

Science Skills Worksheets

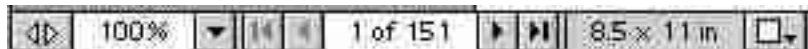
To jump to a location in this book

1. Click a bookmark on the left.

To print a part of the book

1. Click the Print button.
2. When the Print window opens, type in a range of pages to print.

The page numbers are displayed in the bar at the bottom of the document. In the example below, “1 of 151” means that the current page is page 1 in a file of 151 pages.



WORKSHEET

1

THINKING SKILLS

Being Flexible

It's a hot, sunny summer day. Pedro Garcia is riding in the car with his father and his 8-year-old brother, Joaquin. Suddenly, there's a loud BANG! inside the car; Pedro's ears are ringing, and warm, fizzy cola is spraying everywhere. In the back seat, Joaquin looks startled. His father, with cola running down the back of his neck, pulls to the side of the road and stops the car. He reaches back and picks up a can of foaming cola from the seat beside Joaquin. He asks Joaquin, "Son, did you shake this can?" Joaquin answers, "No, I didn't touch it." Mr. Garcia thinks out loud, "What else could have caused the can to explode?" Pedro says, "I think that can has been in the car for a while." They all want to know what happened.

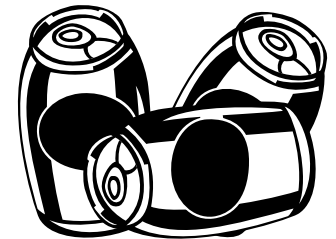
Flexible Thinking

In the scene above, Mr. Garcia came to what he thought was the obvious conclusion, that Joaquin shook the can and then opened it. But Joaquin said he hadn't. To solve the mystery, Mr. Garcia used flexible thinking. *Flexible thinking* is when you **consider different explanations** for an event or a chain of events. In this case, Mr. Garcia wondered, "What else could have caused the can to explode?" Mr. Garcia came up with the following three explanations:

Flexible thought 1: Perhaps the can had been sitting on the grocery-store shelf for a long time before Mr. Garcia bought it. Finally, it got so old that it just burst open.

Flexible thought 2: Joaquin had brought the can of cola from home, and the can had been sitting in the back seat all day. Maybe while the family was shopping, the sun heated the can of cola until it got hot enough to explode.

Flexible thought 3: Maybe someone had shaken the can a few days ago. As it sat in the back seat, it was shaken more by the movement of the car. Finally, it exploded.



Which explanation seems most likely to you? Why?

Which explanation seems least likely to you? Why?



Being Flexible, continued

Can you think of any other explanations? Explain your own flexible thoughts.

Eventually, Mr. Garcia decided on the most likely explanation. He had never heard of soda cans exploding because they got too old. But he knew that liquids expand when they are heated. He also thought that the movement of the car might have been a factor. Thus, he decided that while they were shopping the sun must have heated the can. Then when they started driving home, the car's motion shook the can a little. Those two factors combined to cause the can to explode.

Flex Your Brain

Here's another chance to practice your flexible-thinking skills. Try to think of a realistic explanation for each of the following examples.

Example 1: You live far from any lake or sea. While digging a hole in your backyard, you find a small, beautiful seashell.

Example 2: One day the branches of a tree near your home are unexpectedly filled with birds.

TROUBLESHOOTING

If you are having trouble thinking of creative explanations, try imagining two people debating what happened in the example. Picture their conversation in detail. If you can imagine their two points of view, then you've just thought of two explanations!

TRY THIS!

Create your own mysterious scenario, and then trade with a classmate. You'll be surprised at the explanations your classmate proposes!

WORKSHEET

2

THINKING SKILLS

Using Your Senses

Imagine that a fourth-grader asks you, “Why did early scientists think that the sun goes around the Earth?” How would you respond?

Because early scientists based their conclusions on their sense of sight, you may have used a phrase like, “It looked like . . .” or “It appeared that . . .” in your answer. Unfortunately, when early scientists relied only on what they saw, they were often fooled.

Observations

By using their sense of sight, early scientists were making **observations**. Although you may not realize it, you make observations about your environment all the time. You constantly see things, hear things, and touch things, and sometimes you taste and smell things, too. Occasionally, like those scientists, you observe something and then find out later that your observation was wrong. The following is an example:

“Yechhhh!” cried Walter as he spit out the first bite of his cereal, “This milk tastes sour!” Then the smell caught his attention, too. It was awful. In fact, he couldn’t believe he hadn’t noticed the sour smell before. “The milk looked fine when I took it out of the refrigerator,” he remarked.

What sense had given Walter incomplete information?

Why *hadn’t* Walter noticed the smell earlier?

Keep Your Eyes and Ears Open

When you are doing scientific work, use your different senses to make accurate and thorough observations. But **remember**—it’s never safe to touch, smell, or taste substances unless your teacher says it is okay.



Using Your Senses, continued

Making Sense

For each sense listed below, describe a situation in which that sense might give you incomplete information. The first one is done for you.

Smell

Some colored markers are scented to smell like food. If you relied only on your sense of smell, you might think that they were food!

Touch

Hearing

Taste

Sight

TROUBLESHOOTING

If you are having trouble thinking of examples, ask yourself, "Are there products designed to imitate or deceive?" For instance, scented markers are designed to smell like food.

TRY THIS!

Put a few unbreakable objects in a shoe box. Give the box to some friends. Ask them to guess what's inside without opening it and to tell you what senses they are using.

WORKSHEET

3 THINKING SKILLS

Thinking Objectively

One day, two students in a science class made observations about a mouse moving through a maze. The mouse could choose from two pathways. Only one of the pathways led to food. Pay attention to how the reports differ.

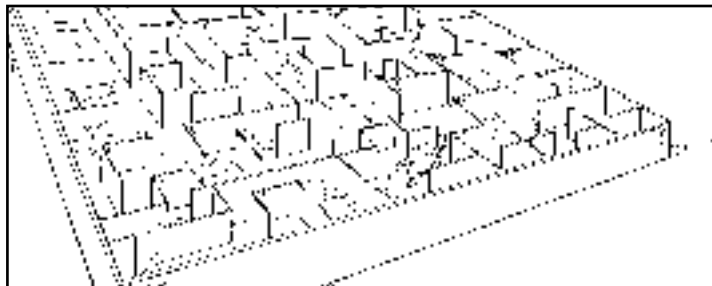
Marie: At first, the mouse peeked down each pathway. It decided to try the one on the left. The mouse started walking down that pathway, but it got confused when it realized there wasn't any food there. Then it turned around and went back. The worn-out mouse must not have eaten all day because it raced down the pathway on the right and ate all of its food.

Rawan: The mouse went to the beginning of each pathway. Then it moved slowly down the left-hand pathway, stopping from time to time. After it reached the end, it turned around and went back to the starting point. Next, the mouse went down the right-hand pathway. It moved quickly, and when it reached the end, the mouse ate all of the food.

Just the Facts

Both students did a good job of observing the mouse's movements, but their observations are very different. How is Marie's description different from Rawan's?

When you make scientific observations, you should try to be **objective**, which means that you describe only the facts. Being objective is important because almost all scientific work involves using observations to make *inferences*. If scientific observations are not objective, then inferences made from them might not be accurate. Was Marie thinking objectively? Why or why not?



Thinking Objectively, continued

Was Rawan thinking objectively? Why or why not?

Thinking Objectively Versus Thinking Subjectively

The opposite of thinking objectively is thinking **subjectively**. When you think subjectively, you tend to add feelings or motivation to your observation. As a result, it's hard to tell which comments are facts and which are pieces of added information. In the example above, which student, Rawan or Marie, was thinking subjectively?

Rewrite the following paragraph so that it is an objective (facts only) account of the event:

The tropical storm hurled straight toward the shoreline, and then it stopped. It lingered in one place for two days, gaining strength—almost like it was waiting for something. Finally, it charged onto land. Everyone started running like crazy for their lives. It must have been hurricane strength by then because the wind ripped the roofs off houses and threw them everywhere.

Now try doing just the opposite. Rewrite the following paragraph so that it is subjective (based on feelings and opinions):

One student placed 10 blocks of ice in a circle on the sidewalk. Each block had a mass of 100 g. Another student placed a larger block of ice on the same sidewalk. The larger block had a mass of 1,000 g. Twenty minutes later, all of the small blocks had melted completely. However, the larger block was only partially melted.

WORKSHEET

4

THINKING SKILLS

Understanding Bias

Read the following report:

Pigeons are dirtier than you think. They eat trash and leave their droppings wherever they go. Pigeons also carry diseases. One time, I was bitten by a pigeon when I tried to shoo it away. I had to get a shot because the pigeon might have given me a disease.

Can you tell how this writer feels about pigeons? Do you wonder if this is the whole story about pigeons? Does the writer say anything *positive* about pigeons? For instance, he or she could have mentioned that pigeons are very successful at living around people. It appears that the writer has a strong opinion about pigeons and that facts may not change that opinion.

What Is Bias?

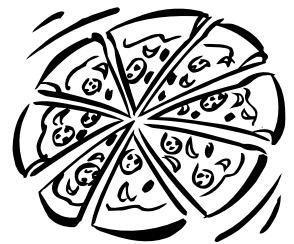
One kind of **bias** is a strong *opinion* about something. You can be biased in favor of something or biased against it. In either case, you may have some facts to support your position, but a bias is based more on feelings and opinions than on facts. In some cases, bias results from a person's past experiences. That may be what happened to the student who was bitten by the pigeon.

Bias Can Be Intentional or Unintentional

Sometimes people use bias on purpose. For example, if you want to persuade someone, you present facts that support your position while leaving out points that don't. If you want your parents to order pizza for dinner, you might remind them that they wouldn't have to cook. However, you probably *wouldn't* mention that healthier, less expensive dinner options might be available.

Another kind of bias is unintentional. It occurs when a person tries to be accurate but does not have complete information. For example, scientists used to think atoms looked like little solar systems. As more information about atoms was discovered, scientists realized their description of atomic structure was wrong. They changed their theories and models based on new information.

Look out for both kinds of bias. In the pigeon example, we get the feeling that the report is not accurate because most of us know from personal experience that pigeons are usually not vicious. In the example about the structure of atoms, though, it is more difficult to detect bias. We have to depend on experts for information about atomic structure. If the experts have incomplete or inaccurate information, that is what we get, even if there is no intent to give wrong information.



Understanding Bias, continued

Detecting Bias

Three of the many possible sources of bias are listed below. Try matching these sources with the paragraphs that follow. There may be more than one answer.

- A.** The writer has received incomplete information.
- B.** The writer is trying to influence or convince the reader.
- C.** The writer’s past experience is influencing his or her thinking.

1. The pollution in our river is caused by the big factory upstream. The people who own the factory are only interested in making money. They don’t care about the environment at all. I heard about them from my friend Barry, and he knows what he’s talking about.

2. Every morning, my grandfather’s rooster crows when it is still dark. About five minutes later, the sun comes up. I don’t know how it works, but my grandfather’s rooster is responsible for the sunrise!

3. On the Internet, I learned about a place where aliens have secretly landed a spaceship on Earth. They’re going to take over the world, and when they do, they’ll put all of the redheaded people like me in charge. You’d better be nice to me!

4. Our new science textbook will be terrific! I have used other textbooks by the same company, and they are always well-written and accurate. One of the teachers at our school says this is the best textbook she’s ever used.

TROUBLESHOOTING

When you read something, ask yourself, “Where did the author get this information?” Sometimes the answer can help you figure out how the author’s comments might be biased.

TRY THIS!

The editorial page of a newspaper is a good place to find biased writing. Editors try to persuade readers. Read an editorial in your local newspaper, and identify the bias in it. Then read the editorial to your classmates, and discuss any bias you find in it.

WORKSHEET

5

THINKING SKILLS

Using Logic

Have you ever wondered how detectives solve a crime? Detectives piece together bits of information to get an overall picture. To do this, they have to draw on partial information, going from the **known** to the **unknown**. Imagine that you are a detective, and try to solve the following puzzle:

Somebody has taken the official game ball from the sports equipment locker. The basketball team must have that ball for the big home game tonight. Three students—Keith, Donald, and Allison—are suspects. Each is carrying a round object in his or her sports bag. The three round objects are two soccer balls and a basketball. Donald and Allison are not carrying the same thing. Allison and Keith are not carrying the same thing. Who has the basketball? How do you know?

IF This, THEN That

Detectives use **logic** to solve puzzles like the one above. Logic is a particular way of thinking that allows you to solve problems. Certain words or phrases are common in this kind of thinking, such as *if this, then that*, *cause and effect*, and *therefore*. In solving the above puzzle, you may have thought, “If Allison and Donald aren’t carrying the same thing, and if Allison and Keith aren’t carrying the same thing, then Donald and Keith are carrying the same thing. Therefore, Donald and Keith have the soccer balls, and Allison has the basketball” (because there is only one basketball and there are two soccer balls). Case closed!

Like detectives, scientists use logic to test their hypotheses and theories. Suppose you hypothesize that putting a spin on a Frisbee™ will make it fly farther. How would you test this? You might use the following *if-then* statements in your logical thinking:

- If a spinning Frisbee consistently goes farther than a non-spinning one, then my hypothesis may be correct.
- If a spinning Frisbee consistently drops quickly, then my hypothesis may be incorrect.



Using Logic, continued

From the Known to the Unknown

The most important tip for using logic is to move from what you *know* to what you *want to know*. One way to do this is to make notes, listing what you know and all the clues you learn as you go along. Just as detectives carry notepads so that they can keep track of clues, you can make lists of your own to solve logic puzzles. Another way to do this is to use graphics to help you visualize what is happening. How does this work? Keep reading to find out!

The Mystery of the Three Stiletto Sisters, Part 1

Betty, Hette, and Letti Stiletto are sisters, and they are going to a concert! When they arrive, they go to their row. There are eight seats in the row, numbered from 1 to 8. Seats 7 and 8 are already taken, and the sisters want to sit together. Betty sits down in seat 5. Hette won't sit in seat 3, and Letti will sit only between two people. In which chair does each sister sit?

Solution

Solve the problem with an information table. Draw 8 boxes to represent the 8 seats, and number them 1–8.

1	2	3	4	5	6	7	8

Add the information you know:

1. Seats 7 and 8 are occupied, so put an X in those seats.
2. Betty is sitting in seat 5, so put a B in that space.
3. Hette won't sit in seat 3, so write "Not H" in that space.
4. Letti will sit only between two people. Remember that for later.

Your table should look like this:

1	2	3	4	5	6	7	8
		Not H		B		X	X

Now decide where Hette and Letti will sit. There are three possible arrangements.

1. Letti in 3, Hette in 4, and Betty in 5
2. Letti in 4, Betty in 5, and Hette in 6
3. Hette in 4, Betty in 5, and Letti in 6

So what's the solution?

Arrangements 1 and 2 won't work because Letti will only sit between two people. So, the only solution is Hette in seat 4, Betty in 5, and Letti in 6.

Using Logic, continued

The Mystery of the Three Stiletto Sisters, Part 2

On page 9 you saw a verbal solution to a logic problem, and on page 10 you saw a visual solution to a logic problem. Both methods are useful—choose the one that works best for you. Let's use both methods to solve the next problem.

