into viewing position. Do *not* change the focus.
4. Sharpen the focus with the *fine-adjustment knob only*. *Do not focus under high power with the coarse-adjustment knob*. The high-power objective will touch the slide if it is in its lowest position. So you must not make large adjustments toward the slide. *Doing so can damage the objective and the slide by driving the objective into the slide.*
5. Readjust the diaphragm to get the best light. If you are not successful in finding the object under high power the first time, return to Step 2. Repeat the entire procedure carefully.
6. Using the fine-adjustment knob, focus on the hairs at the point where they cross. Can you see both hairs sharply at the same focus level? How can you use the fine-adjustment knob to determine which hair is crossed over the other? Sketch the hairs as they appear under high power.

11. When students move the slide away from them, the image moves toward them. When they move the slide to the right, the image moves to the left.

In Part III, students learn how to use the high-power objective of the microscope. In Step 1, they make a wet mount of different-colored hairs and sketch what they see with the low-power objective. They should adjust the mirrors or diaphragm for the best light. In Step 3, students move to the high-power objective without changing the focus. Tell them to use the fine-adjustment knob to get the hairs in focus. Emphasize that large adjustments will make it difficult to focus and could damage the lens if they drive the lens into the slide. For Step 6, they sketch the hairs once they are in focus.

How to Use a Compound Microscope | 867

NOTES:

Answers to Reflect and Connect

1. Images are larger when viewed through a microscope. Type is grainier and shows a dot pattern. Objects are inverted and reversed. They appear to move in the opposite direction of the actual motion of the slide.
2. The high-power objective can focus on only a portion of the depth of the object at any one time.

Reflect and Connect

Work with your partner to answer the following questions in your science notebook.

1. Summarize the differences between an image viewed through a microscope and the same image viewed with the unaided eye.
2. When you view an object through the high-power objective, not all of the object may be in focus. Explain why.

868 How to Use a Compound Microscope