There is a five year difference between the youngest sister and the middle sister and a five year difference between the middle sister and the oldest sister. All of the sisters are younger than 35. Betty is 25 years old. Letti is not the youngest, and Hette and Betty are not 10 years apart. Who is the youngest?

Verbal

Where should we start? When solving a mystery, you want to go from the known to the unknown. Get out your detective note pad, and start by making a list of what you know. (Just the facts!)

Fact 1: Each sister is either five years older or five years younger than the sister nearest her own age.

Fact 2: Betty is 25 years old.

Fact 3: Letti is not the youngest.

Fact 4: Hette and Betty are not 10 years apart.

Fact 5: All the sisters are younger than 35.

Now that we have a list of the facts, let's gather some clues. First, let's use Fact 1 and Fact 2. If Betty is 25 years old and if each sister is five years older or younger than the sister nearest her age, then there are three possible clues. Do the math!

Clue 1: *If Betty is the youngest, then her sisters are 30 and 35 years old.*

$$25\text{-year-old} + 5 = 30 \quad 30 + 5 = 35$$

Clue 2: *If Betty is the middle sister, then her sisters are 20 and 30 years old.*

$$25\text{-year-old} - 5 = 20 \quad 25 + 5 = 30$$

Clue 3: *If Betty is the oldest, then her sisters are 20 and 15.*

$$25\text{-year-old} - 5 = 20 \quad 20 - 5 = 15$$

Okay, let's move on to Fact 3: Letti is not the youngest. This means that Letti must be either the middle or the oldest sister. *Another clue!*

Now let's move on to Fact 4: Hette and Betty are not 10 years apart. That means Letti and either Betty or Hette must be 10 years apart. But Betty cannot be the youngest either (Clue 1 and Fact 5).

Hmmm . . . let's go back through clues 1–3. Which clue told us that Betty's sisters are 10 years apart? Right! Clue 2—if Betty is the middle sister, then her sisters are 20 and 30 years old.

Using Logic, continued

We're almost there! Now, piece it together. Try another list:

1. If Betty's sisters are 20 and 30 years old, and
2. Letti is not the youngest, then we solved the mystery:
3. Hette must be the youngest. **Congratulations!**

Visual

Fact 1: Draw 7 boxes, with each box representing the possible age of one of the sisters. Label the boxes from 5 years to 35 years.

5	10	15	20	25	30	35

Fact 2: Place a B in box 5 to represent Betty.

5	10	15	20	25	30	35
				B		

Fact 3: This clue does not help much at this point, so let's move on to the next one.

Fact 4: Write NOT H in boxes 3 and 7.

5	10	15	20	25	30	35
		Not H		B		Not H

Fact 5: Place an X in box 7 to show that no sister is 35.

5	10	15	20	25	30	35
		Not H		B		X

Let's write down the possibilities left from Fact 1:

1.

5	10	15	20	25	30	35
			L	H	B	X

2.

5	10	15	20	25	30	35
		L	B	H		X

3.

5	10	15	20	25	30	35
			H	B	L	X

But fact 3 eliminates choices 1 and 2—Letti cannot be the youngest. Choice 3 is correct. **Hette is the youngest!**

Using Logic, continued

Sleuthing on Your Own

Here is another mystery to solve on your own.

You are conducting a scientific experiment, and you need a solution with a 13% salt concentration. Four test tubes containing salt solutions are lined up in a test-tube rack, and they are labeled *A*, *B*, *C*, and *D*.

Here's what you do know: *D* has the highest concentration, and *A* does *not* have the lowest concentration. You also know that the concentration of *B* is greater than the concentration of *A*. The salt concentrations are 5%, 9%, 13%, and 17%, but you don't know which test tube contains which concentration!

- a.** Start by making a list. What are the facts?

- b.** Now gather some clues. What is the concentration of *D*?

- c.** What are the possible salt concentrations of *A*? Explain.

- d.** Have you solved the mystery? Which solution do you need? Explain.



WORKSHEET

6 THINKING SKILLS

Boosting Your Memory

Study the following list of the alkali metals. After one minute, turn this sheet over and try to recall the entire list.

Lithium Sodium Potassium Rubidium Cesium Francium

How'd you do? Memorizing lists may not be too much fun, but sometimes it's necessary. Fortunately, there are some tips, tricks, and shortcuts that can help you improve your ability to remember things.

A Tip for Total Recall

One of the best ways to memorize a short list of words is to make up a phrase or sentence in which the first letter of each word matches the first letter of each word in the list. The phrase doesn't have to mean anything; it is usually just easier to remember a phrase than a list of unrelated words. For the alkali metals above, you might use the following phrase:

Little Squirrels Pester Resting Cats Fearlessly

Ah Yes, I Remember It Well . . .

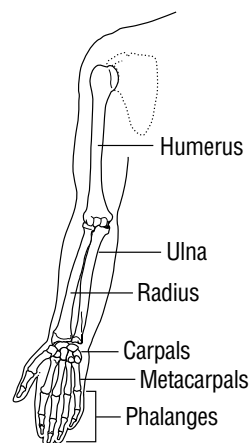
For each of the following lists, make up a phrase or sentence that helps you remember the items on the list in order.

1. The order of the planets in our solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.

2. The hierarchy of categories for biological classification: Kingdom, Phylum, Class, Order, Family, Genus, Species.

Recall It All

Sometimes by picturing the items in your mind and using words or phrases that start with the same sound, you can remember how the items relate to one another. In this way, you create a mental map. For example, to memorize the skeletal structure of the human hand and arm, use words or phrases that have the same beginning sound as each bone. Phalanges are *first*. Metacarpals are in the *middle*. Carpals *connect* the hand to the arm. When looking at your right palm, your radius is on the *right*. The ulna is on the *other* side of the radius, and the humerus is way up *high*.



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Boosting Your Memory, continued

Another tip is to create categories. With categories, you can memorize the key concepts of a broader subject. For instance, suppose you had to describe a rain forest. Would you want to memorize this?

Tropical rain forests occur in a belt around the equator. They are always hot and humid, receiving about 250 cm of rain a year. The climate is ideal for growing plants. In fact, there are more different species of plants growing in tropical rain forests than in any other biome on Earth.

It might be a bit difficult to memorize an entire paragraph about rain forests. Instead, what different categories could you create to describe a rain forest? You might use categories based on descriptive traits, such as location, climate, and vegetation. Memorizing three categories is much easier than memorizing an entire paragraph, don't you think?

Another tip for memorizing lists of things involves creating ridiculous pictures in your mind. The pictures tell a story that links the items together. For instance, if your list included the words *book*, *apple*, and *car*, you might visualize a giant *book* falling from the sky and squashing a bright red *apple* sitting on top of a brand new *car*. The more ridiculous the images, the easier it is to remember your list.

Remember, these are only tips for memorizing. You choose which method works best for you.

Making Memories

Explain the methods you would use for memorizing the following lists.

1. The 10 minerals in order of increasing hardness that describe Mohs' hardness scale: Talc, Gypsum, Calcite, Fluorite, Apatite, Feldspar, Quartz, Topaz, Corundum, and Diamond.

2. The four nitrogen-carrying bases contained in DNA: Adenine, Guanine, Thymine, and Cytosine.

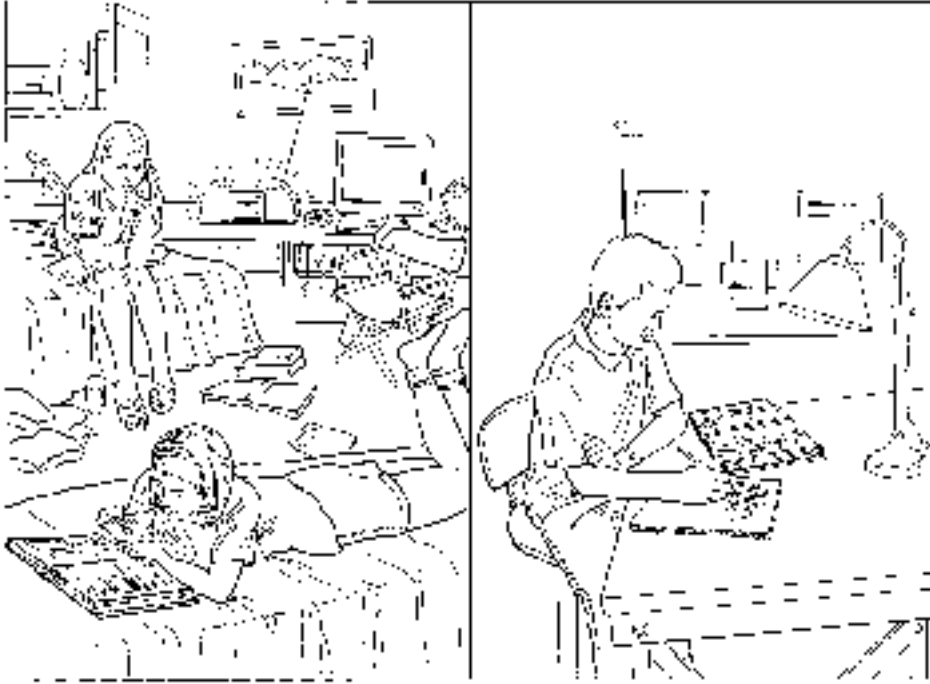
WORKSHEET

7

THINKING SKILLS

Improving Your Study Habits

Calamity Cara and Quiet Quentin have two drastically different studying styles. Examine the pictures provided below.



What are your impressions of Cara's study habits?

How do her habits compare with Quentin's?

What changes could either student make to use time more efficiently?

Improving Your Study Habits, continued

Using Your Time Wisely

Like it or not, studying is a necessary part of learning. It is also important in scientific work. By understanding your own study habits, you can study more effectively. Effective studying leads to two things:

1. You will learn more from your studying.
2. You will need less time to study the same amount of work.

Everyone can improve his or her study habits. The first step in making some changes is understanding your current habits. Think about the place where you usually study or do homework. What is good about your study area? What could you change about your study area?

Some Ideas that Help

Some people find that listening to quiet music helps them concentrate. Others go to a library in order to avoid distractions. Many people find that a bright room allows them to stay awake and focused. Think about how the following factors may influence your study habits:

- Noise level and amount of light in your study area
- Number of people studying with you
- Number of non-studying people nearby (such as family members)
- Frequency of study breaks
- Your degree of physical comfort or discomfort
- Time of day

Making the Change

The next step in improving your study habits is to try changing something. For instance, if you tend to get bored after studying for 30 minutes, try taking a 5-minute study break when you feel your concentration slipping. During your break, walk around. Doing something physical can help you concentrate when you get back to work. In the space below, write three changes to your study habits that you will try. If those changes work, make them a regular part of your studying routine!



WORKSHEET

8

THINKING SKILLS

Reading a Science Textbook

How do you read a book? Do you just dive in and read every word? Or do you skip through it, reading a page here and a paragraph there?

Tools in Your Textbook

Here are some tools that will help you get the most out of your science textbook:

- **The Table of Contents**—At the front of your textbook is a table of contents, which is an overview of each chapter of the book. By checking the table of contents, you can see what topics are in your textbook.
- **Section Objectives**—At the front of each section you will find a list of objectives, which shows you what specific information is covered in a section.
- **The Index**—At the back of most nonfiction books there is an index. The index is more specific than the table of contents, and it usually lists the people, places, things, and ideas in the book. For *aliens*, you could look up the words *alien*, *UFO*, or *spacecraft*.

Finding Information in a Book

Reading is one way to get information from a scientific book or article. It allows you to absorb all the information. But there are several other ways to get information from a book.

- **Section headings, illustrations, and captions**—When you find a page that seems to have useful information, read the section headings on that page to see if they relate to your topic. Then look at any pictures, diagrams, charts, or maps on the page to see if they relate to your topic. Be sure to read the captions under the illustrations.
- **Find key words in the text**—Any word in **boldface type** or *italics* is an important word in that section. By looking at the key words, you can quickly see the main ideas in that section.
- **Read the first and last sentences of each paragraph**—Often, the main idea of a paragraph is in the opening sentence. The last sentence often restates that idea. By reading only the first and last sentences of a paragraph, you can tell if the paragraph is useful.
- **Scan**—Read only a few words here and there. Scan a passage in order to find important key words. By scanning, you can decide which parts of the text you want to concentrate on or skim. In the paragraph on page 19, the key words and ideas are circled.
- **Skim**—Read only one sentence or paragraph here and there. Look for sentences that seem especially important. Skim a passage to get a general idea of what it is about or to determine if you want to read some parts more carefully. In the paragraph on the next page, the sentences you might skim are underlined.

Reading a Science Textbook, continued

Practice

Read the following paragraph, and try the techniques discussed:

Revolution: A New Way of Thinking

When scientists use the word (*revolution*) they are usually referring to a (*radical change in thinking*). For instance, the discovery that the sun—and not the Earth—is at the center of our solar system was a (*scientific revolution*). Astronomers had to rethink all of the established theories about the motion of objects in space. *Their previous understanding, which was based on past observations, needed to be reexamined.* A similar revolution occurred when Einstein proposed that (*space*) and (*time*) were linked in some way. Prior to Einstein’s theories, scientists thought space and time were unrelated. Now, after many experiments, scientists accept the concept of **space-time** as a (*scientific fact*).

In the space below, list the information you get using each technique.

Look at the headings.

Look at the key words.

Read the first and last sentences.

Scan and skim.



Reading a Science Textbook, continued

Now You Try It

Scan the following paragraph, and circle what you think are the key words or phrases. Then skim the paragraph, and underline the words or phrases that you think are important.

Invisible Killer

The killer was invisible to the naked eye. It seemed to pass from person to person, even if there was no physical contact. Antibiotics had no effect on it. The doctors decided it must be an airborne virus. If it was a virus, there was a chance they could still fight it. Finally, by studying and using the blood samples of people who had died from the disease, doctors were able to develop a vaccine.

TROUBLESHOOTING

If scanning and skimming seem to be difficult, don't worry. These two skills take lots of practice. Just keep looking for important words and phrases. Many times they will be in *italics* or **bold type**. When you skim, always start with the first sentence of each paragraph. That is usually the topic sentence.

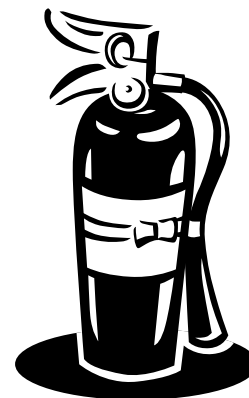
WORKSHEET

9

EXPERIMENTING SKILLS

Safety Rules!

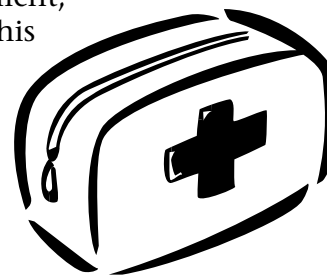
Creating, exploring, inventing, investigating—these are essential to the study of science. Frequently, scientists do their best work in the lab. To make sure that your laboratory experiences are safe as well as exciting and productive, some safety guidelines should be established. It's important that safety rules! So what do you need to know about safety? The following pages offer important guidelines for staying safe in the science classroom. Your teacher will also have safety guidelines and tips that are specific to your classroom and laboratory.

**Start Out Right!**

- **Clutter chaos!** Extra books, jackets, and materials will only get in the way of experiments and create clutter that could interfere with your tasks. On lab days, don't bring anything to the room except the books and materials you will need to complete the lab.
- **Caught in a bind?** Loose clothing, jewelry, and long hair can get in the way of your scientific investigations, so secure loose clothing, remove dangling jewelry, and tie back long hair.
- **Toe trouble!** Avoid wearing sandals or open-toed shoes in the laboratory environment. They will not protect your feet if a chemical or a sharp or heavy object is dropped on them.
- **Flaming beauty?** Certain hair products, such as aerosol hair spray, are flammable and should not be worn while working near an open flame; avoid wearing hair spray or hair gel on lab days.

**Check It Out!**

- **Who ya' gonna call?** Where is the nearest telephone? Are the phone numbers posted for the fire and police departments as well as for the ambulance and poison control center?
- **Safety patrol.** Where is the safety equipment for the laboratory? Know the location of all safety and emergency equipment, such as fire extinguishers, and know how to operate this equipment.

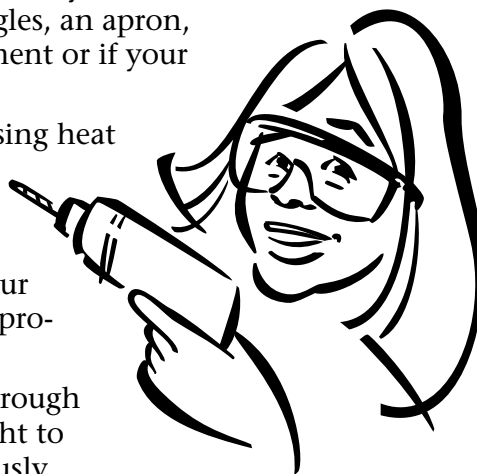


Safety Rules! continued

- **Quick exit!** Know the fire-evacuation routes established by your school.
- **What's up?** Before you begin an experiment, review the supplies you will be using and any safety issues you should be concerned about.

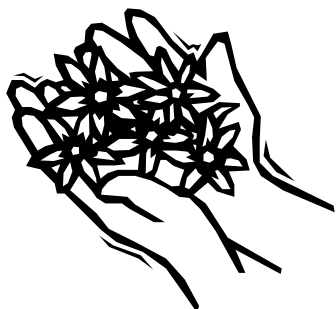
Prevention? Precisely!

- **Safety in numbers.** Never work alone in the laboratory.
- **Better safe than sorry.** Use lab equipment only in the manner that your teacher has demonstrated. If you have a great idea for a new experiment, first share the idea with your teacher—perhaps the whole class will benefit!
- **Food for thought.** The laboratory environment is no place for food, drinks, or cosmetics. Never eat food, drink a beverage, or apply cosmetics while in the lab.
- **Stylin' for safety!** Find out what safety equipment you should be wearing for the lab. Be sure to wear safety goggles, an apron, gloves, or a lab coat if called for in the experiment or if your teacher instructs you to do so.
- **The eyes have it!** Wear safety goggles when using heat or chemicals and when handling objects that may break, expand, or in some way endanger your eyes.
- **Gain no stain!** Certain chemicals can stain your clothing. Wear an apron or laboratory coat to protect clothing while working with chemicals.
- **Solar power!** Never look directly at the sun through any optical device, and never use direct sunlight to illuminate a microscope. Doing so could seriously damage your eyes.
- **Some sharp thinking!** Sometimes sharp objects such as scissors, scalpels, razor blades, knives, and probes are needed in the laboratory. Always exercise extreme caution when using a sharp object in the lab. Never cut an object while holding it in your hand—always use an appropriate work surface. Never use a double-edged razor in the lab.
- **Don't crack up!** Never use glassware that is chipped, scratched, or cracked. Chips, scratches, and cracks cause stress points at which glass can break.
- **Hot news!** Whenever possible, use an electric hot plate instead of an open flame unless the experiment specifically calls for an open flame.



Safety Rules! continued

- **Electrifying idea!** Use caution with electrical equipment. Never use equipment with frayed cords, and make sure that equipment cords are not located where someone could trip over them. Never use an electrical appliance if your hands or clothing are wet. Never use an electrical appliance around water.
- **Keep your cool!** Before working with a flammable liquid or gas, check for the presence of any source of flame, spark, or heat.
- **Chem care.** Always use caution when working with a chemical or a chemical solution. Some chemicals are corrosive, some are poisonous, some are flammable, and some that seem harmless can become hazardous when combined with another chemical.
- **In poor taste.** Never touch, taste, or smell a chemical unless your teacher specifically instructs you to do so. That chemical could cause a reaction when inhaled, touched, or ingested.
- **Don't mix for kicks!** Never mix any chemical unless your teacher specifically instructs you to do so.
- **Do as you oughta, add acid (or base) to water!** Never do the opposite! Pouring water into an acid or base could produce thermal energy and cause dangerous spattering.



- **Aim for the stars.** When heating a chemical in a test tube, never point the test tube at yourself or anyone else.
- **Animal rights and wrongs.** You may occasionally work with living animals in the laboratory. Always show respect for any animal you work with. Always obtain your teacher's permission before bringing an animal to the classroom. Never abuse an animal in any way.

- **Handle with care!** Living plants should also be handled carefully in the laboratory. Never ingest any plant or plant part unless your teacher specifically directs you to do so. When in nature, do not pick any wild plants unless your teacher instructs you to do so.
- **Accidents happen.** In the event of an accident, notify your teacher no matter how minor the accident seems to be, and follow his or her directions immediately.



Safety Rules! continued

A Neat Way to End It!

- **Clean scene!** When you have completed an experiment, clean up your area and return all equipment to its proper place.
- **Sudsational!** Wash your hands with soap after completing an experiment.
- **Don't be a fool, leave it at school!** Never take anything from the laboratory without permission from your teacher.

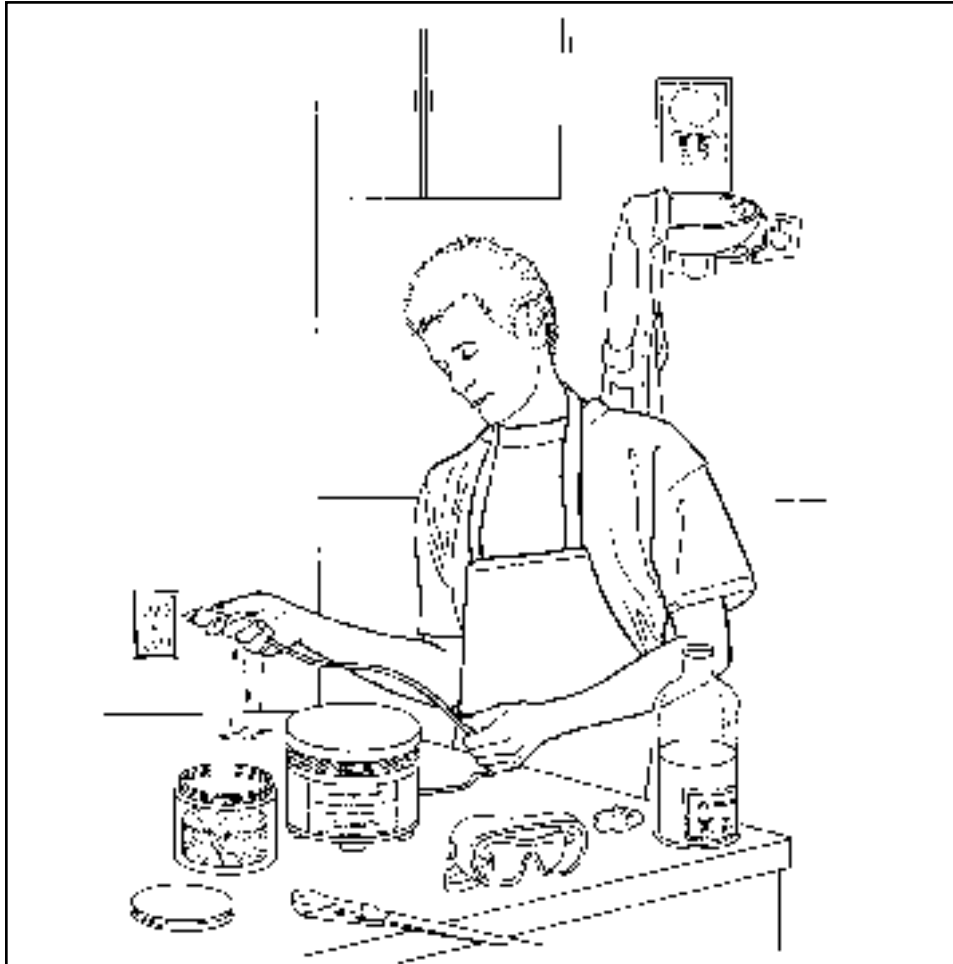
**PANIC BLISTERS****What do I do when ...**

- **a fire occurs?** In the event of a fire, alert the teacher and leave the laboratory immediately.
- **my clothes are on fire?** Stop-Drop-Roll! Stop immediately, drop to the floor, and roll. This is the quickest way to smother a fire.
- **my lab partner's clothes or hair is on fire?** Grab the nearest fire blanket, and use it to extinguish the flames. Inform your teacher.
- **a chemical comes in contact with my eyes?** Wash your eyes with water for at least 15 minutes. Inform your teacher.
- **I spill a chemical on my body?** Rinse the affected area for at least 15 minutes. Inform your teacher.
- **I spill a chemical on the floor?** Keep your classmates away from the area, and alert your teacher immediately.

Safety Rules! continued

Safety Slacker

Study the picture below.



Discuss what safety precautions are not being followed. How can the student improve his safety procedures?

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WORKSHEET

10 EXPERIMENTING SKILLS*Doing a Lab Write-up*

A lab write-up form is a handy way to keep track of your progress at every step of an investigation. It's also a useful tool for summarizing your results. On the next page you will see a copy of a lab write-up form. Look at that form while reading the following description of each category.

Looking at a Lab Write-up

Your lab write-up should be organized into the following categories:

- A. Title:** This is the name of the lab.
- B. Objective:** This is the purpose of the lab, which is usually either to answer a question or to test a hypothesis. The following is an example of each type of objective:
 - How do erosion and deposition take place along a riverbed? (question)
 - Erosion and deposition along a riverbed are predominantly caused by water. (hypothesis)
- C. Materials:** This section lists, in the order they are used, all the equipment, chemicals, or specimens needed to complete the investigation.
- D. Procedure:** These are the step-by-step instructions for doing the investigation.
- E. Data/Observations:** Record all the information you collect and all the observations you make here.
- F. Discussion:** This is where you explain your results and observations, and describe what you think your data mean or prove. Use your data and observations to make inferences. Also report whether your hypothesis was correct or not.

Your Turn!

Perform the quick investigation below. As you do, fill out each section of the lab write-up on the next page.

SPACE CASE

Does air have volume? Find out by doing the following experiment:

- 1. Crumple a piece of notebook paper, and place it in the bottom of a paper or plastic-foam cup so the paper fits tightly.**
- 2. Turn the cup upside down. (The crumpled paper should not fall out of the cup.) Lower the cup straight down into a larger beaker or bucket half-filled with water until the cup is completely underwater.**
- 3. Lift the cup straight out of the water. Turn the cup upright, and observe the paper. Record your observations.**
- 4. Punch a small hole in the bottom of the cup with the point of a pencil. Repeat steps 2 and 3.**
- 5. How do these results show that air has volume? Record your explanation on the lab write-up sheet on the next page.**

Name _____ Date _____ Class _____

Title:

Objective:

Materials:

Procedure:

Data/Observations:

Discussion:

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WORKSHEET

11 EXPERIMENTING SKILLS

Understanding Variables

Malcolm used his grandmother's recipe to bake a loaf of bread.

Bread



Grandma's Favorite Bread

- 1 1/2 cups warm water
- 1 package dry yeast
- 1 teaspoon salt
- 2 tablespoons sugar
- 2 tablespoon melted butter
- 3 1/2 cups flour

Mix all of the ingredients together, and knead well. Cover the dough, and let it rise for 2 hours. Put the dough in a greased pan, and bake at 400° F for about 35 minutes.



Unfortunately, Malcolm's bread collapsed while it was cooking. "Shucks!" he thought, "What could have gone wrong?" What could Malcolm change the next time he makes the bread? Two examples are given for you.

He could add more salt. _____

He could take the bread out of the oven sooner. _____

Varying Your Variables

A **factor** is anything in an experiment that can influence its outcome. A **variable** is a factor in an experiment that can be changed. For example, because you can change the amount of salt in the bread recipe, the amount of salt is a variable.

Malcolm's grandmother suggested that he added too little flour or too much liquid. Therefore, Malcolm thought about changing one of the following three variables:

- the amount of water
- the amount of melted butter
- the amount of flour

Understanding Variables, continued

In science class, Malcolm learned to change only one variable at a time. Why is that important?

Scientists strive to perform controlled experiments. A **controlled experiment** tests only one factor at a time. In a controlled experiment, there is a control group and one or more experimental groups. All of the factors for the control group and the experimental groups are the same except for one. The one factor that differs is called the changed variable. Because the variable is the only factor that differs between the control group and the experimental group, scientists can be more certain that the changed variable is the cause of any differences that they observe in the outcome of the experiment.

Malcolm tried reducing the amount of water to 1 cup. Thus, he made the amount of water the changed variable. What factors did Malcolm control? (Hint: There are several of them! Refer to the recipe.)

As it happened, Malcolm chose the right variable to change. With less water, the bread came out perfect. He concluded that only 1 cup of water should be added.

Inputs and Outputs

The **outcome** describes the results of your experiment. For instance, when you bake bread, the outcome is the quality of the loaf of bread. Often an outcome is something that you have to measure. Following is an example.

Henry and Eliza conducted an experiment using plant fertilizer. They added different amounts of fertilizer to seven pots of bean sprouts. The pots were the same size and had the same type and amount of soil. They were given the same amount of seeds, light, and water. To find out how the fertilizer affected the growth of the sprouts, Henry and Eliza calculated the average height of the bean sprouts in each pot. Here are the factors in their experiment:

Changed variable: amount of fertilizer

Controlled factors: size of pots, amount of light, amount of water, amount of soil, number of seeds

Outcome: average height of bean sprouts



Understanding Variables, continued

Your Turn

Identify the changed variable, controlled factors, and outcomes in the following examples:

- 1. In a recent study, middle school students were given a math exam after various amounts of sleep. One group slept 8 hours or more, and the second group slept fewer than 8 hours. The students had similar skills in math. They ate the same meals the previous day. The study results showed that students who slept 8 hours or more scored better on the exam, while students who slept less than 8 hours scored worse.

Changed variable: _____

Controlled factors: _____

Outcome: _____

- 2. Our science club built a catapult out of craft sticks, glue, and a rubber band. We wanted to determine what size rubber band was best for launching a gumball across the classroom. If the rubber band was too small, the gumball wouldn't travel very far. If it was too big, it would be too loose to work well. We found that a rubber band with a circumference of 11 cm shoots the gumball the farthest.

Changed variable: _____

Controlled factors: _____

Outcome: _____

TROUBLESHOOTING

Remember that variables are things that can be changed. In each scenario, ask yourself what *could* have been done differently.

TRY THIS!

Make the bread recipe that appears on page 28. Remember to add only 1 cup of warm water!

WORKSHEET

12

EXPERIMENTING SKILLS

Working with Hypotheses

When people do scientific experiments, they try to shed light on the unknown or figure out how the world works. How do scientists know where to start? Well, they ask questions.

In order to get answers, scientists start with a puzzling question. Scientists have tried to answer the following:

- How do birds know where to migrate?
- How can we predict earthquakes?
- Is there life elsewhere in our solar system or in the universe?
- Do elephants use sound to communicate?

Then they try to answer their question by making an educated guess. The following are guesses to answer the first question:

- Birds tell direction by watching the sun rise and set.
- Birds have a built-in “road map” to follow.
- Birds can tell direction by sensing the Earth’s magnetic field.
- Birds remember their course by spotting familiar landmarks.

These four sentences are examples of hypotheses. A **hypothesis** is an educated guess or possible answer to a question. Scientists test their hypothesis by doing an experiment. The following is an example:

Question: How do birds know where to migrate?

Hypothesis: Birds are directed by the Earth’s magnetic field.

Experiment: Create an electric circuit that produces a magnetic field. Attach this circuit to a bird so that the bird’s ability to *sense the Earth’s magnetic field*—if such an ability exists—is disrupted. If the bird can still migrate normally, then the hypothesis is probably wrong.

Identifying a Good Hypothesis

Not all hypotheses are useful. Consider the following hypothesis:

Hypothesis: Birds are guided by the spirits of dead antelopes.

Could you design an experiment to test such a hypothesis? Even if you could find spirits of dead antelopes, they would probably be hard to control in an experiment. The point is that a *good* hypothesis is one that can be tested.



Working with Hypotheses, continued

Evaluate each hypotheses based on whether it can be tested, and place an X in the appropriate column.

Hypothesis	Can be tested	Cannot be tested
If the polar ice caps begin to melt, the amount of salt in ocean water will change.		
Dogs use mind control on their owners to be taken for walks and car rides.		
If an animal is deaf, then it cannot hear.		
A propeller with large blades can propel an airplane faster than a propeller with smaller blades can.		

More on Hypotheses

Hypotheses help explain puzzling situations or events. Hypotheses answer “how,” “what,” and “why” questions. Explain each of the following situations with a hypothesis:

1. You hang a bird feeder, fill it with food, but no birds come to it.

Hypothesis: _____

2. In your new house, you see fewer stars from your bedroom window. You’re looking at the same place in the sky.

Hypothesis: _____

3. After you put a plastic food container in the dishwasher, its lid no longer fits correctly.

Hypothesis: _____

TROUBLESHOOTING

Create a two-column table. Label one column “Cause” and the other “Effect.” Put a puzzling situation or event in the “Effect” column. Think of some causes, and list them in the “Cause” column. Every cause you write is actually a hypothesis!

TRY THIS!

You’ve probably heard that you can prove a hypothesis wrong but that you can’t prove it right. Explain why this is true.

WORKSHEET

13

EXPERIMENTING SKILLS

Designing an Experiment

The following report was written by a middle-school science student:

My question was, "Why do some helium balloons last longer than others?" I did research and discovered that balloons aren't filled with pure helium. My hypothesis was that balloons with a higher percentage of helium last longer.

In my experiment, I filled 12 balloons with helium. Four of them were completely filled to 30 cm across. Four were filled to 20 cm across. Four were filled to about 10 cm across. The balloons lasted about the same amount of time, so my hypothesis was not true.

On the report evaluation, the teacher wrote, "Good idea, but you didn't test your hypothesis." What do you think the teacher meant?

How could the experiment be changed to test the hypothesis?

Be Sure to Answer the Question

An experiment should test a specific hypothesis. Always ask yourself, "Does my experiment match my hypothesis?"

For example, Makiko wanted to test the following hypothesis: "Gerbils can think better right after they eat." She built a maze to test her eight gerbils' thinking ability. At first, she planned to test four gerbils right after they had eaten one brand of gerbil food and the other four after they had eaten another brand of gerbil food. Would this experiment test Makiko's hypothesis? Write the hypothesis you think this experiment would test.

Makiko decided she would feed her gerbils at 8 P.M. every evening. Then she would test four gerbils in the maze at 8:30 P.M. and the other four on the following morning. This experiment would test her original hypothesis.



Designing an Experiment, continued

Asking the Question

What hypothesis is each of the following experiments designed to test? For each experiment, provide an appropriate hypothesis.

- 1. Makiko fed half her gerbils all at once. The other half were fed their daily ration in three equal parts—in the morning, at midday, and at night. After a month, all of the gerbils were tested in the maze.

Hypothesis: _____

- 2. Makiko kept half her gerbils in a cage on a table surrounded by plants. She kept the other half in a cage on a table without plants. After a week, she tested the gerbils in the maze.

Hypothesis: _____

A Bit More Practice

For the following puzzling event, propose both a hypothesis and an experiment that tests your hypothesis.

- 3. You return to the car from an all-day shopping spree at the mall. Your favorite CD, which you left on the dashboard, is now stuck.

Hypothesis: _____

Experiment: _____

TROUBLESHOOTING

Write down the different variables that your hypothesis mentions. Your experiment to test your hypothesis should use the same variables. Present your hypothesis to your class, and explain your experiment.

TRY THIS!

Why is it important for Makiko to use more than one gerbil in each of the experimental trials? For instance, in one experiment she fed four gerbils once a day and four gerbils three times a day. Why didn't she just use two gerbils, one for each feeding schedule?

WORKSHEET

14

EXPERIMENTING SKILLS

Using the International System of Units (SI)

In the United States, few people besides scientists use the International System of Units (known as **SI** for *Système Internationale d'Unités*) regularly. SI is becoming more common for two reasons.

- Once you learn and practice SI, it is easier to use than the standard English system.
- As communication systems and businesses become increasingly global, there is a growing need for a worldwide standard measurement system.

These are reasons why students are required to learn SI in school. We already use SI for many things. For instance, most beverages are sold in 2 L or 3 L bottles. What other items are measured with SI units?

Match 'Em Up!

Match the SI unit with the dimension that it measures:

- | | |
|---------------------------|-----------|
| 1. _____ meter | a. volume |
| 2. _____ gram | b. area |
| 3. _____ liter | c. mass |
| 4. _____ square kilometer | d. length |

Match the SI prefix with its meaning:

- | | |
|-------------------------|-------------------|
| 5. _____ <i>nano-</i> | e. one-tenth |
| 6. _____ <i>centi-</i> | f. one thousand |
| 7. _____ <i>micro-</i> | g. one-thousandth |
| 8. _____ <i>kilo-</i> | h. one-millionth |
| 9. _____ <i>deci-</i> | i. one-billionth |
| 10. _____ <i>milli-</i> | j. one-hundredth |

Help is on the way!

An SI Conversion Chart is provided for you in Appendix I on page 79.

Remember

As you read, watch for words such as *nanosecond*, *kilocalorie*, *milliliter*, and *micrometer*.



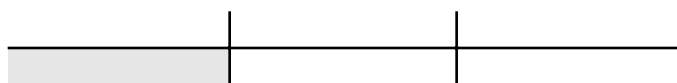
Using the International System (SI), continued

Conversions

Convert between SI and English units with the following factors :

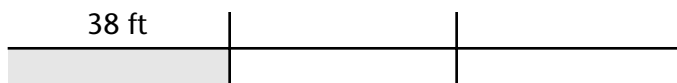
mass	volume	distance
1 lb = 454 g	1 gal = 3.78 L	1 ft = 0.305 m
1 g = 0.0022 lb	1 L = 0.26 gal	1 m = 3.28 ft

There is a handy method of doing conversions based on this figure:

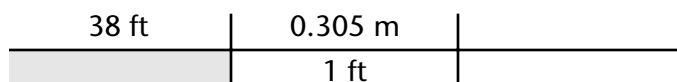


Here's an example: How many centimeters is 38 ft?

Step 1: Put the known quantity in the upper-left space, as follows:

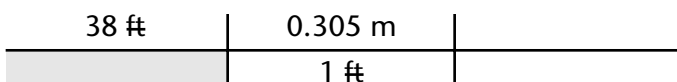


Step 2: Put a conversion factor (also called an *equality*) in the next set of boxes to the right. Make sure that the units match diagonally. We started with feet on top, so we'll put feet on the bottom when we fill in the conversion factor, as follows:



Note: There are two conversion factors listed above for feet and meters. You can use either one as long as you put feet on the bottom.

Step 3: Cross out, or cancel, the units that appear on both the top and the bottom, as follows:

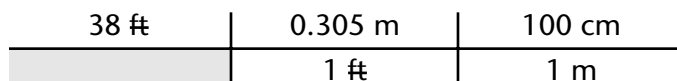


Step 4: Now ask, "Is the unit that's **not crossed out** the one I want?"

- If the answer is yes, then continue to Step 5.
- If the answer is no, return to Step 2.

For our example, the unit that's left is meters. We're looking for centimeters, so we'll return to Step 2.

Step 2: Remember to match units diagonally.



Using the International System (SI), continued

Step 3: Cross out the matching units.

38 ft	0.305 m	100 cm
	1 ft	1 m

Step 4: Is the unit that's **not crossed out** the one I want? Yes, we've got centimeters, so we're ready to solve the problem.

Step 5: To solve the problem, multiply the numbers on the top row:

$$38 \times 0.305 \times 100 = 1,159$$

Then multiply all of the numbers on the bottom row:

$$1 \times 1 = 1$$

Now, divide the top row's product by the bottom row's product:

$$1,159 \div 1 = 1,159$$

The answer is **1,159 cm!**

Your Turn

The following problems will help you practice your metric-to-metric, English-to-SI, and SI-to-English conversions. Be sure to show your work.

1. How many meters is 1,602 ft?
2. How many pounds is 12 g?
3. How many gallons is 0.2 L?
4. How many deciliters is 5 L? (Hint: How many deciliters are in 1 L?)
5. How many meters is 63.9 cm?



WORKSHEET

15

EXPERIMENTING SKILLS

Measuring

Try this puzzle. Suppose that you are given a bottle of water and three beakers. One of the beakers holds 30 mL, one holds 40 mL, and the largest of the three beakers holds 200 mL when full. There aren't any markings on any of the beakers. Describe how you could put exactly 20 mL of water in the large beaker without using any other equipment.

Tools of the Trade

You probably already know that beakers are used for measuring liquid volume. We say that the **dimension of measurement** for a beaker is volume. Examine the following chart, and fill in the empty boxes.

Measurement device	Dimension of measurement
beaker	volume
stopwatch	
beam balance	
graduated cylinder	
	distance or length
	temperature

Precise measurements and accurate readings are very important aspects of scientific experimentation.

Here are some pointers for accurately measuring the volume of a liquid:

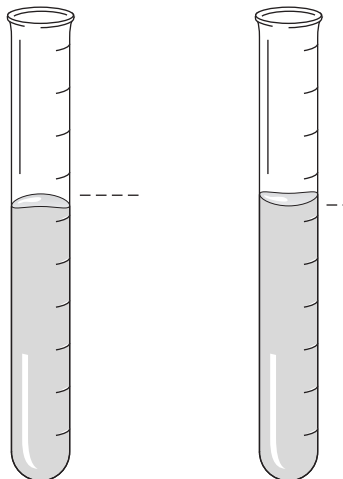
- Place the container on a flat surface.
- Make sure the container is at eye level when you read the volume.
- If you have trouble seeing the level, hold a blank piece of paper behind the container while you read the volume of the liquid.

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Measuring, continued

In a graduated cylinder or beaker, most liquids form a **meniscus**, or a curved upper surface. A meniscus is caused by surface tension. When a liquid, such as water, is more attracted to the walls of the container than to itself, it curves up at the edges like a smile. When some liquids, such as mercury, are more attracted to themselves than to the walls of the container, they curve down like a frown.

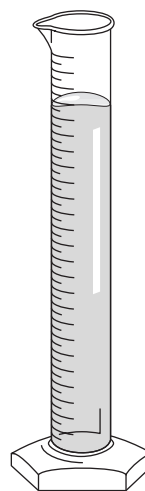
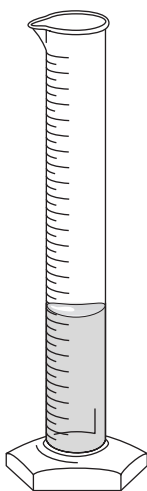
When you read the volume of a liquid, read it from the center of its meniscus, not from the curved edges.



For practice, read the volume of the following liquids. Each longer graduation represents one milliliter.

1. Volume: _____

2. Volume: _____



Measuring, continued

Uncertainty in Measurement

Anne brought a 1 L bottle of vinegar from home to use in an experiment on volcanoes in science class. She poured the contents of the bottle into a large beaker and carefully measured it. She was surprised to find that the vinegar’s measured volume was actually 1.02 L. Anne thought the bottle contained exactly 1 L of vinegar. What possible explanations can you think of for the difference?

Accuracy in Measurement

No measurement is 100 percent accurate. All measurements have some degree of uncertainty. When taking measurements, you should always ask yourself, “How accurate is this measurement?”

For a measurement to be of any worth, it must have something that indicates its reliability. A measurement’s **accuracy** is expressed as its potential amount of error. For instance, the smallest unit of measurement on a metric ruler is usually a millimeter. The most accurate measurement you could possibly make with that ruler is to the nearest millimeter; thus, the measurement’s accuracy is ± 0.5 mm.

This is important because not all measurements have the same accuracy. The total accuracy of your work is only as reliable as your *least* accurate measurement. Following is an example:

Ricardo added the following three liquids to a beaker:

- 7.9 mL of liquid A
- 2.1 mL of liquid B
- 250 mL of liquid C

Measuring, continued

Ricardo measured liquids *A* and *B* with a narrow graduated cylinder that had markings for every 0.1 mL. He measured liquid *C* in a beaker that had markings only for every 10 mL. Thus, the volume of liquid *C* was only accurate to within about 5 mL.

As a result, Ricardo correctly stated that the total volume of the mixture in the beaker was $(7.9 + 2.1 + 250) \text{ mL} = 260 \text{ mL} \pm 5 \text{ mL}$.

Matchmaker

Match the measurement devices below with their level of accuracy.

- | | |
|---|------------------|
| 1. _____ metric ruler with markings as small as millimeters | a. about 0.5 g |
| 2. _____ graduated cylinder with markings as small as 2 mL | b. about 1 mL |
| 3. _____ scale with markings as small as 0.01 g | c. about 0.5°C |
| 4. _____ thermometer with markings as small as 1°C | d. about 1 mm |
| | e. about 0.5 mm |
| | f. about 0.005 g |
| | g. about 0.1°C |

TROUBLESHOOTING

Think of accuracy in terms of money. When someone says, "That costs about \$20," which of the following would you think is most accurate: (a) the price is correct, give or take \$10; (b) the price is correct, give or take \$1; or (c) the price is correct, give or take 1 cent? The most accurate estimate is probably (b).

TRY THIS!

The next time your family buys gasoline, pay attention to how accurately the gas pump tracks the volume of gas—very accurately! For contrast, notice how accurately the car's gas gauge measures the amount of gas in the gas tank—not very accurately!

WORKSHEET

16

RESEARCHING SKILLS

Choosing Your Topic

Your teacher has assigned a research paper, and you have to turn in your topic tomorrow. You are a little worried about finding a topic that meets the teacher’s requirements and that interests you. How can you find the perfect topic for your paper?

Generate Topic Ideas

Begin your search for your topic by thinking about the **subject area** your paper needs to cover. A subject area is a broad or general category. In this case, let’s say your subject area is *the universe*. Now you have to find a **topic** within your subject area. A topic is the narrow area within the broad subject area that your paper is going to be about. Where can you find an interesting topic? Try some of the following:

- Brainstorming (quickly listing all the possibilities that come to mind)
- Your favorite magazines
- On the Internet or World Wide Web
- Skimming through an encyclopedia (hard copy or CD-ROM)

After going through some of the steps listed above, suppose you decide on the topic of *space travel*. Brainstorm again, and in the spaces below, list all the ideas you can about space travel, without stopping to think if they are good or bad topics. The first few are done for you.

space suits, space food, aliens, galaxies, other planets, how far? other life?

Narrow It Some More

How’s your brain doing? Don’t put it away yet. Now narrow your topic even further. Suppose from your brainstorm list above, you choose the topic of *aliens*. Brainstorm again, focusing on this specific topic. Under *aliens*, you should be able to list some very narrow subjects.

life forms, visits to Earth, huge distances in space

Finally, after all the brainstorming, you have picked the perfect topic: *Could life as we know it travel from galaxy to galaxy?* Congratulations!

WORKSHEET

17

RESEARCHING SKILLS

Organizing Your Research

Jorge needed a research topic for his science project. He was interested in sharks, so his teacher suggested a few subjects related to sharks. After some thought, he chose “the whale shark” as his topic.

At the library, he entered “whale shark” as a title search, but that gave no results. He figured he needed to broaden his search, so he typed “shark species” as a keyword. From this, he found that the library contained 97 books related to shark species. He chose the first five on the list: *Shark Species I Have Hunted*, *Sharks Around the World*, *Guide to Shark Species*, *Sharks of the Atlantic Ocean*, and *Identifying Sharks*.

Three hours later, Jorge realized that none of the books contained information that he could use. He needed new material. He decided that the next day he would revise his strategy and start again. **Suggest three things that Jorge might do differently when he starts over.**

Mapping Out Your Strategy

When conducting research, think about your strategy. A strategy can refine your search so that you find exactly the sources you need in an efficient manner. Consider these steps when planning your strategy:

- Pick a topic that interests you and is not too broad or general.
- List your key words.
- List the sources where you might find information (books, CD-ROMs, science magazines, Internet), and list where they might be found (school library, home computer, computer lab, public library).
- Check on-line databases and other on-line sources (such as CD-ROM encyclopedias and on-line science magazines) in addition to the library’s catalog.
- Look more closely at the sources that seem most relevant.
- Scan the book or on-line article.
- Check out or print out sources that have good information.
- Read what you have gathered.



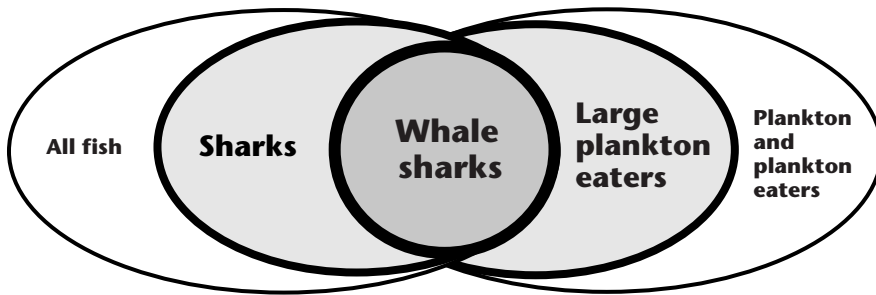
Organizing Your Research, continued

Sometimes it is helpful to write a research plan. It helps you keep things moving by setting a schedule for finishing tasks. You should start with the date the project is due and then work backward. Below is an example.

Research Plan

Date needed	Task
Jan. 20	Check the library for possible sources on shark species.
Jan. 27	Retrieve additional sources about whale sharks on the World Wide Web.
Feb. 1	Evaluate sources, and take notes on them.
Feb. 4	Finish outline for paper on "the whale shark."
Feb. 10	Finish writing and proofread paper.
Feb. 13	Paper due. Hand in finished paper.

A research map is another useful research tool. It can help you think about your topic from a broader perspective, and it can show you how information might be located in more than one source. For example, a research map for a paper on the whale shark might look like this:



Information on whale sharks could be located under the topic "all fish" or under the topic "sharks." If these searches are unsuccessful, try looking under the topics "plankton and plankton eaters," or "large plankton eaters."

WORKSHEET

18

RESEARCHING SKILLS

*Finding Useful Sources***New Directions**

Here's a trick to help you find sources. Before you do your research, **rewrite** your topic a few different ways. For example, suppose your original topic was about aliens. You plan to look for sources about UFOs. To find as many useful sources as possible, rewrite your topic and ask yourself if your research can take a new direction. Different approaches might produce additional useful information. Here are some examples:

Original topic: "Could aliens travel to Earth from another galaxy?"

New title: "The Milky Way and Other Galaxies"

Possible new research direction: Comparing the Milky Way galaxy with other galaxies

New title: "Life As We Know It"

Possible new research direction: What conditions and chemicals are necessary for life as we know it to exist?

Your Turn

Try rewriting these two topic titles and point out a new research direction.

Original topic: "The science of artificial limbs"

Research direction: Medical technology

New title: _____

Possible new research direction: _____

Original topic: "Strange New Insect Species in Canadian Rain Forest"

Research direction: Environmental science

New title: _____

Possible new research direction: _____

TROUBLESHOOTING

Here are a few more tips for doing better research:

1. Try to use several different types of sources for any project.
2. Science is a field that changes quickly, so the more current your source, the better.
3. Think about whether you can make your search strategy more efficient.
4. If you get stuck, remember that it's okay to ask for help!

TRY THIS!

Ask a parent or an older sibling about a research project he or she enjoyed doing. Discuss the search strategies he or she used, and think about whether you could use those strategies too.

WORKSHEET

19

RESEARCHING SKILLS

Researching on the Web

Name one of your favorite Web sites on the World Wide Web.

How did you find that site?

The World Wide Web can be a great source of information. It is like an electronic library with information on almost every imaginable topic!

Professional researchers rely heavily on the Web. In fact, some researchers find most of their sources on-line. Here are a few tips to help you conduct your searches effectively and efficiently.

Caught in the Web

As a Web researcher, you will face two major problems:

- too much information
- unreliable information

So, your challenge is to narrow your search to get the most useful information and to make sure the information is reliable and accurate.

Too Much Information

Here are a couple of hints to help you avoid too much information:

- Most search engines display the best matches at the top of the list. The ones you see first are the ones that are most likely to be useful.
- Do single-word searches by typing in a single keyword. For example, if your topic is “the search for life on Mars” and you type in “Mars” as your word, you may get more than 2,300 responses. If you narrow your search by typing in [“life on Mars” + evidence], you will get fewer responses, but they will be more focused on your topic.

You Try It

Go to the Internet. Type in the key word “armadillo.” How many Web sites did you get in response? Are all of them about the animal called the nine-banded armadillo?

Now type in the key word “nine-banded armadillos.” How many results did you get when you narrowed your search? Were they more closely related to the interesting mammal?

Researching on the Web, continued

Unreliable Information

Just about anybody can post information on the World Wide Web. While much of this information may be very useful, much of it is also incorrect or misleading. As a researcher, how can you tell the difference?

- A rule of thumb is that reliable information comes from reliable sources. Look for information from NASA, The National Geographic Society, government agencies, professional associations, museums, and magazines.
- Be careful about getting information from personal Web sites. They are usually partial collections of information from other sites (like NASA or museums), or they are full of personal opinions, not facts.
- In addition, when doing research, watch out for possible sources of bias. A *biased source* is one that spreads incomplete or misleading information. For example, someone trying to convince you to accept his or her point of view about an issue may give you distorted or wrong information.

Citing Sites

If you use information from a Web site, you must cite that source in a bibliography. To do this, make sure you get the following information about the Web site:

- the author of the material
- the title of the specific Web page that you use
- the name of the Web site containing that specific page
- the date the page was created
- the exact address (or URL) of that page as well as the date you saw it

Format

The following are sample references to imaginary Web sites. Unless your teacher instructs you otherwise, your Web site citations should follow the same format.

Author's name. "Title of page." Title of Web site (Date of page creation). On-line. Name of computer network [Internet, World Wide Web, etc.]. Date you saw it. Available at [address].

Sample #1:

Smitty, Latisha. "My Travels in Georgia." Tisha's Amazing Home Page (Feb. 25, 1998). On-line. World Wide Web. May 23, 2000. Available at <http://www.tisha.edu/travels/ga-98>.

Sample #2:

Association of Light Bulb Users. "Don't Stare Directly at Light Bulbs for a Long Period of Time." Warnings to Light Bulb Consumers (Sept. 1, 1990). On-line. Internet. June 21, 2000. Available at <http://lightbulb-users.org/warnings/staring.htm>.

WORKSHEET

20

RESEARCHING SKILLS

Identifying Bias

Suppose that while researching nutrition, you run across the following:

Vitamin A is an important nutrient. It is used to make rhodopsin, a pigment in our eyes. Thus, Vitamin A is necessary for healthy vision. People can develop night blindness if they do not get enough of it. Carrots are an excellent source of vitamin A. Carrots should be a part of your daily diet.

At first, this paragraph seems to offer good information. Would you be more skeptical if you learned that it was written by people who grow carrots commercially? How would your opinion change? Explain your answer below.

Bias Is Everywhere

Bias is a subjective way of thinking that tells only one side of a story, sometimes leading to inaccurate information or a false impression. When you research, it is crucial that you identify the level of bias in potential sources. Below are some possible sources of bias.

- The writer is relying on incomplete information.
- The writer is trying to deceive the reader.
- The writer wants to believe what he or she is saying.
- The writer’s past experience is influencing his or her thinking.
- The writer is trying to persuade the reader.

In the passage above, the writer does not mention that ingesting too much vitamin A can make people sick. The writer fails to tell the reader that eggs and sweet potatoes are also good sources of vitamin A.

Bias Rating

When reading information, think about what possible bias might be distorting the facts. You might use a scale such as the following:

- 1 = almost totally unbiased; highly objective; accurate
- 2 = mostly unbiased; fairly reliable
- 3 = somewhat biased; accuracy is questionable
- 4 = fairly biased; distorted; probably unreliable
- 5 = totally biased; highly subjective; inaccurate

Identifying Bias, continued

Bias Begone!

As you read the following paragraphs, determine the kind of bias being used. Explain your reasoning.

1. Returning wolves to their native habitats is critically important. The wolf is an original top predator in the natural ecosystems of North America. If these ecosystems are out of balance, they may collapse. If that happens, millions of organisms will go extinct. Even humans are in danger if we do not do something soon. We must make sure that there are wolves in all of North America's remaining natural areas.

2. Scientists use powerful computers to study the Earth's atmosphere. These computers help scientists predict changes in world climate. For instance, scientists use computers to study what might happen if pollution increases or decreases. Computers can also help scientists make recommendations to businesses, individuals, and other polluters. Eventually, we will know enough about climate changes to be able to control them.

TROUBLESHOOTING

When reading a passage, ask yourself, "Will the writer benefit if I believe what is being told to me?" If the answer is yes, then the passage is likely to be biased.

TRY THIS!

Debaters often use bias intentionally to strengthen their position. Select one of the topics above, and have a debate with your classmates. Do your research, choose your position, gather your evidence, and have a vigorous debate!

WORKSHEET

21

RESEARCHING SKILLS

Taking Notes

Suppose you want to write a biography of your favorite movie star and you are invited to have dinner with him or her. What would you talk about? What questions would you ask? And how could you ever remember everything for your book? Well, maybe you could take some notes! You would probably end up with several pages of interesting information.

Take Note of This!

It would be hard to pretend that taking notes for your research paper or speech is just like going to dinner with a celebrity. But there is no getting around it: sooner or later, you will have to take notes for a research project. Here are some questions and tips to get you started.

- How do you think taking notes would help you in doing a research project for science class? Think about your dinner with the celebrity. Why was it important to take notes then?

- Where do you write your notes (in a notebook, on cards)?

- Why do you take notes there?

Places to Keep Your Notes

- **Note cards**—You can organize the cards in any order.
- An organized **notebook**—This is probably the most common place to take notes.
- A **computer** or **word processor**—These allow you to rearrange your information in any order.

Taking Notes, continued

Notes on Taking Notes

Taking good notes requires a lot of practice. Here are a few things to keep in mind as you take notes for a research project:

- Be brief; keep sentences and phrases short and simple.
- Keep it organized; use an outline system.
- Use a shorthand system (in which abbreviations stand for words or concepts) so you don't have to write down every word.
- Stick to the point; don't write down information you won't need.
- Always keep track of the sources where your notes came from; this will make creating your bibliography much easier.
- Transfer the information to note cards or a computer if you will need to reorganize it later.

Here's an Example

Here are a couple of paragraphs and sample notes to help you get started:

Early Models of the Atom. Our understanding of atomic structure has changed dramatically over the years. In the time of Newton, the atom was pictured as a small, hard ball. In 1897, J. J. Thompson proposed the "plum-pudding" model of the atom, in which negative electrons are distributed fairly evenly within a positively charged "pudding." Then in 1911, Ernest Rutherford performed experiments that demonstrated that the atom is mostly empty space. According to his experiments, atoms have a dense central core (the nucleus) containing most of the atom's mass, and some arrangement of electrons circle the core. Two years later, in 1913, Niels Bohr did experiments that gave rise to the planetary model of atomic structure. According to this model, electrons orbit a positively charged nucleus much like the planets of our solar system orbit the sun.

The Atomic Model Today. Today, the planetary model has been replaced. According to the current atomic model, electrons exist in a "cloud" around the nucleus. Think of a swarm of bees (the electrons) buzzing around the outside of a hive (the nucleus).

Sample notes:

I. Early Understanding of Atomic Structure

- A.** Newton's time—small, hard ball
- B.** J. J. Thompson—plum-pudding model
- C.** E. Rutherford—empty space, central core model
- D.** Niels Bohr—planetary model

II. Current Atomic Model

- A.** Planetary model not accurate
- B.** Electron cloud model—electrons swarm around nucleus like bees around a hive



Taking Notes, continued

Now It's Your Turn

Using the notes on page 51 as a model, create your own notes for the following paragraph (the first major idea is done for you):

Bogs, swamps, fens, and marshes are all wetlands. Wetlands are areas of land along lakes, rivers, and ocean coastlines that are covered with water for at least part of the year. Some wetlands are covered by fresh water, some by salt water, and some by a mixture of fresh water and salt water. All wetlands are important because they perform a variety of functions. Wetlands provide a home for many species of plants and animals, some of which don't live anywhere else. Wetlands serve as a *sink*, trapping carbon that would be released into the atmosphere as carbon dioxide. They also function as a filter by removing pollutants from the water and as a sponge by absorbing extra water when rivers overflow.

I. What are wetlands?

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Taking Notes, continued

Notes for a Speech

Suppose you are asked to stand in front of a group and deliver a speech about wetlands. First you'll do research, and then you'll write a speech. But if you take your entire speech with you, you'll end up reading word-for-word to your audience. Boring! Instead, make good speaking notes that will help you remember your speech and allow you to make eye contact with the audience.

Some tips for good speaking notes:

- Use note cards; they're small and won't rustle, so they won't distract your audience.
- Keep only 1 or 2 short notes on each card so you won't have to spend time searching for an idea during your speech.
- Write only the main points and any ideas that you find difficult to remember on your note cards.
- Number the note cards in order, just in case you drop them right before your speech.
- Practice your speech. The note cards will help you remember your speech, but you shouldn't try to write the speech while standing in front of an audience.

Taking Notes in Class

Taking class notes is a lot like taking notes for research. Here are some extra tips for taking notes in class:

- Listen 80 percent of the time, and take notes only 20 percent of the time.
- Use your shorthand system.
- Note the words, ideas, or facts your teacher emphasizes during class.
- When your teacher *tells* you something is important or will be on your test, **write it down!**
- Review and reorganize your notes every evening.

The same basic principles apply to both class notes and research notes: be careful, be organized, and be thorough. Developing your note-taking ability will save you a lot of study time and will make your studying much easier.



WORKSHEET

22

COMMUNICATING SKILLS

Science Writing

Suppose you are a scientist and you have just discovered a cure for “mad cow disease.” Now you want to report your findings to other scientists. **Science writing** is a particular style of writing. It is different from the writing in newspaper articles or mystery stories. Science writing sticks to the facts, observations, and conclusions of an experiment or study. How is this different from the writing in a novel?

Find the Facts

One paragraph below is written like a scientific report, and one is written more informally. Read both paragraphs, and then answer the following questions.

Report #1:

I sat in the chair by the window, watching the rain. It seemed that the rain came down angrily, as if to punish the Earth. As I wrote in my journal, I thought about the earthworms. The worms were coming out of the ground, having been drowned out of their dark lairs. Did they feel differently when they reached the surface? Did they notice the pounding of the rain? Did they sense the poetry of the moment, as I did?

Report #2:

I watched the rain from a chair by the window. I wrote my observations in my journal. The rain was coming down quite hard. After it had been raining for a while, I noticed several earthworms emerging from underground. Over the next 20 minutes, more earthworms appeared. Apparently, as the ground became soaked with water, the earthworms came to the surface for air.

Which style seems more scientific to you? Explain your answer with specific examples from the paragraphs.

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Science Writing, continued

Not Quite Human

When you tell a friend, “My turtle misses me when I am at school,” do you think your turtle really has human emotions? Sometimes we act as if nonhuman things have thoughts or emotions similar to our own. Giving human thoughts, feelings, or actions to nonhuman organisms and objects is called **anthropomorphism**.

Most of the time, anthropomorphism is harmless. But in science writing, it can distort your experimental results and confuse your reader. **Be careful!**

From the two reports on page 54, list examples of anthropomorphism.

How do you think anthropomorphism in a science report can be misleading?

More Suggestions

There are different approaches to science writing. Sometimes you may give a report on your investigation and simply list your facts and observations in order. Other times you may debate a hypothesis. In that case, organize your paper or speech as a series of facts or observations that support your position.

Always remember who you are writing for. Writing your science report for a class of third-graders is different from writing about it for a science magazine. What are some of the differences you can think of? Write those differences below.

TROUBLESHOOTING

The primary characteristic of science writing is that it is **objective**, meaning that it relies on facts and avoids inferences. Keep this in mind as you practice your science writing.

TRY THIS!

Find and contrast two examples of scientific writing. Even though they are both science writing, how are they different?

WORKSHEET

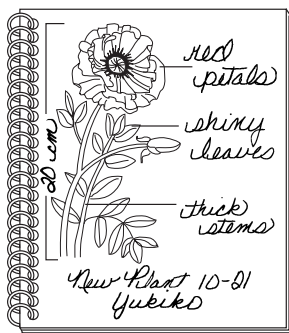
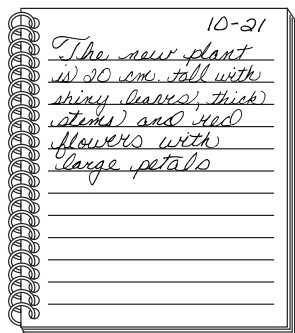
23

COMMUNICATING SKILLS

Science Drawing

Yukiko was walking in the woods, and she discovered a brand new plant. She wanted to share her incredible find with her classmates. Luckily, she was carrying her notebook.

First she described the flower. Then she drew a picture. Both are shown below.



If you were looking for this new plant, which would be more useful Yukiko's description, her drawing, or both?

Drawing is a very important skill in science. Sketching can help you develop your ideas. For example, if you wanted to design a machine that washed dishes, the first thing you might do would be to draw a sketch. Science drawings also help you share your ideas and observations with other people.

Tips for Picture-Perfect Science Drawing

Science illustrations should be neat, clear, and easy to understand.

Starting out

- **Be sharp!** Use a soft lead pencil, and keep your pencil sharp.
- **Sketch it!** On a scrap of paper, make a quick drawing so you can see how much room you'll need for your actual drawing.

Drawing

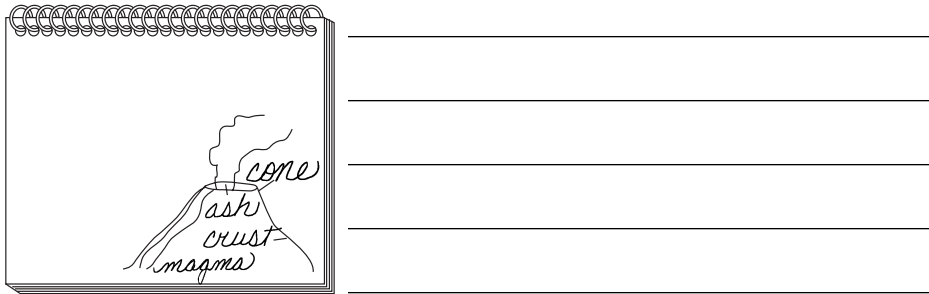
- **Look carefully!** If you are drawing a picture of something that already exists, carefully draw what you actually see, not what you think you should see. Be as accurate as you can, and make your lines clear.
- **The big picture . . .** Draw the large structures first, and then add the details later. If you are drawing someone's face, draw the head first, and then add the nose, ears, and eyes.
- **Details, details . . .** Make your drawings as large as you can, so that all of the details will be easy to see. Don't worry if you use a whole sheet of paper for one picture.

Science Drawing, continued

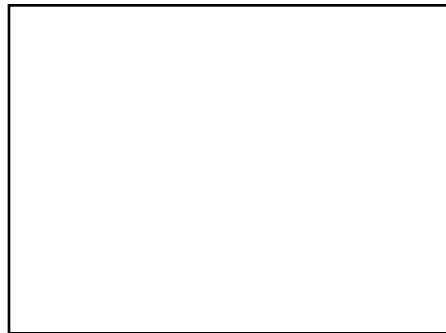
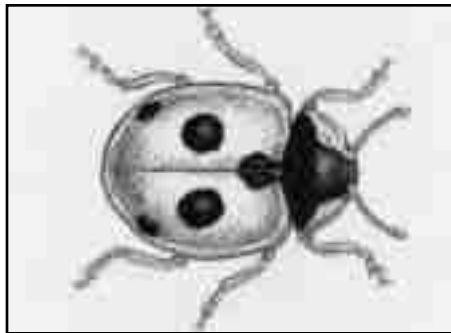
Labeling

- **Label logic** Neatly label the details of the drawing. Using a ruler, draw lines from the detail you are naming to the margins of the paper. Make sure the line clearly touches the part of the drawing you are labeling.
- **Entitled** Title the entire drawing. Include your name and the date.
- **Keep your perspective.** Science drawings are usually not life-size. Include a description of how big the object you drew really was.

1. The following is a poorly drawn illustration. What's wrong with it?
You may want to refer to the Tips for Picture-Perfect Scientific Drawing.



2. Look at the picture of the ladybug, and draw it in the box provided.
Try to make it the same size as the original. Label the head, legs, and body.



TROUBLESHOOTING

If you have trouble drawing the ladybug, try dividing the original picture into four sections. Concentrate on each section separately, instead of on the whole insect, when you draw it.

TRY THIS!

Imagine that NASA has asked you to make five scientific drawings to go on the next deep space probe. Your job is to choose which five things should be represented, draw them, and label the drawings as neatly as you can. Remember, if there are other forms of life in the universe, these drawings will be their first information about Earth.

WORKSHEET

24

COMMUNICATING SKILLS

Using Models to Communicate

A **model** is a representation of an object or system. Models are often used to explain a scientific event or principle, as in the following example:

To show how Earth revolves around the sun, hold a volleyball 1 m away from a table lamp with its light bulb exposed. Turn the volleyball on its axis, and move in a large circle around the light bulb.

1. How does this model demonstrate Earth’s motion around the sun?

2. Based on this example, define *model* in your own words.

3. All models are accurate in some ways and inaccurate in others.

a. In what ways is the model above accurate?

b. In what ways is the model above inaccurate?

4. Briefly describe another model that you have seen or used in science class.

Using Models to Communicate, continued

Your Turn

How could you use a model to explain the following concepts to a fourth-grader? Describe how each model would be constructed or used.

- 5. Most plants absorb water through their roots. The water travels through the plant and is used by the plant's cells. Any excess water evaporates through tiny holes in the surface of the plant's leaves.

- 6. The individual particles in a grain of salt are arranged in a regular pattern. They connect to each other to form a cube. This geometric shape allows more particles to connect, creating a larger cube.

TROUBLESHOOTING

Many toys are models of real things. For instance, think about toy cars and toy trucks. How are these models accurate representations of real vehicles? How are they different from real vehicles?

TRY THIS!

In the exercise above, you thought about how you could use a model to explain certain concepts to a fourth-grader. Now do it! Try out your model on a younger student. Pay attention to how well the student can relate the model to reality.

WORKSHEET

25

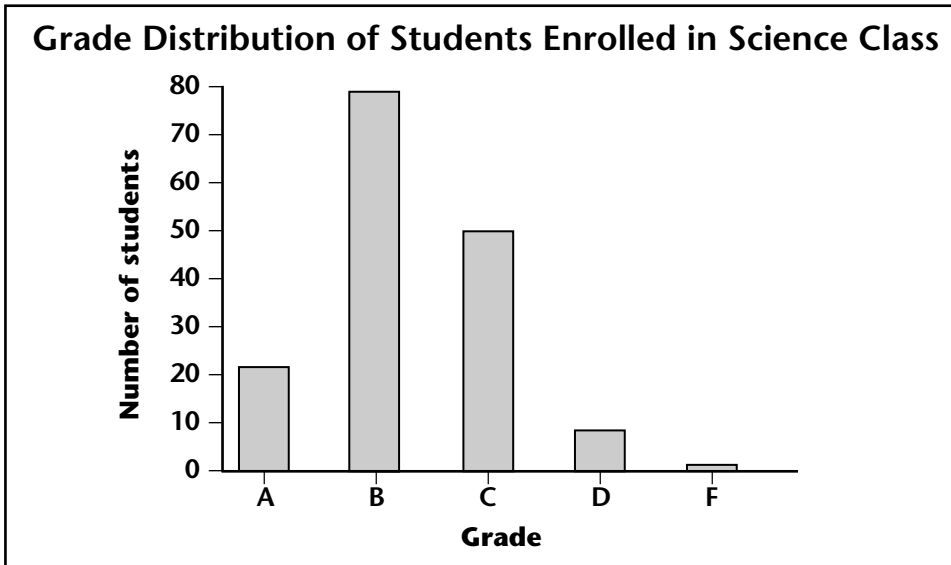
COMMUNICATING SKILLS

Introduction to Graphs

Examine the following table and graph:

Grade Distribution for Students Enrolled in Science Class

Grade	Number of students
A	22
B	79
C	50
D	9
F	2



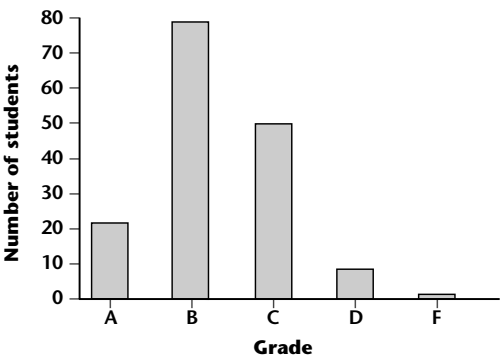
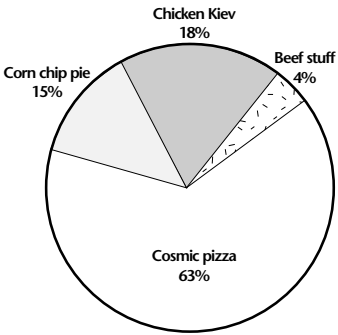
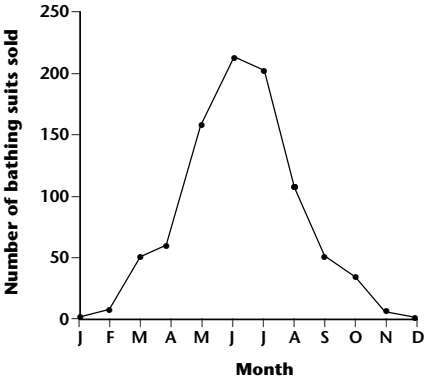
1. Both of these figures display the same information but in different ways. Which figure is easier to understand? Explain why you think so.

2. If you need to get specific data, such as the exact number of students who earned a B, which figure would you use? Explain your answer.

Introduction to Graphs, continued

Choosing the Right Graph

Data tables provide an organized way of viewing information, and graphs are *pictures* of the information in a data table. Sometimes it is faster and easier to interpret data by looking at a graph. It is important to choose the type of graph that best illustrates your data. The following table summarizes the best uses for three of the most common graphs:

Type of graph	Best use for this graph																										
<p>Bar graph Grade Distribution of Students Enrolled in Science Class</p>  <table border="1" data-bbox="321 688 818 1045"> <caption>Grade Distribution of Students Enrolled in Science Class</caption> <thead> <tr> <th>Grade</th> <th>Number of students</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>22</td> </tr> <tr> <td>B</td> <td>78</td> </tr> <tr> <td>C</td> <td>50</td> </tr> <tr> <td>D</td> <td>8</td> </tr> <tr> <td>F</td> <td>2</td> </tr> </tbody> </table>	Grade	Number of students	A	22	B	78	C	50	D	8	F	2	<p>A bar graph is best used for comparing data quickly and easily, such as the grade distribution of students enrolled in science class or the growth of plants in different pots.</p>														
Grade	Number of students																										
A	22																										
B	78																										
C	50																										
D	8																										
F	2																										
<p>Pie graph Percentage of Students Picking Various Lunch Entrees</p>  <table border="1" data-bbox="381 1150 716 1486"> <caption>Percentage of Students Picking Various Lunch Entrees</caption> <thead> <tr> <th>Entree</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>Cosmic pizza</td> <td>63%</td> </tr> <tr> <td>Corn chip pie</td> <td>15%</td> </tr> <tr> <td>Chicken Kiev</td> <td>18%</td> </tr> <tr> <td>Beef stuff</td> <td>4%</td> </tr> </tbody> </table>	Entree	Percentage	Cosmic pizza	63%	Corn chip pie	15%	Chicken Kiev	18%	Beef stuff	4%	<p>A pie graph is best used for showing percentages, such as the percentage of the student body who picked certain entrees for lunch or the percentage of your allowance that will go toward purchasing various things.</p>																
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<p>Line graph Number of Bathing Suits Sold Each Month</p>  <table border="1" data-bbox="321 1581 743 1959"> <caption>Number of Bathing Suits Sold Each Month</caption> <thead> <tr> <th>Month</th> <th>Number of bathing suits sold</th> </tr> </thead> <tbody> <tr> <td>J</td> <td>5</td> </tr> <tr> <td>F</td> <td>10</td> </tr> <tr> <td>M</td> <td>50</td> </tr> <tr> <td>A</td> <td>60</td> </tr> <tr> <td>M</td> <td>160</td> </tr> <tr> <td>J</td> <td>215</td> </tr> <tr> <td>J</td> <td>205</td> </tr> <tr> <td>A</td> <td>110</td> </tr> <tr> <td>S</td> <td>50</td> </tr> <tr> <td>O</td> <td>35</td> </tr> <tr> <td>N</td> <td>10</td> </tr> <tr> <td>D</td> <td>5</td> </tr> </tbody> </table>	Month	Number of bathing suits sold	J	5	F	10	M	50	A	60	M	160	J	215	J	205	A	110	S	50	O	35	N	10	D	5	<p>A line graph is best used for looking at changes over time, such as the number of bathing suits sold each month during the year or the change in your sister's height throughout the year.</p>
Month	Number of bathing suits sold																										
J	5																										
F	10																										
M	50																										
A	60																										
M	160																										
J	215																										
J	205																										
A	110																										
S	50																										
O	35																										
N	10																										
D	5																										

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▲ COMMUNICATING SKILLS ▲

Introduction to Graphs, continued

Choose the Graph

What graph type do you think best presents each set of data? Explain.

1. The percentage of rabbits preferring various foods

Food	Percentage preferring that food
Skippy’s Rabbit Chow	32
Homemade rabbit food	13
Happy Rabbit	10
Joe’s Special Food for Rabbits	44
Premium Rabbit Nutrition Diet	1

2. Albert’s grades for each month of the school year

Month	Grade in science class
September	98
October	94
November	88
December	78
January	82

Month	Grade in science class
February	83
March	86
April	81
May	97

3. The pH of solutions in experimental test tubes

Test-tube number	pH
1	6.7
2	7.1
3	7.4
4	7.1
5	7.0

WORKSHEET

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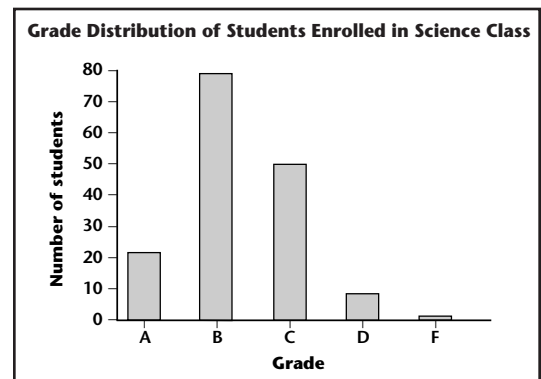
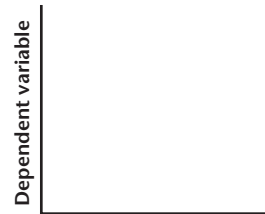
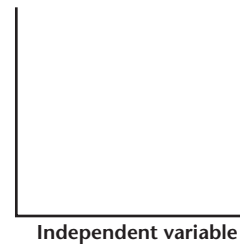
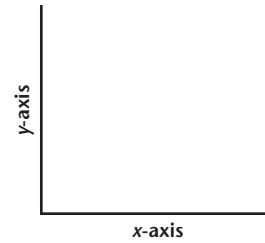
COMMUNICATING SKILLS

Grasping Graphing

When you bake cookies, you must use the right ingredients to make the cookies turn out right. Graphs are the same way. They require the correct ingredients, or components, to make them readable and understandable.

Bar and Line Graphs

- First, set up your graphs with an *x*-axis and a *y*-axis. The *x*-axis is horizontal, and the *y*-axis is vertical as shown in the example at right. The axes represent different variables in an experiment.
- The *x*-axis represents the independent variable. The **independent variable** is the variable whose values are chosen by the experimenter. For example, the range of grades is the independent variable.
- The *y*-axis represents the dependent variable. The values for the **dependent variable** are determined by the independent variable. If you are grouping students by grades, the number of students in each group **depends** on the grade they get.
- Next choose a **scale** for each of the axes. Select evenly spaced intervals that include all of your data, as shown on the grade-distribution bar graph. When you label the axes, be sure to write the appropriate units where they apply.
- Next, plot your data on the graph. Make sure you double-check your numbers to ensure accuracy.
- Finally, give your graph a title. A **title** tells the reader what he or she is studying. A good title should explain the relationship between the variables. Now your graph is complete!



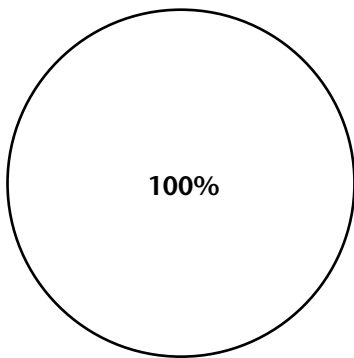
Grasping Graphing, continued

Pie Graphs

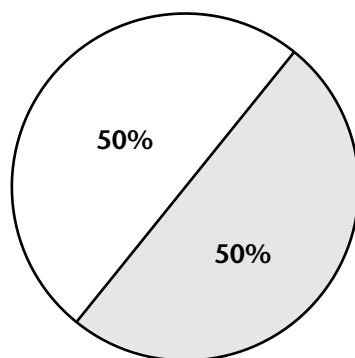
When you convert data to show percentages, you can use a pie graph. Pie graphs are shaped like a circle. The size of each “pie slice” is determined by the percentage it will represent. A full pie is equal to 100 percent, half a pie is equal to 50 percent, and so on.

Like bar and line graphs, pie graphs have independent and dependent variables. The independent variable is whatever the pie or slice of pie represents. The dependent variable is the size of the pie slice, the percentage of the whole it represents.

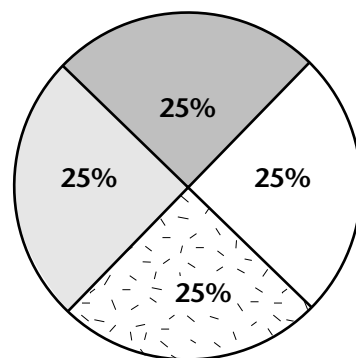
Percentage of Students Picking Various Lunch Entrees



Percentage of Students Picking Various Lunch Entrees



Percentage of Students Picking Various Lunch Entrees



Your Turn

For each table (a) identify the independent and dependent variable, (b) determine the type of graph to use, and (c) provide a title.

1.

Amount of daily sunlight exposure (min)	Average height of plants (cm)
50	14.8
60	14.9
95	15.2
75	15.1
110	16.5
135	17.3
100	16.1
30	11.0

- a. _____
- b. _____
- c. _____

Grasping Graphing, continued

2.

Student	Number of jelly beans consumed
Anthony	15
Keiko	28
Leigh Ann	58
Adam	22
Katie	12
Juan	17

- a. _____
- b. _____
- c. _____

Give It a Try

Graph the data below in your ScienceLog. Don't forget to do the following:

- Select the appropriate graph type.
- Identify the independent and the dependent variable.
- Choose an appropriate scale.
- Label the axes.
- Give your graph a title.

Amount of fertilizer added to soil (g)	Average height of plants (cm)
5	13.2
10	14.1
15	14.9
20	15.4
25	16.5
30	17.3
35	16.1
40	11.0

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COMMUNICATING SKILLS

Interpreting Your Data

Imagine that you are at home taking care of your brother’s dog, Sparky. At 7 P.M., Sparky starts barking. “He might be hungry,” you think to yourself. What are some other reasons that Sparky might bark?

Now suppose that this is the fourth night in a row you’ve taken care of Sparky. You have noticed that every night at about 7 P.M., Sparky starts barking. “Ah-ha!” you say to yourself, “There is a pattern here!”

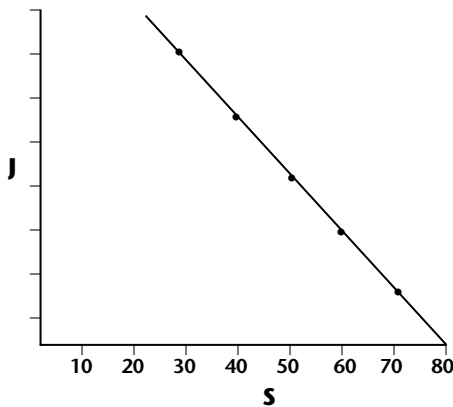
Hidden Patterns

When you collect raw data, patterns are often camouflaged as random numbers. Part of conducting a successful experiment is analyzing your data to find any hidden patterns. Two common data patterns you might see on your graph during an experiment are as follows:

- linear (Your data tend to form a straight line.)
- repeating (Your data cycle repeatedly through the same general points.)

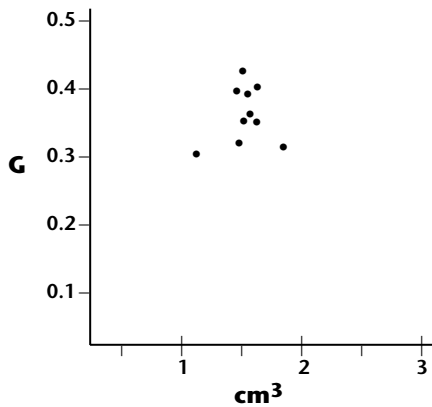
On the graph below, identify the examples of these two patterns.

a.



a. _____

b.



b. _____

Interpreting Your Data, continued

Graph It!

One of the best ways to identify a pattern is to draw a graph. A graph turns random data into a pattern that gives specific information.

Mary tested how fast blocks of clay dry under a bright light. She recorded the time it took different-sized blocks to dry.

Volume of block (cm ³)	27	8	43	125	16	166	64	91
Time to dry (min)	5	3	7	21	4	37	9	14

Graph her data in the space below.

Describe the shape of the pattern that emerges from Mary's data. Mary hypothesized that the drying time for a clay block was **directly proportional** to the block's volume. In other words, her hypothesis predicted that her data would form a straight line. Was her hypothesis correct? Explain your answer.

TROUBLESHOOTING

If you are having trouble telling whether Mary's data form a straight line, try drawing a line from her lowest data point to the highest data point. If her data form a straight line, most of the points should fall on or be very close to the line you just drew.

TRY THIS!

Mary had one additional data point with values of 142 cm³ and 39 minutes. Because this point was different from her other data points, she decided she had made an error while performing that trial. To understand her thinking, plot that point on your graph above.

WORKSHEET

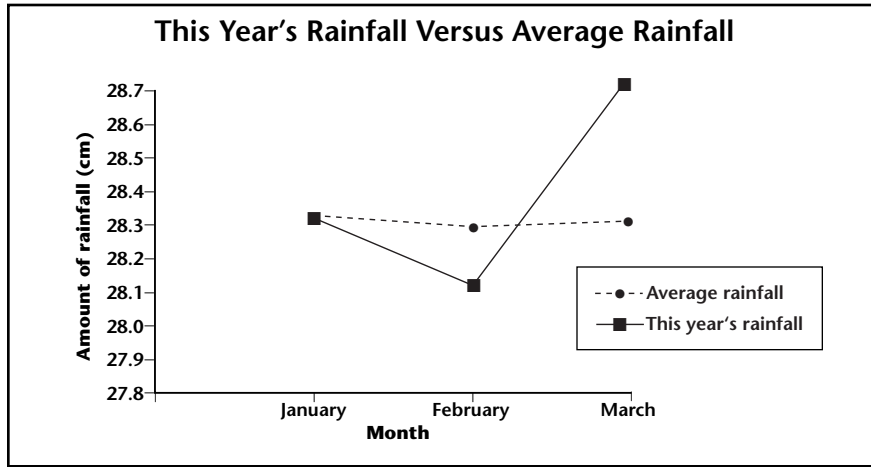
28 COMMUNICATING SKILLS

Recognizing Bias in Graphs

Graphs can be used to display your data at a glance. However, graphs can distort your results if you are not careful. The picture that results may not be **objective**, or without bias or distortion. Look at the first graph.

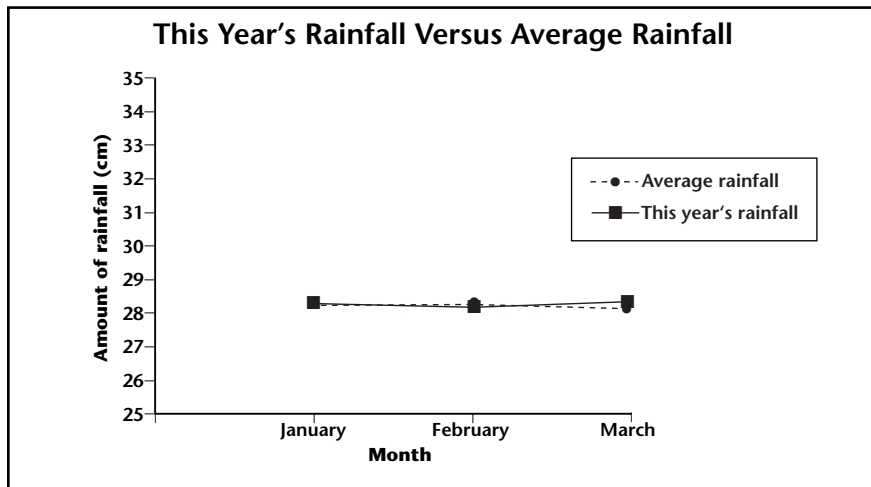
How Much Rain Really Fell?

In the graph below, it appears as though March had drastically more rainfall compared with an average month. But did that really happen?



Wait! March's rainfall was only 0.4 cm above average. On the graph, that looks like a large increase. On the ground, a 0.4 cm increase is not that much. This graph is *biased* because it exaggerates the difference between the two lines. Because the interval between 27.8 cm to 28.7 cm on the y-axis is so small, the difference in rainfall seems very large and noticeable.

If you increase the interval between numbers on the y-axis, the scale becomes larger. That makes the difference between the two lines smaller, as shown below.



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Recognizing Bias in Graphs, continued

Refer to the graphs on the previous page to answer the following questions:

1. What is the range of values on the y -axis in the second graph?

2. How does the difference between the two lines in the second graph compare with the difference between the two lines in the first graph? Which graph is a more accurate picture of the data? Explain.

A Matter of Scale

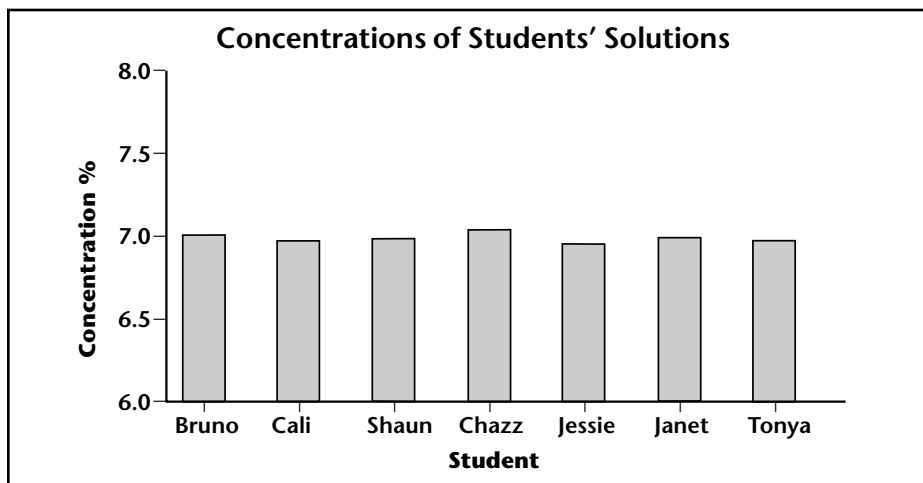
Here is another example of how the choice of the scale can alter a graph.

In an experiment, seven students tried to mix a solution of salt water so that its concentration would be exactly 7.00%. When the teacher tested the concentration of their solutions, he got the following results:

Concentrations of Students' Solutions

Name	Bruno	Cali	Shaun	Chazz	Jessie	Janet	Tonya
Concentration	7.02%	6.99%	7.00%	7.08%	6.97%	7.01%	6.99%

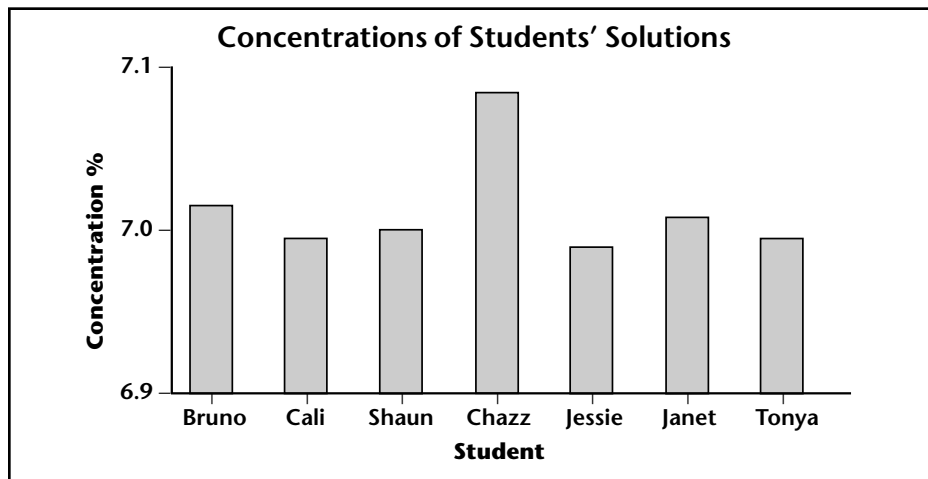
The teacher created the following graph to show the students' results:



Does this graph give you a clear picture of how the concentrations varied? Not really. The bars look so much alike that it's hard to tell the differences between them.

Recognizing Bias in Graphs, continued

Suppose the teacher decreased the scale of the y -axis. The graph would then look like the one below. The variation in the students' results looks much greater, even though it hasn't changed. This graph makes it easier to see the small differences.



Graphs with an Attitude

The data in the chart below were recorded by a student measuring the thickness of four rock layers.

Thickness of Rock Layers

Layer	A	B	C	D
Thickness	11.2	10.8	13.5	11.1

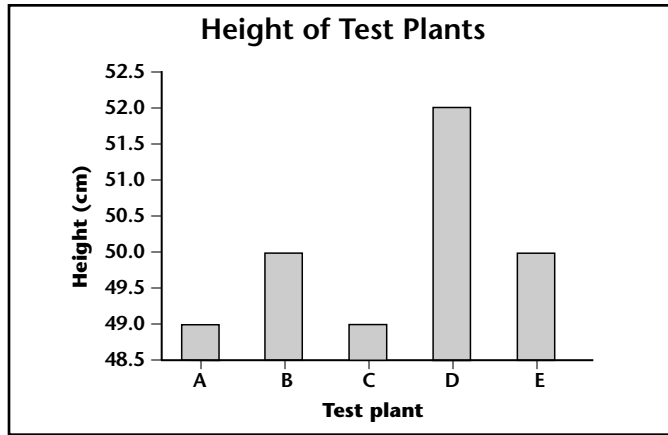
Using the above data, create two graphs in the space below. First show how similar the measurements are. (Hint: Make the scale of the y -axis larger. This makes the difference between the measurements seem smaller.) In your second graph, emphasize the fact that layer C was slightly thicker than the other layers.

Your Graphs:

Recognizing Bias in Graphs, continued

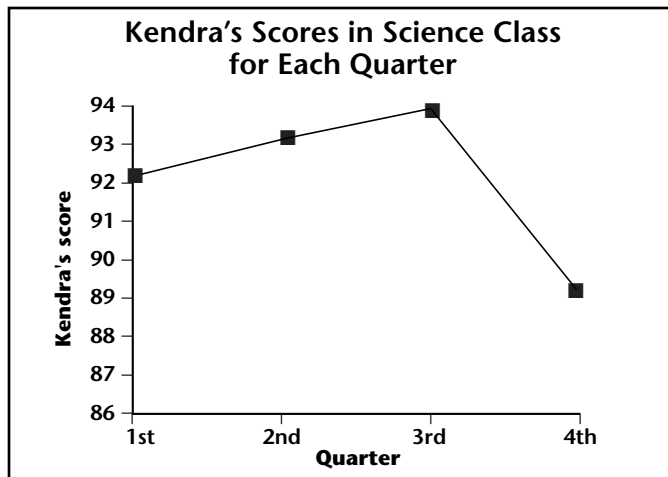
Identifying Bias on Your Own

Graph 1



1. This graph shows that test plant D grew much taller than the other plants. How is this information misleading?

Graph 2



2. This graph shows that Kendra received a much lower grade in science class during the fourth quarter. Do you think what appears to be such a large drop in her grades should worry Kendra? Explain your reasoning.

WORKSHEET

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COMMUNICATING SKILLS

Making Data Meaningful

The following sentences use the word *average* in different ways:

- He was just an ordinary, average guy.
- The average volume of the six solids was 3.2 cm^3 .

1. What is different about the way *average* is used in each sentence?

2. What is similar about the way *average* is used in each sentence?

What Does It All Mean?

Because average can be used in different ways, scientists use the word **mean** instead. In this sense, *mean* is the same as a mathematical average. For instance, to find the mean height of seven students, you add up their individual heights and divide the sum by seven, the number of students.

Suppose the seven students above are third-graders who live in Charlotte, North Carolina. If you wanted to find the mean height of third-graders in Charlotte, you could do one of the following two things:

- You could measure the height of every single third-grader in Charlotte, and then calculate the *population mean*. This would take a long time because there are thousands of third-graders in Charlotte. The **population mean** refers to a mathematical average that has been calculated based on *all* of the available data.
- You could measure the height of several third-graders in certain areas and calculate the *sample mean*. The **sample mean** refers to a mathematical average that has been calculated based on only *some* (a sample) of the available data. The sample mean is an estimate of the population mean.

3. When do you think it is more appropriate to calculate a sample mean? Can you think of any problems with using a sample mean?

Making Data Meaningful, continued

4. When do you think it is more appropriate to calculate a population mean? Can you think of any problems with using a population mean?

Mode, Median, and Range

Mode, median, and range are other important mathematical tools for interpreting data. The **mode** is the value that occurs most often in a set of data. For example, imagine you are counting the number of slices of pepperoni on certain pieces of pizza. Following are the outcomes for 10 pieces:

Number of Pepperoni Slices per Piece of Pizza

Pizza piece	A	B	C	D	E	F	G	H	I	J
Pepperoni slices	5	5	2	3	2	5	6	1	2	5

Which number occurs most often in the data set? By counting how many times each number appears, you find that 5 appears most often. Therefore 5 is the *mode*. It is possible to have more than one mode in a set of data. If two values *tie* for the most occurrences, the data set has two modes. For example, if there had been one more 2 in the data above, the modes would have been 5 and 2.

The **median** is the middle value of a set of data listed in numerical order. If a set of data contains an even number of items, it will have two middle numbers. In this case, to find the median, you average the two middle numbers.

Let's find the median for the data set listed above. First, put the data in numerical order, from least value to greatest value.

1 2 2 2 3 5 5 5 5 6

Notice there are two middle numbers in this set, 3 and 5. We must average them then to get the median; $(3 + 5) \div 2 = 4$, so 4 is the median!

The **range** is the difference between the greatest number and the smallest number in the data set. Range shows how much the data set varies. Let's find the range of the set of data above. The greatest number is 6, and the smallest number is 1. To find the difference, we subtract 1 from 6.

$$6 - 1 = 5$$

The range for the data set is 5, so the data vary over 5 values.

Making Data Meaningful, continued

Your Turn

Find the statistical measures for the following sets of data:

5. 3, 5, 7, 9, 5, 6, 4, 3, 2, 22

a. Mean

b. Mode

c. Median

d. Range

6. 4, 19, 3, 19, 4

a. Mean

b. Mode

c. Median

d. Range

WORKSHEET

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COMMUNICATING SKILLS

Hints for Oral Presentations

Tomorrow, Gabe has to give a speech about pearls in his science class. Before going through this worksheet, he was very worried, but now he is confident that he has a well-organized speech.

Giving a speech or an oral presentation is a real challenge to many people. This worksheet offers some hints for organizing your speech, controlling stage fright, and watching your language.

Organizing Your Speech

Just like a written report, a speech has three main parts: an *introduction*, a *body*, and a *conclusion*. Here are some hints about each of these parts to help you get organized.

■ The Introduction

The beginning of your speech is the **introduction**. The introduction can be as short as a few sentences. It is very important for the following three reasons:

- It gets the attention of your audience.
- It is a way for you to gain the audience's respect and "good feelings."
- It gives you the chance to build the audience's interest in your topic.

Gabe's introduction will read, "Did you know that some jewelry is made by animals? It's true, only oysters make pearls."

What makes a good introduction?

Tell Them What You Are Going to Tell Them

Here are some hints for writing an interesting introduction. Choose one.

- Surprise your audience; begin your speech with a startling statement, get their attention.
- Begin your speech with a question. Let the audience think about it for a few moments, and then answer the question. The audience will be listening for your answer.
- Begin your speech with a quotation that fits your topic.
- Begin your speech with a personal reference. If your speech is about how bicycles stay upright when being ridden, tell the story of how you learned to ride your bike.
- Begin your speech with an audio-visual presentation that supports your topic.

Hints for Oral Presentations, continued

■ **The Body**

After your introduction comes the **body** of your speech. In the body, you develop all your main ideas or main points.

Below are the main points Gabe will include in the body of his speech.

- A.** why and how oysters make pearls
- B.** facts about natural pearls
- C.** how people “farm” pearls

To organize the body of your speech, follow the guidelines below.

Tell Them What You Want to Tell Them

- **Select** the main ideas you want to cover.
- **Outline** all the material you plan to include in your speech (all your main ideas plus all the supporting information that goes with them).
- **Organize** your speech in a logical, interesting pattern.

Here are some patterns to consider:

- ➔ chronological order (follow the order in which things happen),
- ➔ problem and solution (present a problem, then offer your solution to it),
- ➔ cause and effect (talk about a condition, then discuss the causes of that condition), or
- ➔ topical order (break down your topic into parts, then discuss each of the parts).

■ **The Conclusion**

The **conclusion** is the last, but not the least, part of your speech. Like the introduction, it should be only a few sentences long. A good conclusion is brief but powerful. It emphasizes the key ideas of your speech, and it focuses the emotions of your audience. A good conclusion will leave your audience excited, sad, glad, angry—or whatever emotional response you intend—if you prepare it properly.

Gabe chose to end his speech humorously. His conclusion reads, “Beauty is in the eye of the beholder. The pearl, which is a treasure to man, is only an annoyance to the oyster.”

Hints for Oral Presentations, continued

The Big Finish! Tell Them What You Told Them

Choose one of the following paths to a powerful conclusion:

- Use a short restatement of your most important information. This is the quickest and easiest type of conclusion, but usually the least interesting.
- Make a recommendation or propose a change; tell the audience what you want them to do.
- Give a stirring ending by using a strong quotation, telling a story, using an illustration, or relating a personal experience. This will intensify the audience's feelings; they will feel what you want them to feel.

Giving Your Speech—Overcoming Stage Fright

Stage fright is the nervousness that people feel before and during the presentation of a speech.

Overcoming Stage Fright

Before your speech, you should—

- Prepare everything carefully and completely; give yourself plenty of time for practice.
- Look your best; dress in the way that makes you feel most confident.
- Relax tense muscles; close your eyes, stretch, breathe slowly, and be positive.
- Remind yourself that you are prepared and that you have something interesting to share with the audience.
- Be confident, and let your body language show it! Take a deep breath, then go for it!

During your speech, nervousness may cause—

- Queasy feeling or butterflies; once you get started, these symptoms will go away.
- Dry mouth; start your speech slowly, and as you continue, dry mouth will disappear.
- Word fumbles as you begin; practice several different opening lines so you will be comfortable with a variety of ways of getting started.
- Perspiration, squeaky voice, trembling; **ignore** these reactions, your body will return to normal once you get rolling.
- Thoughts like "I want to quit!" **Don't give up!** Finish your speech, no matter how bad it seems.

There are a few things you need to know about stage fright:

- **It is perfectly normal to be nervous.** Even experienced speakers get a little nervous before they speak.
- Believe it or not, **your audience probably will not even notice** your nervousness! On the inside, you may feel tense or jittery, but it probably doesn't show on the outside.

Hints for Oral Presentations, continued

- ➔ The more you **practice** before your speech (and the more speeches you give), the more confident you will become. Each time you make an oral presentation or practice your speech, you will make fewer and fewer mistakes. Pretty soon, making an oral presentation might even become fun! It's true!

Finally, Watch Your Language!

Language comes in two forms, verbal and nonverbal. *Verbal language* is what you say and write. *Nonverbal language* is how you communicate without words, such as with your appearance, your body language (facial expression, eye contact, gestures, posture, and movement), and the sound of your voice. When you give an oral presentation, both what you say and **how you say it** are very important.

Lookin' Good!

Here are suggestions for improving your nonverbal language:

- **Look at** individuals in your audience; let them know you are speaking directly to them, it will keep their interest.
- Your **facial expression** should reflect what you are saying. If your subject is serious, your expression should be serious; if you are excited about something, your face should show your excitement.
- **Don't worry about your hands!** Start off with your hands by your sides or on the speaker's stand. Relax. Soon your hands will begin to move naturally, as if you were having a normal conversation with your audience.
- Never slouch, slump, or look sloppy! **Stand up straight**, and show your audience that you are confident and proud of your work!
- Let your **enthusiasm** show in your voice.

Speech! Speech!

Now you are ready to give your speech.

- ➔ Remember to speak clearly and distinctly.
- ➔ Do not rush.
- ➔ Do not panic.
- ➔ If you've chosen a topic you enjoy and you're prepared, **YOU CAN DO IT!** Relax!

And once it is over, you'll be surprised; you may want to do it again!

Good Luck!